



TECHNICAL SUMMARY NOTEBOOK

FLOOD-WARNING SYSTEM
AND
FLOOD-INUNDATION MAPPING
For the Driftwood River and Sugar Creek Near Camp Atterbury,
Indiana

SUBMITTED BY: Unites States Geological Survey
 Water Resources Division
 Indiana Water Science Center

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GENERAL DOCUMENTATION

BACKGROUND AND PURPOSE

Activities and infrastructure at Camp Atterbury can be affected by large floods on the Driftwood River. Flooding can disrupt transportation, military exercises and other base activities. New technologies developed by the U.S. Geological Survey (USGS) and National Weather Service (NWS) can provide Camp Atterbury with real-time flood information and flood information forecasted up to 5 days out; this information can assist Camp Atterbury officials in mitigating the effects of flooding on base activities.

The purpose of this project is to develop a library of flood inundation maps for use by Camp Atterbury. This project will produce, using the most recent science and information technologies, a flood library that can be viewed interactively through the NWS' Advanced Hydrologic Prediction Service (AHPS) Web pages and also downloaded in a GIS file format for use in Camp Atterbury GIS applications. The library will consist of a set of flood extent and depth maps at set water-level (stage) intervals (for example, a map for each one foot of stage). The maps will be created such that users will be able to view each map in reference to base features such as streets and buildings. Maps will be provided for the reach of the Driftwood River that extends from the downstream limit of the base to the upstream limit of the base.

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The study as originally planned included only the Driftwood River. Upon further review it was determined that Camp Atterbury was developing a significant piece of property north of Hospital Road along Sugar Creek. Approximately five miles of Sugar Creek from the mouth to the railroad bridge was added. A one mile section of Big Blue River was also included.

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Scope of Work of Study Effort

The scope of the study is to produce an Inundation Map Library tied to Driftwood River near Edinburgh USGS streamgage and NWS flood forecast point with:

- Shape files - A series of inundation maps will be created for all selected water surface elevations in the form of ESRI shape files. The shape files will be edited to remove unconnected ponded areas.
- Raster Depth Grids - Flood depth grids in ESRI Grid format will be attributed with flood depths in units of feet for each mapped inundation level.
- Metadata - Federal Geographic Data Committee (FGDC) compliant metadata will be created for all GIS files.
- Support Information - Supporting data used in the hydrologic, hydraulic, and terrain analyses for the study area with all geographic data referenced to Geographic Coordinates, and the North American Vertical Datum of 1988.
- Web-Presence - Inundation Maps will be indexed to NWS Flood Forecasts for the Driftwood River near Atterbury and accessible via NWS AHPS 24x7.
- Documentation - Brief project summary report capturing calibration techniques, quality assurance processes, lessons learned, new methods developed,

recommendations, and overall synopsis of both topographic and engineering data assessment / inventory and inundation map libraries.

Note: The 3 stream reaches studied have been assigned an alphabetical designation (A-Big Blue River, B-Driftwood River, C-Sugar Creek that is reflected throughout the organization of this Technical Summary Notebook.

A. Big Blue River

The Big Blue River flows generally southwest. The downstream study limit is the confluence with the Driftwood River. The upstream study limit is the U.S. Highway 31. This stream reach is approximately one mile in length. The upstream limit was determined to be a minimal length for inclusion in the model.

B. Driftwood River

The Driftwood River flows generally to the south. The downstream study limit is 0.5 miles downstream of Lowell Road. The upstream study limit is the confluence of Sugar Creek and Big Blue River. This stream reach is approximately 11.2 miles in length.

C. Sugar Creek

Sugar Creek flows generally to the south. The downstream study limit is the confluence with Driftwood River. The upstream study limit is 0.5 miles upstream of the U.S. Railroad. This stream reach is approximately 5.2 miles in length.

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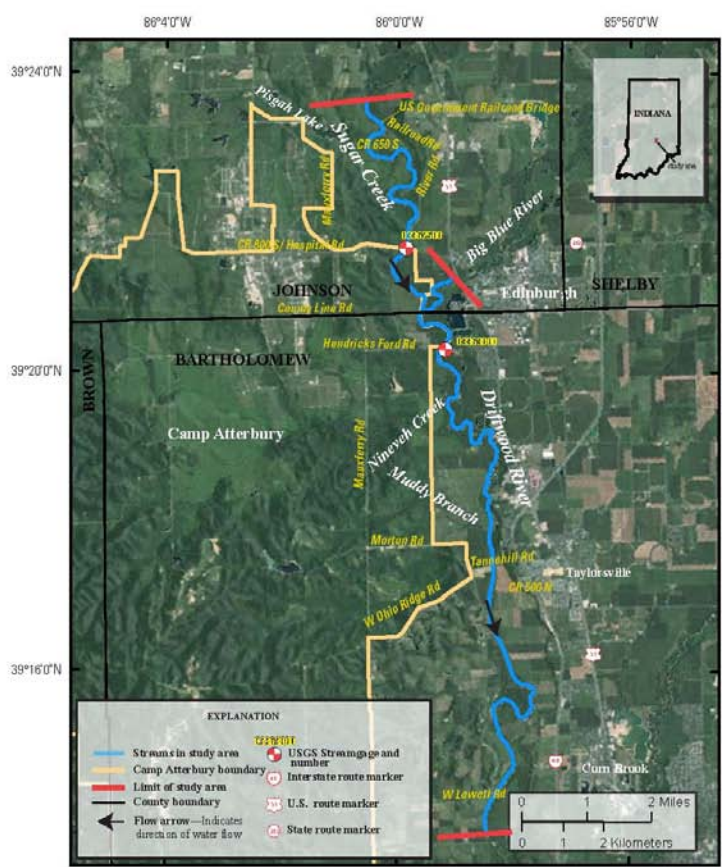


Figure 1. Location of study reach for the Driftwood River and Sugar Creek and locations of USGS streamgages and National Weather Service forecast site.



Figure 1. Location streamgages and

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Figure 1. Map of study area.

ENGINEERING ANALYSES

MODELING APPROACH

A 1-D HEC-RAS model (Version 4.1) was used with the steady flow computation. The bridge geometry was collected using GPS with a GLONAS receiver. The previous FEMA Flood Insurance Study (FIS) was used for comparison purposes.

FEMA FIS were obtained for both Bartholomew (1981) and Johnson (2007) Counties. The Special Flood Hazard zones were used as comparisons for the inundation maps.

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HYDROLOGIC ANALYSES

Normal depth using a slope of 0.001, was used as the boundary condition for the steady flow data at the downstream end of the Driftwood River study area. The most recent rating for streamgage 03363000, was used for calibrating the model.

Table 1. Rivers and corresponding discharges at stages 9-17 used in the HEC-RAS model.

River	RS	stage9	stage10	stage11	stage12	stage13	stage14	stage15	stage16	stage17
Big Blue River	5680	2761	3364	4036	5113	6418	8102	10466	14702	22275
Driftwood River	59460	5020	6116	7339	9297	11670	14730	19030	26730	40500
Driftwood River	46600	5227	6368	7642	9680	12151	15337	19815	27832	42170
Driftwood River	31976	5274	6426	7711	9768	12261	15477	19994	28085	42553
Driftwood River	10067	5384	6560	7872	9972	12518	15800	20412	28672	43442
Sugar Creek	27344	2188	2666	3199	4052	5086	6420	8294	11650	17652
Sugar Creek	23053	2230	2718	3261	4131	5185	6544	8455	11876	17994
Sugar Creek	12209	2259	2752	3303	4184	5251	6628	8564	12028	18225

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Profile

A. Stream Gage Selection and Rating Suitability

The Driftwood River near Edinburgh, Indiana 03363000 has record from 1941 to 1991 and was reactivated in 2011 with funding from Camp Atterbury to establish the site for AHPs. Several measurements were made at the site during high water in the spring of 2011 to confirm the upper end of the rating curve. Flood forecasting information from this site will help the military base move troops and supplies during times of high water. In agreement with NWS flood stages to be modeled range from 9 to 17 feet.

Sugar Creek near Edinburgh, Indiana 03362500 has record from 1943 through the current year. The current rating was used to estimated flows to the Driftwood River.

B. Stream Gage Datum

The datum of Driftwood River near Edinburgh 03363000 is 636.598 NAVD 88. The datum of Sugar Creek near Edinburgh 03362500 is 645.833 NAVD 88.

HYDRAULIC ANALYSES

HEC-RAS (version 4.1) was used to model flood profiles for all streams analyzed in this study effort. After the initial hydraulic models calculations were completed, warnings presented by the HEC-RAS model were reviewed. The results were assessed for validity, accuracy, and appropriate engineering practices. Some of the areas of concern included: 1) critical water-surface calculations, 2) water-

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surface elevation differences between adjacent cross-sections, and 3) correct usage of ineffective flow areas.

After the initial areas of concern were addressed, the HEC-RAS models were recalculated. All remaining warnings generated by HEC-RAS were reviewed and judged acceptable for the final models presented in this study. Table 2 shows the models used and the model analysis date for each stream submitted in this project.

Table 3. Summary of the hydraulic model version and analysis date for each of the studied stream reaches.

Flooding Source	Hydraulic Model Version	Model Analysis Date	
Big Blue River	HEC-RAS 4.1	3/9/2012	Deleted: 12/5/2011
Driftwood River	HEC-RAS 4.1	3/9/2012	Deleted: 12/5/2011
Sugar Creek	HEC-RAS 4.1	3/9/2012	Deleted: 12/5/2011

Special Hydraulic Considerations

Solution Check at Bridges

During high flow conditions, it is possible for pressure flow to occur at a bridge or culvert. Pressure flow occurs when the water surface on the upstream side of a bridge equals or exceeds the low chord elevation. The validity of this type of solution was checked at all bridges where the water-surface elevation derived from the energy equation was found to be within 1.0 foot of the low chord elevation of a bridge.

The standard-step method (energy equation) is applicable to the widest range of hydraulic problems (U.S. Army Corps of Engineers, 2002a). However, if flow conditions are such that the bridge opening may act like a pressurized orifice, (flow comes in contact with the low chord) pressure flow computations are warranted.

A. Big Blue River

Work conducted by the USGS

Cross sections surveyed in the field and synthetic cross sections (derived from a digital elevation model (DEM) map obtained from LIDAR for parts of Bartholomew and Jackson Counties) were used to develop a step-backwater model to establish the selected flood profiles for the three streams discussed in this report.

Scope of Work

The Big Blue River flows generally southwest. The downstream study limit is the confluence with the Driftwood River. The upstream study limit is the U.S. Highway 31. This stream reach is approximately 1 mile in length. The upstream limit was determined to be a minimal length for inclusion in the model.

Hydraulic Baseline

Stationing used for the hydraulic baseline for this stream is referenced to feet upstream from the confluence with Driftwood River.

Cross-Section and Contracted Opening Geometry Data Surveyed in the Field

The USGS surveyed 3 open channel sites for this reach of Big Blue River. All surveys were referenced to the North American Vertical Datum of 1988 (NAVD 88) and the North American Datum of 1983 (NAD83).

Synthetic Cross-Sectional Geometry Data

No synthetic cross sections were created for Big Blue River.

Starting Flow Values

The flow rates for Big Blue River junction with the Driftwood River were determined by its drainage area percentage. The values used were 55% of the flows at the Driftwood gage [based on drainage area contributions](#).

Manning's Roughness Coefficients

Manning's roughness coefficients (n) for the main channel and overbank areas of Big Blue River were determined from field observation and aerial photographs by experienced personnel. Estimates of Manning's roughness coefficients for the main channel were 0.38, and ranged from 0.08 to 0.09 for the overbank areas. FIS n -values: 0.045 for main channel, 0.070 for overbanks.

Flow Lengths

Main channel and overbank flow lengths were computed through the use of HEC-GeoRAS (U.S. Army Corps of Engineers, 2009). Flow paths are drawn in the GIS by the user for both the main channel and overbanks. HEC-GeoRAS computes all flow lengths based on the flowpaths estimated by the user.

Hydraulic Structure Solution Reviews

There were no hydraulic structures on this reach.

Profile Verification (or Calibration)

Profiles and flow rates were compared to coordinated discharges for Big Blue River. The values for stages 16 – 17 were within 5% of the coordinated discharges for the 10 year and 50 year floods.

Backwater Elevation

Big Blue River was not modeled as being subject to backwater.

Conclusion of Hydraulic Analyses for Big Blue River

B. Driftwood River

Work conducted by the USGS

Cross sections surveyed in the field and synthetic cross sections (derived from a digital elevation model (DEM) map obtained from LIDAR for parts of Bartholomew and Jackson Counties) were used to develop a step-backwater model to establish the selected flood profiles for the three streams discussed in this report.

Scope of Work

The Driftwood River flows generally to the south. The downstream study limit is the 0.6 miles downstream of Lowell Road. The upstream study limit is the confluence of Sugar Creek and Big Blue River. This stream reach is approximately 11.2 miles in length.

Hydraulic Baseline

Stationing used for the hydraulic baseline for this stream is referenced to feet upstream from the cross section approximately 0.6 miles downstream of Lowell Road bridge.

Cross-Section and Contracted Opening Geometry Data Surveyed in the Field

The USGS surveyed 3-4 cross sections at 3 hydraulic structures and 22 open channel sites for this reach of Driftwood River. All surveys were referenced to the North American Vertical Datum of 1988 (NAVD 88) and the North American Datum of 1983 (NAD83).

Synthetic Cross-Sectional Geometry Data

Using a geographic information system (GIS), the USGS used LiDAR digital elevation models (DEM) to obtain supplemental cross-sectional data for Driftwood River. A total of 39 synthetic cross-sectional profiles were generated by use of the DEM at desired locations along the stream reach. In-channel data for all synthetic cross sections were estimated by interpolation from cross-sectional data surveyed in the field.

Starting Water-Surface Elevations

Since the gage on Driftwood River is approximately 10 miles upstream from the initial section, the rating curve could not be used. The method used for the boundary conditions is normal depth from thalweg

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and water surface slope estimates (from FIS) near the downstream end of the study. Using .001 as the slope produced reasonable results at the Lowell Road bridge when compared to the FIS.

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Manning's Roughness Coefficients

Manning's roughness coefficients (n) for the main channel and overbank areas of Driftwood River were determined from field observation and aerial photographs by experienced personnel. Estimates of Manning's roughness coefficients range in value from 0.038 to 0.044 for the main channel, and from 0.040 to 0.12 for the overbank areas. FIS n -values: 0.045 to 0.06 for the channel, 0.045 to 0.080 for the overbanks.

Flow Lengths

Main channel and overbank flow lengths were computed through the use of HEC-GeoRAS (U.S. Army Corps of Engineers, 2009). Flow paths are drawn in the GIS by the user for both the main channel and overbanks. HEC-GeoRAS computes all flow lengths based on the flowpaths estimated by the user.

Hydraulic Structure Solution Reviews

For this study, all hydraulic structure computations were reviewed for the appropriate modeling solutions (see Special Hydraulic Considerations section of Hydraulic Analyses). Initial reviews focused on the type of solution computed at each structure (energy equation based or based on pressure and/or weir-flow equations). Table A1 shows the river station, a location description, the type of structure, the presence of road overflow, and the solution type of all structures affecting the 9-17 foot stage profile for Driftwood River.

Table 4. Summary of hydraulic structure solutions for the Driftwood River.

River station (feet)	Location Description	Structure type	Presence of road overflow	Solution type
3,572	W. Lowell Road	Bridge	No	Pressure
28,959	Tannehill Road	Bridge	Yes	Weir
54,718	Hendricks Ford Road	Bridge	Yes	Weir

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Profile Verification (or Calibration)

The Driftwood River model was calibrated by the use of the most current (discharge measurement verified) stream gage stage-discharge rating. All of the water-surface elevations for the profiles at the gage were within 0.16 foot of rating number 39 dated 04/18/2011.

Profile	Rating Elevation	Model Elevation	Difference
9	645.6	645.51	0.09
10	646.6	646.60	0.00
11	647.6	647.47	0.13
12	648.6	648.59	0.01
13	649.6	649.54	0.06
14	650.6	650.45	0.15
15	651.6	651.48	0.12
16	652.6	652.73	-0.13
17	653.6	653.75	-0.15

Date

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FEMA flood profiles were compared to the model derived water-surface elevations. The model derived water-surface elevations are reasonable.

Backwater Elevation

Driftwood River was not modeled as being subject to backwater.

Conclusion of Hydraulic Analyses for Driftwood River

C. Sugar Creek

Work conducted by the USGS

Cross sections surveyed in the field and synthetic cross sections (derived from a digital elevation model (DEM) map obtained from LIDAR for parts of Bartholomew and Jackson Counties) were used to develop a step-backwater model to establish the selected flood profiles for the three streams discussed in this report.

Scope of Work

Sugar Creek flows generally to the south. The downstream study limit is the confluence with Driftwood River. The upstream study limit is 0.5 miles upstream of the U.S. Railroad. This stream reach is approximately 5.2 miles in length.

Hydraulic Baseline

Stationing used for the hydraulic baseline for this stream is referenced to feet upstream from the confluence with Driftwood River.

Cross-Section and Contracted Opening Geometry Data Surveyed in the Field

The USGS surveyed 3-4 cross sections at 3 hydraulic structures and 11 open channel sites for this reach of Sugar Creek. All surveys were referenced to the North American Vertical Datum of 1988 (NAVD 88) and the North American Datum of 1983 (NAD83).

Synthetic Cross-Sectional Geometry Data

Using a geographic information system (GIS), the USGS used LiDAR digital elevation models (DEM) to obtain supplemental cross-sectional data for Sugar Creek. A total of 21 synthetic cross-sectional profiles were generated by use of the DEM at desired locations along the stream reach. In-channel data

for all synthetic cross sections were estimated by interpolation from cross-sectional data surveyed in the field.

Starting Flow Values

The flow rates for the Sugar Creek junction with the Driftwood River were determined by its drainage area percentage. The values used were 45% of the flows at the Driftwood gage based on drainage area contributions. Each estimated flow was then referenced to the rating for Sugar Creek. The elevations for those flows were used as calibration checks at the Sugar Creek gage.

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Manning's Roughness Coefficients

Manning's roughness coefficients (n) for the main channel and overbank areas of Sugar Creek were determined from field observation and aerial photographs by experienced personnel. Estimates of Manning's roughness coefficients range in value from 0.031 to 0.035 for the main channel, and from 0.08 to 0.10 for the overbank areas. FIS values: 0.030 to 0.050 for main channel, 0.065 to 0.090 for overbanks.

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Flow Lengths

Main channel and overbank flow lengths were computed through the use of HEC-GeoRAS (U.S. Army Corps of Engineers, 2009). Flow paths are drawn in the GIS by the user for both the main channel and overbanks. HEC-GeoRAS computes all flow lengths based on the flowpaths estimated by the user.

Hydraulic Structure Solution Reviews

For this study, all hydraulic structure computations were reviewed for the appropriate modeling solutions (see Special Hydraulic Considerations section of Hydraulic Analyses). Initial reviews focused on the type of solution computed at each structure (energy equation based or based on pressure and/or weir-flow equations). In the cases where road overflow occurred at a culvert, a submergence check was made. In the cases where the hydraulic model computed weir flow at a culvert that was determined to be submerged, the culvert was replaced with composite sections. Table A1 shows the river station, a location description, the type of structure, the presence of road overflow, and the solution type of all structures affecting the 9 -17 foot stage profiles for Sugar Creek.

Table 5. Summary of hydraulic structure solutions for Sugar Creek

River station upstream of mouth (feet)	Location Description	Structure type	Presence of road overflow	Solution type
7040	Hospital Road	Bridge	No	Energy
18,389	County Road 650 South	Bridge	Yes	Weir
24,840	U.S. Government Railroad	Bridge	No	Energy

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Profile Verification (or Calibration)

The Sugar Creek portion of the model was calibrated by the use of the most current (discharge measurement verified) stream gage stage-discharge rating at the Sugar Creek gage. All of the water-

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surface elevations for the profiles at the gage were within 0.25 foot of rating number 41 dated 09/02/2008.

Profile	Rating Elevation	Model Elevation	Difference
9	653.45	653.4	0.05
10	654.02	654.03	-0.01
11	654.62	654.68	-0.06
12	655.48	655.64	-0.16
13	656.42	656.66	-0.24
14	657.53	657.48	0.05
15	658.93	658.85	0.08
16	660.86	660.65	0.21
17	662.25	662.36	-0.11

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FEMA flood profiles were compared to the model derived water-surface elevations. The model derived water-surface elevations are reasonable.

Backwater Elevation

Sugar Creek was not modeled as being subject to backwater.

Conclusion of Hydraulic Analyses for Sugar Creek

MAPPING INFORMATION

GEOSPATIAL MAP DOCUMENTATION

A discussion or listing is presented in this section that should provide the reader with sufficient information to describe aspects of the geospatial data used for the study.

At a minimum, metadata should include the following:

Section 1: Identification information

This includes the **title, creator or originator of the data**, and **abstract** describing the content of the dataset, **time period, keywords, contact information** for a person or organization for questions

Section 2: Data Quality Information

Contains information about the **resolution or scale of the data, accuracy of the data, processing steps, and sources of the data** (if source data were used).

Section 3: Spatial Data Organization

Specifies **data type** as vector or raster.

Section 4: Spatial Reference Information

Details the **projection or coordinate system**.

Section 5: Entity Attribute Information

Provides a **definition and description of the attributes** in the tables or fields in a dataset.

Section 6: Distribution information

Gives information about how the data can be obtained

Section 7: Metadata Reference

Information about the format and **contact information** for the creator of the metadata.

A useful reference that provides more detail is "FGDC Don't Duck Metadata. Metadata Quick Guide", April 2006 version.

It is available online at <http://www.fgdc.gov/metadata/documents/MetadataQuickGuide.pdf>

Surveys conducted by the USGS

The USGS conducted both Global Positioning System (GPS) and bathymetric surveys for this study. The GPS surveys were conducted using a GLONAS receiver and INCORS base stations.

The horizontal datum for the survey is the North American Datum of 1983 (NAD83), Indiana State Plane (Indiana East) coordinates. The vertical datum for the survey is the North American Vertical Datum of 1988 (NAVD 88).

GPS surveys were conducted by the USGS using Real-Time Kinematic (RTK). Control for the USGS survey was established using a combination of water-surface checks and a county benchmark tablet. A comparison of the published coordinates and surveyed coordinates are shown in Table 6 below.

Table 6. Comparison of published coordinates to USGS surveyed coordinates. All data shown in feet, NAD83, and NAVD88.

Reference mark number	Benchmark Name	Published Easting	Published Northing	Published Elevation	Surveyed Easting	Surveyed Northing	Surveyed Elevation	Delta Elevation
1	IFC&WRC BM JON 12, 1956			673.00	232617.287	1507903.669	672.66	0.44
2	Driftwood gage reading 03363000			648.12			648.10	0.02
3	Sugar Creek gage reading 03362500			656.48			656.24	0.24

Accuracy of Mapping Data

Selected data collected during the GPS field surveys were used by the USGS to perform quality-control checks of the mapping data.

Development of Depth Grids

Depths grids were produced in HEC-GeoRAS. The modeled water-surface elevations for all profiles were written to a RAS GIS Export File. This water-surface data in conjunction with terrain elevation data was used for floodplain delineation and determination of water surface depths.

MISCELLANEOUS REFERENCES

Federal Emergency Management Agency, 2003, Guidelines and Specifications for Flood Hazard Mapping Partners, April 2003, 1779 p.

Federal Geodetic Control Committee, 1984, Standards and Specifications for Geodetic Control Networks, 34 p.

Federal Geographic Data Committee, 1998, Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy (FGDC-STD-007.3-1998), 28 p.

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