BASE FLOOD ELEVATION DETERMINATION MODULE

FEDERAL EMERGENCY MANAGEMENT AGENCY

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NOLTE
BEYOND ENGINEERING

ABSTRACT

The FEMA Base Flood Elevation Determination Module is a Visual Basic application that uses ArcObjects. The application automates the process of determining the base flood elevation (BFE) and flood status of properties within communities. Currently, this process is conducted manually by use of hard copy Flood Insurance Rate Maps (FIRM). Developed in conjunction with FEMA's current Map Modernization efforts, this application is envisioned as a viewer that will be distributed by FEMA at no cost to communities, allowing a rapid and more accurate means of determining the BFEs for structures within the Special Flood Hazard Areas (SFHA) of the FIRMs.

INTRODUCTION

The Federal Emergency Management Agency (FEMA) is entrusted by the Federal government to administer the National Flood Insurance Program (NFIP). This program provides federally backed flood insurance to the residents of qualifying communities throughout the nation. The most highly visible icon of the NFIP is the Flood Insurance Rate Map (FIRM). These maps identify flood prone areas within a community. The maps are typically used by the banking and insurance industry to determine the need for the purchase of flood insurance in the Special Flood Hazard Areas (SFHA) of communities that are in the NFIP. The communities also use the FIRMs for identifying whether structures are in or out of the SFHA, and for elevation requirements and compliance with local building codes. Elevation requirements are usually a case of a structure's elevation in reference to the Base Flood Elevation (BFE) as determined from the FIRM.

In 1997 the Federal Emergency Management Agency (FEMA) began an ambitious program called "Map Modernization". Its goals were simple.

- Conversion of the FIRMs to a digital format
- Application of emerging technologies
- Increased involvement of State and Community partners
- Increased Customer Service
- Promote an increased awareness of flood risks

Conversion of the FIRMs to a digital format is well underway and is progressing smoothly. One area that is only recently being addressed, due to the emergence of GIS technology, is that of a quick and accurate method for determining the BFE for an identified structure within the SFHA. If a method can be economically constructed for our partners that already have or are entering into using this new arena of GIS technology, then it would help to increase the involvement of our community partners and lead to an increased level of customer service. The positive spin off would be an increased awareness of flood risks.

THE PROBLEM

From 1968 to about the early 90's, FEMA has collected and presented its data using conventional analog technology. With the advent of digital data gathering technology in the early 90's, FEMA has collected data in a digital fashion but has displayed or presented its product in an analog fashion, i.e. paper maps. Since FEMA now has a library of digital data coupled with a uniform set of digital specifications, we now have the basics for using the new digital gathering technologies such as LIDAR and GIS for the display and queries of our information. FEMA's digital specifications for Digital Flood Insurance Rate Maps (DFIRMs) can be found at http://www.fema.gov/fhm/gs_main.shtm

In an effort to close the last three feet, i.e. the distance between the community's floodplain manager and the public, FEMA-Region IX wanted to create a tool for the communities that would use off-the-shelf digital FIS data and would enable the communities to have an on-demand system for displays and queries such as:

- The Base Flood Elevation (BFE) within a Special Flood Hazard Area (SFHA)
- The Base Flood Elevation of a structure within an SFHA
- The location of a structure relative to the boundaries of the SFHA
- The location of a structure relative to a floodway
- The relative contour elevations of a site in relationship to the location of a potential structure.

Our goals for this new tool:

- Use only existing data that is normally collected during a Flood Insurance Study (FIS). This would enable any community with a FIS that adheres to our latest specifications to use the product.
- Minimal amount of data manipulation to convert it into a usable form for its use.
- Make it fit the regular operating scheme of how a community currently processes any queries. This was a very important consideration. If a community uses their parcel base as starting point for all of their work, then our model should use that as its link to the SFHA and thus the BFE determination.
- Make it generic so that a community could use it as a base and add in other databases and layers and necessary. Don't make it an exclusive BFE determination tool!
- User friendly and simple in use.

We have chosen to call this tool the Base Flood Elevation Determination Module (BFEDM) and will describe our solution.

THE SOLUTION

The Base Flood Elevation Determination Module is a Visual Basic program that was created to assist in the determination of the Base Flood Elevation as it relates to a delineated flood plain. More specifically, the program allows one to locate a specific site using an assessor parcel number. The BFEDM viewer can zoom and pan to the specified parcel and allow an interactive query using the cursor to determine the Base Flood Elevation (BFE) of a flood plain that traverses the area. The program is intended to provide a more precise means of determining the BFE using digital information and thereby eliminate the interpolation that was necessary with the paper FIRM.

As with any mapping endeavor, the accuracy of the reported information is only as accurate as the information used to assemble the map data. A goal in creating this application was to determine the calculated BFE to within 0.1 foot. The program can easily report the BFE with this degree of precision and beyond, but it is entirely dependent upon the accuracy of the delineated flood plain, the accuracy of the community base map and the methods used to create the virtual flood plain surface that the program uses to calculate the surface elevation.

METHODOLOGY

This paper presents the methodology used to assemble data that can be used by the BFEDM and report Base Flood Elevation Data as well as flood plain boundary, parcel location and building locations.

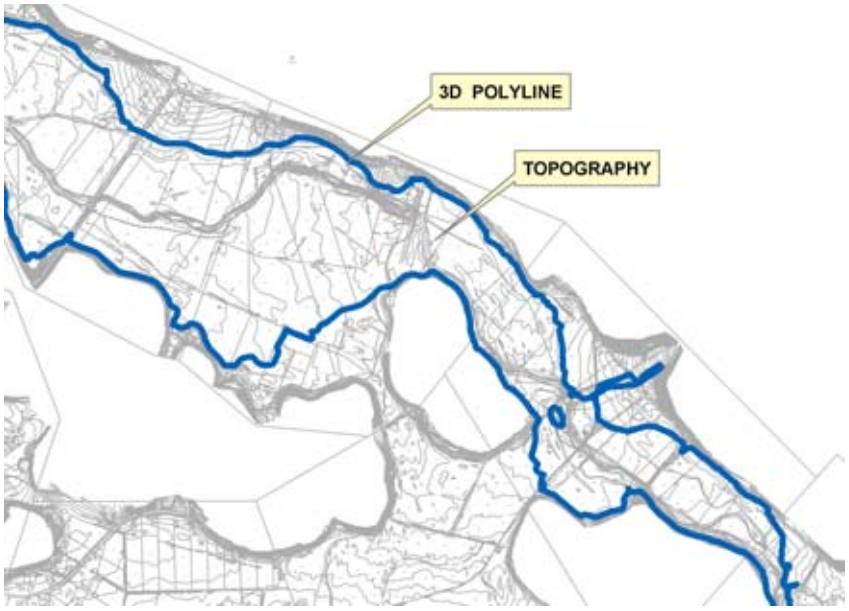
The development of the BFEDM was conducted as part of a Flood Insurance Study (FIS). The FIS provides updated flood plain delineation and Base Flood Elevations (BFE) for a community that is in the NFIP.

Flood plains are not flat. As they traverse a community, they wind and twist through their confines as they flow from a higher elevation to a lower elevation. In moderately hilly terrain, a flood plain exhibits a high degree of slope in contrast to flatter terrain as found in the central valleys of California or throughout much of the Midwest. No matter where they exist, flood plains vary continuously in elevation. In order to determine elevation anywhere along the surface of the flood plain, a method was needed to model the actual surface of a predicted flood plain and then calculate “on-the-fly” the surface elevation at any point along the flood plain’s surface.

The ability to calculate the elevation of the flood plain surface at any point was addressed by creating a virtual surface of the flood plain. The virtual surface mimicks the actual surface characteristics of the flood plain and provides a means to calculate the surface elevation using tools within the ArcMap or BFEDM program.

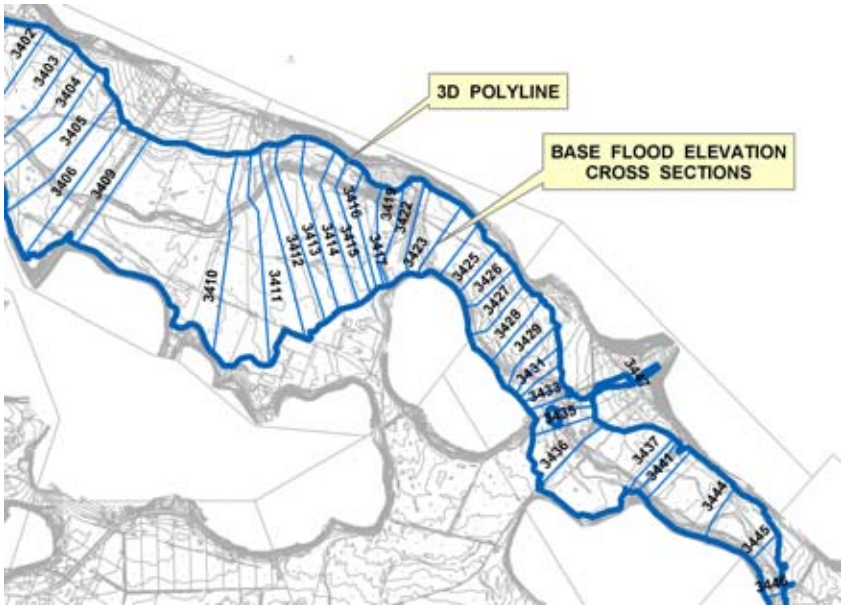
Delineated Flood Plain Boundary

The construction of the virtual surface model of the flood plain was accomplished by first obtaining the newly derived flood plain boundary as shown above. In the case of this particular re-study project, the boundary was a simple polygon boundary that did not possess elevation information.



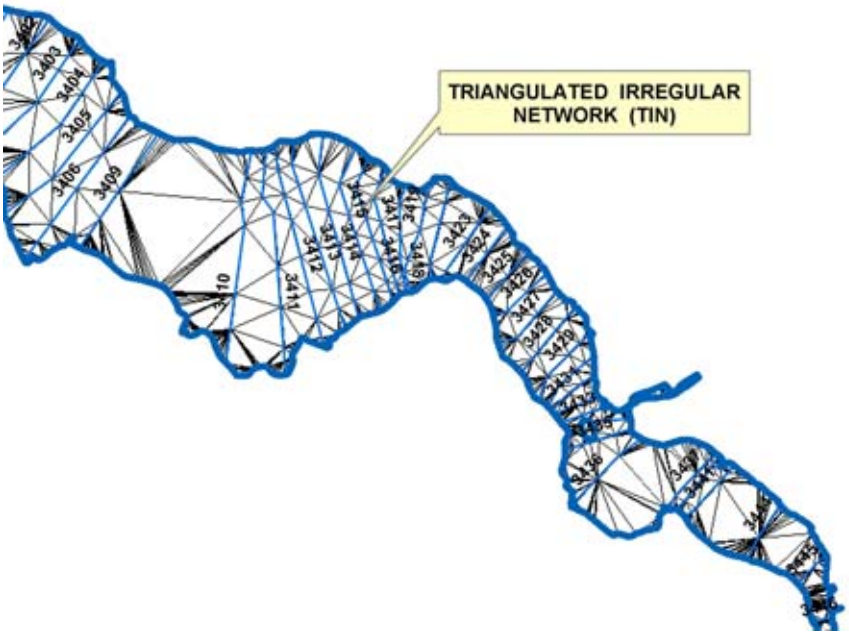
Flood Plain Boundary Draped over Topographic Data

In order to create a flood plain boundary that exhibited the three dimensional character of the limits of a flood plain, it was necessary to drape the flood plain boundary over the actual topography of the community that it was flowing through and transfer the ground elevation to the flood plain boundary. The topography from this re-study area had been produced through aerial photogrametric means and had contour intervals of two feet.



Flood Plain with BFE Contours

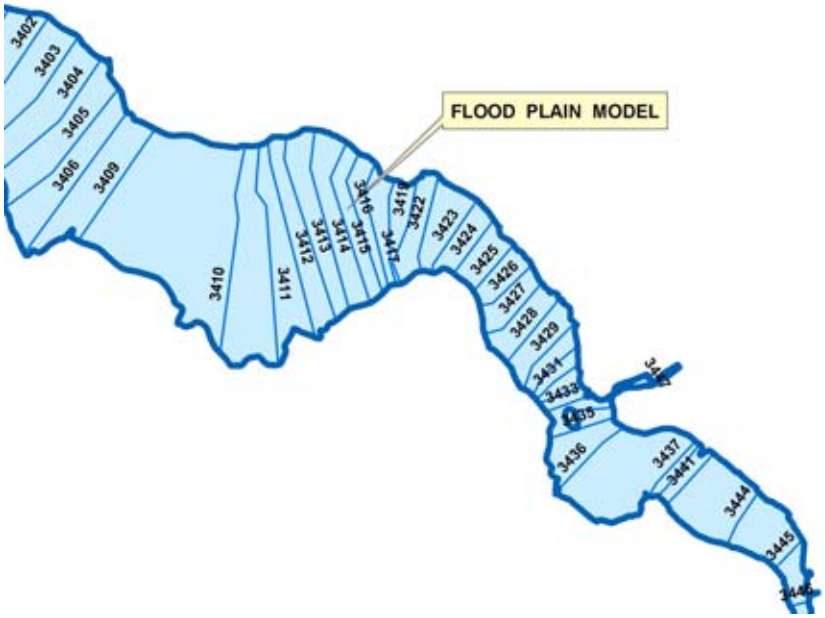
At this stage, additional data in the form of the Base Flood Elevation Contours were added to indicate known flood plain surface elevations as they traversed the surface of the flood plain. The image above illustrates the elevation assignments of the BFEs as they decrease in elevation from right to left indicating that the flood plain is flowing downstream right to left.



Triangulated Irregular Network (TIN)

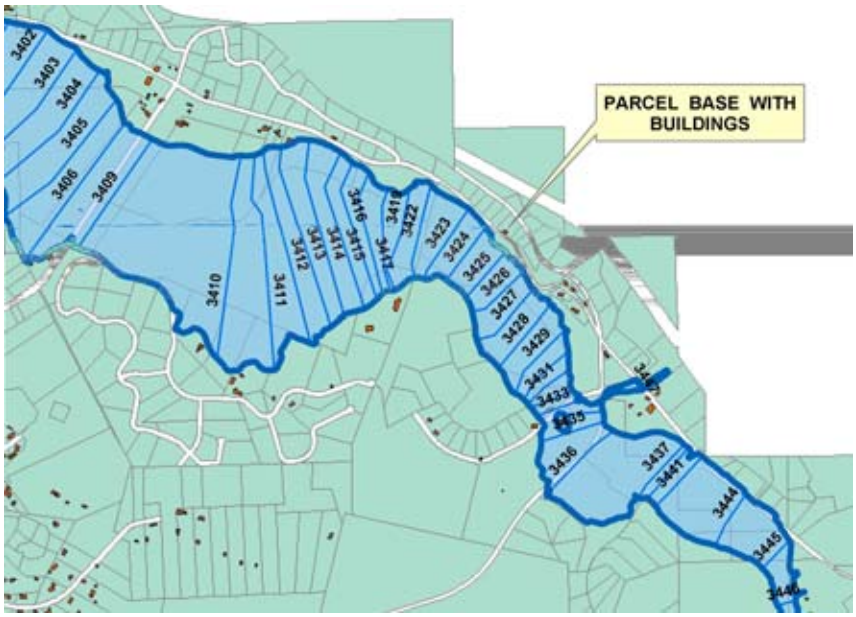
Using tools within the 3D Analyst extension of ArcInfo, the three-dimensional flood plain boundary and the BFE contours with their respective elevations were used to create a Triangulated Irregular Network (TIN) that modeled the anticipated surface of the flood plain. The TIN model is made up of three-dimensional triangular faces that have X,Y &

Z coordinates at each vertex. The TIN can be queried by the BFEDM viewer and the viewer will return the calculated elevation at any point along the TIN's surface.



Completed Flood Plain Model

To create the illusion of reading the surface of a flood plain to gain elevation data, the TIN is made transparent in order to allow it to be queried by the viewer yet not be distracting.



Community Base Map with Flood Plain

The final step is to add the underlying community parcel base map to the data set. This places the virtual surface of the flood plain in correct position relative to the community, its parcels and buildings. The three dimensional model of the flood plain as shown above is now ready to be displayed and queried by the BFEDM viewer.

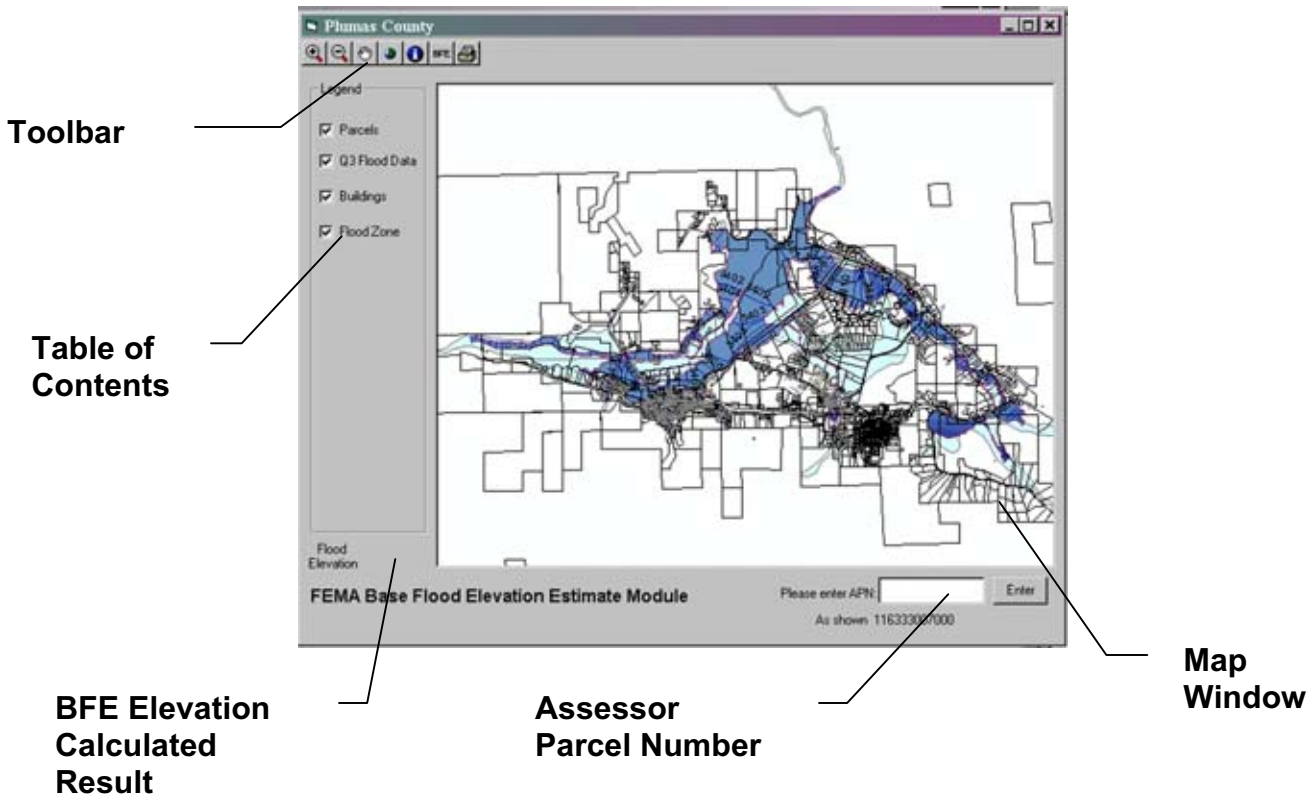
BASE FLOOD ELEVATION DETERMINATION MODULE (BFEDM)

The Base Flood Elevation Determination Module is a Visual Basic application that uses ArcObjects. It requires a current license for Environmental Systems Research Institute ESRI's ArcView or ArcInfo, Version 8.x to be resident on the computer platform from which it is operated. The program reads industry standard ESRI shape files, coverages and AutoDesk CADD drawing files.

The basis for the operation of the BFEDM is the ability to locate a desired parcel within a community. The BFEDM then allows the user to select any point within the boundaries of an identified flood plain and will report the calculated surface elevation of the flood plain at the selected point. This operation uses the functionality of the ArcView or ArcInfo programs to query the surface of a Triangulated Irregular Network (TIN) and calculate the elevation of the TIN's surface. This function is initiated at the moment the user clicks on a point on the surface of the TIN and the elevation is then calculated "on-the-fly". Besides providing flood elevation information, any other information contained within the attribute data tables can be displayed on a point and click basis.

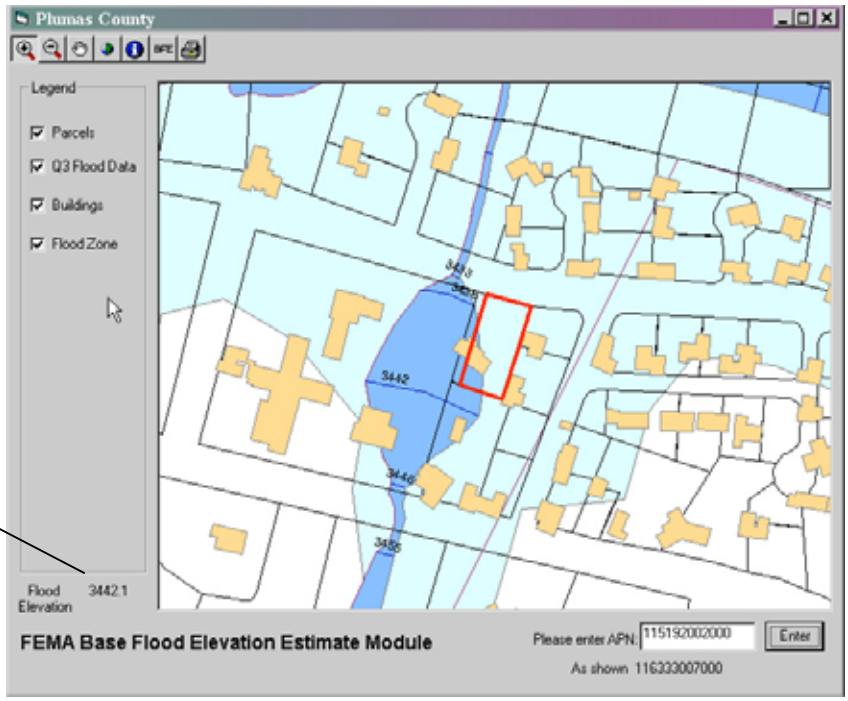
Although the flood plain surface is represented as a virtual surface and can be used to report the flood plain surface at any point, the "highest" flood plain elevation within a building footprint necessitated the use of hard-coding the actual elevation and adding it to the building attribute table. This was accomplished by converting the flood plain TIN model to a raster and then using the Zonal Statistics tools within the Spatial Analyst extension to determine the actual "highest" flood plain elevation within the boundary of all building polygons that intersected the flood plain.

In the BFEDM map window, the TIN is actually transparent and is not visible. It resides just above the flood plain polygon and represents a virtual surface that mimics the actual delineated flood plain surface.



BFEDM - Graphical User Interface

As illustrated in the image above, the BFEDM viewer consists of a map window to display the various map layers such as the parcels, buildings, flood plain boundary and Base Flood Elevation contours. A table of contents located on the left side of the map window allows the user to toggle on or off the layers within the map window. A Toolbar is located at the top of the screen and provides tools for manually navigating around the map window as well as providing tools to query or display map attribute data. An assessor parcel number entry window is located at the bottom right side of the screen to allow for discreet parcel searches and a Base Flood Elevation window is provided on the bottom left side of the screen to report the calculated Base Flood Elevation for any point along the flood plain surface.



Calculated Base Flood Elevation

Selected Parcel with Flood Plain

Once a parcel number is entered and executed, the Map Window pans and zooms to the selected parcel and provides a red highlight to indicate the selected location. In the image above, a flood plain and its associated BFE contours are shown to pass through the desired parcel as well as buildings within the immediate vicinity. In this view, a point and click on the blue flood plain area would return a calculated elevation of the Base Flood Elevation of the flood plain which would appear in the BFE Elevation window. Likewise, a point and click on a building within or intersected by the flood plain would return the highest anticipated flood plain elevation within the boundaries of the building polygon.

The files used by the BFEDM program consist of ESRI shape files, coverages, TINs and AutoDesk CADD drawing files. The files reside in a Geodatabase and include "Layer Files" that specify the appropriate symbology for each layer such as line type, line weight, line color and polygon fill color to be used when displaying the map and provide a standardized look and feel.

SUMMARY

The BFEDM provides a means to extract flood hazard data from digital map sources using Geographic Information Systems technology. It allows a user to easily determine flood plain proximity as well as Base Flood Elevation data without the burden of extensive training or expense. The BFEDM is anticipated to be delivered to communities within SFHA re-study areas to allow greater ease in determining flood plain boundary locations as well as provide additional data contained within FEMA's digital map products.

ACKNOWLEDGEMENTS

The FEMA Base Flood Elevation Determination Module (BFEDM) was produced by the Geographic Information Systems group at Nolte Associates, Inc., under the guidance of Les Sakumoto, Project Officer, Federal Emergency Management Agency, Region IX, and Scott Lyle, Project Manager, Nolte-San Diego.

The BFEDM was devised and written by Nolte Associates, Inc., as part of a FEMA contract with Borcalli & Associates.

Basic data were furnished by FEMA and Plumas County and Del Norte County, California.

The methodology used to extract Base Flood Elevation data from digital flood plain information was developed by Dean Halstead, with support from Les Sakumoto, Charmaine Yeung, Les Clark, Scott Lyle and Jeff Daniel.

Programming for the BFEDM was written and compiled by Charmaine Yeung with support from Joshua Whiting, Gary Smith, Umair Khan and Bradley Waldrop.

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