Big Rock and Welch Creek Flood Study, Kane County, Illinois

by
Amanda J. Flegel, Jennifer L. Byard, and Sally A. McConkey

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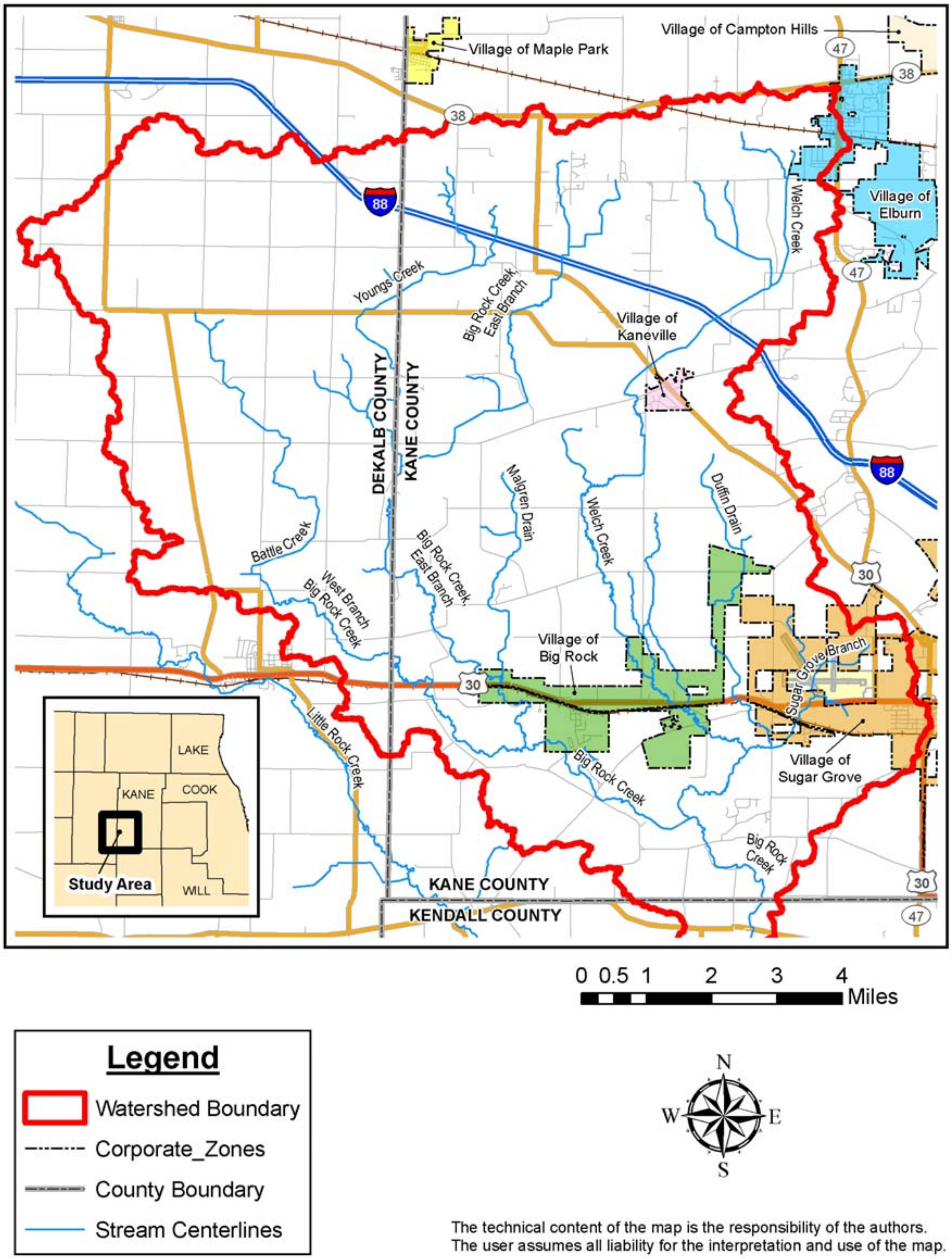
Village of Campton Hills
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Village of Elburn
Welch Creek
Youngs Creek
Big Rock Creek, East Branch
Village of Kaneville
DEKALB COUNTY
KANE COUNTY
Malgren Drain
Welch Creek
Duffin Drain
Battle Creek
West Branch Big Rock Creek
Big Rock Creek, East Branch
Village of Big Rock
Sugar Grove Branch
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The technical content of the map is the responsibility of the authors.
The user assumes all liability for the interpretation and use of the map.

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Abstract

Big Rock and Welch Creeks are located in southwestern Kane County, Illinois. This area of Kane County is expected to experience development in the coming years; thus an accurate representation of local flood hazards is important. Regulatory floodplain maps now in effect for these streams show floodplain boundaries based on observations of flood events that occurred more than 30 years ago and lack engineering analyses that meet current standards and expectations. The purpose of this project is to better define flood hazards posed by streams in the Big Rock and Welch Creek watershed based on hydrologic and hydraulic analyses of existing conditions. Illinois State Water Survey (ISWS) staff worked with Kane County and community representatives to identify stream reaches for study and the level of study detail for each reach. Hydrologic and hydraulic analyses were conducted and used to delineate floodplain boundaries corresponding to the 1-percent-annual-chance flood, the base flood used by the Federal Emergency Management Agency (FEMA) for regulatory flood protection. Information was generated using spatial datasets and field data. Digital floodplain boundaries and attendant data are stored in the FEMA-prescribed Digital FIRM (DFIRM) database format for ready incorporation in the regulatory maps upon review and approval by FEMA. This study will provide information for floodplain management in both urban and rural areas.

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Project Overview

Big Rock and Welch Creeks are located in southwestern Kane County, Illinois. This area of Kane County is expected to experience development in the coming years; thus an accurate representation of local flood hazards is important. Flood hazards are depicted as floodplain boundaries on Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs). These maps are used for regulatory purposes and for floodplain management. Accurate identification of flood hazards developed from engineering analyses provides important information for floodplain management and regulation, with the benefit of reduced risk for the public. FIRMs now in effect for these streams show floodplain boundaries based on observations of flood events that occurred more than 30 years ago and lack engineering analyses that meet current standards and expectations. The purpose of this project is to better define flood hazards posed by streams in the Big Rock and Welch Creek watershed based on hydrologic and hydraulic analyses of existing conditions.

Illinois State Water Survey (ISWS) staff worked with Kane County and community representatives to identify stream reaches for study and the level of study detail for each reach. Hydrologic and hydraulic analyses were conducted and used to delineate floodplain boundaries corresponding to the 1-percent-annual-chance flood, the base flood used by FEMA for regulatory flood protection. Information was generated using spatial datasets and field data. The flood study was conducted in accordance with Illinois and FEMA regulatory standards. Digital floodplain boundaries and attendant data are stored in the FEMA-prescribed Digital FIRM (DFIRM) database format for ready incorporation in the regulatory maps upon review and approval by FEMA. This study will provide information for floodplain management in both urban and rural areas.

Acknowledgments

This material is based on work supported by the Kane County Department of Environmental Concerns. This project is part of the Smart Growth Floodplain Monitoring Project, Kane County, Illinois, sponsored by the Natural Resources Conservation Service.

Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the University of Illinois.

The project work involved a number of disciplines and talented individuals without whose contribution the project could not have been performed. The Illinois Department of Natural Resources, Office of Water Resources provided land surveying support. Many staff from the ISWS, Center for Watershed Science contributed to the project. Jim Slowikowski supervised the installation of gages and collection of the precipitation, stage, and discharge data. Aaron Thomas assisted with the preparation of the input for the HEC-RAS models, identification of gage locations, and site reconnaissance. Ryan Meekma provided geographic information system support and prepared the digital flood maps and the DFIRM geospatial database. Becky Howard formatted the report. Sara Olson provided guidance for preparation of the graphics. Lisa Sheppard edited the final report.

Scope of Work

The Big Rock Creek/Welch Creek watershed flood study includes approximately 68 stream miles. Two levels of flood study were conducted; a limited-detail flood study was conducted for 38 stream miles and an approximate study was conducted for 30 stream miles in the Big Rock Creek/Welch Creek watershed areas within Kane County.

Two meetings were held with Kane County and community representatives. The first meeting was to outline the project, identify stream reaches for which limited-detail and approximate study would be conducted, and collect community data such as bridge plans. A second meeting was held to examine preliminary floodplain boundaries generated from models prepared for the study and to collect documentation of observed flood extent.

The project included assimilating crest stage gages operated circa 1961-1975 and precipitation data at existing gages in the watershed vicinity. A temporary precipitation gage was installed as well as stream stage gages at four locations in the watershed. Precipitation and stream stage data, including periodic discharge measurements, were collected from May to November 2008 at the stream gage sites. Field measurement of bridge and culvert dimensions at critical locations was performed. Surveys conducted by the Illinois Department of Natural Resources, Office of Water Resources (IDNR/OWR) provided valuable stream channel configuration information, bridge elevation data, and datum of the temporary stage gages.

The U.S. Army Corps of Engineers' Hydrological Engineering Center-Hydrologic Modeling System (HEC-HMS), version 3.2 (Scharffenberg and Fleming, 2008), was used to compute flood discharges. The 1-percent-annual-chance discharge was calculated at locations throughout the watershed. Gage data collected during the project were used to prepare the hydrologic model.

The U.S. Army Corps of Engineers' Hydrological Engineering Center-River Analysis System (HEC-RAS), version 4.0 (Brunner, 2008; Warner et al., 2008), was used for hydraulic modeling. Digital elevation data available from Kane County were used to generate cross section data input for the model. Where available, as-built bridge plans were reviewed and used to model these structures. Where bridge plans were not available, field measurements and survey data were collected. Photos were taken throughout the watershed to document existing conditions and determine roughness coefficients for modeling.

Modeling results were incorporated in the FEMA DFIRM database format, and maps and tabular data were prepared. The information will serve as the basis for submittals to the IDNR/OWR for discharge certification and to FEMA to update the regulatory DFIRM.

Level of Study Detail

Three levels of investigation are used for FEMA studies and are shown on Flood Insurance Rate Maps (FIRMs). The three levels are approximate, limited-detail, and detailed studies. The objective of each level of study is to determine the boundaries of floodplains representing the area that has a 1-percent chance of inundation in any given year (100-year floodplain). The type of analysis and data requirements are different for each level of study. The expected accuracy increases with an increasing level of study intensity.

Approximate floodplain boundaries may be delineated using a variety of information sources. Discharges may be estimated and simple engineering analyses are used such as normal depth or backwater model estimation of flood depths with minimal assessment of the influence of structures and significant confluences. This level of study produces floodplain boundaries with no attendant engineering data published in the FEMA Flood Insurance Study (FIS).

Limited-detail studies (also known as enhanced Zone A studies) require more rigorous analysis than approximate studies, and typically only the 1-percent-annual-chance flood is considered. FEMA is currently updating the requirements for limited-detail studies. In the past, limited studies could be conducted using hydrologic models or regression equations for discharge calculations, and hydraulic model input could be generated from detailed terrain data coupled with limited information on structures that may affect flood elevations (e.g., bridges and culverts included in the model do not require detailed hydraulic modeling). In the past, products from the limited-detail study were Zone A floodplain boundaries shown on the FIRMs. The community received 1-percent-annual-chance elevations at cross sections, flood profiles, and data tables that may be used for floodplain management, but these were not necessarily published in the FIS. Anticipated revisions to specifications for limited-detail studies include use of the Zone AE designation on the FIRMS as well as showing cross sections and base flood elevations (BFEs) and providing profiles in the FIS.

Detailed studies require hydrologic and hydraulic analyses that involve calculating discharges preferably from frequency analysis of gaging station records, or calibrating models to observed discharges and stages (or some combination of both) and detailed survey and topographic data. Study products are Zone AE floodplain boundaries and floodways, flood elevations and profiles for the 10-, 2-, 1-, and 0.2-percent-annual-chance floods, and floodway data tables published in the FEMA Flood Insurance Study (FIS).

The level of study should reflect the level of risk associated with the flood hazard. This may be characterized as a function of population density within the floodplain and level of anticipated growth. Floodplains in areas with high population density and/or high anticipated growth are mapped using information from detailed hydrologic and hydraulic analyses; floodplains with medium population density and modest growth may be adequately mapped using information from limited-detail studies; and floodplains in areas of low population and small or no anticipated growth are delineated adequately using approximate methods.

Identification of Reaches for Study

In northeastern Illinois, the IDNR/OWR regulates construction within the floodways of streams draining one or more square miles. Typically, floodplains are shown on FIRMs for stream reaches draining one or more square miles. A screening tool developed at the ISWS was used to identify the upstream limits for approximate floodplain mapping. Approximate floodplains were mapped for streams draining one or more square miles within the study watersheds. Stream reaches draining less than 1 square mile (sq mi) were mapped if there was an existing floodplain. Stream reaches in areas of apparent development were identified in collaboration with Kane County and community representatives through meetings and correspondence. The reaches selected for limited-detail and approximate study are shown in Figure 1.

Watershed Description

The Big Rock and Welch Creek watershed drains to the Fox River. Welch Creek joins Big Rock Creek 10.3 miles above its confluence with the Fox River. Big Rock Creek joins Fox River at 31 miles above the confluence with the Illinois River, south of the Kane–Kendall County boundary. The Big Rock and Welch Creek watershed is located in Kane, DeKalb, and Kendall counties in northeastern Illinois, and covers a drainage area of 108 sq mi at the southwestern Kane County boundary. Urban areas within the watershed include a small portion of the Village of Elburn to the northeast, the Village of Sugar Grove to the east, and the Villages of Big Rock and Kaneville.

Land use is primarily agricultural. The watershed is reported to consist of 78 percent row crops, 11 percent rural grassland, 5 percent forest, 1 percent surface water and 5 percent urban areas (IDOA, 2003). The watershed is 98 percent hydrologic soil group B (USDA/NRCS, 2007), and thus has a moderate infiltration rate when thoroughly wet, such as during a major flooding event.

Available Geospatial Datasets

Illinois land cover data circa 1999-2000 was used in this study (IDOA, 2003). This spatial database uses five major land use classifications (agricultural, forested, urban, wetland, and other) and 23 different categories, including seven different agricultural land use categories and three urban land use categories.

Soils data from the U.S. Department of Agriculture, Natural Resources Conservation Service (USDA/NRCS) were obtained from the Soil Data Mart, State Soil Geographic Database (USDA/NRCS, 2003). The database uses map unit compositions (MUID) to characterize the soil and define the hydrologic soil group.

Two sources of topographic data were used. Watershed boundaries and other inputs required for hydrologic models were determined from 1/3 arc/second (approximately 10 meters) digital elevation models (DEM) from the National Elevation Dataset prepared by the U.S. Geological Survey (USGS, 2005). Data for hydraulic modeling were extracted from the Kane County topographic data, which have 2-foot contour intervals, and were prepared using aerial photography obtained during spring 2001.

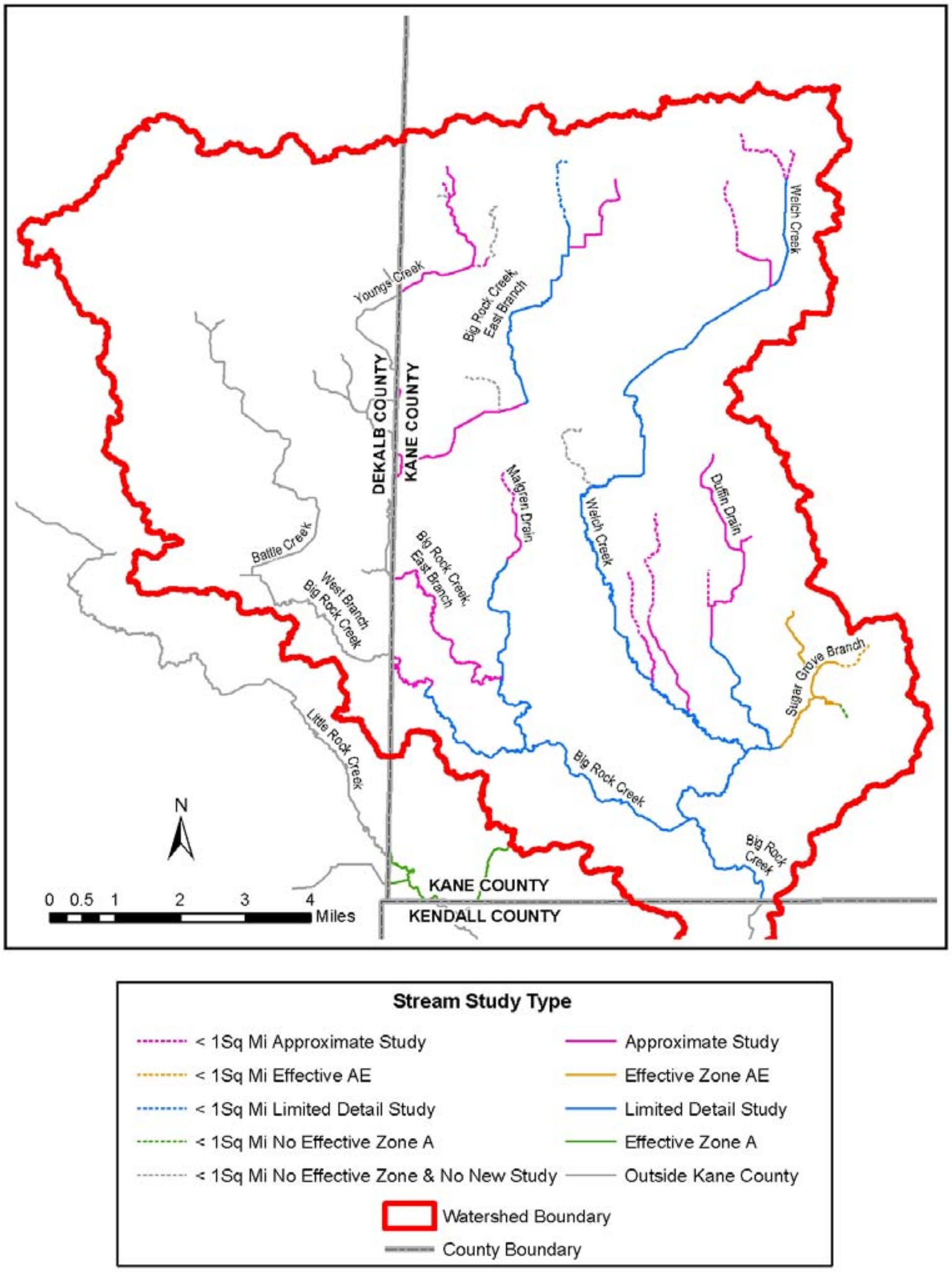

Figure 1. Limited-detail and approximate study reaches in the Big Rock and Welch Creek watershed

Historical Flood Events

Precipitation Data

Total daily precipitation data are available from the Aurora College station (National Climate Data Center, NCDC), cooperative station 110338, from January 1, 1948 to the present. The Aurora College station is about 8 miles east of the watershed near the Fox River. Hourly precipitation data have been collected at a gage located at the Aurora Municipal Airport since February 1, 1975. The Aurora Airport gage is at the far-eastern edge of the watershed just north of U.S. 30.

Discharge Data

There are no active stage or discharge gages in the watershed. The United States Geological Survey (USGS) has published annual peak discharge values for two crest-stage gages in the watershed. One of these gages was located on East Branch Big Rock Creek near Big Rock (USGS gage 05551900), providing 15 years (1965-1979) of estimated peak discharge data. The other gage, located on Welch Creek near Big Rock (USGS gage 05551930), also resulted in estimated peak discharge values for 16 years (1965-1980). Crest-stage data were collected at eight additional sites in the watershed during approximately the same time period. The locations, streams, years of record, and dates of peak gage height are noted in Table 1. No single storm event set the peak year of record for the entire watershed during the period of record.

The peak discharge published for the East Branch Big Rock gage (05551900) is 1580 cubic feet per second (cfs) on May 16, 1974. The second highest published discharge is 1410 cfs on June 15, 1972. Likewise, peak discharge of 694 cfs, published at the Welch Creek gage (05551930), is on May 16, 1974, and the second largest discharge published for the period is 563 cfs on June 15, 1972.

Twenty-four-hour precipitation totals (6 p.m. to 6 p.m.) are available for May 1974 and June 1972 from the Aurora College station (located east of the watershed). The May 1974 storm started on May 13 with 0.21 inches of rain. From May 14 through 6 p.m. on May 16, an additional 2.16 inches of rain occurred. By 6 p.m. on May 17, another 1.45 inches were recorded. Storms typically travel from west to east in this area. Given the location of the precipitation gage relative to the watershed, some of the precipitation recorded by 6 p.m. on May 17 may have contributed to the observed peak flows recorded on May 16, 1974. A rainfall estimate for the May 1974 event is at least 2.5 inches over about 72 hours. The June 1972 storm started on June 12, 1972, and between June 12 and June 15, 3.56 inches of rain fell over about 96 hours.

The extent of flooding that occurred during the October 1954 flood event is recorded in the U.S. Geological Survey Hydrologic Atlases (Allen, 1966a, 1966b; Mycyk and Walter, 1972; Mycyk et al., 1973). More than 3 inches of rain fell early in October, but the storm event that

Table 1. Historical Stream Stage Gages in the Big Rock/Welch Creek Watershed

Stream name/location	*USGS station*	*Road crossing*	*Drainage area*	*Period of record*		*Peak year of record* *Highest*	*Peak year of record* *2nd Highest*
Big Rock Creek at Big Rock	05551915	Price Road	51.4	1965	1975	5/16/1974	6/15/1972
East Branch Big Rock							
near Kaneville	05551860	Harter Road	4.89	1965	1975	2/6/1965	2/10/1966
near Hinckley	05551890	Lasher Road	13.5	1965	1975	5/16/1974	5/12/1966
near Big Rock *	05551900	U.S. 30	21	1965	1979	5/16/1974	6/15/1972
West Branch Big Rock							
at Hinckley	05551910	Pritchard Road	24.4	1965	1975	2/6/1965	2/10/1966
Youngs Creek							
near Maple Park	05551870	County Line Road	4.79	1965	1975	6/15/1972	4/22/1973
near Kaneville	05551880	McGirr Road	11.4	1965	1975	2/6/1965	6/15/1972
Welch Creek							
at Kaneville	05551920	Dauberman Road	10.4	1965	1975	6/15/1972	5/16/1974
near Kaneville	05551925	Scott Road	16.4	1965	1975	6/15/1972	5/16/1974
near Big Rock*	05551930	Granart Road	22.4	1965	1980	5/16/1974	6/15/1972

Note: *Discharge also recorded.

resulted in the highest flood observed by local residents in 71 years (Mycyk et al., 1973) occurred after 10.48 inches of rain fell on October 10, 1954.

Since the 1954 flood, the largest flood on record occurred on July 18, 1996 when 16.91 inches of rain were recorded at the Aurora College station. No discharge or stage elevations were recorded on the Big Rock and Welch Creek streams.

Water surface elevations recorded on the East Branch Big Rock and Welch Creeks are shown in Table 2.

Table 2. Water Surface Elevations on the East Branch Big Rock and Welch Creeks

		Elevation, feet msl			
Stream	*Location*	*10/10/1954*	*06/15/1972*	*05/16/1974*	*09/13/2008*
East Branch Big Rock	Near Big Rock at U.S. Highway 30	708 (estimated)	703.61	703.95	NA
Welch Creek	Near Big Rock at Granart Road	689 (estimated)	687.44	688.09	689.01

Field Data Collection

The key to an accurate hydrologic and hydraulic model is having observed data for calibration. To this end, one precipitation gage and four stage gages were installed in the watershed. The Big Rock/Welch Creek project (BRWC) gages were operated from May to November 2008. During their operation, a precipitation event near the one-percent-annual-chance flood occurred. This event was used to calibrate the model, and is described in detail in this report. Gage descriptions can be found in Appendix A.

Field surveying was performed by the Illinois Department of Natural Resources, Office of Water Resources (IDNR/OWR) staff. Surveying included establishing the datum of the state gages and measuring eight bridge sites with stream cross sections. Surveyed bridge locations can be seen on Figure 18 in this report. A table reporting surveyed and bridge source data is located in Appendix B.

Field visits by ISWS staff were also conducted to collect measurements of bridge heights, widths, and culvert dimensions. Photographs taken during these field trips helped to determine the appropriate Manning's roughness coefficient (Manning's *n*) values.

Precipitation Gage

The BRWC precipitation gage was located near the center of the watershed. A map of the precipitation gage in relation to the watershed and sub-basins is provided in Figure 2. Precipitation was recorded at intervals of 15 minutes. A summary of peak precipitation events is noted in Table 3.

Table 3. Precipitation Events Recorded at Project Gage

Time period	*Duration (hours)*	*Total precipitation (inches)*	*Corresponding Bulletin 70, % annual event*
September 12, 1:00 p.m. to September 14, 1:45 p.m.	48.75	8.24	Approximately 100-year event
September 4, 5:15 a.m. to 9:45 p.m.	16.5	2.88	Approximately 2-year event
July 12, 5:15 a.m. to 8:15 a.m.	3	2.54	Approximately 7-year event
May 11, 1:00 a.m. to 11:00 a.m.	10	2.19	Approximately 2-year event

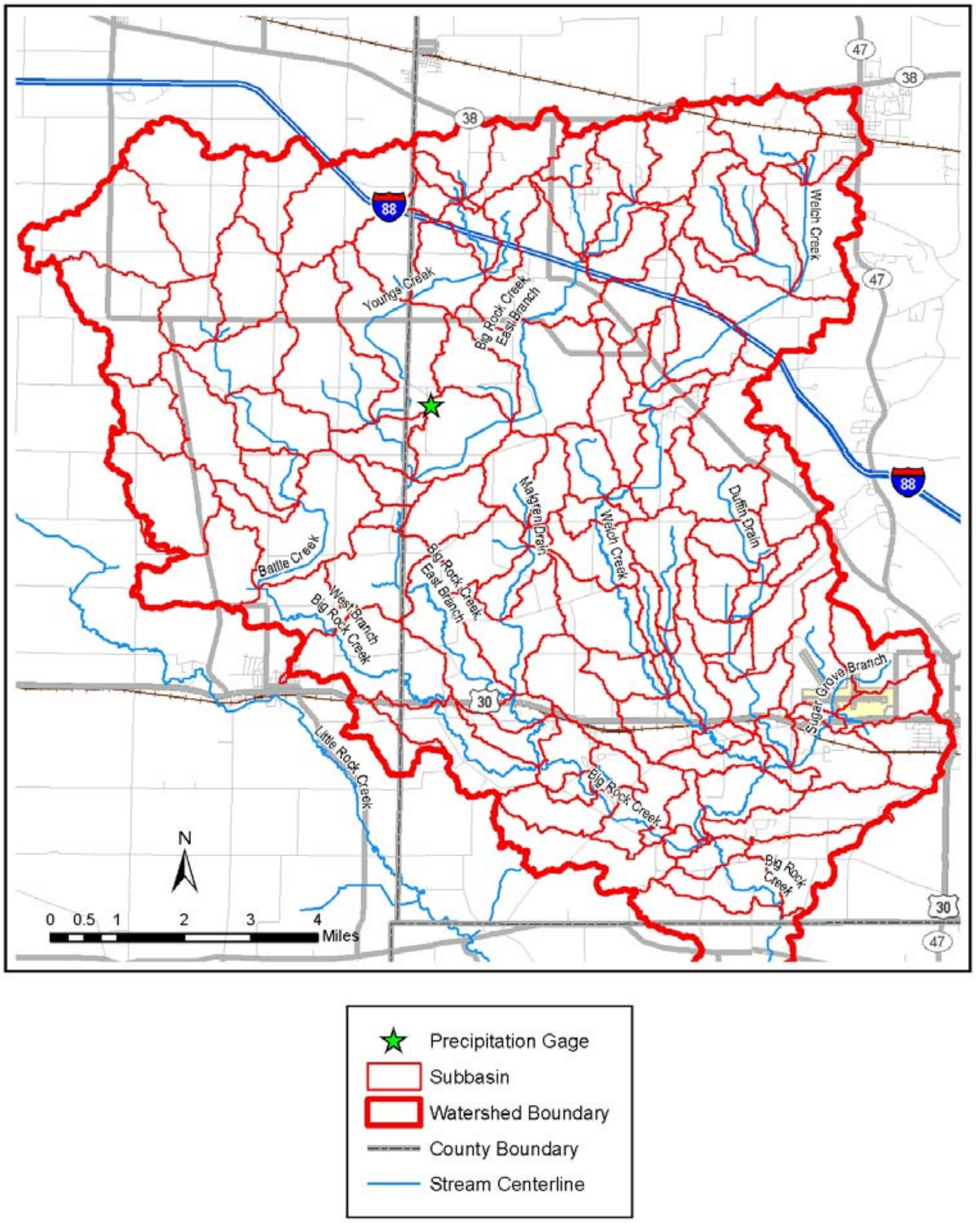

Figure 2. Big Rock/Welch Creek flood study sub-basins and precipitation gage location

Stream Stage Gages

Stage gages were installed at four locations at the downstream reaches of the watershed, and the data were used to calibrate hydrologic and hydraulic models. Gages were located in pairs, two on each stream, so that the stage information also could be used to estimate reach discharges and calibrate the hydrologic model. Gage locations are shown in Figure 3. The stage data were collected in increments of 15 minutes. Discharges were measured periodically to estimate the stage-discharge relationship at the gages. Observations at the gages were compared with model-simulated water surface elevations.

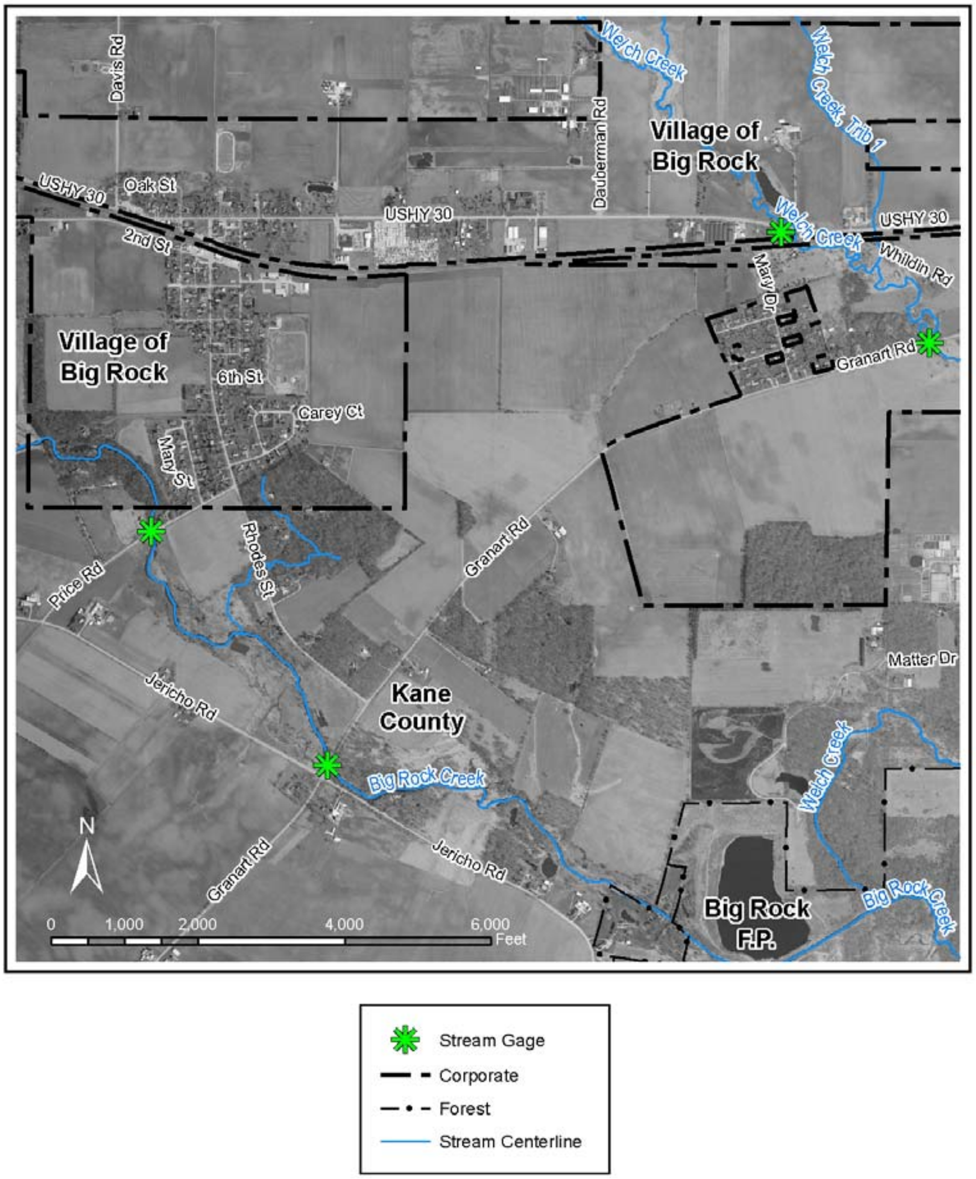

Figure 3. Big Rock/Welch Creek flood study stage gage locations

September 12-14, 2008 Event

Based on the project gage data, the mid-September storm began in the afternoon of September 12, with the first precipitation recorded at 1 p.m. The storm was preceded by 2.9 inches of precipitation recorded on September 4 and 0.07 inches of rainfall fell September 6-10. Rainfall was 0.39 inches on September 12. Rain continued throughout most of the day on September 13 with periods of intense rain; by 4:15 p.m., another 6.58 inches of rain were recorded at the watershed gage. Total accumulation for September 13 was 6.7 inches. Another 1.2 inches of rain fell on September 14.

At the Aurora Municipal Airport cumulative precipitation on September 12 was 0.52 inches (midnight to midnight). On September 13 total accumulation was 5.52 inches, and on September 14 the total recorded precipitation was 0.33 inches.

More intense hourly precipitation was recorded at the study gage than recorded at the Aurora Municipal Airport gage located to the east of the study gage. The storm lost intensity as it moved from west to east across the watershed. The precipitation distribution resulting in the September flood event can be seen in the two graphs below (Figures 4 and 5). Eighty percent of rain occurred in the first 24 hours at the project gage.

The September flood event was recorded at each stage gage. An increase in water depth of 7 and 9 feet was recorded at the Big Rock Creek gages, and an increase of 6 and 8 feet was seen at Welch Creek gages. Peak stages occurred on September 13 at approximately 5:15 p.m. at the Welch Creek gages (about 28 hours after the start of the precipitation) and at approximately 11:15 p.m. at the Big Rock Creek gages (about 34 hours after the start of the precipitation). The stages recorded at the gages are shown in Figures 6 and 7. A second peak is visible in the Welch Creek records, while Big Rock Creek has a steadily descending limb.

During the September event a number of roads in the watershed were overtopped and extensive flooding was observed. These observations provided additional insights to the nature of flooding in the watershed.

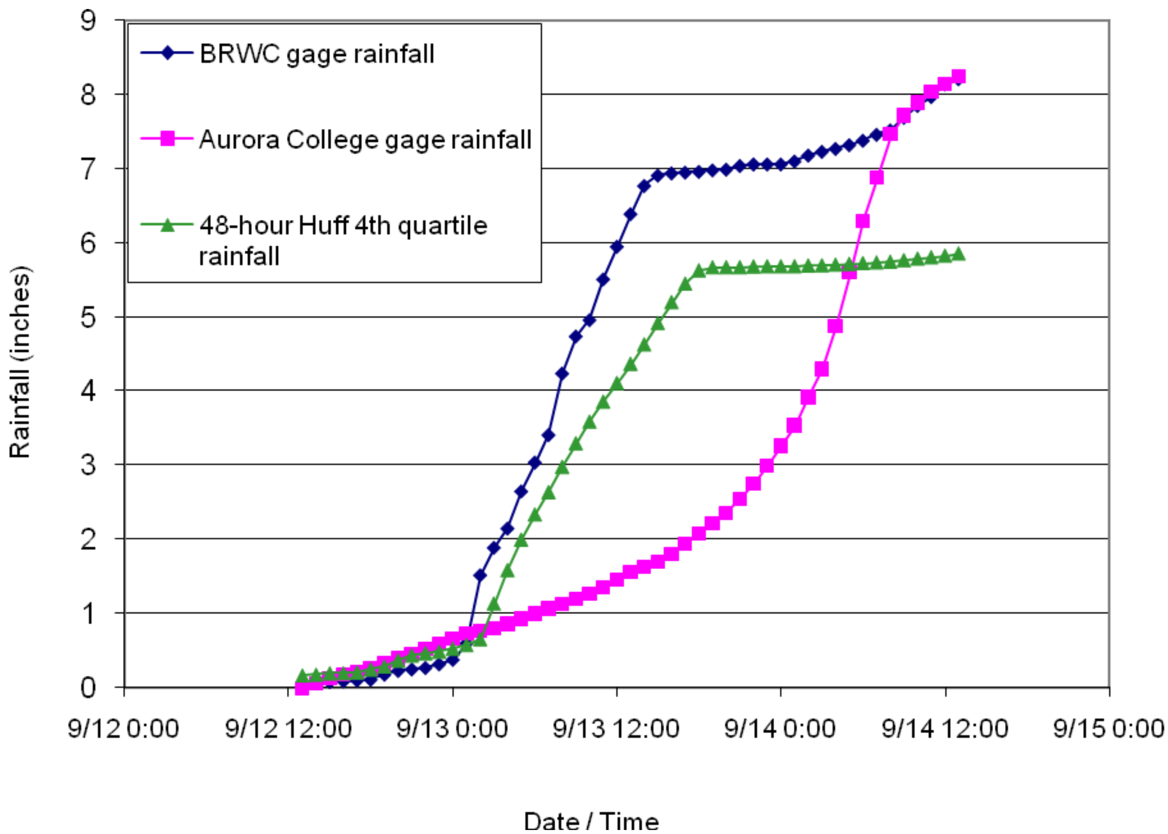

Figure 4. Comparison of the September 12-14, 2008 rainfall distribution at the project and Aurora College rain gages to the 48-hour Huff 4th quartile rainfall distribution

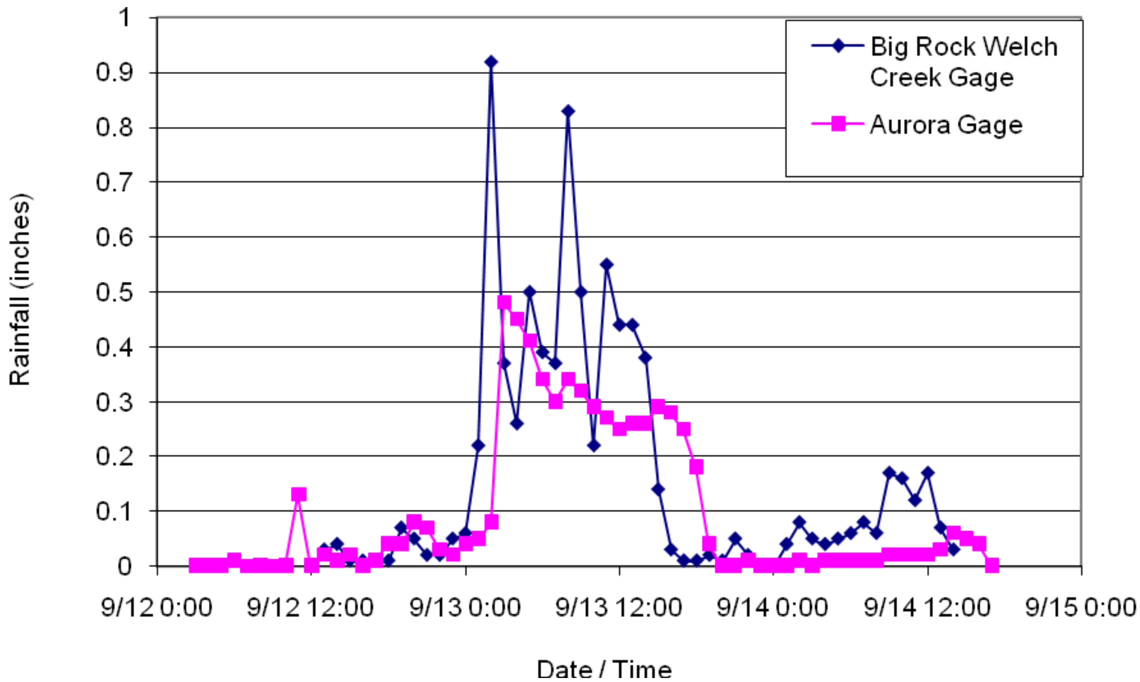

Figure 5. Hourly precipitation for the Big Rock/Welch Creek project and Aurora gages, September 12-14, 2008

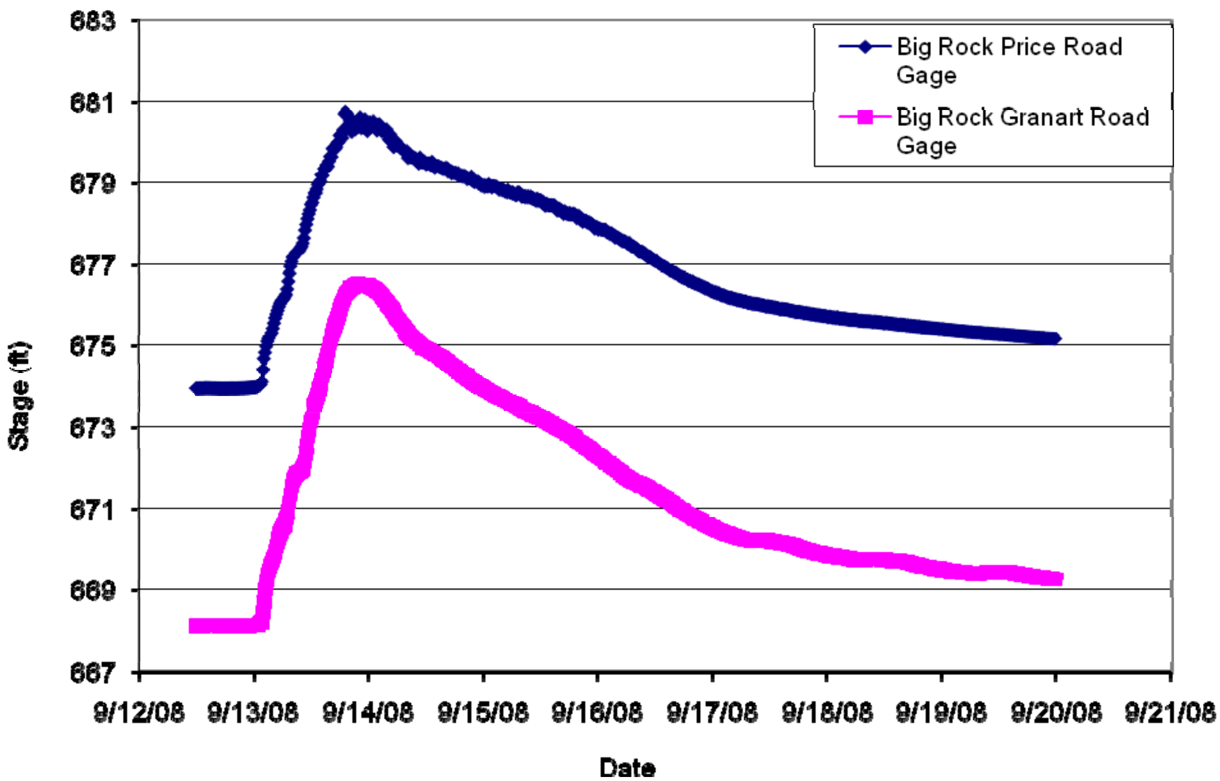

Figure 6. Big Rock Creek stage gage records for September 2008 flood event

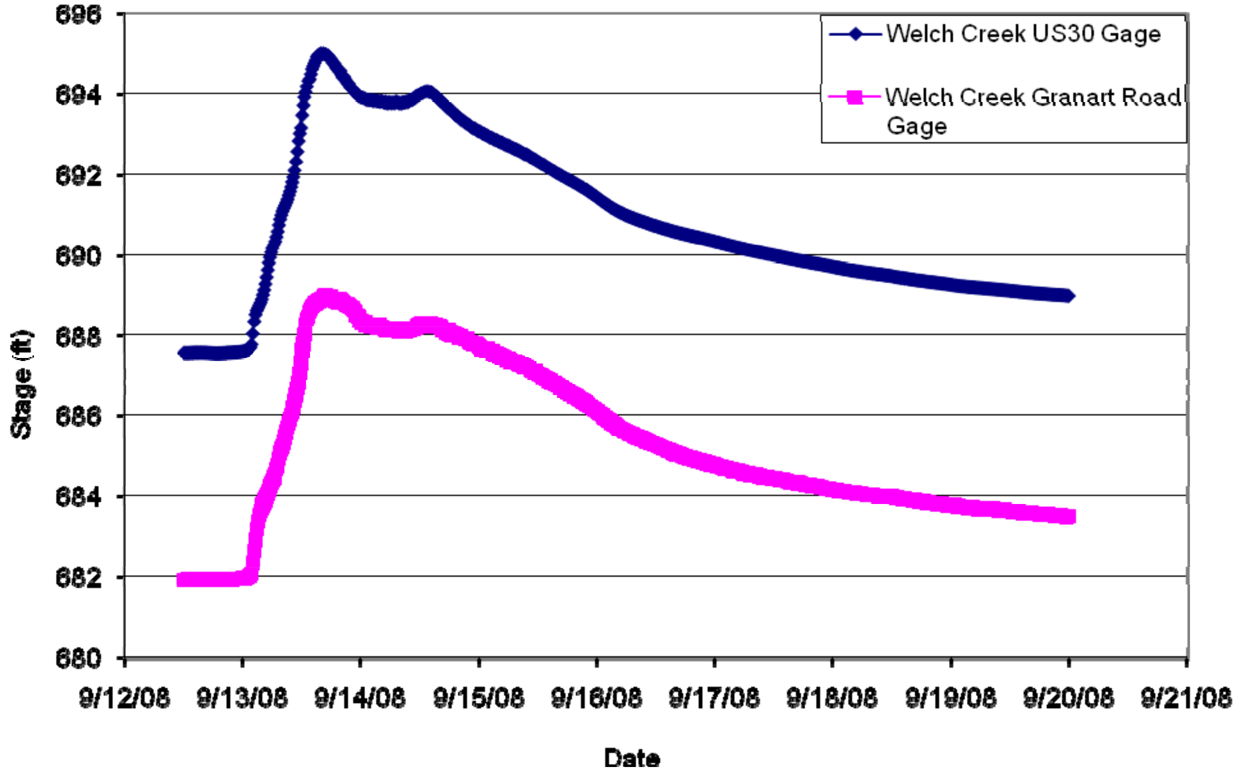

Figure 7. Welch Creek stage gage records for September 2008 flood event

Hydrologic Modeling

The goal of the hydrologic analysis was to create a model, calibrate it to a large storm event, and use the model to simulate the 1-percent-annual-chance flood discharge at locations throughout the watershed. The Big Rock and Welch Creek watershed hydrology was modeled using HEC-HMS version 3.2 (Scharffenberg and Fleming, 2008). The analysis was performed using the SCS Curve number loss method, Clark Unit Hydrograph translation method, and Muskingum Cunge and Modified Puls routing calculations. Total rainfall of 7.83 inches from *Frequency Distributions and Hydroclimatic Characteristics of Heavy Rainstorms in Illinois* (Huff and Angel, 1989) and the 48 hour, fourth-quartile Huff distribution, reported in *Time Distributions of Heavy Rainstorms in Illinois* (Huff, 1990), were used for the 1-percent-annual-chance event simulation.

Subwatershed Delineation and Hydrologic Model Data

HEC-HMS modeling uses spatial information, including sub-basin data and river reach routing information. Sub-basin areas, river reach lengths and river reach slopes were determined by using the DEM downloaded from the USGS National Elevation Dataset. This dataset was used for hydrology rather than using Kane County topography, which has a higher resolution, because of the availability of topography for the portion of the watershed in DeKalb County. The USGS DEM has adequate resolution for the hydrologic modeling aspect of this study. Both ArcHydro (Maidment, 2002) and HEC-geoHMS version 1.1 (USACE, 2003) were used to determine the physical hydrologic parameters and to generate required input.

Sub-basins were initially divided based on desired calculation points and then further subdivided to create a more uniform division of the watershed area. Sub-basins were divided into areas less than 3 square miles. Sub-basin divisions are shown in Figure 2 as well as on the work map available in Appendix E. The total drainage area was calculated using automated methods and the drainage areas agree with the drainage areas reported at former USGS gage stations on Welch and East Branch Big Rock Creeks (Soong et al., 2004).

Soils data and land use spatial data were reviewed to estimate precipitation losses due to infiltration using the SCS Curve number method. State Soil Geographic Database (STATSGO) soil data for the watershed are shown in Figure 8. STATSGO soil data are generalized for use with large areas by grouping soil associations as map units. Map unit compositions IL10, IL12, IL14, and IL 46 were found in the studied watershed. These units are characterized by hydrologic soil group percentages, noted in Table 4. Land cover data from Land Cover of Illinois 1999-2000 classification are displayed in Figure 9.

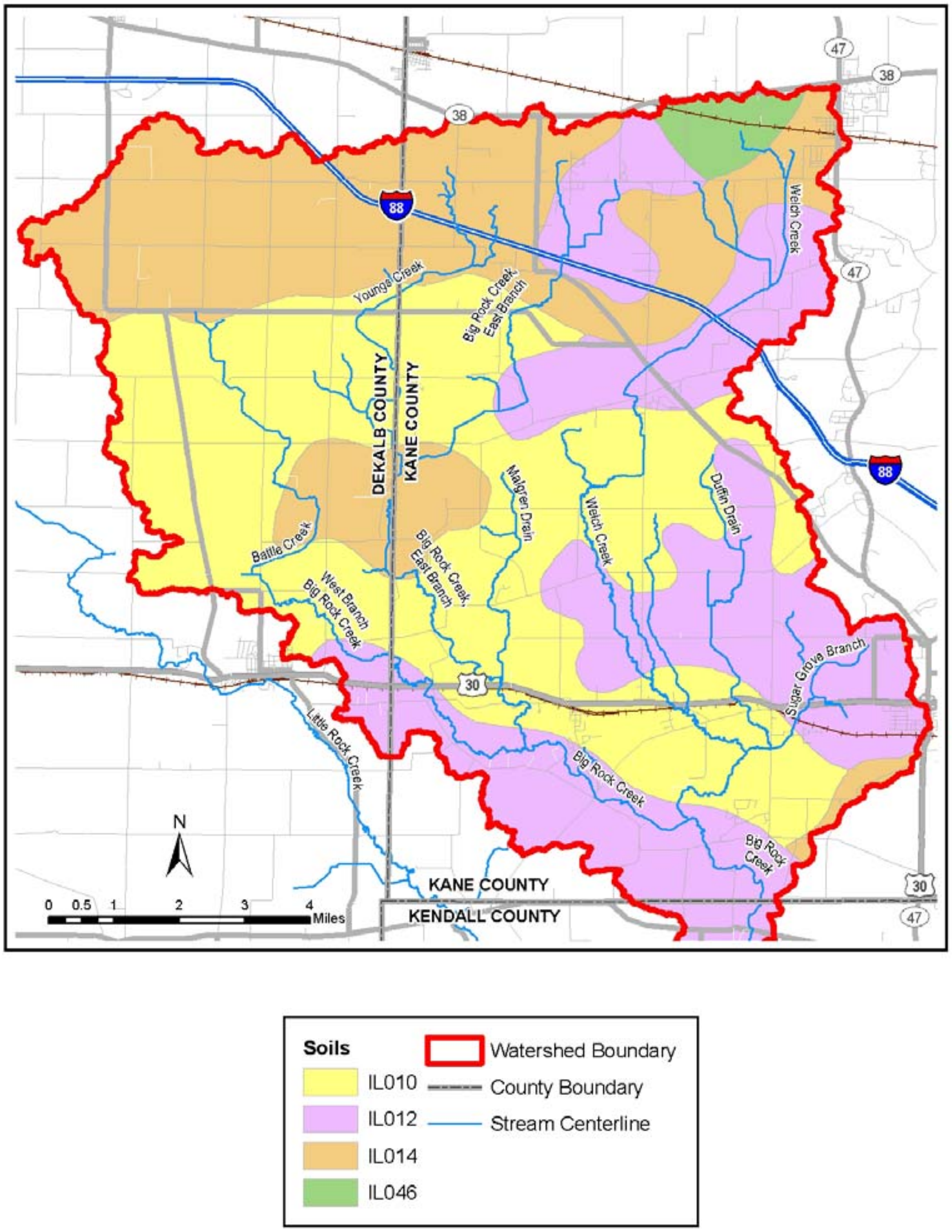

Figure 8. Soil data map for Big Rock/Welch Creek watershed depicting the Stat Soil Geographic Database (STATSGO) map unit identification numbers

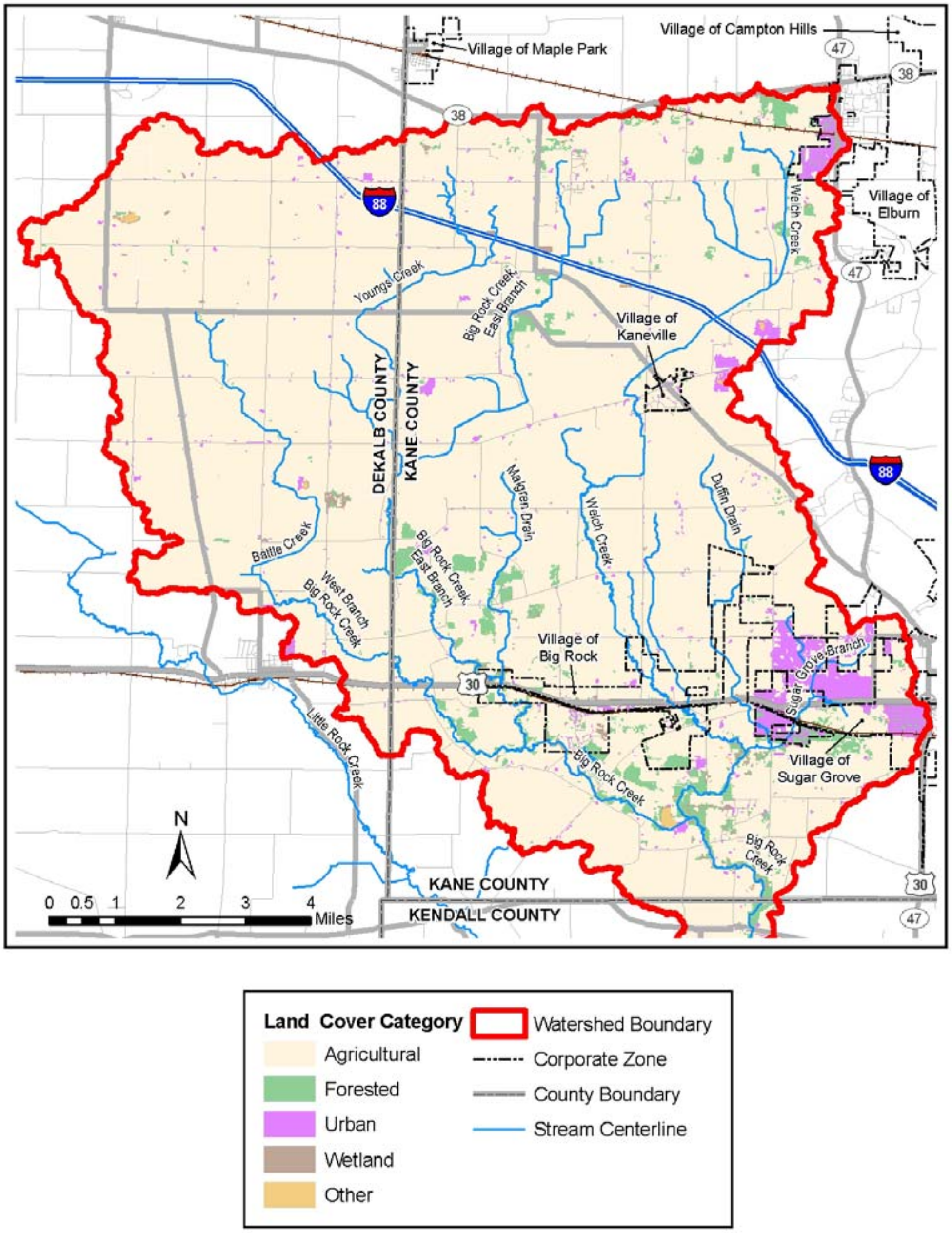

Figure 9. Land cover data for the Big Rock/Welch Creek watershed from Land Cover of Illinois 1999-2000

Table 4. Soil Map Units

	Hydrologic Soil Group Percentage			
MUID	*A*	*B*	*C*	*D*
IL010	0	97	3	0
IL012	0	100	0	0
IL014	0	100	0	0
IL046	0	100	0	0

ArcCN is a script written to generate curve numbers given soil and land-use data using ArcGIS (Zhan and Huag, 2004). ArcCN was used to calculate a weighted average curve number for each sub-basin based on hydrologic soil type-land use combinations. These initial curve numbers were adjusted using a single multiplier over the watershed during the calibration process.

The Clark Unit Hydrograph option was selected for transformation calculations in the hydrologic model. Initial parameters for this method of determining time of concentration and storage coefficients were determined using the USGS 2000 *Equations for Estimating Clark Unit-Hydrograph Parameters for Small Rural Watersheds in Illinois* (Straub et al., 2000). These initial time-of-concentration and routing coefficient values were adjusted evenly over the watershed during the calibration process, which is outlined below.

Channel routing calculations were completed with the Muskingum-Cunge method for the majority of the watershed. Multiple eight-point cross sections were created for different channel bottom widths. These simplified cross sections were determined per engineering review of the available surveyed cross sections in the watershed. The simplified cross sections have an 8-foot channel depth, 2:1 channel side slopes, and an overbank width of 600 feet. The channel depth and overbank width were designated with the goal of providing a reasonable, simplified, and conservative cross section template for the entire watershed. The eight-point cross section allowed the specification of channel and right and left overbank Manning's *n* values. For the hydrologic routing calculations, the channel Manning's *n* value is estimated to be 0.045, and the overbank value is estimated to be 0.07. Reach length and slope were determined using automated methods, as noted above.

A review of the hydraulic model indicated there were some reaches with significant storage caused by restrictive bridges with large embankments. In these reaches, the results from the HEC-RAS model were used to determine a discharge/volume rating curve. The rating curve was then used with the Modified Puls routing calculation in the hydrologic model.

Base flow was not used in this model as the base flow would not be considered critical for the 1-percent-annual-chance flood event.

Flood Discharge Calculation of September 12-17, 2008 Using the Slope-Area Method

As noted in the Field Data Collection section, a precipitation gage and four stage gages captured data for the September 2008 flood event in the watershed. This information was used to compute reach discharges for Big Rock and Welch Creek.

The method for calculating discharges from the stage data was based on equations presented in *A Simplified Slope-Area Method for Estimating Flood Discharges in Natural Channels* (Riggs, 1976). This method removes the subjective Manning's *n* values and calculates discharge with only water-surface slope and cross sectional area. The standard error is reported to be 20 percent. The discharge equation is:

$$\log Q = 0.366 + 1.33 \log A + 0.05 \log S - 0.056(\log S)^2$$

where Q = discharge in cfs; A = reach average flow area in square feet; S = bed slope.

Equations for the average cross sectional area of the reach based on the downstream gage height were determined using the HEC-RAS model to create a rating curve for the downstream water depth and average flow area in the reach. The results of the RAS model were plotted to determine the depth-area relationship, as shown in Figure 10. The resulting best fit equations for the average cross section area are:

$A = 8.461D^2 + 38.755D$ for water depths below 8' and

$A = 7.2195D^2 + 94.703D-354.11$ for water depths above 8'

where A is the reach average flow area in square feet and D is depth in feet at the Granart Road gage.

Discharge values calculated with the Riggs Simplified Slope Area Method and the field discharge measurements made during the September 2008 flood are shown in Figure 11. The field measurement values were used to evaluate the accuracy of the discharge calculation. As shown in Figure 11, the Riggs method values appear to be low when compared to the field measurement. The calculated discharge value of 4770 cfs is 76 percent of the measured field discharge value of 6260 cfs at approximately 5 p.m. on September 13. A comparison of the calculated depth discharge rating curve and multiple field measurements taken at the gage reach during the gaging period is shown in Figure 12.

A stage discharge graph of Riggs equation discharge calculations and all field discharge measurements were reviewed to determine if the low-flow discharges could be estimated from the Riggs equation. A closer examination shows the calculated discharges are high when compared to field-measured low-flow discharges (Figure 13). As the goal of the project is to delineate the 1-percent-annual-chance floodplain, Riggs discharge calculation was selected, but it should not be used for low-flow discharge calculations. Further review of gage data could be

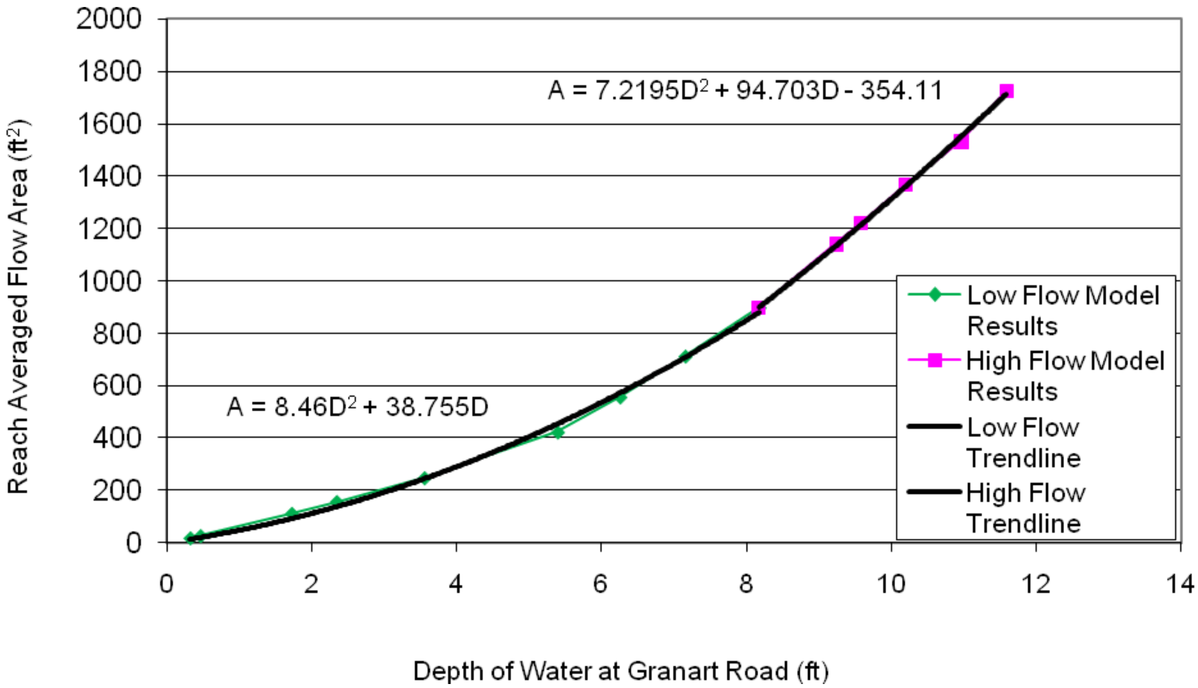

Figure 10. Depth/average flow area rating curve for the reach of Big Rock Creek between the two project stage gages at Granart Road and Price Road

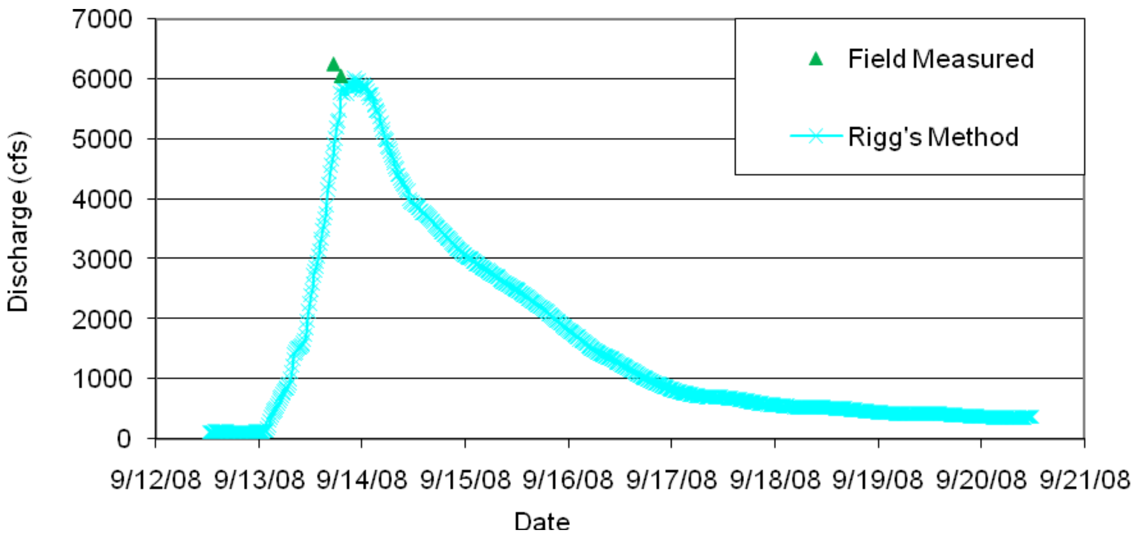

Figure 11. Comparison field measurements and calculated hydrographs for Big Rock gage reach (Price Road to Granart Road)

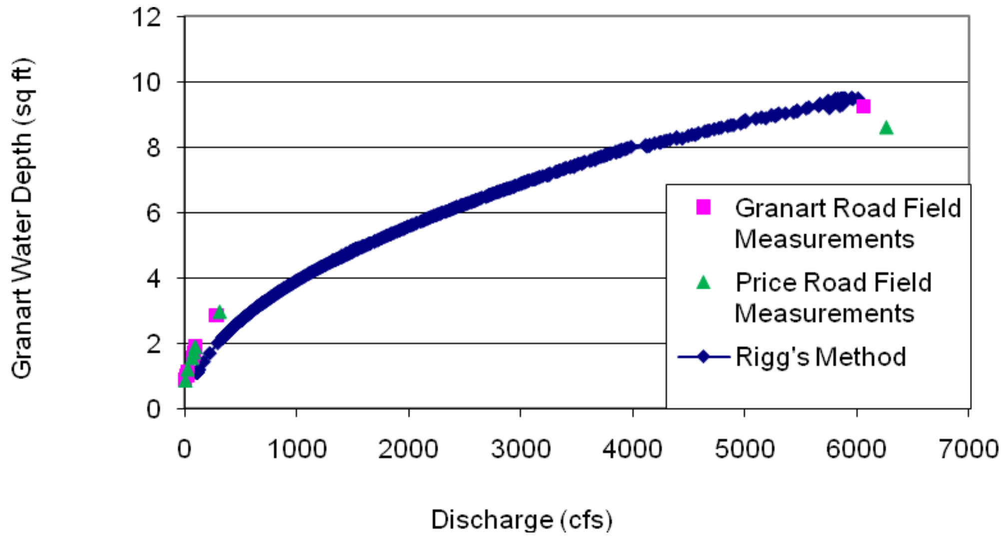

Figure 12. A comparison of the results of the Manning's equation depth-discharge rating curve used to calculate the discharge from the stage gage data and the field measured discharges

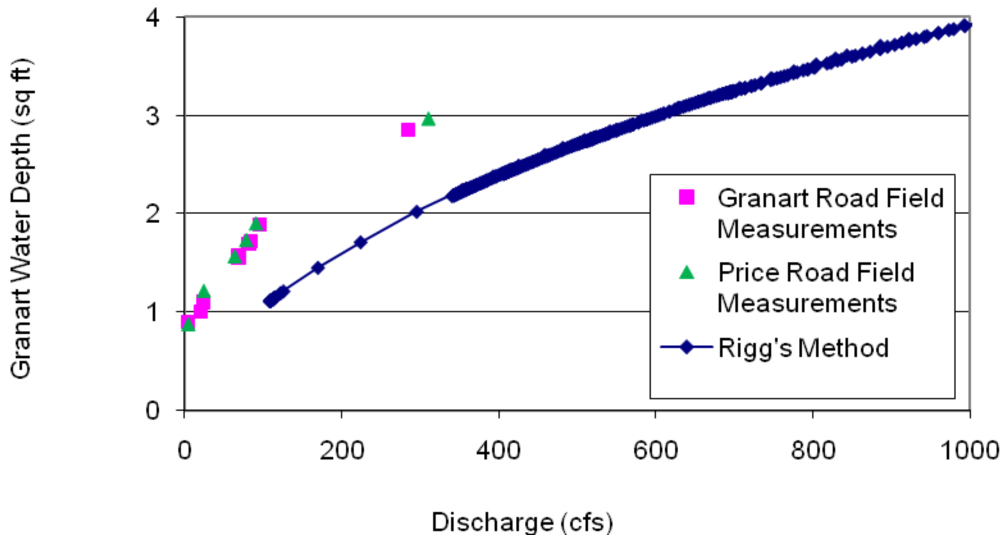

Figure 13. A closer look at the differences in the low flow results of the Manning's equation depth-discharge rating curve used to calculate the discharge from the stage gage data and the field measured discharges

completed to address the calculation of low flows given the recorded stage data, but this is beyond the scope of the project.

Analysis of the discharge calculation method was also completed for Welch Creek stage gages. However, from the analysis it was determined that the railroad bridge between the two gages causes backwater that affects the slope of the water surface profile during high discharge events. As a result of this effect, discharges computed using the simplified slope calculations are expected to be inaccurate. For this reason, the Welch Creek discharges alone were used for model calibration.

Model Discharge Calibration to September 12, 2008 Event Gage Data

Calibration of the HEC-HMS model was achieved by refining the curve number, initial abstraction, time of concentration, routing coefficient, and Manning's *n* values to adjust the model output based on observations. These input variables were determined using estimation equations and knowledge based on physical data, as described above, but their final values are a result of the calibration process.

Measured precipitation during the September 12-14, 2008 event was compared for two recording rain gages: the rain gage installed specifically for this project, located near the center of the watershed, and the gage located at the Aurora Airport. A review of the radar data available from the National Climatic Data Center NEXRAD Data Inventory showed that more than 80 percent of the watershed had a total storm precipitation over 8 inches. The project precipitation data, which recorded a total precipitation of 8.24 inches, was used for the entire watershed without integrating the Aurora Airport rainfall gage data, which recorded a total precipitation of 6.37 inches.

The September 12-22 precipitation data from the project gage were input to calibrate the HEC-HMS model to the discharges on Big Rock Creek. The initial intent of the project was to calibrate the model using the discharge values calculated using the paired stage information. As a field discharge measurement was taken within two hours of the peak stage on Big Rock Creek, the field measurement served as the primary measure of calibration. Secondary consideration was given to the discharge values calculated via the Riggs slope-area method, as described above.

The peak flow and peak time of the hydrograph were of primary consideration for model calibration. The Price Road field discharge measurement of 6260 cfs was taken 2 hours before the peak stage reading. From the time of the discharge measurement, the stage increased 1 foot before reaching the peak stage. The peak discharge was calibrated above the field measurements and Riggs discharge values based on this data. Total volume was not a primary consideration for calibration.

Final calibration of the HEC-HMS model was achieved by uniformly increasing the routing coefficient from its initial values and making peak flow adjustments with the curve number values. Final model input values can be found in Appendix C.

A comparison of the initial model hydrograph, the calibrated model hydrograph, the calculated hydrograph, and field measurements are provided in Figure 14. Table 5 lists the final results of the calibrated model at key locations. A spreadsheet with the full global summary of model results is also located in Appendix C.

Total volume was not considered a primary goal for calibration, as peak discharge and time of peak discharge are the key storm characteristics for floodplain management. The model has been calibrated to these values for this purpose. However, it should be noted that there is a difference between the calculated hydrograph using the stage data recorded at Big Rock Creek and the model results in respect to the falling limb of the hydrographs. For this study, the Clark routing coefficients were adjusted by a single coefficient to provide a hydrograph that lacked the second peak seen in the pre-calibration HMS results. The adjustment puts the routing coefficient much higher than initial values calculated using *Equations for Estimating Clark Unit-Hydrograph Parameters for Small Rural Watersheds in Illinois* (Straub et al., 2000). The large routing coefficient adjustment and remaining difference in the hydrographs may indicate a storage issue within the watershed upstream of the Big Rock gage location. Further discharge data and consideration for the low flow issues previously noted would be required to address these inconsistencies.

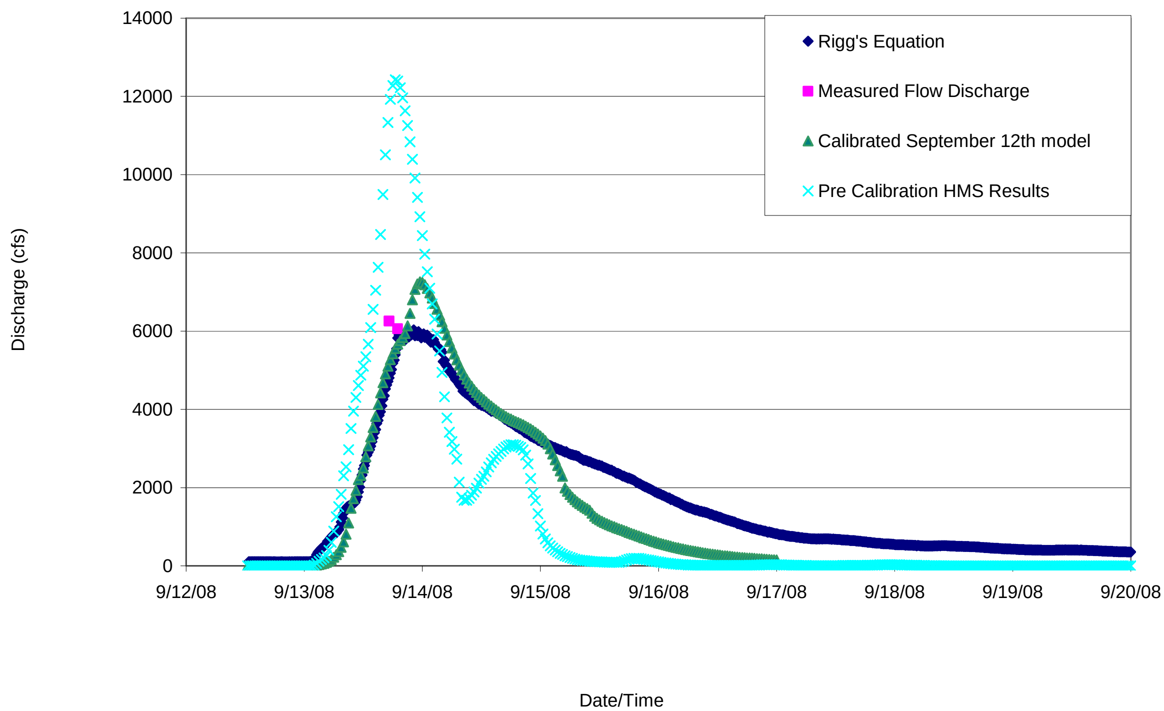

Figure 14. Comparison of the measured discharge, calculated discharge using Manning's equation, and HMS initial and final September 2008 flood event discharge hydrographs at Big Rock Creek at Granart Road

Table 5. Big Rock/Welch Creek September 2008 Flood Event HMS Model Results

			Final September 2008 flood calibration		
Location	*HEC-HMS station*	*Drainage area (sq. miles)*	*Peak discharge (cfs)*	*Time of peak*	*Volume (inches)*
Confluence of Young's Creek & East Branch Big Rock	J_EB&YC	22.5	3,202	13Sep2008, 17:00	5.7
Confluence of East Branch Big Rock and Malgren Drain	J_EB&MD	31.7	4,050	13Sep2008, 19:30	5.66
Confluence of Welch Creek and Welch Creek Tributary 1	J_WC_WCT1	21.1	2,432	13Sep2008, 18:00	5.62
Confluence of Welch Creek and Sugar Grove	J_WC&SG	36.1	3,973	13Sep2008, 18:30	5.62
Confluence of East Branch and West Branch Big Rock Creek	J_BR&EB&WB	60.7	7,175	13Sep2008, 22:30	5.67
Confluence of Big Rock Creek and Welch Creek	J_BR&WC	104.4	11,158	14Sep2008, 00:00	5.63
Downstream county boundary and Big Rock Creek	Outlet	108.2	11,340	14Sep2008, 01:00	5.62

One-Percent-Annual-Chance Flood HMS Simulation

Rainfall data from *Frequency Distributions and Hydroclimatic Characteristics of Heavy Rainstorms in Illinois* (Huff and Angel, 1989), commonly known as ISWS Bulletin 70, are coupled with rainfall distributions reported in *Time Distributions of Heavy Rainstorms in Illinois* (Huff, 1990) for the 1-percent-annual-chance flood model. Bulletin 70 rainfall and appropriate Huff distributions are required for Illinois and Federal approval of flood studies. Total storm rainfall depths for the 1-percent-annual-chance storm event were adjusted using the aerial reduction factors for the 108 sq mi watershed. Rainfall used in the hydrologic model is listed in Table 6. These total depth rainfall values were then paired with one of the four Huff distributions based on the storm duration to simulate the 1-percent-annual-peak flood discharge values.

Table 6. Northeastern Illinois Bulletin 70 Rainfall in Inches (Sectional Frequency Distributions Reduced by Aerial Reduction Factors)

Storm period (hr)	*Recurrence interval (%)* 20%	10%	2%	1%	0.2%
3	2.11	2.49	3.60	4.22	6.09
6	2.54	2.98	4.32	5.06	7.39
12	3.05	3.58	5.17	6.06	8.74
*18	3.26	3.82	5.53	6.48	9.39
24	3.57	4.20	6.07	7.13	10.15
48	3.93	4.62	6.57	7.83	11.04

Note: *Aerial-point ration interpolated from the 12 hr and 24 hr adjustment factors.

A critical duration analysis was completed. To determine the appropriate storm time period, each of the 6-hr, 12-hr, 18-hr, 24-hr, 48-hr, and 72-hr storms were considered. As shown in Table 7, the 48-hour storm resulted in the largest discharge values.

The 48-hour peak 1-percent-annual-chance flows were input to the HEC-RAS model for floodplain determination.

Hydrologic Model Discharge Analysis and Comparison to Historical Data and Similar Watersheds

The results of the 1-percent-annual-chance HEC-HMS simulations were compared with other discharge estimates from regression equations, discharge observations, and peak discharges published in the literature (Figure 15). Big Rock and Welch Creek Regression Analysis values at gage locations using the equations outlined in *Estimating Flood-Peak Discharge Magnitudes and Frequencies for Rural Streams in Illinois* (Soong et al., 2004) are included for comparison. Additional nearby watershed 1-percent-annual-chance discharge values from the same publication are also graphed. Blackberry Creek watershed study discharge values from the USGS Scientific Investigations Report *Continuous Hydrologic Simulation and Flood Frequency, Hydraulic and Flood-Hazard Analysis of the Blackberry Creek Watershed, Kane County, Illinois* (Soong et al., 2005) were considered most relevant as the watershed study was recently completed. A table with specific locations, discharge sources, discharges, and drainage areas is provided in Appendix D.

Total rainfall on the 49-hour September event, an observed 8.24 inches, resulted in an HEC-HMS simulated peak flow of 11,340 cfs at the downstream boundary. The 1-percent-annual-chance flood event simulated using the HEC-HMS model had a corresponding rainfall of 7.83 inches over 48 hours and resulted in higher peak flow of 12,624 cfs. Although the rainfall durations were similar, the model simulation produced a higher peak discharge from a smaller rainfall because of differences in the temporal distribution of the rainfall. The observed rainfall distribution can be seen in Figure 4.

Table 7. One-Percent-Annual-Chance Critical Duration Results

	6-hour storm event			*12-hour storm event*			*18-hour storm event*		
Location	*Peak discharge (cfs)*	*Time of peak*	*Volume (in)*	*Peak discharge (cfs)*	*Time of peak*	*Volume (in)*	*Peak discharge (cfs)*	*Time of peak*	*Volume (in)*
Confluence of Young's Creek and East Branch Big Rock	2,407	Day 1, 09:00	2.78	2,974	Day 1, 12:15	3.65	2,963	Day 1, 15:30	4.03
Confluence of East Branch Big Rock and Malgren Drain	2,907	Day 1, 12:00	2.75	3,661	Day 1, 15:30	3.62	3,746	Day 1, 18:30	3.99
Confluence of Welch Creek and Welch Creek Tributary 1	1,787	Day 1, 10:30	2.7	2,210	Day 1, 13:45	3.56	2,257	Day 1, 17:15	3.93
Confluence of Welch Creek and Sugar Grove	2,866	Day 1, 10:30	2.71	3,581	Day 1, 14:15	3.57	3,681	Day 1, 17:45	3.94
Confluence of East Branch and West Branch Big Rock Creek	5,185	Day 1, 14:45	2.74	6,479	Day 1, 19:00	3.6	6,731	Day 1, 22:00	3.97
Confluence of Big Rock Creek and Welch Creek	7,946	Day 1, 16:00	2.71	9,893	Day 1, 20:15	3.56	10,383	Day 1, 23:30	3.92
Downstream county boundary and Big Rock Creek	8,071	Day 1, 17:00	2.7	10,043	Day 1, 21:15	3.56	10,542	Day 2, 00:15	3.92

	24-hour storm event			*48-hour storm event*			*72-hour storm event*		
Location	*Peak discharge (cfs)*	*Time of peak*	*Volume (in)*	*Peak discharge (cfs)*	*Time of peak*	*Volume (in)*	*Peak discharge (cfs)*	*Time of peak*	*Volume (in)*
Confluence of Young's Creek and East Branch Big Rock	3,393	Day 1, 23:15	4.61	3,473	Day 3, 00:00	5.21	3,266	Day 3, 20:20	5.5
Confluence of East Branch Big Rock and Malgren Drain	4,256	Day 2, 02:00	4.57	4,386	Day 3, 02:45	5.12	4,239	Day 3, 22:40	5.28
Confluence of Welch Creek and Welch Creek Tributary 1	2,553	Day 2, 00:15	4.5	2,638	Day 3, 01:00	5.03	2,542	Day 3, 21:40	5.23
Confluence of Welch Creek and Sugar Grove	4,195	Day 2, 00:30	4.51	4,408	Day 3, 01:30	5.05	4,251	Day 3, 23:00	5.2
Confluence of East Branch and West Branch Big Rock Creek	7,714	Day 2, 05:00	4.53	7,990	Day 3, 05:30	5.03	7,714	Day 4, 01:40	5.13
Confluence of Big Rock Creek and Welch Creek	11,874	Day 2, 06:15	4.49	12,403	Day 3, 06:15	4.98	12,310	Day 4, 02:20	5.05
Downstream county boundary and Big Rock Creek	12,068	Day 2, 07:00	4.48	12,624	Day 3, 07:00	4.97	12,585	Day 4, 03:20	4.98

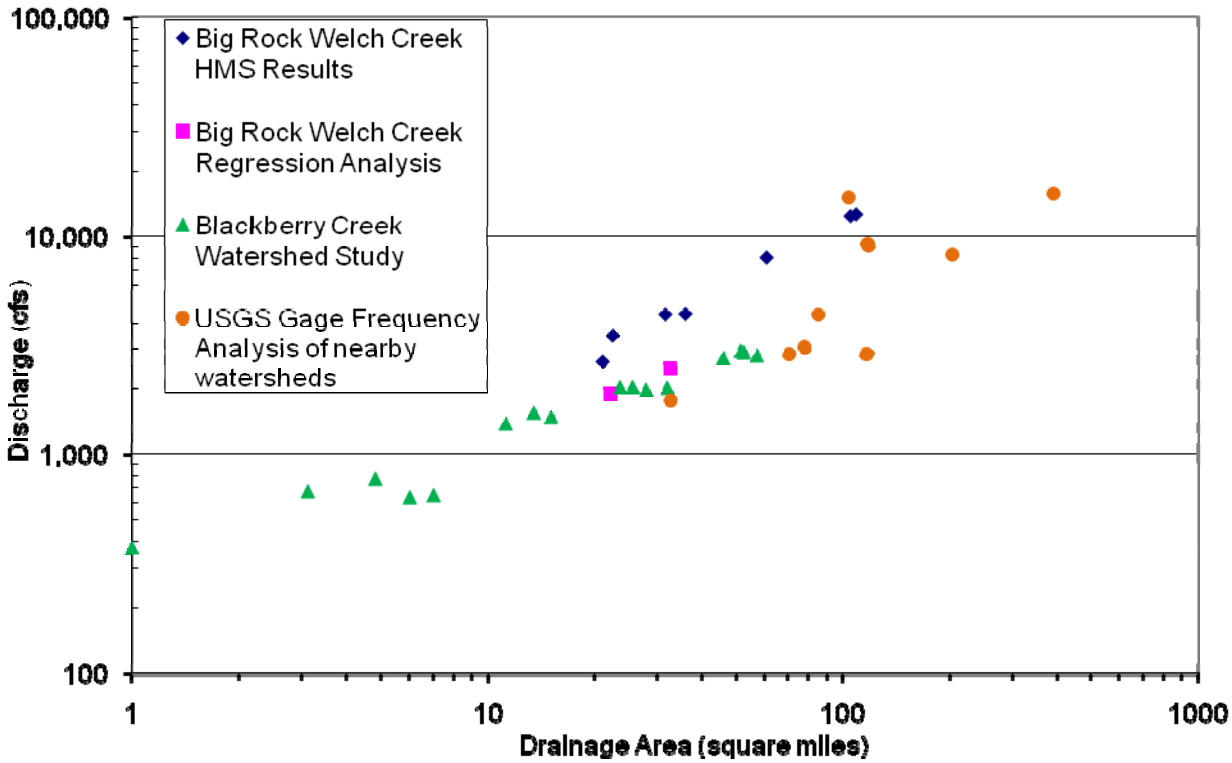

Figure 15. Comparison of the 1-percent-annual-chance discharge/drainage area relationship for the Big Rock/Welch Creek and other published watershed discharges in the area

Areas Requiring Further Review for a Detailed Analysis

Further comparison of Big Rock/Welch Creek and the northern watershed hydrology results could be completed if the county should desire a more detailed study warranting a model calibrated to the total volume of the storm. The additional calibration points from the northern Kishwaukee headwater watersheds would allow an analysis of curve number values, initial abstraction, transformation parameters, and discharge volume between the two studies for further refinement of the HEC-HMS model.

Given the objectives and scope of this project, some assumptions, further detailed below, were made with respect to the characteristics of Big Rock Lake, the Rich Harvest property, field tiling, and split flows. The issues are identified and should be considered when a detailed flood study of the area is conducted.

Big Rock Lake is located on Big Rock Creek just upstream of the confluence of Welch Creek and Big Rock Creek. Its impact on flood discharge was reviewed to estimate the effect of this relatively large storage area on the 1-percent- annual peak discharge calculations. No physical data were available on the size, elevations, or depth of the lake. Given the scope of work for this study, a simplistic view of the impact of this lake on peak discharges was considered. It was estimated that the lake surface area is approximately 34 acres and the low point of the berm is 10 feet above the normal water elevation, and would store 340 acre-feet (ac-ft) of water prior to filling the storage area. After filling the storage area, it was assumed the water diverted into the lake would flow through the lake to the “outlet” low point at the downstream end of the lake. With some very approximate assumptions, it was calculated the lake would be full in the first quarter of the storm hydrograph, while peak discharge would occur closer to the midpoint of the storm. The lake appears to have a minimal effect on storm peak discharge. Given the lack of data, the complicated nature of correctly modeling the lake, and minimal downstream impact, no further analysis was pursued. This storage area was not incorporated into the HEC-HMS model.

The Rich Harvest property includes multiple inline streams and large detention ponds that may provide storage that could have an effect on the watershed hydrographs. However, storage areas have not been included in this hydrologic model. The impact of the storage area is not expected to be large enough on peak flows and subsequent delineation of the floodplain area.

Field tiles were not incorporated in the watershed study. All tile drains were considered to have a minimal impact on the high flows of the 1-percent-annual-chance flood event. No allowance was provided for flow that is diverted from the stream channel to a field tile or flow from a field tile into the stream. This assumption may require further review for a detailed study. Specifically, along Duffin Drain there is a culvert that discharges just upstream of the crossing with U.S. 30. The location and source of the tile drain is unknown and thus could not be accounted for in this study.

There appears to be a split flow location on Welch Creek Tributary 1 northwest of the Dauberman and Wheeler intersection. The elevation data suggest that flow may divert from the indicated channel and follow the Dauberman ditch to join Welch Creek Tributary 2. This would impact the flows calculated for both tributaries below this intersection. The final hydrologic model for this watershed study assumes no diverted flow at this location.

Hydraulic Modeling

A hydraulic model was prepared to simulate water surface elevations. The HEC-RAS version 4.0 (Brunner, 2008) model was selected as it is accepted by FEMA and widely used in the industry. The HEC-RAS model was calibrated using data from the September 2008 storm event. The calibrated model in turn was used to simulate 1-percent-annual-chance flood elevations for the stream reaches. Output from this simulation provides the basis for profiles and flood hazard mapping.

Study Reaches

Hydraulic analysis of the watershed was divided into two levels of study: limited detail and approximate. The level of study for each reach was reviewed at the stakeholder meeting and finalized by the county. A limited-detail study was completed on the more urban and developing reaches, while an approximate study was completed on the more rural stream reaches. Figure 1 shows the level of study completed for each reach.

Two hydraulic models were prepared: one hydraulic model for Welch Creek and its tributaries and one for Big Rock Creek and its tributaries. The decision to use two independent hydraulic models was based on practical use issues. The watersheds were kept separate to keep the size of the model appropriate for ease of use. Limited-detail and approximate study reaches did not need to be separated.

The level of study determines the detail of data input to the hydraulic model. Table 8 summarizes some differences in the hydraulic modeling for each type of study. Stream hydraulics for both levels of study were completed using HEC-RAS version 4.0 software (Brunner, 2008).

Input Data

HEC-RAS requires riverine geometry, Manning's *n* values, structure geometry, and flow data to perform the one-dimensional riverine water surface elevation analysis.

Table 8. HEC-RAS Input Data for Each Level of Study

	Limited detail	*Approximate*
Cross sections	LiDAR/surveying/Kane contours with engineering review	Automated using Kane County 2001 topography
Manning's	Engineering review	Automated calculation using Manning's *n* values associated with land cover
Bridges	Surveyed/plans/field measurements	None

Much of the required input data concerns the physical aspects of the river reach: channel dimensions, slope, etc. This information was primarily gleaned from the Kane County 2001 topography. The Kane County topographic data were derived using photogrammetric techniques from photography taken on 4/14/2001 and 4/18/2001. The mapping meets United States National Map Accuracy Standards (NMAS) for 1inch equal to 100 feet scale maps and has a horizontal accuracy of plus or minus 3 feet and exceeds the standard for mapping at 1inch equal to 500 feet scale maps. Kane County topographic data have a vertical accuracy of plus or minus 1 foot at the 90 percent confidence level. These data meet the standards for mapping at 1 inch equal to 500 feet with an equivalent topographic contour of 2 feet. Kane County provided countywide digital datasets including a Digital Terrain Model (DTM) dataset with mass points and break lines. A uniform grid digital elevation model (DEM) with 2-foot cells was created from this data for this project. The uniform grid with this resolution can be readily and quickly processed in the ArcGIS environment. The U.S. Army Corps of Engineers HEC-GeoRAS (Ackerman, 2005) software was used to automate the input process. Cross section locations for all reaches are shown on the work map in Appendix E.

The downstream boundary condition for Big Rock Creek was determined using the normal depth method with a slope of 0.0015. The downstream boundary condition for the Welch Creek model was the water surface elevation simulated by the Big Rock model. The 1-percent-annual-chance peak water surface elevation on Big Rock Creek was used for the downstream boundary condition in the Welch Creek model because the hydrologic model indicates a coincident peak flow.

Flows calculated as described in the hydrology section of this report were input to the hydraulic model at the upstream end of the hydrologic reach.

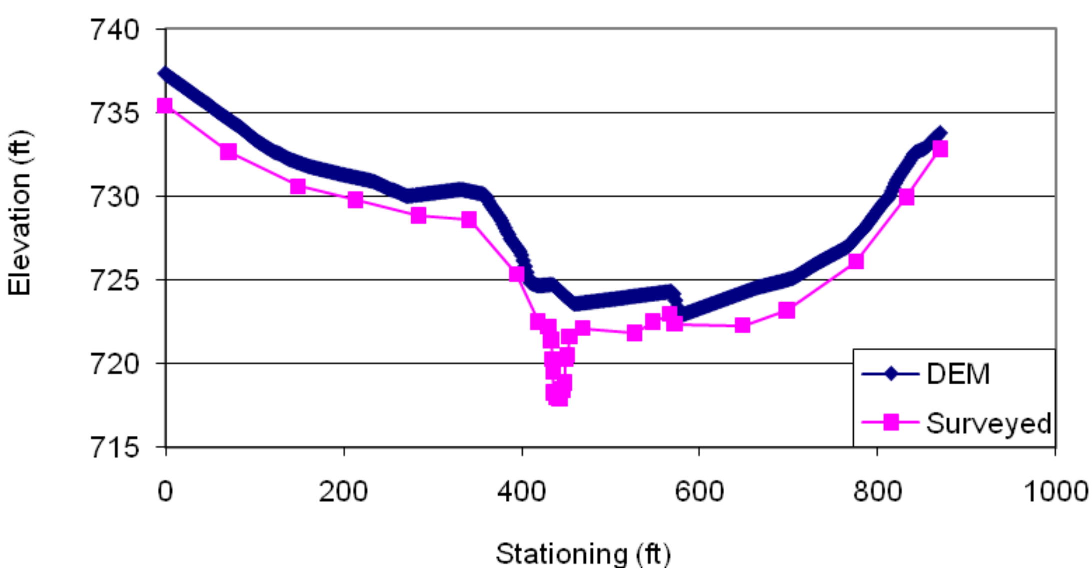

Figure 16. Cross section survey comparison to Kane County topography

Limited-Detail Study Input Data

The majority of the cross section and stream geometry data for the limited-detail study were determined from the Kane County topography. A few cross sections were surveyed by the IDNR/OWR in key locations. Cross sections outside of Kane County topographic data limits were determined from the USGS National Elevation Dataset. Additional cross section information was taken from available existing bridge plans.

Sixteen river cross sections and seven bridges in the watershed were surveyed by the IDNR/OWR. The surveyed cross sections were compared to those created with the Kane County topography. Figure 16 shows the cross section data comparison on Welch Creek just downstream of Scott Road. As the Kane topography was generated from photogrammetric data, stream channels are not represented in the topographical data. The comparison also shows survey data elevations to be lower than the DEM at this location. Along the overbanks, the survey data are an average of 1.57 feet below the DEM cross section at this particular location. Due to the limited number of surveyed cross sections and their location near bridge crossings, the comparison cannot be assumed to hold for the entire watershed. In general, consideration should be given to the stated vertical accuracy of the LiDAR data when comparing other topographic sources or in future detailed studies.

DEM data often do not represent the deeper channel geometry. The geometry of cross sections generated from the DEM were reviewed and edited to add the stream channel. Stream channel bed elevations were interpolated using the slope between known bed elevations, generally at the bridge cross section. Stream widths were estimated from aerial photography, and side slopes were assumed to be approximately 1:2. Figure 17 shows the edited channel geometry of a cross section.

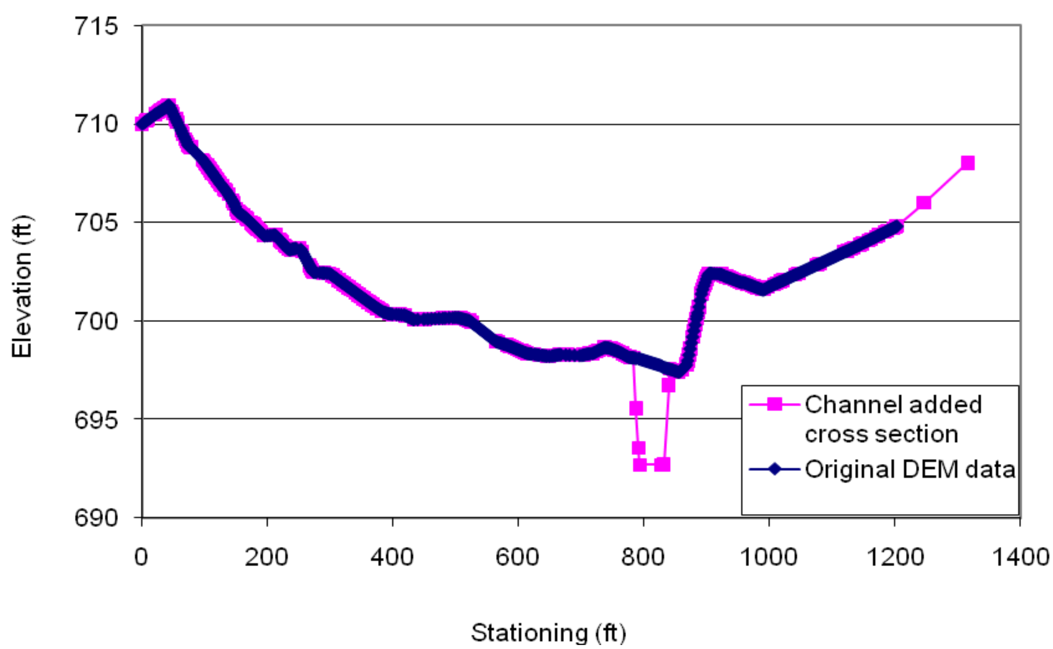

Figure 17. Edited channel geometry for a DEM cross section

Manning's *n* values were based on multiple field visits and aerial photography. The overbank Manning's *n* values range from 0.01 to 0.11 and the channel Manning's *n* values range from 0.02 to 0.045. A value of 0.01 was used at pond and Big Rock Lake locations.

Bridge data were acquired by three methods. First, an effort was made to gather existing bridge plans. If bridge plans were not available, field measurements were made. Field measurements included basic structural geometry such as culvert size and material, or bridge opening width and height. The IDNR/OWR completed surveying at six bridges in the watershed. Figure 18 summarizes the source of watershed bridge data.

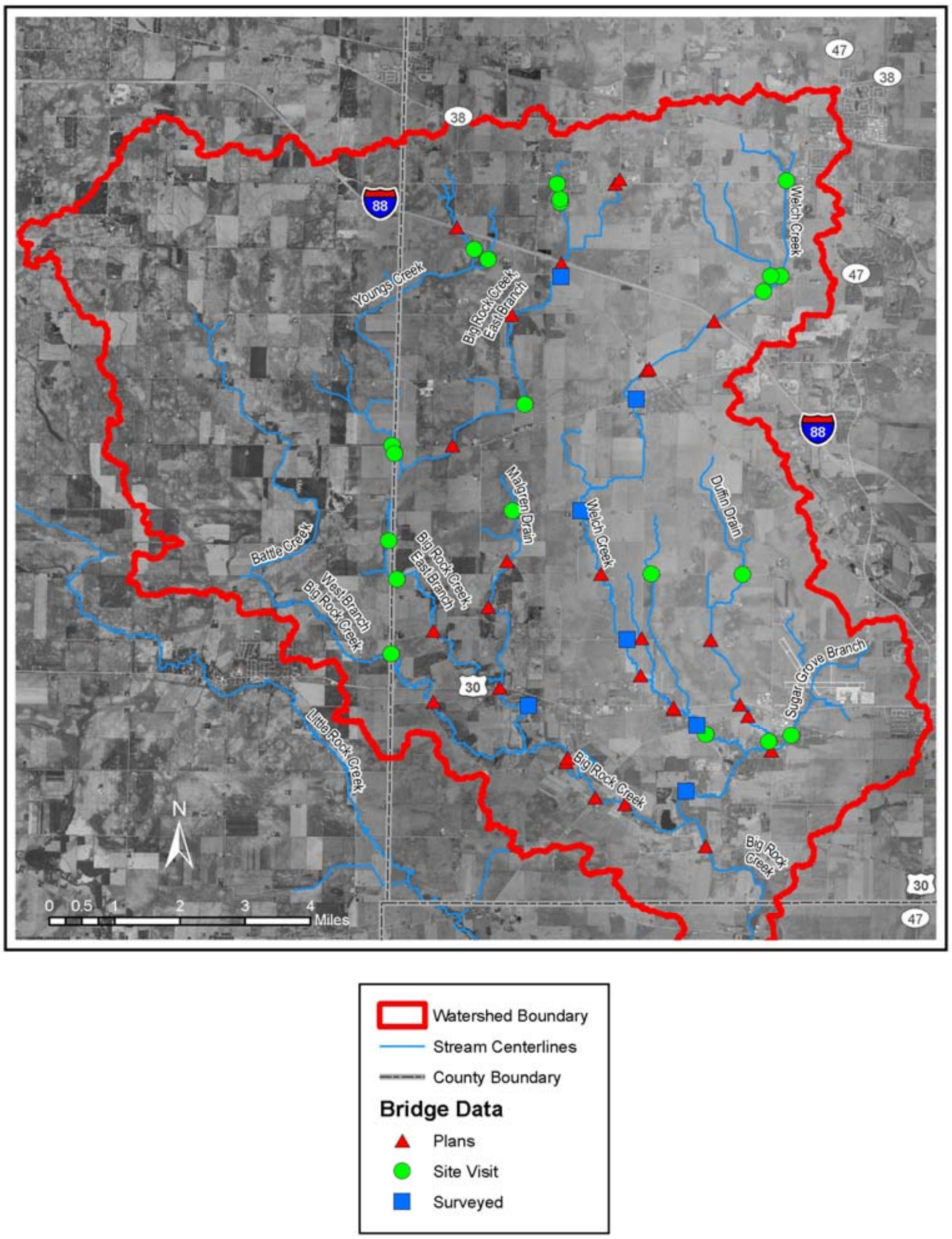

Figure 18. Type of bridge data available for use in the HEC-RAS hydraulic models of Big Rock and Welch Creek

Bridge ineffective flow areas were used based on contraction and expansion ratios of 1:1 and 2:1, respectively.

Approximate Study Input Data

Cross sections derived from the topographic data were not altered or enhanced to show the stream channel on approximate study reaches. Also, no bridges were input to the approximate study reaches.

Manning's *n* values were determined with different methods for the approximate and limited-detail reaches. Values for the approximate reaches were automatically generated from land cover data using HEC-GeoRAS routines. Manning's *n* values were assumed for each land use category from the Land Cover 1999-2000 dataset (USDA/NRCS, 2003). The Manning's *n* values corresponding to each land use category are given in Table 9.

Model Calibration Using the September 12, 2008 Flood Event

The model was calibrated using data from the September 2008 flood event. Peak discharges calculated using HEC-HMS were input to the RAS model, and water surface elevations and subsequent extent of flooding simulated by the model were compared with observations and information recorded at the stage gages. Input parameters such as Manning's *n* values and ineffective flow areas were adjusted so that model simulation would approximate observation as closely as possible. Table 10 summarizes the comparison of the model results

Table 9. Manning's *n* Values Associated with Land Use Data

LU code	*Land cover category*	*Manning's value*
10	**Agricultural Land**	
11	Corn	0.05
12	Soybeans	0.05
17	Rural Grassland	0.04
20	**Forested Land**	
21	Upland	0.11
30	**Urban Land**	
31	High Density	0.045
32	Low/Medium Density	0.05
35	Urban Open Space	0.04
40	**Wetland**	
41	Shallow Marsh/Wet Meadow	0.09
50	**Other**	
51	Surface Water	0.01

Table 10. Big Rock and Welch Creek September 13 Peak Gage and Model Water Surface Elevations

Stream	*Location*	*Gage data (feet)*	*Model results (feet)*
Big Rock Creek	Price Road	680.72	682.68
Big Rock Creek	Granart Road	676.53	676.34
Welch Creek	U.S. 30	695.0	695.1
Welch Creek	Granart Road	689.0	689.45

with water surface elevations recorded at the four gages. Table 11 compares observations made by persons on site during the flood event to model results. Anecdotal observations were collected at a meeting of the stakeholders. Maps of the watershed showing the first simulation of the September 2008 event were examined by the stakeholders at the meeting. The maps were marked to show observations at bridges and flow patterns throughout the watershed.

Discussion of Observations and Model Simulation

The model peak water surface elevation results are within one-half foot of the recorded peak stages at Welch Creek gages and Big Rock Creek gage at Granart Road. The model results for the Big Rock Creek gage at Price Road are 2.0 feet higher than the gage data. The profile between the two gages roughly matches the slope of the channel bed and appears reasonable. The Big Rock Creek stormwater system outlets just downstream of Price Road gage. Storm sewers were not considered for the watershed hydrology, and the impact of the system should be reviewed when a detailed study is conducted.

Granart Road across Duffin Drain was reported to have overtopped during the September flood. The model does not show the bridge to have overtopped. It is recommended that further review of this area be completed for a detailed study. Plan data from 1998 were used for this bridge data. Surveyed data or further study of the crossing would allow for consideration of sedimentation as a cause of the increased water surface elevation.

Keslinger Road on Welch Creek was also reported to have overtopped during the flood event. However, the model simulation does not indicate overtopping. This difference may be due to flows from the water treatment facility of Elburn. These flows were not included in this study. These flows and their effect on the water surface elevation at the upstream reaches of Welch Creek should be reviewed for a detailed analysis.

Observation of the September flood and the model results both show Duffin Drain overtopping U.S. 30. The model also shows the railroad just downstream of Duffin Drain overtopping. Further review should be given to this area for a detailed study. The Duffin Drain flood may extend to the east tributary between U.S. 30 and the railroad. The 30- inch culvert at the tributary may convey some of the Duffin Drain flow and reduce the water-surface elevation between these two structures. Surveying would be required to confirm there is a flow between these two streams.

Table 11. September 2008 Flood Observations

Stream	*Location*	*Verification data*	*Model results*
Big Rock Creek Watershed			
Big Rock Creek	Pedestrian Bridge	Observation of bridge not being overtopped	Approx. model water surface elevation is 665.78 ft with an estimated bridge floor elevation of 666 ft
Big Rock Creek	Jericho Road	Observation of bridge not being overtopped	Model peak water surface elev. overtops roadbed by 0.8 ft
West Branch Big Rock Creek	U.S. 30	Observation of bridge not being overtopped	Model water surface elevation 9 ft below the road profile
East Branch Big Rock Creek	U.S.30	Observation of bridge not being overtopped	Model water surface elevation 5 ft below the road profile
East Branch Big Rock Creek	Hinckley Road West of East Branch	Observations show area is inundated	The topography does not support flooding due to river flow in this area. These homes are estimated to be 12 ft above the floodplain
East Branch Big Rock Creek	Perry Road	Photographs of bridge being overtopped	Model peak water surface elev. overtops roadbed by 0.2 ft
Welch Creek Watershed			
Welch Creek	Camp Dean (north)	Observed estimation of crest over 3 ft above road	Model water surface peak is 2.6 ft above road
Welch Creek	U.S. 30	Observation of bridge being overtopped by a few inches	Stream gage results were used for verification
Welch Creek	Rich Harvest Bridge	Observed stage crest at bridge floor	Model water surface elevation is 0.75 ft above bridge deck
Welch Creek	U.S. 30 to confluence with Sugar Grove	Agreement with preliminary map of modeled September 12 flood limits	No changes to this area since public meeting
Welch Creek	Keslinger Road	Observation of bridge being overtopped	Model water surface elevation 5 ft below the road profile
Duffin Drain	Granart Road	Observation of bridge being overtopped	Model water surface elevation 2.5 ft below the road profile
Duffin Drain	Rich Harvest Private Drive	Observation that the flooding reaches but doesn't overtop Dugan Road	Water surface elevation supports observation
Duffin Drain	U.S. 30	Agreement with preliminary map of modeled September 12 flood limits	No changes to this area since public meeting

Hydraulics at Big Rock Lake should be examined for a detailed study. A two-dimensional flow model is required to accurately model stream conditions at this location. For the purposes of this model, only the portion of the lake 100 feet east of the berm was considered as an active flow area. This area appears to convey flow through the lake to the downstream outlet. The lake area east of this active flow area was modeled as ineffective flow.

There is a significant increase in the water surface elevation just upstream of the lake. This jump is a critical flow transition, and is believed to be caused by the steep slope of the channel bed and the narrowing of the floodplain at the lake, combined with the backwater effect from the confluence.

Some of the observed flooding appears to be a consequence of inadequate storm water drainage, rather than flooding from the overtopping of the receiving streams. These include the Village of Elburn, flooding west of East Branch Big Rock Creek between U.S. 30 and Hinckley, and flooding near Oaken and Dugan Roads 1 mile east of Big Rock Creek. Confirmation of the source of flooding, whether these flooded areas are from stormwater or overbank river flow, will require more specific data. A review of the area should be completed for a detailed study.

One-Percent-Annual-Chance Floodplain

After calibrating the HEC-RAS Big Rock Creek and Welch Creek models using the September event, they were used to simulate the 1-percent-annual-chance flood elevations. The 1-percent-annual-chance discharges computed using the HEC-HMS model were input to the hydraulic model and an additional review was completed to revise any ineffective flow areas as necessary.

HEC-RAS output data for the regulatory 1-percent-annual-chance floodplain are located in Appendix F. Profiles for the limited-detail reaches are provided in Appendix G. The Key to Cross Sections, also located in Appendix G and organized by stream with the profiles (the style used in FEMA flood insurance studies), provides the cross reference between model cross section numbers and lettered cross sections.

The area inundated by the proposed 1-percent-annual-chance flood was mapped using the Kane County 2001 topographical data. All floodplain mapping was completed in accordance with FEMA standards. Floodplain boundaries are interpolated between cross sections. Floodplain boundaries were initially delineated using the digital elevation model and computer-assisted techniques. The floodplain was then refined with a GIS and engineering review and compared with the Kane County contours. Base flood elevations (BFEs) have been included for the limited-detail reaches. Floodplain maps have been included in Appendix H.

The watershed study joins the effective detailed study on Sugar Grove Branch. The proposed water surface elevation of 679.89 feet (North American Vertical Datum, 1988) matches the existing floodplain water surface elevation of 679.8 feet at the downstream end of the detailed reach within the FEMA-required .50 feet. This is approximately 3,790 feet above the confluence with Welch Creek and Sugar Grove Branch.

The proposed and effective floodplains can be compared by viewing the pdf files provided in Appendix E. The proposed floodplain generally follows the effective Zone A or is slightly narrower than the existing floodplain.

Summary

Big Rock and Welch Creeks are located in southwestern Kane County, Illinois, an area that is expected to experience significant population growth and attendant development in the coming years. The purpose of this project was to prepare updated maps showing watershed flood hazard areas that reflect current conditions. There are approximately 81 stream miles within Kane County in the Big Rock and Welch Creek watershed. Two levels of flood study were conducted; a limited-detail flood study was conducted for 38 stream miles and approximate study was conducted for 30 stream miles in Big Rock Creek and Welch Creek watershed areas within Kane County. These two levels of study were selected to estimate adequately the extent of the flood hazards while maximizing the number of stream miles studied. More detailed and rigorous analyses were used along reaches where development is anticipated, and less rigorous analyses were used in areas expected to remain primarily rural in nature.

The study included evaluation of existing data, including precipitation, stage, flood hazard mapping, and plans and specifications for structures such as bridges. Available stream data were collected more than 30 years ago and no long-term stream discharge or stage records were available for statistical determination of the annual chance of discharge. A model was required for hydrologic analysis, and precipitation, stream stage, and discharge data were collected for model calibration. Given that the purpose of the modeling effort was to simulate conditions during an extreme flood event (1-percent-annual chance-flood), the intent of the model calibration was for high flow events. Data collected during the September 2008 storm provided valuable information for model calibration.

Hydrologic and hydraulic models were prepared using spatial datasets, survey data, and field measurements. These models were calibrated to the September 2008 storm event using recorded precipitation, discharge, stage data, and field observations of the extent of flooding during the event. The calibrated models were then used to simulate discharges and flooding elevations for a 1-percent-annual-chance event, which is the base flood used for floodplain mapping. The extent of flooding is depicted by interpolating calculated flood elevations at locations along each stream reach and using these elevations to delineate the floodplain boundary.

The results of the analyses are summarized with profiles showing flood elevations along stream reaches that were studied using limited-detail methods. The 1-percent-annual-chance floodplain boundary is shown for both limited-detail and approximate study reaches on accompanying maps. These results will assist floodplain managers and planners. Should development in any area increase significantly, then it would be appropriate to perform a more detailed study with higher accuracy standards and evaluation of the floodway. This report provides information on additional analyses that should be taken into consideration when a detailed study is performed in the future.

The Federal Emergency Management Agency (FEMA) is the primary agency responsible for preparing and distributing maps and studies defining flood hazards. These maps and studies are used for regulatory purposes and for flood insurance determinations. FEMA has published guidelines and specifications for hydrologic and hydraulic analyses as well as mapping standards

and digital data standards. These standards were used in preparation of this study with the anticipation of submitting the technical data to FEMA for adoption as part of the Kane County's Flood Insurance Study and Flood Insurance Rate Maps.

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