CHAPTER 4

Mapping Standards and Methods

4.1 Purpose

An important result of a floodplain hydrologic-hydraulic assessment is a plot of the floodplain and floodway on a suitable map. With the advent of the statewide LiDAR and orthophotography project, a more enhanced mapping and elevation dataset is now available for floodplain mapping efforts. Therefore, the purpose of this chapter is to provide resources on procuring and implementing new LiDAR datasets and to document legacy sources used on prior mapping efforts to help evaluate previous projects.

It is extremely important that the horizontal and vertical datum of the map is known and well documented before starting any project. See Chapter 5 for a thorough discussion of datums.

4.2 Statewide LiDAR and Orthophotography

4.2.1 Background

In 2011, the State of Indiana embarked on a three year project to obtain, compile and present detailed elevation data for the entire state. This project utilizes LiDAR technology to derive elevations from the earth's surface that can be used for floodplain mapping efforts. In addition, high resolution orthophotography was obtained at the same time, in an effort to update the 2005 orthophotographic product for the state.

The data capture was completed in three years on an annual cycle basis. The data for the center of the state was captured in 2011, the eastern part in 2012, and the western part in 2013. This data is now available as either in a Digital Elevation Model (DEM) or in a raw point cloud format. Figure 4.1 depicts the year data for each county was collected.

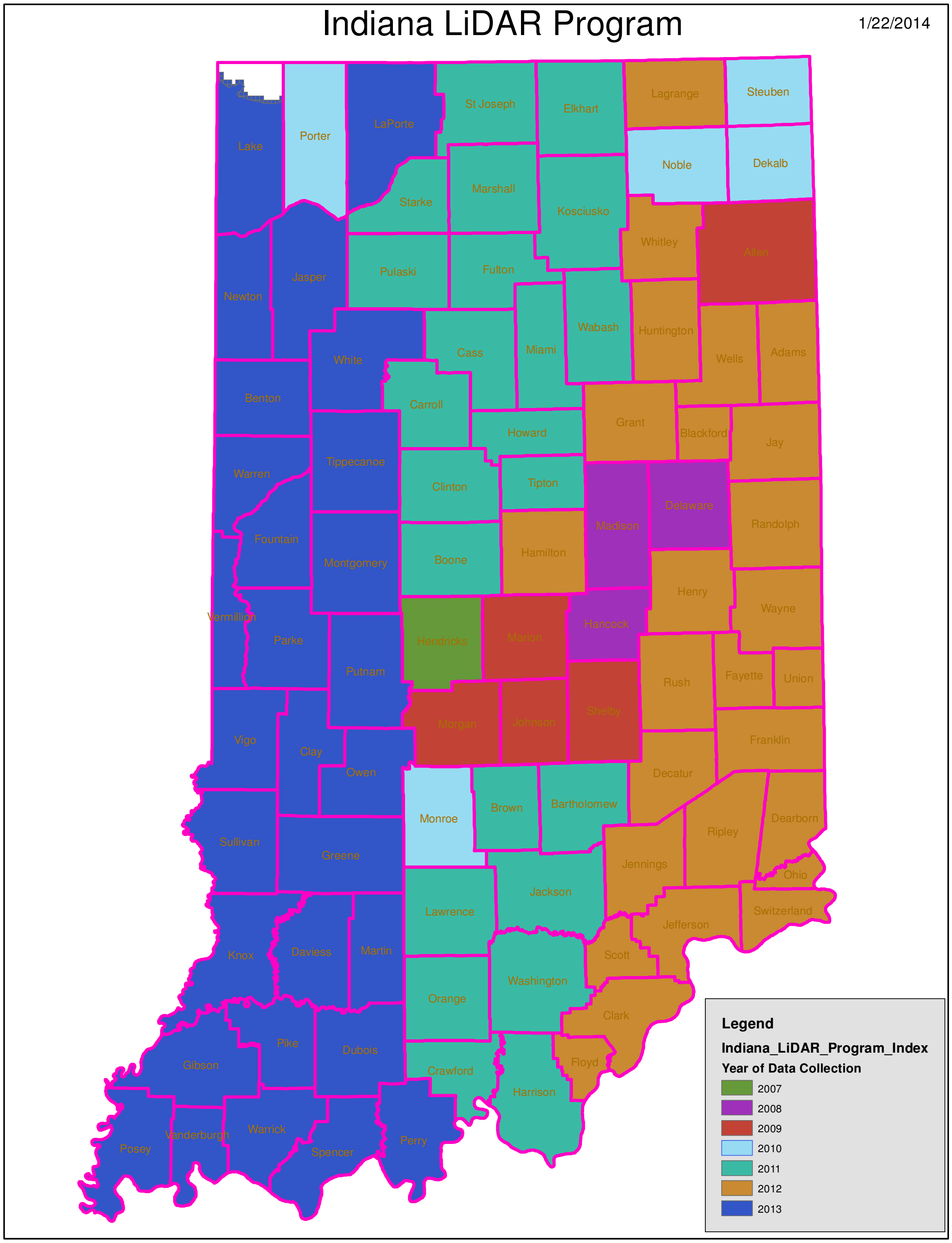

Figure 4.1: Year of acquisition of current LiDAR

4.2.2 LiDAR

LiDAR stands for Light Detection And Ranging. By bouncing rapid pulses of laser light waves off structures and the underlying terrain, a digital 3-D image is generated. LiDAR can distinguish between earth, water, buildings, roads, trees, crops and countless other types of surfaces. The raw LiDAR point cloud includes all of this data, classified by the type of feature the light wave has bounced off of, known as a 'return'.

For the purposes of floodplain modeling, the return of interest is the last return, which represents the bare earth condition of the ground, without buildings, trees and other obstacles.

4.2.3 Derivative products from a LiDAR dataset

For most applications for floodplain mapping, a raw LiDAR point cloud dataset is too dense to manage. Therefore only a subset of this raw LiDAR data is used to extract cross section information and to subsequently plot computed floodplain limits. This subset can be represented in various formats discussed below.

A Digital Elevation Model (DEM) is the most common derivative product of LiDAR data. A DEM is typically (but not always) derived from the bare earth returns of a LiDAR mission. It is represented in the form of a grid of elevation points placed at a specified pixel or point spacing. For the Indiana Map LiDAR, "hydro-flattened" DEMs, a 5-foot pixel spacing were used. The hydro-flattening provides a constant (or smoothly sloping) representation of water features in a DEM. This processing is essential because light pulses used for the LiDAR are erratically absorbed by water thereby skewing the water surface elevations. Breaklines were digitized using orthophotography datasets and set as a filter during DEM compilation process.

A Triangular Integrated Network (TIN) consists of a network of interconnected triangles with known elevations at each triangle vertex. Since the elevation of each vertex of a triangle within a network is known, elevations along the plane defined by the triangle can be computed. TINs' are commonly derived from less intensive data sources (such as traditional photogrammetry). A TIN dataset generated from a dense LiDAR point cloud for a large area can become extremely large and unwieldy. However, for small sites, with extra processing of the point cloud data, a TIN may be more accurate than a DEM.

Contours, represented by lines of equal elevation on a surface, are another derivative product of the LiDAR point cloud. Though contours can be generated easily using a LiDAR point cloud data, DEM or TIN surface, extra processing may be required to create smooth “map quality” contours.

In most cases, cross-section data for hydraulic modeling should be taken directly from the DEM or TIN information, even though the DEM or TIN may be of sufficient density and accuracy to create quality contour information. Contours are useful for visualization and presentation of the data.

4.2.4 Obtaining LiDAR data

The LiDAR data can be obtained from two places:

A. The Indiana Spatial Data Portal (ISDP) has LiDAR data available in several formats on their website gis.iu.edu listed below:

   - Bare-earth DEM with hydro-flattening (both tiled and county mosaics)
   - Classified LiDAR point cloud data
   - Hydro breaklines

   The ISDP web portal (gis.iu.edu) provides additional details pertaining to the aforementioned formats and their use.

B. OpenTopography (opentopography.org) also hosts LiDAR datasets for most counties within Indiana. This website allows the user to download data within a user-defined area of interest. The LiDAR point cloud data can be queried in a number of different formats to generate a specific subset that can be downloaded by the user.

4.2.5 Using LiDAR data in a hydraulic model

Typically, a hydro-flattened DEM is used as a base DEM for deriving cross section information. A number of computer programs such as HEC-GeoRAS, can be used to extract elevation data for a cross section and import or export this data into a hydraulic model.

Be aware of the horizontal datum and units of the DEM being used. If the DEM is referenced to a UTM datum, the units are likely to be in meters, and therefore the distances in the extracted data will also be in meters. The ISDP LiDAR dataset, spatially referenced to the Indiana State Plane coordinate system, is in feet.

There is a limit of 500 points in a cross section when importing them in HEC-RAS. When a cross section is extracted from a DEM, there is an elevation point for every pixel. It is therefore common to have cross sections with more than 500 points. Using the "Cross section point filter" within HEC-RAS will pare down the elevation points to under 500 without compromising the cross section shape and integrity.

For floodplain modeling, it is very important to note that the LiDAR technology is not capable of determining elevations under water. Therefore, in such situations, use the LiDAR data with caution. If elevations of the stream bottom are known, then this information should be used to enhance the geometry in the hydraulic model. For small streams with very little water during the LiDAR data capturing process, the stream bottom elevations that are derived from LiDAR may be acceptable, but there may be limitations in determining channel dimensions because of the DEM pixel size in comparison to the channel. For larger streams, site survey or bathymetric methods should be investigated and incorporated into the hydraulic model as necessary.

4.3 Other Sources of Mapping

4.3.1 IDNR "Floodplain" Mapping

Typically, IDNR mapping is at a horizontal scale of 1" = 200' with a contour interval of two feet. An index to these maps appears on the IDNR website. Because these maps were specifically created for delineating floodplain and floodway boundaries, they are ideal for use as base maps. These maps cover many of Indiana's major urban streams. While these maps are ideal for establishing base conditions, they may not be suitable for existing conditions. Many of these maps were prepared in the 1960's and 1970's, thus, many of their features may be outdated. Refer to the top of the previously mentioned IDNR website Publications List for map ordering information.

4.3.2 County or City Mapping

Many county and city governments are developing their own sources of mapping for use in local zoning, planning, and engineering activities. While these maps vary in horizontal scale and contour interval, they usually meet IDNR "Floodplain" mapping standards. IDNR does not distribute county and city mapping. Therefore, potential users are asked to contact local planning, engineering, surveying, or other appropriate offices to learn more about and possibly acquire county and/or city maps.

Many counties have developed GIS sites, with mapping data such as parcels and other community information. In some cases elevation information is included in these mapping portals; any data used for developing floodplain models should be reviewed and confirmed that the data meets any requisite accuracy requirements. Datum information should also be confirmed and noted.

4.3.3 FEMA Workmaps

FEMA often has detailed contour mapping (known as workmaps) created for use in Flood Insurance Studies. In the past, FEMA's minimum standards for their mapping has been a horizontal scale of 1" = 400' with a contour interval of four feet. Recently, FEMA has adopted more detailed standards for floodplain mapping. However, these older FEMA workmaps may be suitable for plotting floodplain and floodway limits.

Since these maps were used in the production of flood insurance studies, they may have the floodway and floodplain information drafted on them, however, this information should be used with caution since the flood information themes or layers on these maps may have been subsequently changed for final publication of the FIS. Maps in the FIS are the final authority on floodplain and floodway limits. Copies of some FEMA workmaps are available from the IDNR, although many have been lost. Refer to the FIS text to determine what base mapping was used in the creation of the FIS maps.

4.3.4 Local Development Project Plans

Public works and other projects often include the development of maps. Examples of such projects are storm and sanitary sewer systems, roads and bridges, subdivisions, water and wastewater treatment plants, and industrial/commercial developments. These maps may be suitable for plotting floodplains and floodways. However, because these maps were not specifically created for floodplain use, they must be examined carefully for contour suitability, horizontal and vertical datums, and the overall accuracy.

4.3.5 Ohio River "Strip Mapping"

The USACE created this mapping in the mid 60's for the Ohio River and its overbanks. Arranged by pool reach, this mapping has a horizontal scale of 1" = 600' and the contour interval is five feet, with some 2 ½ foot supplemental contours. The vertical datum of the elevation data on these maps is the Sandy Hook Datum; not the National Geodetic Vertical Datum (NGVD) of 1929. The appropriate conversion from Sandy Hook Datum to NGVD 1929 is available by request from the IDNR's Surveying and Mapping Section. As with the DNR "Floodplain Mapping" and the FEMA workmaps, these maps provide historical topographic information but may not reflect current conditions.

4.3.6 Other Historic Mapping

Other "strip" mapping exists for major rivers in Indiana such as the Wabash, White and East Fork White Rivers. However, this mapping is typically much older than the Ohio River mapping (dating from the 30's in many cases) and, therefore, is only useful for historical purposes. The Corps of Engineers also compiled mapping for use in design of the major reservoirs in the state, including a couple (Lafayette and Big Pine) that were never constructed. These maps are officially out of print, but copies can be made of maps in IDNR files.

When researching a site or a particular model, it can be useful to have a source for historical orthophotos that can show changes in land use or of a site over time. There are many sources of historical orthophotos available, including the IU GIS Portal, the aerial IGS Indiana Historical Aerial Photo Index, the IUPUI Historical Aerial Archive, and the State Land Office / Indiana Commission on Public Records.

4.3.7 2005 IndianaMap Digital Elevation Model

This section is provided for historical information sake but the data has been superseded.

In 2005, the State of Indiana conducted a large scale orthophoto data acquisition project to develop an initial base map for the IndianaMap. High quality orthophotos (at a scale of 1" = 200' for the entire state, 1" = 100' for selected counties) are available for download at the IU GIS portal, and are also the base for many applications, including the Digital Flood Insurance Rate Maps and Google Earth. Along with this data a Digital Surface Model (DSM) and a Digital Elevation Model (DEM) were also produced, and are available at the IU GIS Portal. The DEM is certified to a 10' contour interval, but should be used with caution, since it was processed using automated techniques, and has known problems in vegetated areas. More information regarding DEM's is in Section 4.2.

Digital Orthophoto Quadrangles (DOQs) are digital, georeferenced aerial photographs that have been published by the U.S. Geological Survey (USGS) and are available for the entire state. This data has been mostly superseded by the IndianaMap data. For additional information on DOQs, refer to the USGS website.

4.3.8 USGS 7 ½ Minute Quadrangles

These widely known and used maps have a horizontal scale of 1" = 2000' and, in much of Indiana, a contour interval of 10 feet. The 7 ½ minute quadrangles are ideal locating and planning tools, but with the advent of the statewide LiDAR, they should no longer be used for any detailed hydrologic or hydraulic assessment.

USGS Quadrangle maps can be obtained from the IDNR map sales office. They are also available in a digital format from the USGS, the IU GIS portal, and from many third party vendors.

4.4 Site Specific Topographic Mapping

If an adequate site map does not exist for a floodplain and floodway study, then an option is to develop a site specific map for use in determining and plotting flood themes or information. Additionally, the nature of the project may require that detailed site topography be obtained for other uses (e.g., grading, site layout, and utilities). Therefore, in the planning stages of a project, the compilation of adequate data for floodplain mapping is one of the considerations in the overall tasks for and costs of a project.

From the perspective of the IDNR, some factors to consider when planning site specific mapping are:

- For large scale residential, commercial, and industrial projects, mapping should, at a minimum, be obtained at the standard used for IDNR floodplain mapping, that is, a horizontal scale 1" = 200', and a contour interval of two feet. The Indiana Map LiDAR data is more than adequate for these purposes, but may need to be supplemented with survey or other more detailed information. These types of projects are where severe flood losses could occur and inaccurate mapping may lead to understatement of flood risks and/or improper land use. The floodway delineation process, in particular, becomes clearer and easier when quality mapping is used. The indicated scale and contour standards should also be used for the planning of water related projects (e.g., wastewater treatment plants, regional detention ponds, and levees). If possible, the mapping should extend beyond the point of interest, so that downstream starting elevations and upstream effects can be analyzed at the same level of detail.

- Smaller scale developments (i.e., five lots and/or five acres or less) typically do not need mapping as detailed as that required for larger scale developments. Judgment should be used in determining the optimum scale and contour interval, weighing the cost of the mapping versus the actual potential for flood damage in the area being considered. Single lot residential and small commercial and industrial developments could use the Indiana Map LiDAR data for these purposes.

4.5 FEMA Floodplain mapping zones

FEMA, along with the IDNR Division of Water, has been continuously updating Flood Insurance Rate Maps (FIRMs) through the Cooperating Technical Partner (CTP) program. DFIRMs are available on FEMA's Map Service Center Website, and shown on the Indiana Floodplain Information Portal (INFIP).

Flood insurance zone designations shown on the DFIRMs are assigned to a community based on the results of the engineering analyses. These zones are as follows:

- Zone A

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

- Zone AE

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

- Zone AH

  Zone AH is the flood insurance risk zone that corresponds to the areas of 1-percent-annual-chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

- Zone AO

  Zone AO is the flood insurance risk zone that corresponds to the areas of 1-percent-annual-chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-foot base flood depths derived from the detailed hydraulic analyses are shown within this zone.

- Zone AR

Zone AR is the flood insurance risk zone that corresponds to an area of special flood hazard formerly protected from the 1-percent-annual-chance flood event by a flood-control system that was subsequently decertified. Zone AR indicates that the former flood-control system is being restored to provide protection from the 1-percent-annual-chance or greater flood event.

- Zone A99

Zone A99 is the flood insurance risk zone that corresponds to areas of the 1-percent-annual-chance floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No BFEs or depths are shown within this zone.

- Zone D

Areas with possible but undetermined flood hazards. No flood hazard analysis has been conducted. Flood insurance rates are commensurate with the uncertainty of the flood risk.

- Zone V

Zone V is the flood insurance risk zone that corresponds to the 1-percent-annual-chance coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no BFEs are shown within this zone.

- Zone VE

Zone VE is the flood insurance risk zone that corresponds to the 1-percent-annual-chance coastal floodplains that have additional hazards associated with storm waves. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

- Zone X

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

IDNR "Floodplain" Mapping:
http://www.in.gov/dnr/water/2454.htm#flood%20plain%20mapping

IU GIS Portal:
http://www.indiana.edu/~gisdata/

USGS Mapping:
http://geography.usgs.gov/

IUPUI Historical Aerial Archive:
http://atlas.ulib.iupui.edu/Aerials/home.html

IGS Indiana Historical Aerial Photo Index:
http://129.79.145.7/arcims/IHAPI/index.html

Indiana Commission of Public Records -- Aerial Photographs:
http://www.in.gov/icpr/2414.htm

FEMA Guidelines and Specifications for Flood Hazard Mapping Partners
http://www.fema.gov/library/viewRecord.do?id=2206

FEMA Procedure Memorandum 61
http://www.fema.gov/media-library/assets/documents/19742?id=4345

FEMA Map Service Center:
http://msc.fema.gov

The Indiana Floodplain Information Portal (INFIP)
https://dnrmaps.dnr.in.gov/appsphp/ifdms