Base Level Engineering

Over the past five years, FEMA Region 6 has been evaluating its investment approach and data preparation work flow to establish an efficient and effective change in operation, generating an approach that:

- Allows FEMA to review its current flood risk inventory against newly prepared flood risk information
- Generates a stream network of hydrologic and hydraulic modeling that can be further refined by local data and further investment
- Allows efficient Flood Insurance Rate Map (FIRM) update in unmodernized and underserved areas that are currently lacking flood risk information
- Supports follow-on project investments for Discovery and Flood Risk Identification and Assessment
- Provides a range of valuable flood risk information that may be locally used as planning data during the update of flood risk mapping, providing a bridge of information where there is currently a gap

The Base Level Engineering approach creates data that may be used to assess stream inventory, prioritize watersheds or stream segments for further study, provides a sounding board and initiates a discussion with communities that revolves around risk information, risk identification and indication of flood risk abatement and mitigation strategies that may reduce current or future flood risk.

How is Base Level Engineering (BLE) used?

The Region's project selection benefits from a data based approach for investment and project planning. Base Level Engineering (BLE) has a variety of uses and is produced in a manner to enrich flood risk understanding discussions throughout the current Risk MAP project lifecycle, as indicated below:

CNMS Assessment – BLE information allows FEMA and its State and community partners to review the state of the current flood risk inventory. This watershed stream network coverage produces the 1% plus and 1% minus coverage required to review flood information that is currently included on the Regions Flood Insurance Rate Maps (FIRMs). In some cases, the modeling produced supports the current floodplain indicated on the FIRMs, in other cases, the BLE results indicate areas where the flood hazard information may require update. Additionally, the availability of BLE information allows the Region an indication of where flood hazard information may be necessary (unmapped/unmodernized areas).

Regional Multi-Year Planning – BLE is produced to assist the multi-year planning effort of the Region and is key to Region 6's investment approach. Watershed selection is completed each year with input from Federal, State and local partners. Region 6 has worked closely with Mapping Partners, State NFIP Coordinators and State Hazard Mitigation Officers to select HUC8 watersheds and river basins for Base Level Engineering initiation. The initial investment and production of BLE is intended to prepare information that assist further project planning and produces the data required for local flood risk information discussions.

Discovery – BLE is a key component for the Discovery phase of projects. The availability of BLE information provides FEMA a data-based starting point for conversations with the local communities about existing flood risk and mitigation strategies. BLE information is produced in a manner that indicates to communities where additional local information (structure/crossing survey or as-built drawings) may be necessary. The BLE datasets provide tangible datasets for more effective interaction with local communities to identify and understand areas where the current FIRM does not adequately identify flood risk. Additionally, communities are provided the BLE datasets during the Discovery phase for local use and planning purposes.

Unmapped/Unmodernized Areas – BLE datasets are produced to meet the current technical mapping standards outlined in *FIMA Policy 204-078-1 Standards for Flood Risk Analysis and Mapping.* This allows FEMA Region 6 to move efficiently from Discovery to the update of the FIRMs, preparing Zone A maps for communities that are currently underserved by the National Flood Insurance Program. The BLE approach also produces a range of flood risk datasets to include Floodplains (10%, 1% and

0.2% annual chance events), Water Surface Elevation Grids (1% and 0.2% annual chance events), Flood Depth Grids (1% and 0.2% annual chance events), and Hazus Flood Risk Assessment. This wealth of information is intended to elevate the delivery of Zone A FIRMs. Production of countywide FIRMs in areas that are currently unmodernized or unmapped allows FEMA to work with local communities, industry and Cooperating Technical Partners to expand the partnerships and further inform the National Flood Hazard inventory with the submittal of Letters of Map Revision.

Support of Local Floodplain Management Activities – FEMA Region 6 and its State partners are supportive of local community adoption of the BLE results to support floodplain management activities. Community access to the data allows the community to review the data prior to FIRM update or creation. This arms communities with data to assist regulation and development decisions without mandatory purchase of flood insurance and other requirements that are unearthed by creation/update of a FIRM and provides flood risk information for areas of on-going development where FIRMs may not indicate flood risk. The availability of BLE modeling provides communities a discussion point with local developers and provides them digital model files for refinement.

Support to Local Hazard Mitigation Planning Efforts – BLE datasets are used to produce a watershed or river basin Flood Risk Report, Flood Risk Database and series of Flood Risk Maps. These Flood Risk Products have been reworked by FEMA Region 6 to better interact with local hazard mitigation planning efforts. The re-worked flood risk products provide insight to local communities about how datasets may be used locally in advance of an updated FIRM map.

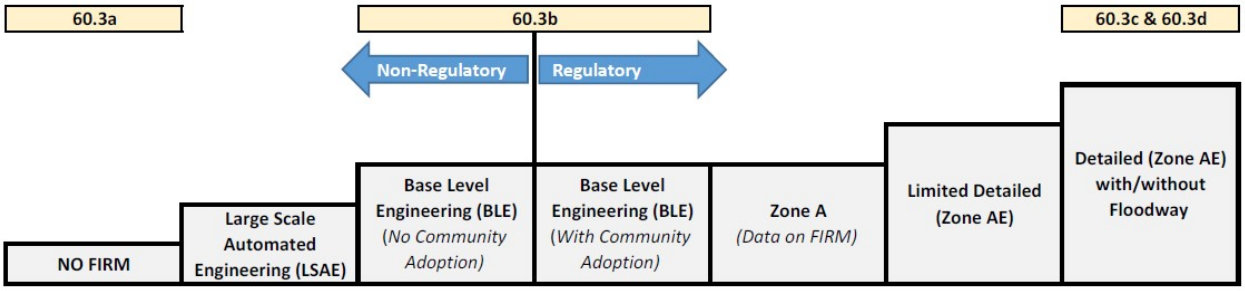
Support to Local Grant Applications – The R6 BLE approach includes the preparation of the 10%, 1% and 0.2% annual chance floodplain, WSEL and Flood Depth Grids for the 1% and 0.2% events. The 10% floodplain allows State and local communities to easily determine if a Benefit Cost Analysis is required, structures within the 10% floodplain are not required to do a BCA. The availability of the 1% and 0.2% floodplains, water surface elevation and flood depth grids also provide point and click information that is required for a number of FEMA grant applications. Additionally, the BLE datasets may be used as a starting point for local engineering assessments greatly reducing the burden on local communities to produce engineering information in support of their local grant requests for mitigation projects.

Public Data Release – Only after review of the BLE data with State and Local officials has occurred, FEMA Region 6 may release the BLE information through an interactive data portal. Region 6 has worked with its providers to prepare an interactive website to provide residents, local officials and our State and Federal partner to review and produce an “estimated” Base Flood Elevation using the BLE datasets produced. The sites allows users to produce a site specific report for any location within the 1% annual chance floodplain and it produces a site specific report that can be used for local discussions about individual risk. The site was prepared to assist local communities to interact with the BLE datasets. The site is available for use at: https://apps.femadata.com/estbfe

Risk Identification and Assessment Projects – Following the Discovery phase, FEMA may decide to make further investments to refine the BLE modeling based on community input and data collected during the Discovery phase. BLE modeling can be refined to upgrade the hydrologic information or enhance hydraulic input for stream crossings (culverts, bridges, or in-line dams) to produce a more detailed model where necessary. FEMA Region 6 would like to work with communities to identify areas of current or future development (20-30 year window) or areas of mitigation interest for community restoration or renewal to provide the engineering information necessary for further investigation. Data produced during Risk Identification and Assessment projects will inform FIRM updates and revisions.

Disaster Response – BLE uses a watershed based approach that creates datasets throughout the basin which can be used for disaster response and recovery. Estimated Water Surface Elevation (WSEL) and Depth Grids can be used to quickly develop Advisory Base Flood Elevations (ABFEs) for use by local communities during the recovery effort.

Scalability – ***Most importantly, all data produced during a BLE investment effort is scalable.*** The data resulting from a BLE analysis can be updated as needed and used for the eventual production of regulatory and non-regulatory products, outreach and risk communication, and MT-1 processing. The intent of the Region is to build an inventory of watershed models that covers the entire Region 6 geography, for this reason, all flood risk projects in the Region will originate with a Base Level Engineering investment (County, HUC8, HUC4 or State geography may be used).



Base Level Engineering – Data Creation Process and Deliverables

The Region invests in the production for Base Level Engineering information for Countywide Paper Reduction Projects and any watershed of interest. Base Level Engineering (BLE) is the minimal investment for the Region to allow the Region to build a base level understanding of flood risk for the watersheds throughout the Region.

Base Level Engineering (BLE) data is produced on a countywide or watershed geography and is only produced where high quality ground elevation is available. The BLE data creation process incorporates automated modeling techniques with traditional model development and manual data entry procedures to produce regulatory quality flood hazard boundaries for the 1-percent annual chance event as well as estimates of flood hazard boundaries for multiple recurrence intervals.

Stream Selection. FEMA creates a watershed stream network coverage that initiates with the current flood hazard inventory coverage identified in the CNMS database. FEMA and its Mapping Partners review these against the National Hydrography Dataset (NHD). The NHD medium resolution data inventoried by the US Geological Survey (USGS) Maps created at a 1:100,000 scale is used to review the water courses within the area of concern. In the vicinity of population centers of 1,000 or more are reviewed for additional mileage against the high resolution data inventoried by the USGS Quadrangle maps created at a 1:24,000 scale. The intent of this review is to identify streams and water courses and create a complete stream network for Base Level Engineering data preparation.

Terrain. The BLE is only initiated in watersheds and project areas where high resolution ground elevation meeting Quality Level 1 or Quality Level 2 data is available. Topographic datasets are combined into a composite DEM surface with a 10-foot cell resolution. The 10-foot DEM is used to digitize the stream network using available National Flood Hazard Layer (NFHL) and National Hydrography Dataset (NHD) data for reference. The 10-foot DEM is sampled directly for cross section takeoffs supporting hydraulic analysis, visual QC, and to support floodplain mapping tasks. A 50-foot DEM is created by resampling the 10-foot DEM. The stream network created from the 10-foot DEM is burned into the 50-foot DEM and used for hydro enforcement to support hydrology tasks including development of flow vectors and basin delineation.

Hydrology. BLE produces hydrology information based on USGS regional regression equations, utilizing gage analysis where stream gages with sufficient records exist. Basins are delineated in shapefile format using the 50-foot DEM. Basins are typically delineated up to 1 sq. mile for areas outside of

population centers greater than 1,000 and up to 0.5 sq. mile for those areas inside population centers. Equation specific parameters are calculated for each basin including but not limited to drainage area, main-channel slope, and annual precipitation. Gage analyses are typically performed according to Bulletin 17B using Peak FQ. Discharges are compared and if it is determined that an adjustment is needed, it is applied either locally or for the entire watershed, whichever is appropriate. Flows are also reduced, where appropriate, at significant flood control structures (dams) depending on how the regional regression equations account for regulated flow.

For 2-D analyses, spatial and temporal precipitation data from NOAA Atlas 14 Point and GIS-based Precipitation Frequency Estimates is used. To account for the inability HEC-RAS v5.0.3 to handle interception and infiltration, an excess precipitation time-series from rainfall-runoff model, such as HEC-HMS, is used as the hyetograph input into the HEC-RAS precipitation boundary condition. The 1% plus and minus analyses are developed using error bands on the precipitation estimates and curve numbers used in the HEC-HMS model to develop the excess precipitation hyetographs.

Hydrologic data is developed for the 10%-, 4%-, 2%-, 1%-, and 0.2%-annual chance flood events in addition to the 1%-plus- and 1%-minus-annual chance flood events for both 1D and 2D analyses.

Hydraulics. The hydraulic approach for BLE analysis consists of using the terrain model in combination with hydrology input to establish water surface elevations. For 1-D steady-state analysis, HEC-RAS v 4.1 is used as the computer model to compute water surface elevations on a stream by stream basis. Proprietary software is used to establish model stream orientation, initial hydraulic cross section layout and stationing, assign roughness coefficients to cross sections, and to develop all input files for the HEC-RAS program. ESRI's ArcMap program is used to review and refine cross section layout orientation. Manning's roughness coefficients (n-values) are determined using the 2011 National Land Cover Data (NLCD) dataset in combination with n-values from Chow (1959) and Calenda, et al. (2005). Additional 1-D hydraulic specifics include:

- Cross sections placed upstream and downstream of major roadway structures and dams
- Normal depth as boundary condition
- Adjusting models to avoid drawdowns greater than 0.5 foot
- Resolution of crossing profiles involving the 1-percent annual chance event
- Incorporation of Flood Control dams.

The 2-D BLE approach is used in areas where the terrain indicates that a traditional 1-D model would not accurately reflect the hydraulic properties of the watershed. For 2-D analyses, HEC-RAS v5.0.3 is used to compute water surface elevations. Breaklines are added at select locations within the 2D mesh to enhance the analysis. Consideration is given to large or hydraulically significant features, such as dams or other large embankments, and culvert and bridge openings not reflected in the terrain model. These enhancements facilitate significantly improved representations in the model at key features that require finer resolution than the nominal mesh cell size. In addition to multiple frequency modeling and mapping output, velocity grids are generated for each work area.

Hydraulic data is developed for the 10%-, 4%-, 2%-, 1%-, and 0.2%-annual chance flood events in addition to the 1%-plus- and 1%-minus-annual chance flood events for both 1D and 2D analyses. Modeling is delivered to the Mapping Information Platform, stream modeling is delivered by stream in folders collecting all streams in a HUC10 subbasin.

Floodplain Mapping. The 10-percent, 1-percent and 0.2-percent boundaries are mapped using a routine that develops water surface elevation grids based on the 10-foot cell size DEM developed from the LiDAR. This product is converted to a polygon for cleaning. The cleaning routine involves manual inspection of the polygons to identify and remove areas of disconnected flooding. In general, areas with a size of less than 5,000 square feet are removed and all others are investigated to determine whether they should be considered as potentially part of the special flood hazard area (SFHA). This investigation is aided by the ground DEM and aerial imagery.

Following the removal of disconnected flooding areas and other boundary adjustments, the small islands in the floodplain are filled. Islands with a size between roughly 5,000 and 30,000 square feet are inspected and, in general, islands that were less than 10,000 square feet are filled.

Once the island filling process is complete, the water surface raster mapping routine is run and set to conform to the polygon boundary. This ensures that the water surface raster and the floodplain boundary are consistent with each other. The depth raster product is created at the end of the process by performing a raster subtraction with the water surface elevation raster and the ground DEM.

For 2-D analyses, raw rasters are categorized by depth and used to create SFHA polygons for the 10-percent, 1-percent and 0.2-percent events. Polygons are developed for depths greater than 0.5 foot and for the streams identified in the watershed's stream network.

CNMS Validation. Initial assessments A1, A2, A3 and validation check A4 are evaluated for CNMS inventory of Zone A studies. Research is conducted to determine the topography, hydrology, development conditions and modeling methods of the effective data. The BLE /effective Zone A comparison (validation check A5) method leverages the existing Floodplain Boundary Standard (FBS) certification procedures described in FEMA SID 113, but with a slight modification. This modified FBS comparison approach uses the 1-percent plus and 1-percent minus flood profiles and horizontal and vertical tolerances described in the First Order Approximation - Methodology, Validation, and Scalability Guidance Procedures (Version 1.5). For the comparison of BLE and effective Zone A points are placed typically every 200 feet along the floodplain boundaries for comparison. Validation is performed on a stream by stream basis to gain the maximum number of Valid stream miles.

Hazus Flood Risk Assessment. BLE utilizes the latest version of Hazus to produce a basic loss analysis to serve as the baseline for the BLE database (L_RA_AAL). With the refined depth grids created for the BLE analysis, an updated loss analysis within Hazus (L_RA_Refined) is performed. The loss results are compiled and delivered within the deliverable database. The Hazus Project, known as an .hpr, is also exported from Hazus and delivered.

Base Level Engineering Deliverables

- BLE report documenting the data and processes used,
- Hydraulic models organized in HUC10 watershed folders
- A watershed geodatabase containing:
- HUC8 Area
- Political areas from effective
- Flood Risk Database with the following Datasets
- Detailed study area identifying the effective detailed areas to alert communities that there is a more detailed analysis available
- Detailed study line identifying the effected detailed stream centerlines. This dataset contains the same information as the detailed study area
- Flood hazard floodplain polygons for the 10-percent, 1-percent and 0.2-percent events
- Water areas as identified in the effective data
- Water line for all BLE streams modeled (1-D only)
- Cross sections for all BLE streams modeled (1-D only).
- Areas of mitigation interest including flow constriction areas, overtopping structures, etc.
- Census block areas used in the Hazus run
- Hazus Flood Risk Assessment (Level 2 – defined flood extent) result tables
- WSEL and depth grids for 1-percent and 0.2-percent events
- CNMS updated database containing the validation results of the BLE study
- Hazus Level 2 models that include the BLE result grids