Flood Map Modernization

Floodplain Boundary Standard Audit Procedures

Version 2.0
October 17, 2007

FEMA

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1. Introduction

One goal of Flood Map Modernization (Map Mod) is to provide reliable and defendable flood hazard maps. To achieve this goal, the Department of Homeland Security's Federal Emergency Management Agency (FEMA) issued Procedure Memorandum No. 38 (PM38) to provide guidance for the implementation of the Floodplain Boundary Standard, which was originally introduced in Section 7 of FEMA's November 2004 *Multi-Year Flood Hazard Implementation Plan* (MHIP).

In general, most standards for a Digital Flood Insurance Rate Map (DFIRM) project are established when the scope of work is set. Examples of this include specifying the source(s) of terrain data, where the field survey will be performed, and the hydrologic and hydraulic (H&H) analysis for the study reach. Different study reaches within the study area may use different procedures to correspond to the appropriate risk class. The only true checks that can be performed after the study is submitted are to verify that the procedures described in the scope of work were followed properly and that the actual end product of the flood boundary matches the best available terrain data.

The reliability of the floodplain boundary delineation is quantified by comparing the computed flood elevation to the ground elevation at the mapped floodplain boundary. The tolerance for how precisely the flood elevation and the ground elevation must match varies based on the flood risk class, which is a function of population, population density, and/or anticipated growth in floodplain areas.

PM38 laid out FEMA's plan for moving forward with implementing the Floodplain Boundary Standard. This document provides an overview of how FEMA will determine compliance with the Floodplain Boundary Standard, explains how to determine risk classes, provides an overview of data compilation needed for audits, describes FEMA FBS Self-Certification and audit procedures (Figure 1), and summarizes the results of pilot application to a flood map project. Additionally because PM38 requires mapping partners to provide FBS Self-Certification:

- within 30 days of the issuance of a study Preliminary, and
- within 30 days of the issuance of a study's Letter of Final Determination (LFD) if the floodplain boundaries have been modified during the post-preliminary processing of that study,

FEMA hopes this document will assist mapping partners in better understanding how they can self-certify their own projects and provide the necessary FBS Self-Certification documentation to satisfy PM38's requirements.

FEMA will rely on the mapping partner provided FBS Self-Certification documentation as the main mechanism for verification and tracking compliance with the Floodplain Boundary Standard, which will be further augmented by National FBS Audits of select projects using the GIS-based method described in Section 6.2 of this document. FEMA also provides engineering and mapping tools for mapping partners to use in the preparation of flood studies and DFIRMs. These tools are provided over the internet through the FEMA Mapping Information Platform (MIP) via the Internet. Mapping partners can use the WISE^{TM} Tool, which contains functionality for automated flood hazard boundary quality assessments, to check the accuracy of their floodplain boundaries. Procedures for using the WISE Tool are provided in Section 6.2 of this document.

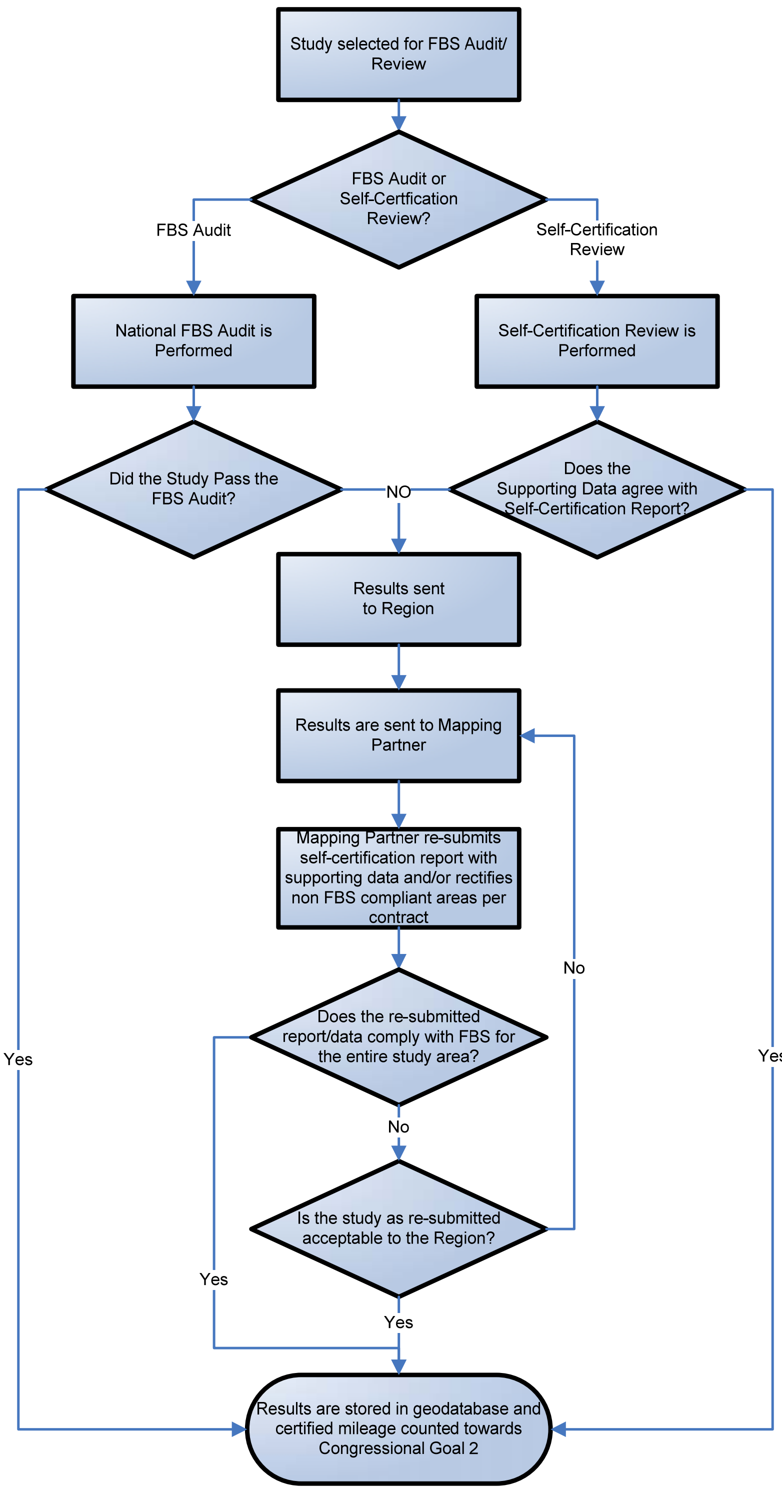

Figure 1. Audit Process

2. Project Selection Process

2.1. FBS Self-Certification Audit and National FBS Audit Eligibility and Selection Criteria

All map projects produced with Map Mod funding are eligible for audit. No projects will be audited while they are in the post-preliminary stage. All studies contracted to meet PM38 will have their FBS Self-Certification documentation appraised to ensure compliance with the self-certification requirements set forth in PM38. Additionally, FEMA Regional staff will be asked to periodically nominate projects that would be representative of each Region's total project inventory based on types of study, and risk class for a National FBS Audit. A sub-set of these nominated studies may than be subjected to a National FBS Audit to further test the overall study quality being produced with respect to the quantitative quality criteria defined in PM38.

2.2. Funding for Audits

Funding for the audit process includes two categories: funding for performing the audits and funding to fix the maps when the maps fail to meet standards.

The NSP will be performing the audits with funding received from HQ for selected projects throughout the entire program duration. However, funding for correcting maps that failed audits will depend on when the contracts for those projects were awarded.

Because FEMA required compliance with the Floodplain Boundary Standard in late 2005 (via PM38), DFIRM projects can be grouped in two categories:

- **Contracted between 2003 and 2005** – These studies may or may not comply with the Floodplain Boundary Standard because the standard and the requirement to comply may not have been in place during this time period.
- **Contracted in 2006 and beyond** – These studies must comply with the Floodplain Boundary Standard.

If DFIRM projects were contracted between 2003 and 2005 and compliance with the Floodplain Boundary Standard was not required in these contracts, it will be the Region's discretion to provide the funding to bring the maps they select in compliance with the standard. For all projects contracted in 2006 and beyond, it is the mapping partner's responsibility to fix maps that do not pass the audits to ensure compliance with the Floodplain Boundary Standard. As previously stated, the mapping partner is required to submit their QA report stating compliance with the standard as not all studies will be audited.

3. Flood Risk Class Determination

The Floodplain Boundary Standard—the tolerance for how precisely the flood elevation and the ground elevation should match—varies based on flood risk. Therefore, flood risk must be determined for each flooding source to identify what Floodplain Boundary Standard must be met and what level of study is required.

In Procedure Memorandum 38, FEMA defined five risk classes and specified floodplain boundary vertical accuracy requirements as shown in Table 2.

Table 2. Floodplain Boundary Standard for Flood Insurance Rate Maps

		Delineation Reliability of the floodplain boundary per study methodology [1]	
Risk Class	**Characteristics**	**Detailed**	**Approximate**
A	High population and densities within the floodplain, and/or high anticipated growth	+/- 1.0 foot/ 95%	+/- 1/2 contour 95%
B	Medium population and densities within the floodplain, and/or modest anticipated growth	+/- 1.0 foot/ 90%	+/- 1/2 contour 90%
C	Low population and densities within the floodplain, small or no anticipated growth	+/- 1.0 foot/ 85%	+/- 1/2 contour 85%
D	Undetermined Risk, likely subject to flooding	NA	NA
E	Minimal risk of flooding; area not studied	NA	NA

[1]The difference between the ground elevation (defined from topographic data) and the computed flood elevation.

In addition to vertical accuracy tolerances defined in Table 2, a horizontal accuracy of +/- 38 feet will be used to determine the compliance with the vertical tolerances defined for each risk class. This horizontal tolerance will address varying floodplain delineation techniques (automated versus non-automated) and map scale limitations.

Because FEMA began requiring compliance with the Floodplain Boundary Standard in FY05, DFIRMs initiated prior to FY05 did not have this requirement in their scopes and, therefore, do not have identified risk classes. The NSP will use the national risk class dataset to determine the proposed risk classes for studies that were contracted prior to FY05. The Region will finalize these classifications and give them back to the NSP to use for the audits.

For mapping projects that began in FY05:

- The mapping partner performing the DFIRM work should determine the initial risk classes for the study flooding sources before mapping begins and present these classifications to the Region
- The Region will finalize these classifications and give them back to the mapping partner to use in adhering to the prescribed risk class Floodplain Boundary Standard tolerances

The methodology below outlines how risk classes can be determined for mapping projects.

3.1. Methodology for Determining Risk Classification

A national Risk Analysis Census Block Group dataset (shapefile) has been compiled that contains the following risk parameters by block group:

- Population
- Population growth
- Housing units
- Flood insurance policies
- Flood insurance claims
- Repetitive loss claims
- Repetitive loss properties annually
- Declared flood disasters

Each individual risk factor for each census block group was determined by taking the parameter value for each census block group and dividing it by the national total of the parameter. Each parameter was then ranked by decile. The parameter deciles were weighted and then added together. This sum was then divided by eight to determine the risk percentage of that census block group for the nation. The census block group risks were sorted in ascending order and given a deciles range, with “0 percent to 10 percent” as the top decile, followed by “10 percent to 20 percent,” etc.

For risk class determination, the assigned risk class must be made at the stream level. The risk of the census block group can be used for guidance; however these must be adjusted based upon the individual needs of the Region, state or local government. For instance, if a stream is in a top decile group, such as 0 percent to 10 percent, then flows into a decile group of 80 percent to 90 percent, and then back out to a 0 percent to 10 percent decile group, the Region may decide to study the entire length of stream by full detailed study methods—which would be Risk Class A.

Various factors can also be used to determine the risk class of an individual reach. These factors include:

- Census block group risk ranking
- Minimum length of classification of any individual flooding source segment
- State and local ordinances or regulations
- Critical facilities that are near the floodplain
- Mobility of the population group within the census block group
- Projected growth of the watershed
- State and local interviews
- Probability of the loss of life
- Probability of the loss of property

For new studies, the method described below can be used to determine preliminary risk classes for use in scoping meetings. Using the shapefile with the Preliminary National Risk Class, the Regional Management Centers can use the geographic information system (GIS) to:

1. Select from this shapefile all the Block Groups that cover the study area
2. Export the selected Block Groups to a new shapefile named X_RiskClassifications (where X = the study name)
3. Make a thematic map of the study boundaries with the corresponding Block Group Risk Classes
4. Review risk classes with the Region and other stakeholders at the scoping meeting
5. Revise risk classes and the shapefile as necessary as a result of scoping meetings
6. Finalize study risk classes in X_RiskClassifications

4. Pre-Audit Data Compilation

Before the flood hazard boundary audit process begins, it is important to have all of the appropriate files readily available in a format that can be used by the WISE-based tool or by an analyst performing a GIS-based audit. The data gathering process is critical to the success of the audit.

4.1. Data Needs

The following data types must be assembled before the flood hazard boundary audit can begin. Depending on the flood zone designations (approximate or detailed), not all of the below material may be available or relevant.

DFIRM Files

- Flood Hazard Boundaries - S_FLD_HAZ_LN and S_FLD_HAZ_AR
- Streamline - S_WTR_LN
- Hydraulic baseline – S_PROFIL_BASIN
- Digital cross-sections – S_XS
- General Structures – S_GEN_STRUCT
- Base map information – one of the below, depending on base map:
  - S_TRANSPORT_LN or
  - Raster images, i.e., DOQQs or aerials

Support Files

- Terrain Data- DEM, TIN, Mass PTS, LIDAR, topographic contours
- FIS profile (with backwater added) and Floodway Data Tables (FWDTs)
- Historical (Pre-Map Modernization) Work Maps
- Modeled and mapped cross sections
- Hydraulic Data

4.1.1. Terrain Data

It is important to obtain the exact terrain data source that was used to create the flood hazard boundary. For new or recent studies, this will be relatively easy, but older detailed studies may not have available digital terrain data or work maps to use in the audit process. For the exact terrain data specifications, please refer to FEMA's *Guidelines and Specifications*.

5. FBS Self-Certification

Reiterating the FBS Self-Certification requirement defined in PM38, all DFIRMs contracted in FY05 and subsequent years must meet the Floodplain Boundary Standard and provide self-certification documentation reflecting the DFIRM's adherence to the standard. To satisfy the Self-Certification requirement, DFIRMs will be deemed in compliance with the Floodplain Boundary Standard provided:

- A signed statement from the mapping partner (including a completed report as described in Attachment B) stating delivered flood map products are in compliance (i.e. self-certification) are uploaded to the MIP.

The self-certification supporting information can be generated by either following the guidance provided in this document or developing processes that provide the necessary documentation to quantifiably demonstrate that the requirements specified in Table 1 of PM38 have been satisfied.

Mapping partners shall provide the following information to satisfy the self-certification reports:

- Self-Certification review type (GIS or WISE)
- Description of materials used to perform the audit
- Mapping partner performing the audit
- Self-Certification date
- Date submitted to Region
- Names of stream reaches audited
- Total stream length audited
- Number of floodplain boundary points audited
- Number of floodplain boundary points passed
- Number of floodplain boundary points failed
- Shapefile of points tested including exceptions
- Pass/Fail percentages for study FBS risk classes
- 100k NHD Subbasin Pass/Fail shapefile if reporting results below study level pass
- Stream name and length that passed audit

If the entire study cannot meet the Floodplain Boundary Standard, self-certification documentation, which is a required deliverable for every project, must be submitted on a NHD 100k sub-basin level. The NHD 100k sub-basin file can be obtained from your Regional Management Center. The audit procedures in Section 6 describe how to calculate the sub-basin pass rates.

6. Audit Procedures

This section describes procedures for evaluating the reliability of a study's floodplain boundaries in flood insurance rate maps (FIRMs). There are two types of audits that will be performed:

1. A FBS-Self Certification Audit (FEMAs primary audit type), and
2. The National FBS Audit.

The FBS Self-Certification Audit will entail a review of the FBS Self-Certification report and supporting data that has been uploaded to the MIP to ensure there is the necessary information to quantifiably demonstrate that the requirements specified in Table 1 of PM38 have been satisfied.

The National FBS Audits will be based on the GIS based procedures defined below (6.2), and will be performed on a small number of Regionally nominated studies to further test the overall study quality being produced with respect to the quantitative quality criteria defined in PM38.

6.1. Methodology for DFIRM Conversions

The DFIRM Conversion study type is only appropriate if neither better or equivalent quality topographic data nor the original work maps are available and there is documentation that indicates that redelineation of the floodplain boundary onto available topographic data would degrade the quality of the delineation. In the cases where digital conversion is appropriate, only a FBS Self-Certification audit will be performed.

6.2. GIS-Based Audit Methodology

The GIS-based approach described below is based on the utilization of a GIS system. The terms used in outlining the methodology are based on ESRI's ArcGIS system. This approach can be used with various vendor-specific GIS systems, but the terminology and exact processing steps may differ. A methodology for testing Zone A floodplain boundaries is described in Section 6.1.2. Below are the major processing steps for performing the GIS-based audit:

- Prepare Audit and Terrain Data with GIS technology
- Create additional audit features
- Select streams for audit
- Create stream specific audit features
- Perform audit on streams
- Roll-up stream specific audit features into the Study specific audit features
- Validate results for compliance with the FBS risk class tolerances
- Compile Audit Report
- Submit Audit Report to the Region

6.2.1. Procedures for Auditing Floodplain Boundaries Determined by Detailed Study Methods

The procedures outlined in this section are intended to audit floodplain boundaries in Zones AE, AH, AO, and VE. The major processing steps are as follows:

1. Ensure that you have all digital and non-digital data, including the final X_RiskClassifications shapefile, defined in Section 3.1.
2. Start a new GIS project.
3. Load all applicable digital data into the GIS project
4. Build a study level TIN = TIN_STUDY using the digital terrain information. (perform this step only if the mapping partner does not provide a study level TIN)
   - If the study terrain data is non-digital, the terrain maps will have to be scanned and georeferenced so that ground elevations can be assigned to the points by hand.
5. Extract the detailed 1-percent-annual-chance flood lines and export them to a new shapefile/feature class = DETAILED_FLD_HAZ_LN_STUDYX (example: DETAILED_FLD_HAZ_LN_Henrico) and add the new file to the GIS project.
6. Using the DETAILED_FLD_HAZ_LN_STUDYX file, create a new point shapefile/feature class = TEST_PTS_STUDYX, which has points that are evenly spaced along the DETAILED_FLD_HAZ_LN (every 100ft) and add the TEST_PTS_STUDYX to the GIS project.
7. Add the following fields to the TEST_PTS_STUDYX attribute table.
   – FldELEV – type = numeric, 6, 2
   – GrELEV – type = numeric, 6, 2
   – ElevDIFF – type = numeric, 6, 2
   – RiskClass – type = string, length = 2
   – Status – type = string, length = 2
   – Validation – type = string, length = 20
   – Comment – type = string, length = 100
8. Zoom into a randomly selected detailed stream.
9. Select the S_XS and TEST_PTS_*STUDYX* for that stream, and export the selected S_XS and TEST_PTS_ *STUDYX* to new shapefiles/feature classes = S_XS_*STREAM* and TEST_PTS _*STREAM*, (example: TEST_PTS _GooseCk) and add them to the GIS project.
10. Review the TEST_PTS _*STREAM* and note any points that fall at or between general structures as exceptions = GS_Except in the validation column.
11. Review the TEST_PTS _*STREAM* for points that fall in backwater areas and assign them elevations based on their associated profile in the FldELEV attribute field.
12. Build a TIN = TIN_*STREAM* using the S_XS_*STREAM* file using the elevations stored in the WSEL_REG field, for coastal zones use the S_CST_TSCT_LN to build the TIN_*STREAM* TIN for coastal areas.

13. Intersect the TEST_PTS_*STREAM* with the TIN_*STREAM* to get the interpolated S_XS elevations onto the TEST_PTS_*STREAM* FldELEV attribute field.
14. Continue processes until all detailed streams are tested, ensuring that you save a TEST_PTS_*STREAM* and TIN_*STREAM* file for every stream tested.
15. Merge all your TEST_PTS_*STREAM* files into one AUDIT_*STUDYX*_PTS shapefile/feature class.
16. Intersect AUDIT_*STUDYX*_PTS with the TIN_*STUDY* to transfer the interpolated terrain elevations onto the AUDIT_*STUDYX*_PTS GrdELEV attribute field.
    - If terrain was not available in digital format, terrain elevations will have to be assigned by hand from the georeferenced terrain maps.
17. Determine if the AUDIT_*STUDYX*_PTS passes the equal to or higher then the 95 percent pass percentage at the +/- 1.0 ft threshold, if so then the study passes and no more analysis needs to be done and skip to step 26.
18. If the AUDIT_*STUDYX*_PTS fails the equal to, or higher then the 95 percent pass percentage at the +/- 1.0 ft threshold, then intersect the AUDIT_*STUDYX*_PTS with the X_RiskClassifications shapefile to transfer the Risk Classes onto the AUDIT_*STUDYX*_PTS.
19. Determine the status of each point based on tolerances of the risk class it belongs and calculate into the Status field the attribute Pass = “P” and Fail = “F”.
20. Select out the individual Risk Classes to their own AUDIT_*STUDYX*_PTS_*RskClass* shapefile/feature.
21. Now determine if the AUDIT_*STUDYX*_PTS passes the equal to or higher then pass rate for each audit study’s risk classes, if so then the study passes and no more analysis needs to be done and skip to step 26.
22. If the AUDIT_*STUDYX*_PTS fails the to equal to or higher then pass rate for each audit study’s risk classes then intersect the AUDIT_*STUDYX*_PTS with the NHD 100k subbasin shapefile
23. Add new filed attribute to the AUDIT_*STUDYX*_PTS file.
    - Subbassin – type = string, length = 50.
24. Calculate the Subbassin field in the AUDIT_*STUDYX*_PTS file with the intersected NHD 100k subbasin shapefile.
25. Now determine the AUDIT_*STUDYX*_PTS pass rate for each audit study’s risk classes at the subbasin level.
26. Record/Report Results in FBS Self-Certification Report/Audit
27. Submit FBS Self-Certification Report/Audit Audit Report along with the audit spatial files to the MIP.

See ***Attachment A*** for platform specific approach to performing this type of audit.

6.2.2. GIS-based Methodology for Checking Zone A Floodplain Boundaries

Since the Zone A floodplain boundaries are not associated with a given BFE on the DFIRM, a more general approach must be taken to audit the flood boundaries. The following is the proposed approach:

Ensure that you have all digital and non-digital data, including the final X_RiskClassifications shapefile, defined in Section 3.1.

7. Start a new GIS project.
8. Load all applicable digital data into the GIS Project.
9. Build a study level TIN = TIN_STUDY using the digital terrain information. If the study terrain data is non-digital, the terrain maps will have to be scanned and georeferenced so that ground elevations can be assigned to the points by hand.
10. Extract the approximate 1-percent annual flood lines and export them to a new shapefile/feature class = APPROX_FLD_HAZ_LN_STUDYX and add the new file to the GIS project.
11. Extract the approximate 1-percent annual flood polygons and export them to a new shapefile/feature class = APPROX_FLD_HAZ_PLY_STUDYX and add the new file to the GIS project.
12. Clip the S_WTR_LN with the APPROX_FLD_HAZ_PLY_STUDYX polygon feature to create a new APPROX_WTR_LN shapefile/feature class.
13. Note: If there is no S_WTR_LN in the ZONE A areas, one will have to be created manually using the base map information before the clipping can occur
14. Using the APPROX_WTR_LN file, create a new point shapefile/feature class = A_WTR_PTS_STUDYX, which has points that are evenly spaced along the APPROX_WTR_LN (every 500ft) and add the TEST_PTS_STUDYX to the GIS project.
15. Create a new line shapefile/feature class, audit cross-section lines (A_XS_STUDYX), by drawing audit cross sections perpendicular to APPROX_WTR_LN at the A_WTR_PTS_STUDYX.
16. Assign every A_XS_STUDYX a unique ID.
17. Intersect the A_XS_*STUDYX*s with the APPROX_FLD_HAZ_LN_*STUDYX* and use the intersection points of the two to create a new point shapefile/feature class AUDIT_*STUDYX*_PTS being sure to transfer the A_XS_*STUDYX*s unique IDs to the AUDIT_*STUDYX*_PTS.
18. Add the following fields to the TEST_PTS_STUDYX attribute table.
    - GrELEV1 – type = numeric, 6, 2
    - GrELEV2 – type = numeric, 6, 2
    - ElevDIFF – type = numeric, 6, 2
    - RiskClass – type = string, length = 2
    - Status – type = string, length = 2
    - Validation – type = string, length = 20

– Comment – type = string, length = 100

19. Intersect AUDIT_*STUDYX*_PTS with the TIN_*STUDY* to transfer the interpolated terrain elevations onto the AUDIT_*STUDYX*_PTS GrdELEV attribute field.
20. Note- If terrain was not available in digital format, terrain elevations will have to be assigned by hand from the georeferenced terrain maps
21. Break the resulting AUDIT_STUDYX_PTS into two new shapefile/feature class by doing a unique selection on the attribute XS_ID field and export the first selection to AUDIT_STUDYX_PTS1, reverse the selection and export the second selection to AUDIT_STUDYX_PTS2.
22. Do a table join of AUDIT_STUDYX_PTS2 to AUDIT_STUDYX_PTS1.
23. Calculate the ElevDIFF of AUDIT_STUDYX_PTS1 by subtracting GrELEV1 from GrELEV2.
24. Determine if the AUDIT_*STUDYX*_PTS1 passes the equal to or higher than the 95-percent pass percentage at the +/- ½ contour threshold; if so, then the study passes and no more analysis is necessary, skip to step 27.
25. If the AUDIT_*STUDYX*_PTS1 fails the equal to or higher than the 95-percent pass percentage at the +/- ½ contour threshold, then intersect the AUDIT_*STUDYX*_PTS1 with the X_RiskClassifications shapefile to transfer the Risk Classes onto the AUDIT_*STUDYX*_PTS1.
26. Determine the status of each point based on tolerances of its risk class and calculate into the Status field the attribute Pass = “P” and Fail = “F”
27. Select out the individual Risk Classes to their own AUDIT_*STUDYX*_PTS1_*RskClass* shapefile/feature.
28. Determine the pass rate for each audit study’s risk class, if the study now passes at the Risk Class level, no more analysis is necessary, skip to step 27.
29. If the AUDIT_*STUDYX*_PTS fails the to equal to or higher then pass rate for each audit study’s risk classes then intersect the AUDIT_*STUDYX*_PTS with the NHD 100k subbasin shapefile.
30. Add new filed attribute to the AUDIT_*STUDYX*_PTS file.

    – Subbasin – type = string, length = 50

31. Calculate the Subbassin field in the AUDIT_*STUDYX*_PTS file with the intersected NHD 100k subbasin shapefile.
32. Now determine the AUDIT_*STUDYX*_PTS pass rate for each audit study’s risk classes at the subbasin level.
33. Record/Report Results in FBS Self-Certification Report/Audit
34. Submit FBS Self-Certification Report/Audit Audit Report along with the audit spatial files to the MIP.

6.3. WISE-Based Audit Methodology

Figure 13 outlines the methodology to perform the audit using the WISE™ Tool available via the MIP.

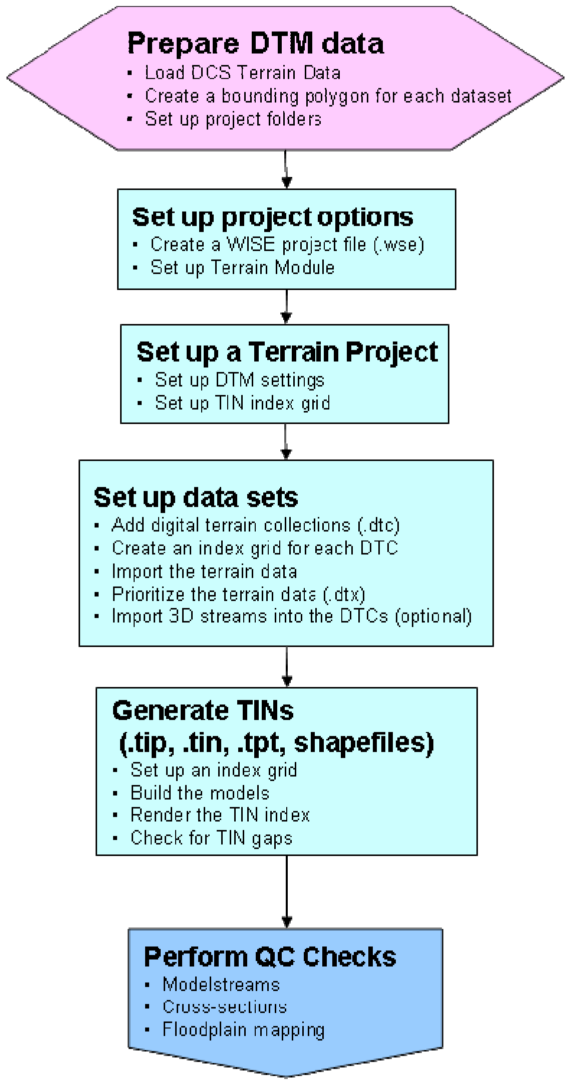

Figure 13. Audit Workflow Using WISE™

6.3.1. Submittal of Data to the MIP for WISE-based Flood Hazard Boundary Audits

If the MIP Tools were used in the preparation of terrain, hydrologic, and hydraulic data, no additional preparation is required to begin the audit procedure. To use the WISE-based procedures, Data Capture Standards (DCS)-compliant terrain data and *Guidelines and Specifications* Appendix L flood hazard boundary files (see Section 3.1 for details) need to be submitted to the MIP Data Depot before the WISE Tool can be used. If the MIP Tools were not used in the preparation of study data, the mapping partner is required to ensure that all submittals meet the specifications in Appendix L (for DFIRM data) and Appendix N (for terrain data) of the *Guidelines and Specifications*. Furthermore, the WISE-based procedures require DCS compliant files in specific formats. The exact specification for the DCS-compliant files can be found in the DCS described in Appendix N of the *Guidelines and Specifications*.

To load data onto the MIP to use the WISE tool, the data needs to be submitted on a CD or DVD to the following address:

DFIRM Data Depot
Attn: MIP Help
3601 Eisenhower Avenue
Suite 130
Alexandria, VA 22304-6425

To ensure prompt processing of the data, the following is required:

Structure the data in a logical fashion, following the data submission standards for DFIRM data outlined in Appendices L and N of the *Guidelines and Specifications*.

Include a Readme.txt file and contact information. Failure to follow the requirements outlined above may result in processing delays. If there are any questions, contact the FEMA Map Assistance Center at (877) FEMA MAP.

6.3.2. Conducting a WISE-based Audit

The WISE-based audit process may begin only if the data resides on the MIP, and is in the correct format. Users performing the audit must be trained in the use of the WISE™ Tool Terrain module, and Hydraulics modules. Users also must have a valid user account on the MIP to be able to access the tools. Both user accounts and training requests are available by contacting miphelp@mapmodteam.com or by contacting the corresponding FEMA RMC for your study.

The flood hazard boundary audits in WISE™:

- Compare the Appendix L flood boundary with cross-section elevations and TINs.
- Returns vertices along the flood hazard line to show the elevation differences between the modeled vs. mapped boundaries.
- Displays error results in a point shapefile table that can be used for further analysis.

The function compares the elevation from a WISE™ Digital Terrain Model (TIN files) and produces an error point for any discrepancy greater than the specified tolerance. The default tolerance is 2 feet, but this value should be set to 1.0 feet so that the resulting shapefile can be analyzed for all Risk Classes. Results are shown in the number of vertices tested and the pass/fail percentage and failed vertices are exported out to a user specified shapefile. This function may take several hours to run but can be canceled once it has started. Once completed, the Mapping Results window will present the results of the comparison of cross-section elevations to terrain source elevations (Figure 14).

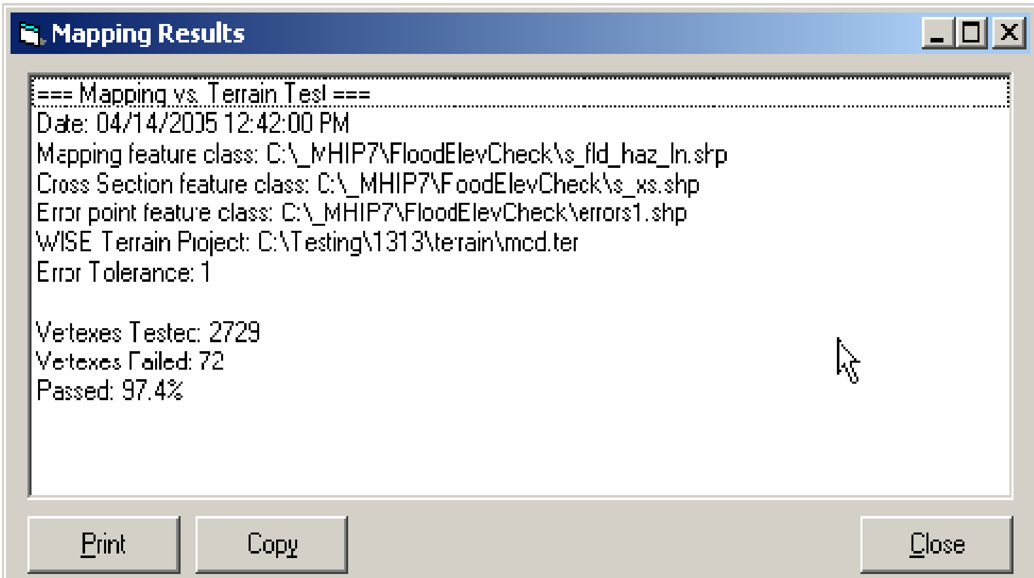

Figure 14. Mapping Results Window –
Comparison of Cross-section Elevation to Terrain Source Elevation

If the audit score is equal to or higher than the 95-percent pass percentage at the +/- 1.0-foot threshold, then the study passes and no more analysis is necessary. Otherwise:

1. Load the resulting error point shapefile into a GIS application along with the X_RiskClassifications shapefile,
2. Join the two shapefiles spatially, so that the Risk Classes are assigned to every point
3. Rescore the test results using the tolerances of the joined Risk Classes
4. If the study passes using the joined Risk Class tolerances, no more analysis is necessary
5. If the study still fails, create a new shapefile of all out points that fall outside their Risk Class tolerance and submit the shapefile to the responsible mapping partner for validation and exceptions.

6.3.3. MIP WISE-based Audit Example

The following outlines the major steps to perform the WISE-based audit using the MIP.

6.3.3.1 Prepare DTM Data

After submittal of DCS data to the MIP, the first step in the Non-WISE™ user audit workflow is preparing your DTM (terrain) data. All necessary files must be loaded to the proper folder structure (Figure 15) on the MIP and bounding polygons must be created.

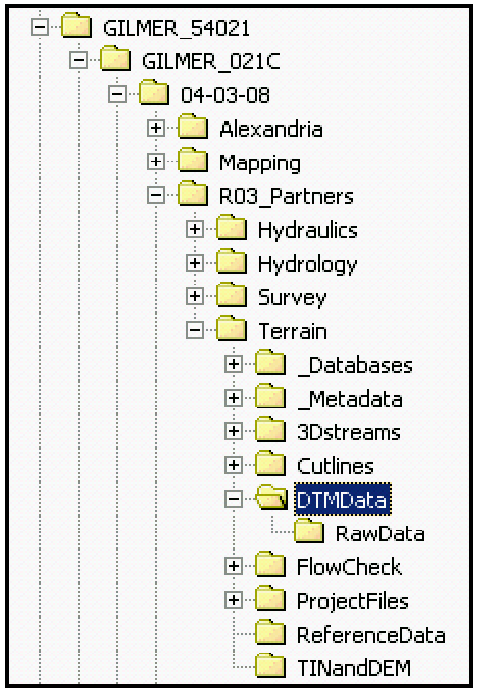

Figure 15. Example of MIP Terrain Module Folder Structure

To produce accurate models; the user must prepare terrain data before the data set is added to the project. In addition to these steps, overlaps must be eliminated in the WISE™ digital terrain collection (DTC) data. The following steps are required:

1. Obtain data for all major streams within the study boundary. Failure to cover the entire study area will cause procedures to fail.
2. Determine the accuracy of each data set to place a higher priority on more accurate data when you build the model. The density of data will determine the grid size for analysis.
3. Create a bounding polygon shapefile for each data set or collection of data sets. The bounding polygon can be irregular or have several parts, but only one shape per shapefile is allowed. The bounding polygon should include all of the drainage area but exclude areas with no data, as far as possible. If the polygon includes area with no data, good data may be overwritten in the prioritization process.

The bounding polygon can be refined after importing the data into the Terrain Project, but must be completed prior to building TINs and DEMs.

When the study covers a very large area and/or the data is dense, processing time may be improved by breaking the area into sub-areas. Create a shapefile with a bounding polygon for each sub-area. Import the data set into a DTC for each sub-area and WISE™ will use only the data that falls within each bounding polygon.

Step-by-step procedures for preparing DTM data can be found on pages 1 and 2 of the January 2005 *Using the WISETM Terrain Module, A User Guide for the Watershed Information System* manual.

6.3.3.2 Set Up Project Options

The first step is to set up the project within WISE™. Figure 16 is a screen shot showing the creation of a project and Figure 17 shows setting the project options.

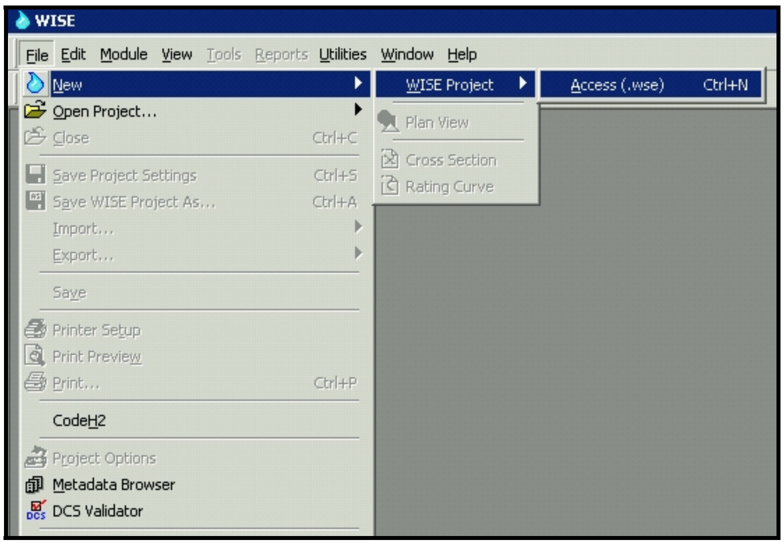

Figure 16. Creating a New WISE™ Project

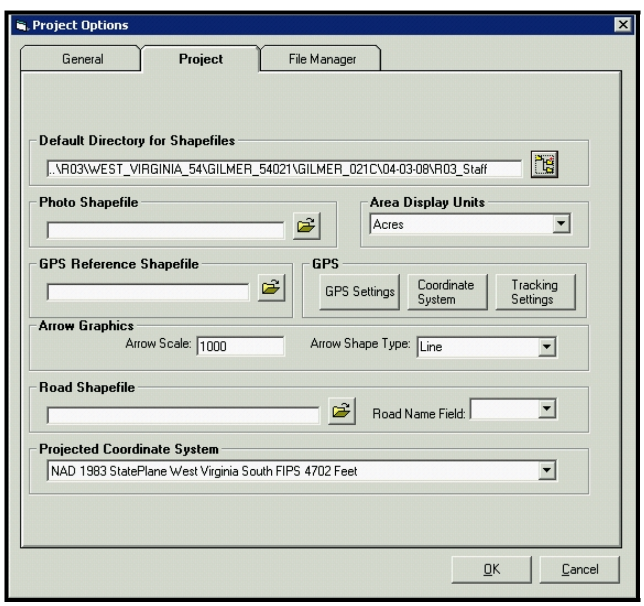

Figure 17. Setting WISE™ Project Options

Step-by-step procedures for creating a WISE™ project can be found on pages 3 and 4 of the January 2005 *Using the WISE™ Terrain Module, A User Guide for the Watershed Information System* manual.

6.3.3.3 Set Up a Terrain Project

The next step is to set up a terrain project within WISE™. Figure 18 is a screen shot showing the project options.

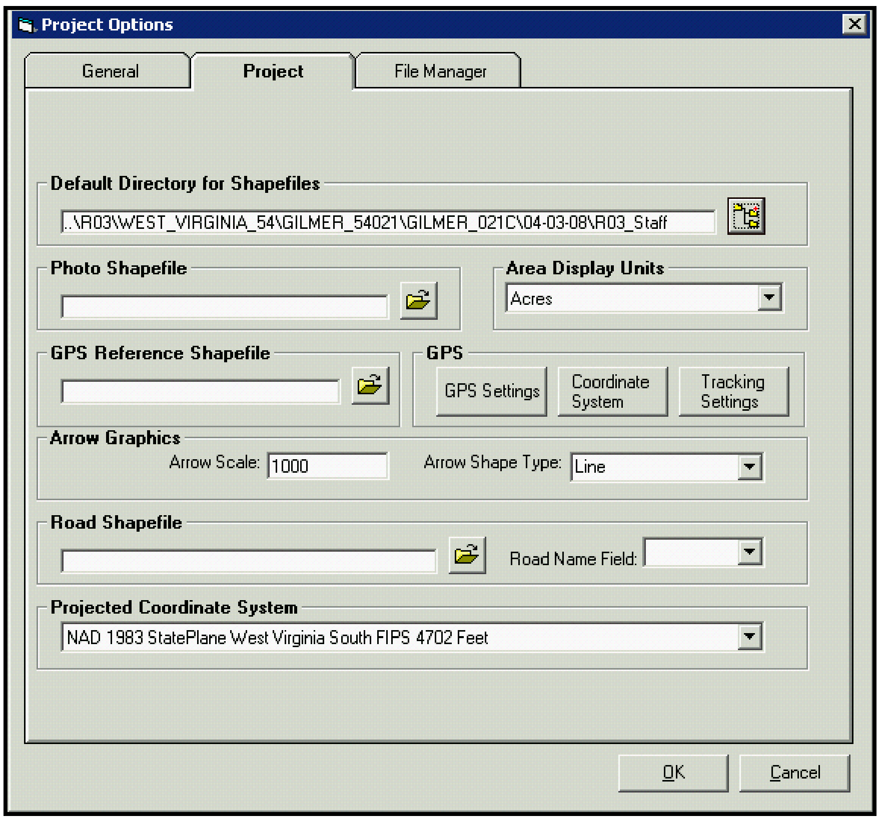

Figure 18. WISE™ Terrain Project Settings Dialog Box

Step-by-step procedures can be found on pages 9 through 16 of the January 2005 *Using the WISE™ Terrain Module, A User Guide for the Watershed Information System* manual.

6.3.3.4 Set Up Data Sets

Step-by-step procedures can be found on pages 17 through 22 of the January 2005 *Using the WISE™ Terrain Module, A User Guide for the Watershed Information System* manual.

6.3.3.5 Generate TINs

Step-by-step procedures can be found on pages 27 through 34 of the January 2005 *Using the WISE™ Terrain Module, A User Guide for the Watershed Information System* manual.

6.3.3.6 *Import DCS-compliant hydraulic projects into WISE™*

WISE™ can import a hydraulics project that was prepared with other software if it complies with the DCS. To minimize import errors, run the DCS Validaton tool on the WISE™ hydraulics project before attempting to import it into WISE™. See WISE User Manual regarding how to use the DCS Validaton tool.

Instructions for importing a DCS-compliant hydraulics project are outlined on page 75 of the *Watershed Concepts Hydraulics Module User Guide*, Version 2.09. Check the Watershed Concepts website (www.watershedconcepts.com) periodically for updates to the software and user manuals. DCS-compliant files are required by FEMA for all submittals.

6.4. Audit Challenges

Areas around hydraulic structures and the downstream ends of tributaries cause unique challenges for the audit process, and therefore will require special handling to ensure false results are not reported. The below challenges impacting failed points will be screened by the NSP and flagged as potential exceptions and be made available to the Regions for review. The impact of these failed points will be reported to the Region to help determine the compliance with the standard.

6.4.1. Hydraulic Structures

At many bridges and culverts, the hydraulic structures are not overtopped. If the floodplains are mapped solely on elevation, this would result in floodplains that stop just downstream of roads and then resume upstream of the roads. Instead, the floodplain is usually mapped to the width of the floodway through the structure, or just wider than the floodway. Therefore, these points should not be considered in establishing the pass/fail percentage rate for a study audit and marked as exceptions in the audit report.

6.4.2. Tributaries and Backwater Areas

Another problem area may exist at the downstream ends of tributaries that have been studied by detailed or approximate methods. In some cases, the boundaries downstream of the first cross-section on the tributary are in a transition area where a linear relationship does not govern the mapping of the floodplain boundaries. Test points falling in these areas will require assignment of study elevations using a combination of the cross-sections data and profile information.

Attachment A – Example - Procedures for Auditing Floodplain Boundaries Determined by Detailed Study Methods

The following example is for Henrico County, Virginia. The Henrico DFIRM is a vector-based DFIRM that was sent out preliminary in 2005 before the Floodplain Boundary Standards had gone into effect. The terrain used to delineate Henrico's floodplain boundaries were 2-foot contours developed by the County in 2002. The methodology and procedures demonstrated in this example are based on ESRI's ArcGIS 9.0 with ESRI's 3D Analyst. While major processing steps are shown, the user is expected to be proficient with the ArcGIS and 3D Analyst and familiar with their use and functionality.

A. Set up the GIS Project with all relevant data sets

Load all the data into a new ArcMap document; for Henrico (Figure A1) the initial data sets used are:

- S_FLD_HAZ_LN
- S_FLD_HAZ_AR
- S_WTR_LN
- S_XS
- S_GEN_STRUCT
- S_TRANSPORT_LN
- 2002 two-foot county contours
- HenricoCo_RiskClassifications

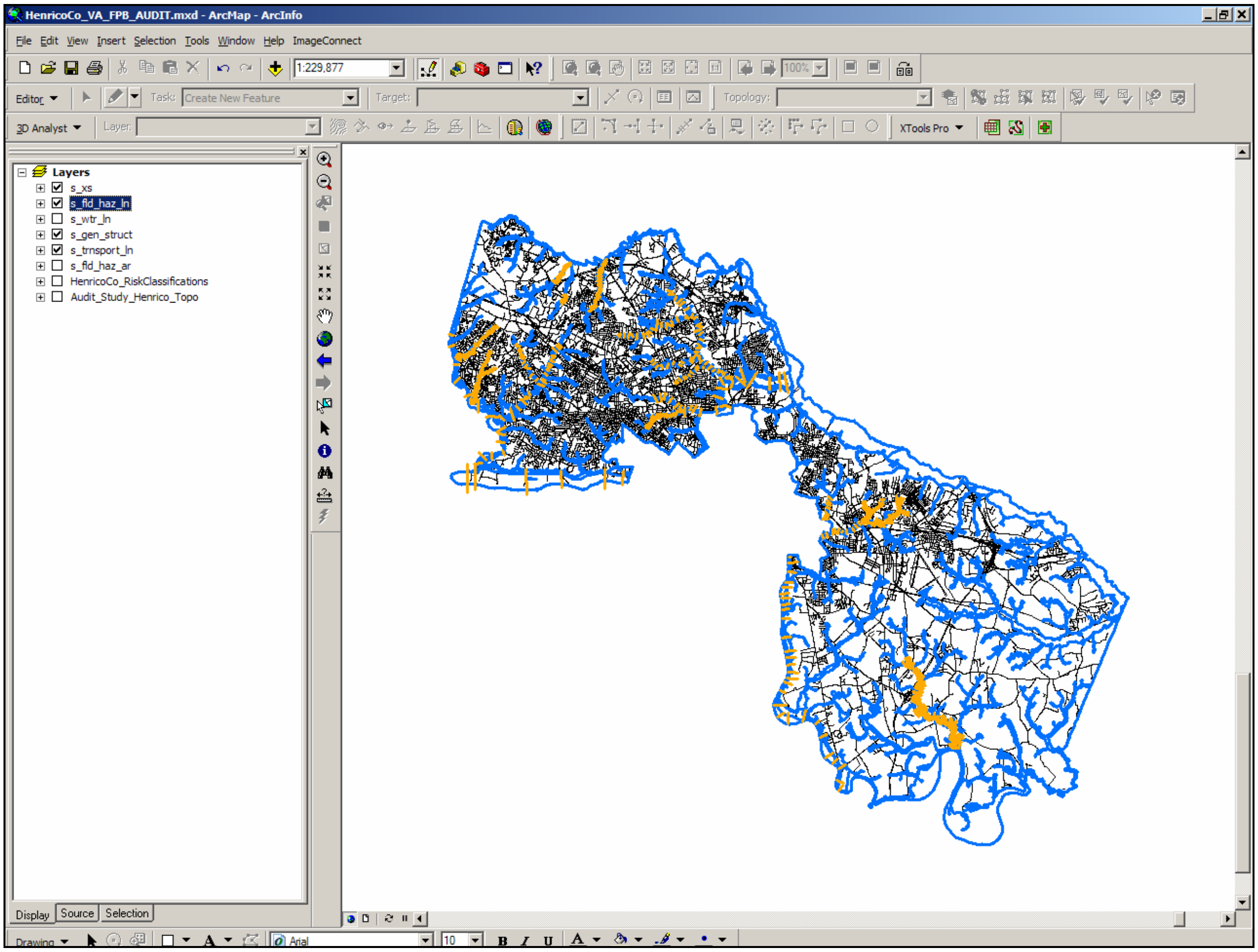

Figure A1. ArcMap file with Necessary Layers

B. Create Audit Data Sets

- Build the TIN_HENRICO (Figure A2) with the Henrico two-foot contours
- Extract the detailed 1 percent-annual-chance flood polygons and export them to a new shapefile/feature class = DETAILED_FLD_HAZ_PLY_HENRICO and add the new file to the GIS project.

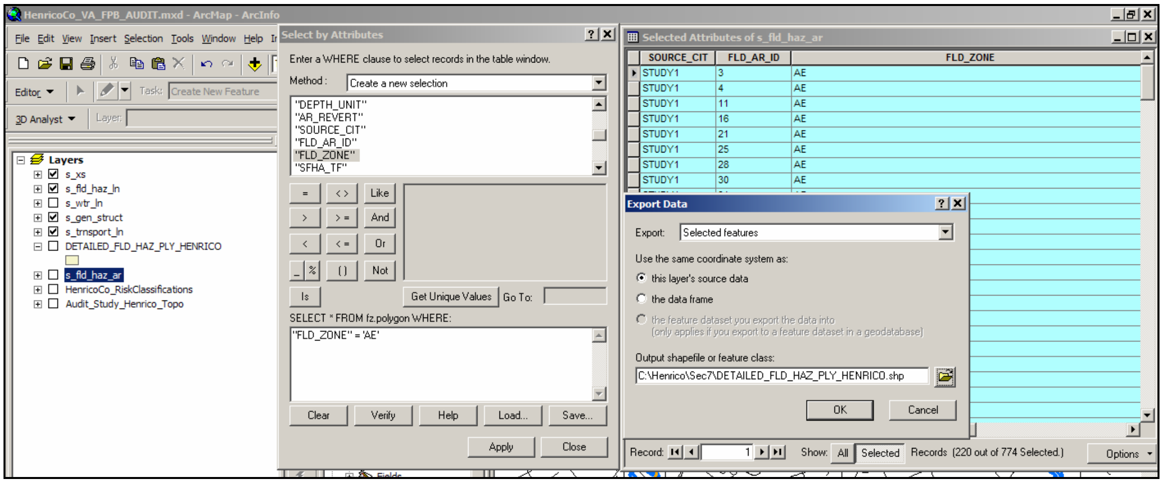

Figure A2. Extracting the 1-percent Flood Boundaries

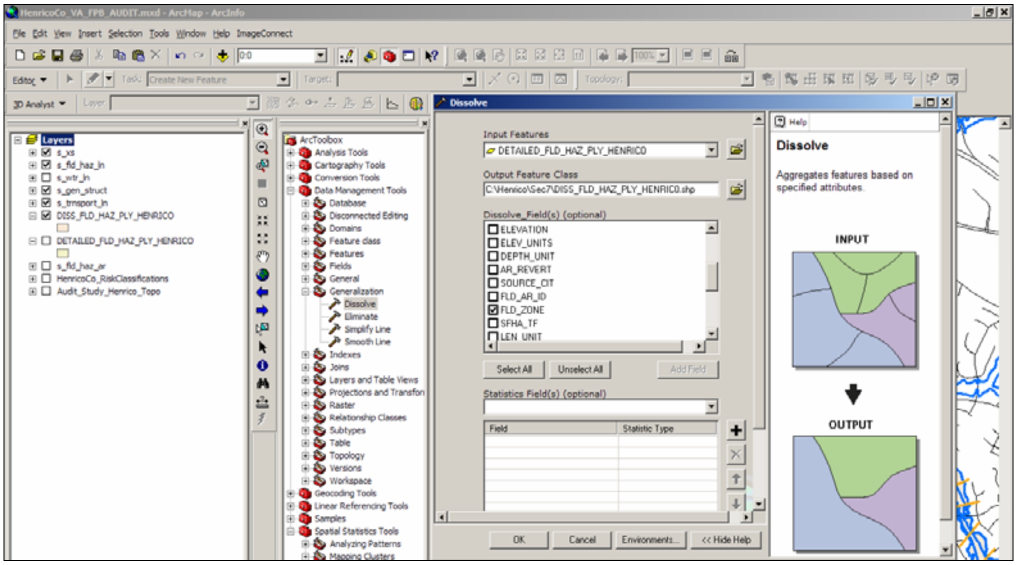

Figure A3: Dissolving the 1-percent Flood Hazard Polygons

- Dissolve the DETAILED_FLD_HAZ_PLY_HENRICO polygons (Figure A3) on the FLD_ZONE attribute to a new shapefile/feature class DISS_FLD_HAZ_PLY_HENRICO
- Convert the DISS_FLD_HAZ_PLY_HENRICO to DETAILED_FLD_HAZ_LN_HENRICO (Figure A4) (XTOOLS can be downloaded for free from http://www.xtoolspro.com; all the functionality needed is available under the free version.)

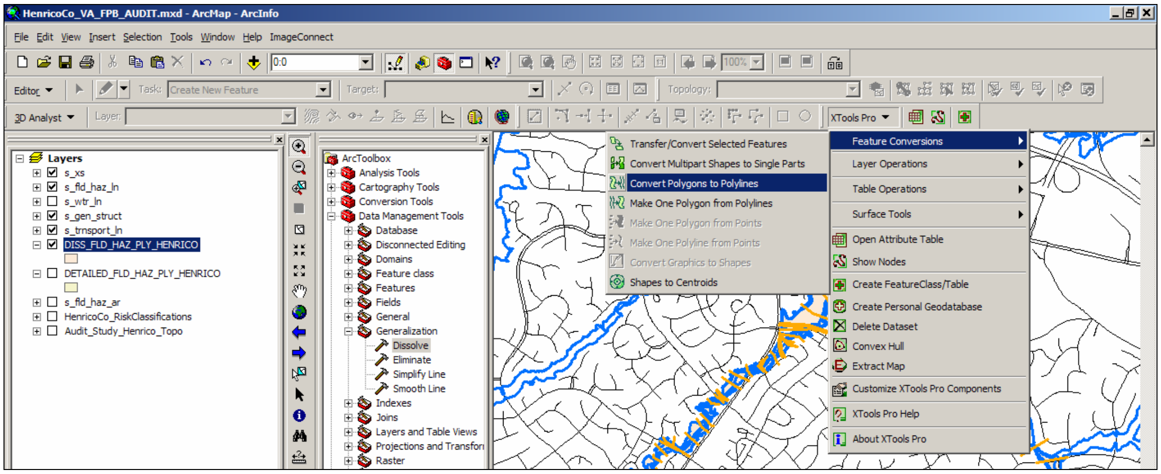

Figure A4. Converting Polygons

- Using the DETAILED_FLD_HAZ_LN_STUDYX file, create (Figure A5) a new point shapefile/feature class = TEST_PTS_STUDYX, that has points that are evenly spaced along the DETAILED_FLD_HAZ_LN (every 100ft) and add the TEST_PTS_STUDYX to the GIS project (You can download a free script to do this from ESRIs website http://arcscripts.esri.com/details.asp?dbid=11406).

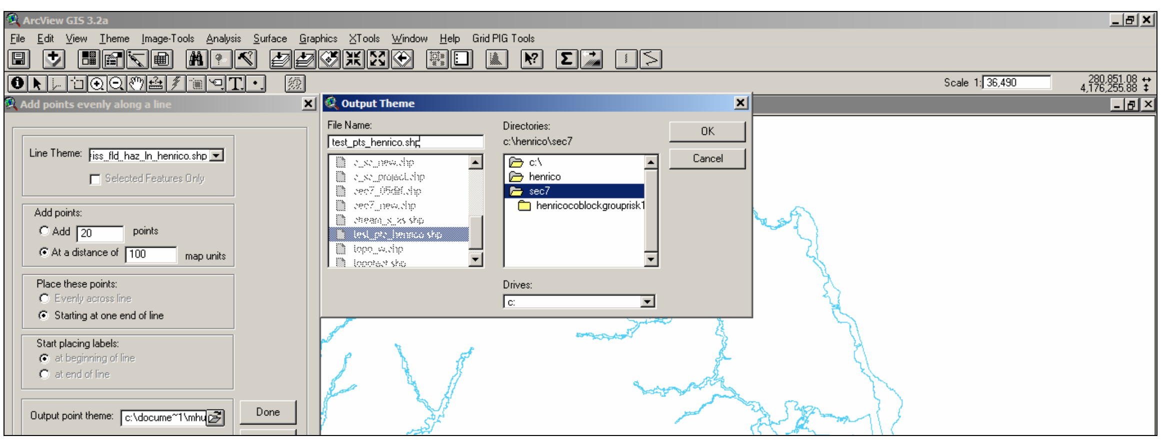

Figure A5. Create New Shape File

- Add the following fields to the TEST_PTS_HENRICO attribute table (you can accomplish this in ArcMap or ArcCatalog).
  - FldELEV – type = numeric, 6, 2

- GrELEV – type = numeric, 6, 2
- ElevDIFF – type = numeric, 6, 2
- RiskClass – type = string, length = 2
- Status – type = string, length = 2
- Validation – type = string, length = 20
- Comment – type = string, length = 100

- Zoom in to a randomly selected detailed stream (Figure A6) and select the S_XS and TEST_PTS_STUDYX for that stream, and export the selected S_XS and TEST_PTS_STUDYX to new shapefiles/feature classes = S_XS_STREAM and TEST_PTS _STREAM, and add them to the GIS project.

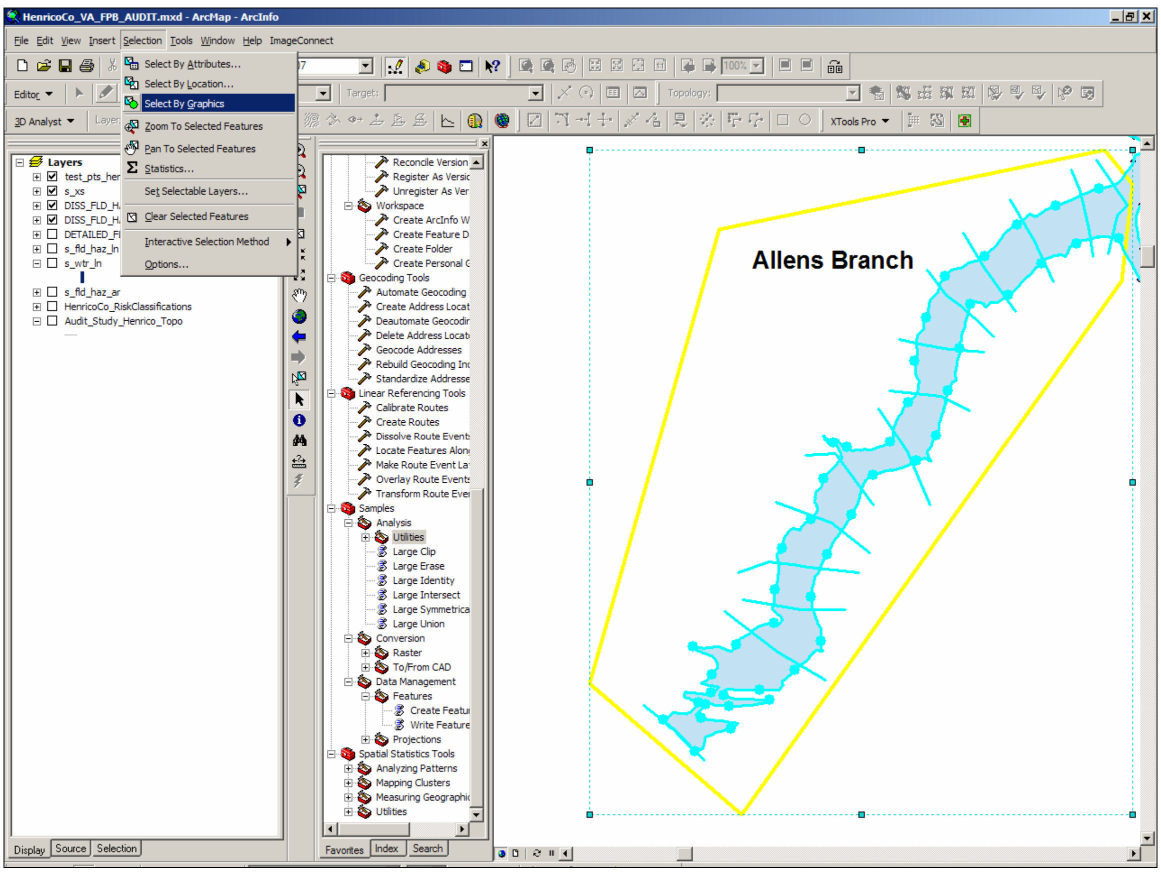

Figure A6. Detailed Stream Selected to Audit

- Review the TEST_PTS _*STREAM* and note any points that fall at or between general structures as exceptions = HYDRO_STRUCT (Figure A7) exception in the validation column.

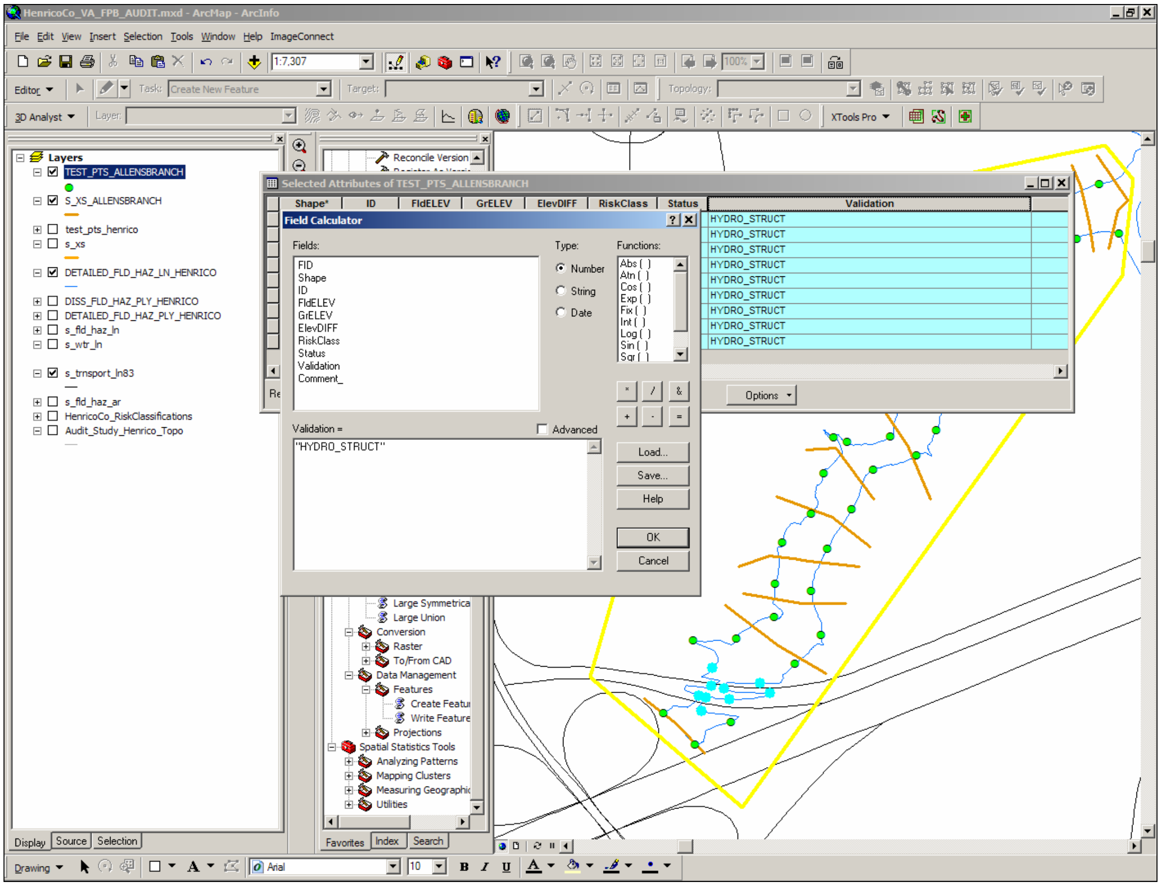

Figure A7. Identifying Exceptions

- Build a TIN = TIN_*STREAM* using the S_XS_*ALLENSBRANCH* file (Figure A8) using the elevations stored in the WSEL_REG field.

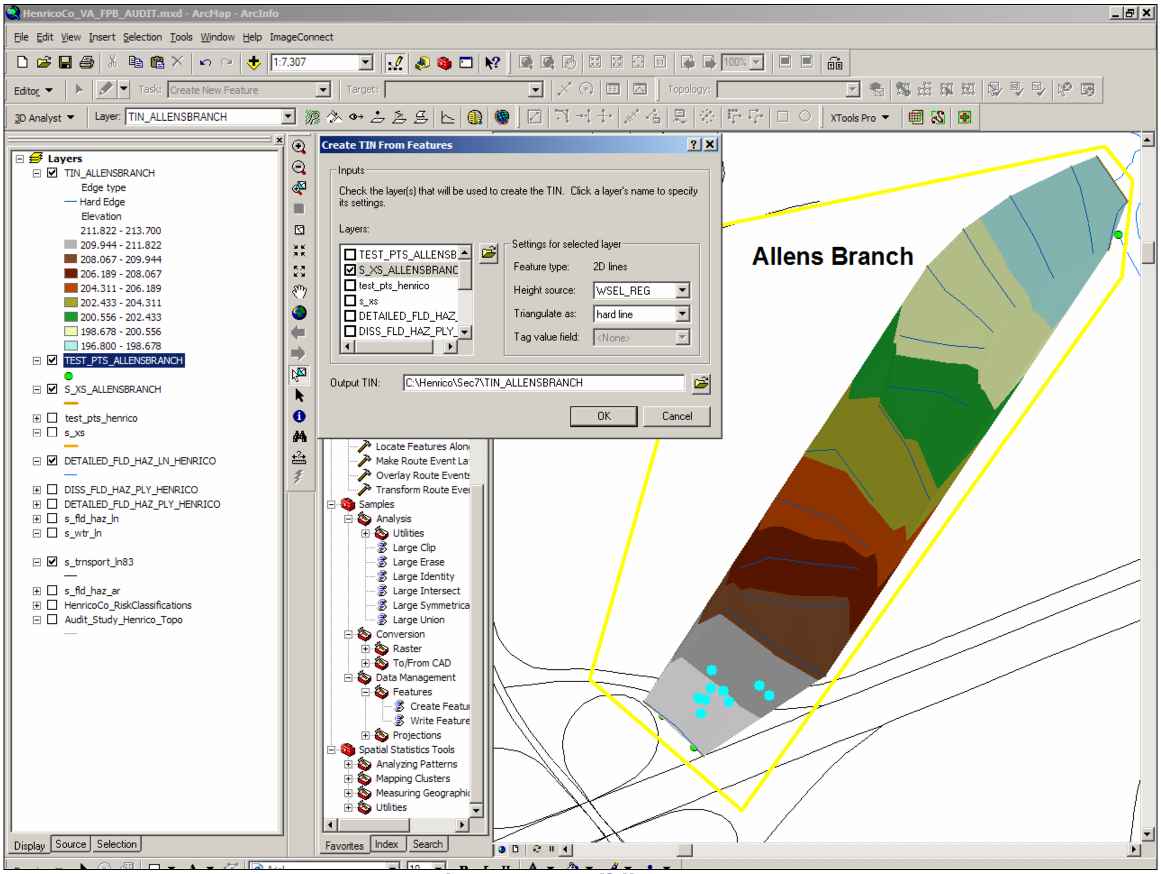

Figure A8. Building a TIN

- Intersect the TEST_PTS_ALLENSBRANCH with the TIN_ALLENSBRANCH to get the interpolated S_XS elevations (Figure 19) onto the TEST_PTS_ALLENSBRANCH FldELEV attribute field – you can use 3D analyst the following free script from ESRI http://arcscripts.esri.com/details.asp?dbid=13151.

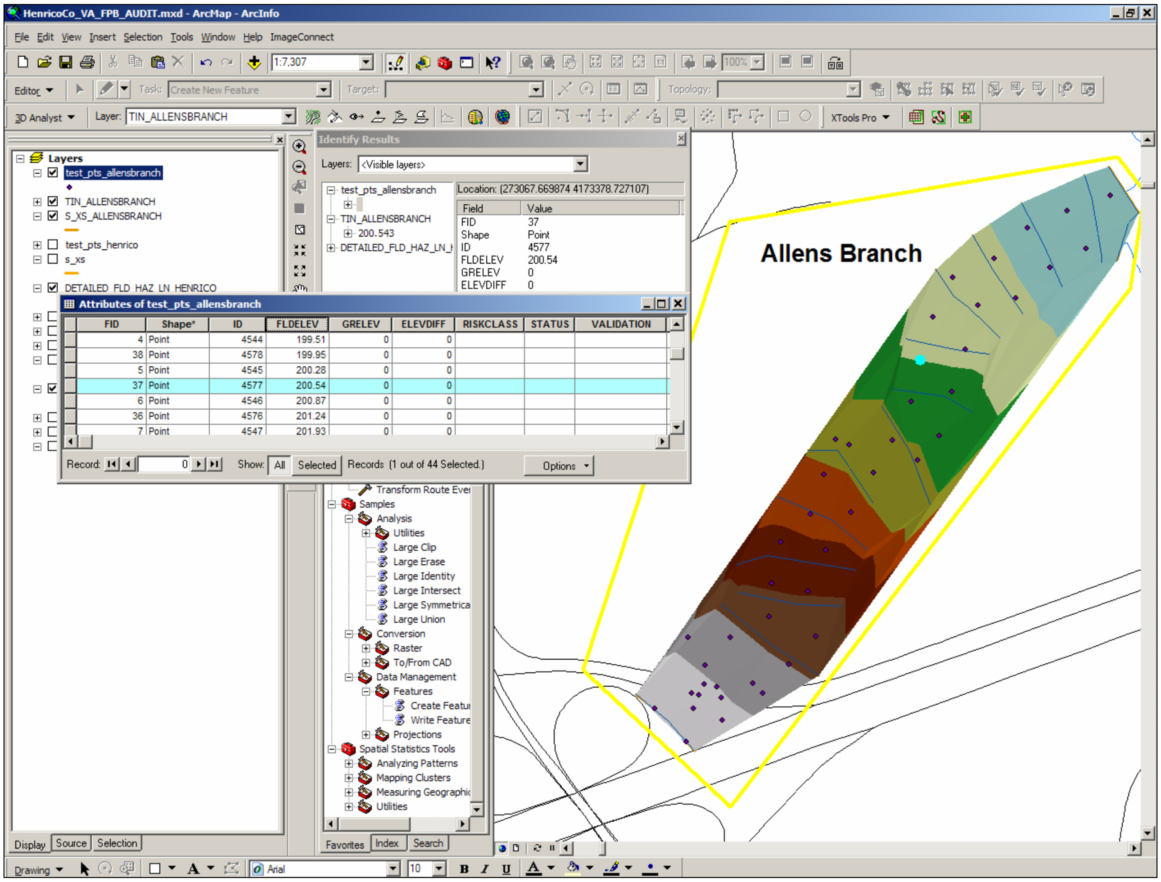

Figure A9. Elevations Being Compared

In the above example, a point in TEST_PTS_ALLENSBRANCH is identified after the intersect so one can see the TIN_ALLENSBRANCH elevation (201.04) matches the FldELEV (201.04) value in TEST_PTS_ALLENSBRANCH.

- Continue process until all detailed streams are tested, ensuring that you save a TEST_PTS_STREAM and TIN_STREAM file for every stream tested.
- Merge all your TEST_PTS_STREAM files into one AUDIT_HENRICO_PTS shapefile/feature class.
- Intersect AUDIT_HENRICO_PTS with the TIN_HENRICO to transfer the interpolated terrain elevations into the AUDIT_HENRICO_PTS GrdELEV attribute field.
- Determine if the AUDIT_STUDYX_PTS passes the equal to or higher then the 95 percent pass percentage at the +/- 1.0 ft threshold; if so then the study passes and no more analysis needs to be done and you can Record/Report Results in FBS Self-Certification Report/Audit.
- If no, intersect Risk Classification polygon with AUDIT_HENRICO_PTS.

- Analyze against FBS vertical standard for respective risk class
- If study passes, Record/Report Results in FBS Self-Certification Report/Audit
- If no, intersect AUDIT_HENRICO_PTS with the NHD 100k sub-bassin file
- Add new filed attribute to the AUDIT_HENRICO_PTS file.
  - Subbassin – type = string, length = 50.
- Calculate the Subbassin field in the AUDIT_HENRICO_PTS file with the intersected NHD 100k subbasin shapefile.
- Now determine the AUDIT_HENRICO_PTS pass rate for each audit study's risk classes at the subbasin level.
- Record/Report Results in FBS Self-Certification Report/Audit.
- Submit FBS Self-Certification Report/Audit Audit Report along with the audit spatial files to the MIP .

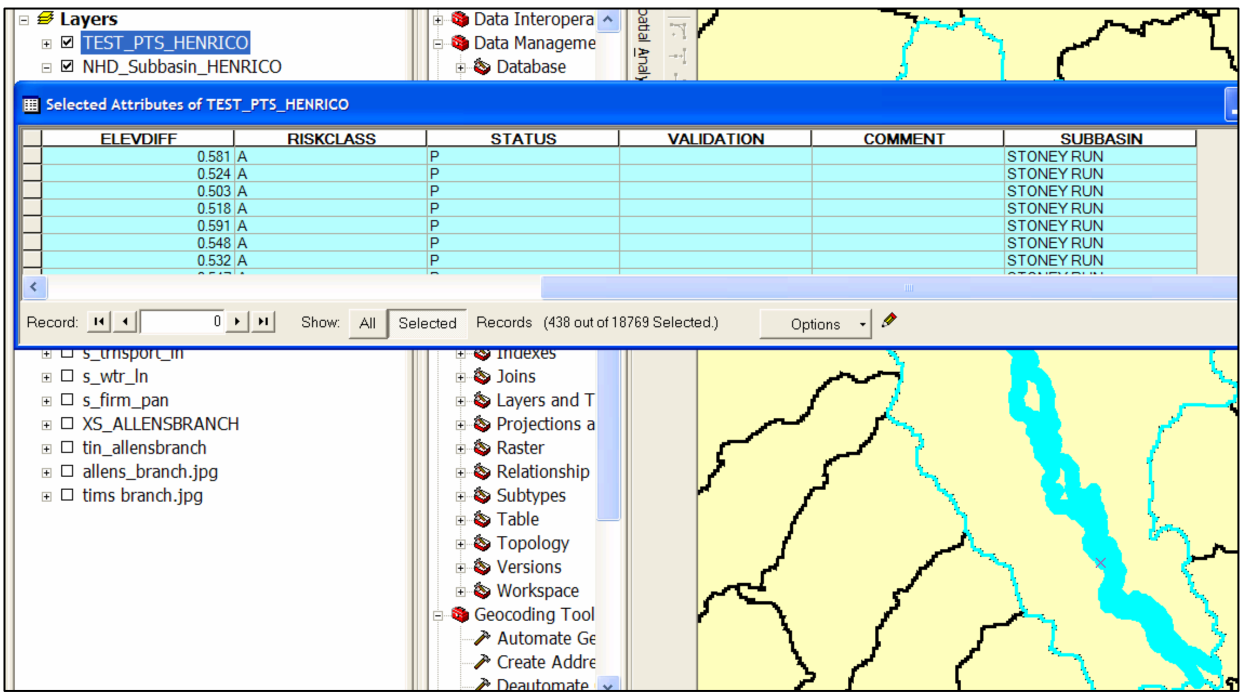

Figure A10. AUDIT_HENRICO_PTS being attributed with NHD 100k sub-basin name

Attachment B - Floodplain Boundary Standard Audit Report

1. Review type		4. Description of materials reviewed	
2. Mapping partner			
3. Final approver & date		5. Reference ID	

6. Reviewer & Date (list all reviews completed before final approval)						

7. Number	8. Description	9. Results	10. Comments
1	Names of stream reaches audited		
2	Total stream length audited		
3	Number of floodplain boundary points audited		

7. Number	8. Description	9. Results	10. Comments
4	Number of floodplain boundary points passed (see attached shape file)		
5	Number of floodplain boundary points failed (see attached shape file)		
6	Overall pass/fail percentages for study audit risk classes		
7	Stream name and length that passed audit		