D.2.12 Study Documentation

This subsection summarizes the reporting requirements for coastal Flood Insurance Studies (FISs) on the Atlantic and Gulf of Mexico (herein referred to as Gulf) coasts, with emphasis on the intermediate data submissions that document the basis and results of coastal flooding analyses during the course of the FIS.

The Mapping Partner shall fully document the coastal flood hazard determination for each affected community. FIS reports and FIRMs form the basis of Federal, State, and local regulatory and statutory enforcement mechanisms and are subject to administrative appeal and litigation. Mapping Partners must ensure that all technical processes and decisions are recorded and documented. This report will provide detailed data needed by FEMA or the community to reconstruct or defend the study results on technical grounds. The minimum information required for the engineering report is summarized below.

Reporting requirements for coastal studies shall follow guidance provided in Appendix M: Guidance for Preparing and Maintaining Technical and Administrative Support Data for the preparation of a Technical Support Data Notebook (TSDN). The TSDN shall consist of the following four major sections, which are described in more detail in Appendix M:

- General Documentation;
- Engineering Analyses;
- Mapping Information; and
- Miscellaneous Reference Materials.

The material compiled for these sections of a coastal study TSDN will be similar to a riverine study, with the exception of the Engineering Analyses section. The Engineering Analyses section of a TSDN for a coastal study shall be formatted to reflect the intermediate data submissions required for such studies.

D.2.12.1 General Documentation

This portion of the TSDN incorporates background information compiled by the Mapping Partner related to changes in scope; special problem reports; minutes of meetings held with the FEMA, communities, and other Mapping Partners; and all correspondence for the study effort (email and hard copy). A complete list of TSDN reporting requirements for General Documentation is provided in Appendix M.

D.2.12.2 Engineering Analyses

Intermediate data submissions provide defined milestones in the coastal flood study process for review of the study approach and results. The Mapping Partner shall submit the data to FEMA in the sequence below.

- Intermediate Submission No. 1 – Scoping and Data Review
- Intermediate Submission No. 2 – Storm-surge Model Calibration and Storm Selection
- Intermediate Submission No. 3 – Storm-surge Runs and Flood-frequency Analysis
- Intermediate Submission No. 4 – Nearshore Hydraulics
- Intermediate Submission No. 5 – Draft Flood Hazard Mapping

The Mapping Partner shall receive review comments within 30 days of receipt of each data submission. The Mapping Partner performing the study shall establish a work plan, so the interim review does not cause any delay in the submission of the draft FIS report and FIRM.

Notes:

- Several different computer codes may be used in the wind, hydrodynamic, and statistical analysis, and several basic computer programs have been listed in numerous FEMA reports. In each section of the engineering report, the Mapping Partner performing the coastal analysis shall list and describe any modifications to these programs and special data inputs used in the study.
- In each section of the engineering report, the Mapping Partner shall provide a complete list of technical references, including computer program references indicating how to obtain copies of the exact program and the input data sources used in the analysis.

D.2.12.2.1 Intermediate Submission No. 1 – Scoping and Data Review

In this report phase, the Mapping Partner shall provide the background information on the study setting and available data relevant to the study area. Any new data needed for the detailed coastal analyses in subsequent phases shall be identified in this phase. Unless otherwise agreed upon with the FEMA Study Representative, the study shall not proceed until all of the information is available and incorporated into the scoping document, which is then submitted for approval by FEMA.

Topographic and Bathymetric Data: If available at this stage, this submission shall include survey control data, topographic data from aerial photography, LIDAR, and field and bathymetric surveys. If survey work is still in progress, the submission shall include available data at the time of submission and a detailed description of the planned survey data collection. Information shall be submitted on the extent of topographic and bathymetric mapping, key mapping parameters (e.g., contour intervals and accuracy standards), horizontal and vertical datum, location and extent of transects, and other pertinent information describing the extent and quality of survey information to be used in the study. If existing community mapping data will be used to supplement survey efforts for the study, the Mapping Partner shall submit information on the date, accuracy standards, datum, extent, and limitations of the mapping.

Tide, Wind, Wave, Current, and Flooding Data: This submission shall include a description of available tidal elevation, windspeed, and wave data that relate to study analysis requirements.

The submission shall include an evaluation of local and regional tide gage records while recognizing that these records include astronomical tide, surge, and possibly other influences (e.g., river flows and wave setup). Residuals based on astronomical tide predictions also shall be included where relevant to the study analysis. The submission shall include the review and selection of wind stations in the vicinity of the study area that can provide reasonable length of record, hourly values, and peak gusts to help estimate extreme wind statistics; the evaluation of available wave or wave hindcast data; the evaluation of available current data and the influence of currents on coastal flooding, if any; and the evaluation of available historical data (measured and anecdotal) on past coastal flood events.

Site Reconnaissance: The results of the site reconnaissance shall be documented to characterize exposure and coastal morphology, inventory existing coastal structures and levees (including buried coastal structures), identify shorelines where beach nourishment has occurred and could influence coastal flooding analyses and mapping, characterize coastal vegetation where it may influence coastal flooding analyses and mapping, locate analysis transects for subsequent field survey and ultimate use in wave calculations, and identify representative reaches with similar exposure, morphology, and features.

Technical Approach: The submission shall describe the technical approach for the analysis of coastal processes and the mapping of flood hazards in the various settings and shoreline morphologies present in the study area.

Hydrodynamic Storm-surge model: This section of the engineering report should address the hydrodynamic storm-surge model employed in performing the coastal study. The model used to calculate the surge elevation has been described in detail in various FEMA documents and only need be cited by reference. The Mapping Partner shall:

- Report the unique model characteristics used for the study, including a discussion of the specific grid system and sub-grid systems employed, the grid used for bottom topography (bathymetry) and the shoreline, small-scale features such as harbors and barrier islands, and the location and conditions applied for the open boundaries to the grid.

- Describe and document the adjustments made to land features to account for erosion.

- Describe and document the method used to determine average ground elevations and water depths within the cells of the grid system. (This discussion is to be augmented by diagrams that show the grid systems as computer listings of the grid data used in the actual model calculations.)

- Describe the method used to relate windspeed to the surface drag coefficient.

- Discuss the Manning's "n" values used in the calculation of bottom and overland friction and provide values in tabular form, including a discussion of any sensitivity tests used to estimate these values in nearshore water. (Nearshore, bottom, and overland friction are important parts of the overall analysis and shall be described with care and in sufficient detail.)

- Provide a graphical depiction of the model cells and grid system as an overlay to the bathymetric charts and topographic maps covering the study area, annotated with the individual cell inputs for the grid system.

- Discuss the treatment of barriers, inlets, and rivers.

- Explain the procedures used to determine inland flooding, including parameterization of local features and selection of the friction factors used for the terrain.

D.2.12.2.2 Intermediate Submission No. 2 – Storm-surge Model Calibration and Storm Selection

Documentation of this phase shall include a description of the calibration, validation and sensitivity analysis of the storm-surge model to be used in the generation of surge elevations for flood frequency-of-occurrence analysis. It shall also include a description of the selection and definition of storm events to be used in the statistical analysis.

Storm Climatology and Storm Windfield Methodology: The Mapping Partner shall describe the basic climatological storm data used and the windfield methodology. The Mapping Partner must map, tabulate, and discuss the methodology in terms of local surge impact and the storm paths used in the analysis. The Mapping Partner must also tabulate and describe in written form the storm parameters, including central pressure deficit, radius to maximum wind, forward speed, shoreline crossing point, and shoreline crossing angle, used in the analysis. It must also identify sources of the basic data used to develop the storm climatology and the method used to sort the data and compare them to the NWS Hurricane Climatology for the Atlantic and Gulf coasts of the United States (NWS 38, U.S. Department of Commerce, 1987). In addition, the Mapping Partner must describe the technique employed to determine the spatial/temporal distribution of storm occurrences (i.e., storms/nautical mile/year), derivation and discretization of storm intensity parameters, and exceedence probability distributions, and provide a graphical presentation of the results, including an overlay to show the orientation of the coast to storm path/direction. The Mapping Partner shall also provide a discussion of storm parameter independence and any unique storm model treatments.

The windfield used in the analysis is a key component in the determination of the storm surge elevation. The Mapping Partner shall give the exact equations used to parameterize the model windfield along with any unique values among the appropriate coefficients and constants used. The submission must include a diagram of the windfield model that shows the surface velocity structure as it changes radially outward from the storm center, provide a comparative graphic depiction of measured windfield(s) and the modeled windfield, if available, describe in detail the method by which winds are reduced as the storm approaches land and moves inland, and report the constants used in windspeed reduction.

Wave Data and Hindcasts: The submission shall describe data and analyses used to select and define storm events for use in response-based analysis of nearshore processes and subsequent statistical analysis of 1- and 0.2-percent-annual-chance flood conditions. Documentation shall include details of the sources of wave and wind data. It shall also include comparisons between alternate sources, in cases for which more than one is available and feasible for use in the study, and comparison with local measurements. Documentation of incident deepwater waves should

include period, direction, and directional spreading parameters. The selection of coefficients for angular spreading and spectral peakedness parameters shall be clearly stated and justified.

Storm-surge model Calibration and Validation: The Mapping Partner shall document the calibration and validation of the hydrodynamic surge model. Once the hydrodynamic storm-surge model and grid have been constructed, calibration and validation are performed. Model calibration involves changing (fine tuning) values of model input parameters or coefficients in an attempt to replicate observed conditions within a given acceptable range. Validation confirms that the model has been calibrated to a set of conditions which are spatially and temporally representative of actual field conditions. Sensitivity runs are used to investigate the effect that small changes in the chosen grid and 'tuning parameters', will have on the computed flood and tide levels. Calibration and validation runs compare computed results with observed water levels. Sensitivity runs compare computed results with other computed results.

When observed (or model simulation) data are employed to calibrate (or compare) hydrodynamic storm-surge model results with other available studies, the Mapping Partner shall give a complete description of this calibration procedure (or model comparison), including a listing of measured and simulated tidal data. Calibration (and model comparison) is an important aspect of the model analysis; therefore, the Mapping Partner shall describe these activities with sufficient detail and care to allow an independent reviewer to understand the exact procedures and local historical records employed.

Sheltered Waters – Hindcast Waves: Documentation shall be provided on fetch length determination and corresponding windspeeds, directions, and durations for use in hindcast analyses. This shall include documentation of windspeed adjustments and windfield hindcast methods.

Sheltered Waters – Water Levels: The Mapping Partner shall document the characteristics of tide gages located within or near the study area that will potentially be used in study analyses or validation. Methods adopted to infer the variation of tidal datums between gages shall be documented, as shall procedures used to transpose data from one site to another. If a field effort is undertaken to determine the variation of tidal datum within ungaged regions, the Mapping Partner shall fully document that effort, including the locations of observations; a description of observation methods and instrumentation, dates and times of all observations, meteorological and oceanographic conditions during and preceding the period of observation, and other factors that may have influenced water levels or that may affect interpretation of the results. If surge variation was inferred from tide variation, the Mapping Partner shall document the basis for similarity assumptions and the manner in which the inferences were made. Inlet analyses shall be documented, including all procedures, methodological assumptions, field surveys (dates, times, procedures, instrumentation, and findings), and all inlet data adopted from other sources.

Proposed Transect Location Map: The Mapping Partner should submit one or more maps as appropriate depicting the location and orientation of transects to be used in the subsequent wave elevation determination analyses. The transect location map(s) should be at a suitable scale and should show transects of sufficient length to account for modeling of all coastal flooding conditions.

D.2.12.2.3 Intermediate Submission No. 3 – Storm-surge Modeling and Flood-Frequency Analysis

Documentation shall be provided on the methods used to estimate the 1- and 0.2-percent–annual-chance coastal flooding conditions. Documentation may include response-based and simulation methods (e.g., JPM, Monte Carlo, or EST), depending on study setting. Methods of extrapolation of hindcast and/or measured data to 1- and 0.2-percent–annual-chance values should be documented, including comparisons between alternate procedures, if appropriate. In cases for which extreme value analyses of wave, wind, water level, and residual tides are used, the submission shall include documentation of the analyses to develop frequency relationships, including a description of the data sets and analytical assumptions.

Joint Probability Methodology (JPM): If the JPM is used, the Mapping Partner shall summarize, map, and report the values and combinations used for storm parameters, annual storm density, spacing between storms, and the storm tracks used in the analysis in this section of the engineering report. The Mapping Partner shall compare the information above to the probabilities reported in the NWS Hurricane Climatology for the Atlantic and Gulf coasts of the United States (NWS 38, U.S. Department of Commerce, 1987). Specifically, the Mapping Partner shall:

- Note the total number of simulations.
- Summarize tidal elevation data, if used, in sufficient detail to remove any doubt as to the values used in the simulations.
- Describe the method used to determine the contribution of tide to the total water level.
- Describe storm occurrence rate or storm density, the definition of the storm region used to define storm density, and storm kinematics and intensity with respect to their use in the joint probability calculation.
- Report and discuss comparisons to long-term gage statistics.
- Describe and report adjustments to account for the combined probability of coastal and riverine flooding for each area where this approach was taken.

Monte Carlo Simulations: The requirements for Monte Carlo study documentation are similar to those described above for JPM studies, but should also include a tabulation of the cases randomly simulated, or specification of an algorithm by which those cases can be reconstructed. The Mapping Partner should also provide justification for the number of simulations, including appropriate evidence of convergence at the extreme levels.

Empirical Simulation Technique (EST): If the EST method is used, the Mapping Partner shall summarize all of the historical and hypothetical storms that were used and the manner of EST implementation. Specifically, the Mapping Partner shall:

- Document the storm occurrence rate for the study area, as used in the Poisson annual occurrence assumption;

- Document the historical storm selection process, listing all storms chosen for the analysis;

- Document the manner in which hypothetical storms were constructed, such as by track displacement of historical storms and/or by EST resampling and random walk procedures;

- Document the source of wind and pressure data for all simulated historical storms;

- Summarize tidal elevation data and describe the methods by which the tides and surge are combined;

- Discuss any special steps taken to reduce the impact of sample error while addressing local geographic variability of storm occurrence and implications of period-of-record limitations;

- Report and discuss comparisons to long-term gage statistics; and

- Describe and report adjustments to account for the combined probability of coastal and riverine flooding for each area where this approach was taken.

D.2.12.2.4 Intermediate Submission No. 4 – Nearshore Hydraulics

The nearshore hydraulics phase shall provide documentation of methods applied and detailed analyses conducted before the hazard zone mapping phase.

Wave Information: The Mapping Partner shall document all assumptions used to define waves. In sheltered waters, the documentation shall include a summary of fetch determination, winds (speed, direction, and duration), and bathymetry used in hindcasts. The documentation shall include the approximations or assumptions used in the analysis. When observational data, such as wave buoy data, are available, the wave height, period, and spectral parameters should be compared to the predicted waves.

Wave Transformation: The Mapping Partner shall document the assumptions, methods, and results of all analyses of wave transformations conducted for the study. This documentation shall include selection of offshore and nearshore points, source of transformation coefficients, and any special assumptions regarding local transformation processes, such as sheltering and reflection. If a spectral wave model is applied for nearshore transformation, all modeling factors shall be sufficiently documented so the modeling effort can be reproduced if necessary. If a field effort is undertaken to validate transformation models, the field work shall be summarized in detail, including times and locations of all observations, general conditions at the time the work was performed, a full description of all equipment and procedures, and a summary of all data in archival form. A description of the bathymetric data used in the transformation calculations shall also be provided.

Runup, Setup, and Overtopping Analyses: The Mapping Partner shall document the runup, setup, and overtopping analysis assumptions, methods, input data, and results. This shall include a determination of runup heights and stillwater elevations (SWELs) and determination of flood

insurance risk zone parameters (1- and 0.2-percent-annual-chance flood depths, overtopping splash penetration and overtopping rate, and overland flow velocity) at each transect. This shall include a description of profiles used, runup reduction factors, and the basis for splash zones to be used in hazard mapping. The documentation shall include a description of any observations or measurements used to validate or adjust analysis results, any deviations from recommended procedures in Subsection D.2.8, any difficulties encountered in the analyses, and the technical decisions or approaches taken in their resolution. The Mapping Partner should include one or more transect location maps as appropriate and include computer printout listings for the input and output data, keyed to the transect location map(s), as an appendix to the report.

Wave Dissipation and Overland Propagation: The Mapping Partner shall describe the areas where wave attenuation was investigated, and document the analysis assumptions, methods, input data, and results. This shall include documentation of any field observations or measurements, as well as available historical or anecdotal information regarding wave attenuation during flooding events. The Mapping Partner should include one or more transect location maps as appropriate and include computer printout listings for the input and output data, keyed to the transect location map(s), as an appendix to the report.

Coastal Armoring Structures: The Mapping Partner shall describe assumptions and investigations of the various coastal armoring structures (e.g., seawalls, revetments, bulkheads, levees, etc.) in the study area relevant to stability and capability to withstand 1-percent-annual-chance water-level and wave conditions. This documentation shall include any assumptions or approximations used in the analyses. The same documentation shall be required in the event that coastal structures are apparently buried and not visible, but are indicated by information collected during the study. In cases where the Mapping Partner could not determine whether a given structure would survive the 1-percent-annual-chance flood intact, and where multiple analyses were conducted for the structure (i.e., intact condition, failed condition/removed from the analysis transect), the Mapping Partner shall document each analysis and record the structure condition used to map flood insurance risk zones and BFEs. This information will be useful in the event a map revision is requested based upon a structure condition different from that used as the basis for the FIRM. The Mapping Partner shall consult with the FEMA Study Representative regarding the treatment of levees (single levees or multiple-levee systems) during the study.

Beach Stabilization Structures: The Mapping Partner shall document the treatment of beach stabilization structures (e.g., groins, offshore breakwaters, sills, etc.) during the study. If the Mapping Partner proposes removal or modification of beach stabilization structures (or their shoreline effects) during the 1-percent-annual-chance flood, the Mapping Partner shall document the existence, history of, and shoreline response to beach stabilization structures and consult with the FEMA Study Representative.

Miscellaneous Structures: If miscellaneous structures (e.g., piers, port and navigation structures, bridges, culverts, tide gates, etc.) are present in the study area and could exert a significant influence on nearshore waves, currents, sediment transport, or backshore ponding, the Mapping Partner shall document the data, methods, and procedures used to evaluate the stability of these structures during the 1-percent-annual-chance flood and their effects on coastal flooding. This documentation shall include assumptions or approximations used in the analyses.

Erosion Analyses: The Mapping Partner shall document the erosion analysis assumptions, methods, input data, and results. If the erosion analysis is not preformed with the established erosion assessment methods (such as the 540-square-foot erosion criteria), the Mapping Partner shall provide historical documentation or other justification to provide that the method utilized will yield a feasible and technically sound eroded profile. The Mapping Partner shall document any unusual conditions in the study area and the methods proposed to map hazard zones based on these conditions. These may include the effects of beach nourishment and/or floodborne debris; special hydrodynamic considerations in tidal inlets and passages; the effects of riverine inflows, unusual erosion or other sedimentation characteristics; unusual structure effects and/or the effects of multiple levees, and any other factors that the Mapping Partner considers relevant to mapping flood hazards accurately.

D.2.12.2.5 Intermediate Submission No. 5 – Draft Flood Hazard Mapping

The draft flood hazard mapping phase shall provide documentation of the methods used to convert the results of the detailed hydraulic analyses into flood insurance risk zones.

Flood insurance risk zone Limit Identification: The Mapping Partner shall document the analysis results used in the determination of hazard zone limits and BFEs. This shall include a summary table, by transect, of results for 1-percent wave envelope, 1-percent SWEL, and determination of flood insurance risk zone parameters (1-percent and 0.2-percent flood depths, overtopping splash penetration and overtopping rate, overland flow velocity, overland wave propagation, and PFD location), as appropriate. In addition, the summary shall include a description of the basis for erosion and coastal structure conditions (e.g., overtopping cases, method of profile determination, failed and buried coastal structure cases, etc.) used in the determination of the hazard zones.

Flood insurance risk zone Map Boundary Delineation: The Mapping Partner shall provide draft work maps for the study area showing all flood insurance risk zone limits identified along the transects resulting from the detailed analyses and transferred to the topographic work maps. This submission shall describe the engineering judgment used to interpolate and delineate hazard zones between transects, including land features that might affect flood hazards, changes in contours, and the lateral extent of coastal structures. It shall also provide detailed documentation and technical justification of adjustments in the hazard zone mapping due to observed historical flood data and/or damages in the study area.

The Mapping Partner shall also incorporate all intermediate submissions and modifications based on review comments in each phase into the Engineering Analyses section of the TSDN.