Appendix C
Initial Hydrologic Engineering Management Plan (HEMP) for a Flood Damage Reduction Feasibility Study

C-1. Scenario

a. The study objective is the development of a flood protection plan for a community experiencing periodic flooding from a stream draining a few hundred square miles. The reconnaissance-phase study was based primarily on flood insurance study data and an abbreviated hydrologic engineering analysis. The study has determined that a levee project is economically feasible. The community is willing to be the cost-sharing local sponsor and would like a minimum certifiable level of protection of a 1 percent chance event. A gage with 15 years of discharge data is available at the site, with additional, short-record gages located elsewhere in the watershed.

b. The feasibility phase will establish existing and future without-project conditions. After discussions with the interdisciplinary study team and local sponsor, it was decided that three heights of levee will be studied, along with six combinations of levee height and channel improvements to develop the economic optimum plan. A total of nine alternatives will be evaluated. As all the levee alternatives are along a similar alignment, a detailed interior flood analysis will be evaluated for only the National Economic Development Plan (NED) levee or levee and channel plan. The hydrologic engineer must prepare an initial Hydrologic Engineering Management Plan (HEMP) for the hydrologic engineering cost estimate for the feasibility phase.

c. This sample initial HEMP represents what one might develop at the end of the reconnaissance-phase study for a time and cost estimate for use in the initial project management plan.

C-2. Preliminary Investigations/Initial Preparation

Finalize study objectives; confer with the study team members on hydrologic engineering information requirements, study constraints, development information needs, and field reconnaissance; prepare survey data request; prepare detailed HEMP.

C-3. Development of Basin Model Hydrologic Engineering Center (HEC-1)

a. Calibration of runoff parameters. Using basin gage data, develop unit hydrograph and loss rate parameters for use in the study.

b. Delineation of subareas. Subdivide study watershed based on the need for discharge-frequency information at specific locations: major tributaries, damage index points, routing reaches, project sites, etc.

c. Subarea rainfall-runoff analysis of historic events. Develop historic storm events, and subarea loss rate and unit hydrograph data for ungaged areas.

d. Channel routing characteristics. Determine based on information in Appendix D (Paragraph D-3*d*).

e. Assemble, debug HEC-1 model.

C-4. Hydraulic Studies

a. Prepare Water Surface Profile Data--Code HEC-2 model of study reach, after receipt of surveys. Estimate "n" values, section locations, bridge routines applicable, effective flow areas. Debug model.

b. Calibrate HEC-2 model to gage data and high-water marks from recent floods.

c. Develop storage-outflow relationships and flood wave travel time, by routing reach, for information required in Paragraph C-3*d* above.

C-5. Calibration of Models to Historic Events

Calibrate the HEC-1 and -2 models to recorded events and high-water marks. Make preliminary selection of hydrologic and hydraulic model parameters for hypothetical flood event analysis.

C-6. Frequency Analysis for Existing Land Use Conditions

a. Perform statistical analysis of gaged data for peak discharge-frequency relationship. Also estimate discharge-frequency relationships through available/applicable regression equations at key locations, to use in later comparisons.

b. Hypothetical Storms (HEC-1)--Develop hypothetical frequency storm data from the National Oceanic and Atmospheric Administration HYDRO 35, and National Weather Service Technical Publications 40 and 49. Develop the Standard Project Storm. Develop rainfall pattern for each storm, including precipitation depth-area adjustments. Develop corresponding hydrograph for each hypothetical event throughout the basin using the calibrated hydrologic model of Paragraph C-5.

c. If judged appropriate, further calibrate model to reproduce the peak discharge calculated from the statistical analysis at the gage site. Emphasize the 2-year through 10-year event, since the data record is short. Make adjustments to loss rates and unit hydrograph coefficients for rarer events, as judged reasonable. Compare results to statistical and regression-derived peak discharge frequency relationships; further adjust coefficients as considered reasonable.

d. Using the results of steps *a*., *b*., and *c*., above, adopt a discharge-frequency relationship at each needed location. Develop probability distribution of discharge uncertainty for use in risk-based analyses.

e. Determine corresponding water surface profiles and inundated areas for selected frequencies at required locations. Furnish data to planning and economics.

f. Adopt stage-discharge relationship at each required location for damage computations. At the gage site with 15 years of data, determine deviations about the adopted stage-discharge relationship. Further evaluate through sensitivity studies. Develop probability distribution of stage uncertainty for risk-based analysis.

C-7. Future Without-Project Analysis

Determine future stage-discharge relationships, based on future watershed changes affecting the hydraulics. If necessary, adjust discharge-frequency and stage-discharge risk/uncertainty relationships. Furnish data to economics.

C-8. Levee Alternative Evaluations

For the preliminary levee alignment, develop revised discharge-frequency and stage-frequency relationships for each of the three different levee heights. If judged necessary, determine revised stage-discharge risk/uncertainty relationship. Roughly size a “minimum facility” interior flood control system for each. With the economist, perform risk and uncertainty studies to establish the claimable level of protection (risk-based) and average annual benefits resulting for each.

C-9. Levee and Channel Alternative Evaluation

a. For two sizes of channel, reestablish stage-frequency relationships for each of three levee sizes (six alternatives). Evaluate the discharge and stage uncertainties for with-project conditions. Roughly size a “minimum facility” interior system for each alternative, if necessary. With the economist, perform a risk-based analysis to determine project benefits and claimable level of protection for each alternative. Perform qualitative sediment analyses for channel modifications to roughly determine dredging frequency for channel maintenance. After economic analysis to tentatively establish the NED plan (levee height) from among the nine alternatives, design top of levee grade for controlled overtopping.

b. If a channel modification is included in the NED plan, perform sensitivity tests to determine the importance of channel maintenance assumptions and costs on the NED plan. If a more conservative sedimentation analysis results in significant cost increases, possibly invalidating the NED plan, additional sediment analyses will be required in feasibility. Hydrologic engineering work for a quantitative sediment analysis is not included in this estimate. Adjust final levee grade for any sediment effects.

c. As necessary, furnish hydrologic information, as it becomes available, to other study team members: stage-duration and frequency to environmental, data for Environmental Assessment Report, etc.

d. Nonstructural analysis of emergency procedures in the event of levee overtopping--evacuation and flood warning.

C-10. Residual Flooding and Interior Flood Control

a. Establish residual flooding for remaining flood damages with the NED project. Evaluate higher levels of interior flooding protection compared to the “minimum facility.” Interior flood control measures are distinguished from minimum facilities in that these additional measures require net benefits and minimum facilities do not require incremental economic justification, only cost-effective design.

(1) Using the Interior Flood Hydrology Program, evalu ate two gravity outlets larger than the “minimum facility” at each of the three gravity drain locations.

(2) Evaluate interior excavated storage at the only site where it is currently thought feasible.

(3) Evaluate three capacities of pumping plants at each of two sites.

(4) Evaluate interior ditch improvements for the two main ditches.

b. Forward data to an economist and cost engineer for each increment. Supply hydrologic data for wetland determination and mitigation, as necessary.

C-11. Hydraulic Studies

Some of the design work will have already been incorporated in the above activities.

a. Levees--levee design profile, controlled overtopping design, gravity drain design for “minimum facility,” etc.

b. Channels--channel geometry, bridge modifications, scour protection, channel cleanout requirements, channel and bridge transition design, etc.

c. Drains--size, slope, material, inlet/outlet, operation procedures, etc.

d. Pumping--capacities, start-stop pump elevations, sump design, outlet design, scour protection, operating floor elevations, etc.

C-12. Hydrologic Engineering Reporting Requirements

a. Project Management Plan--Estimate major hydrologic engineering activities in the preconstruction engineering and design (PED) phase, prepare initial HEMP for PED work, prepare time and cost for hydrologic engineering, activity schedule.

b. Hydrologic Engineering Appendix to the Feasibility Report--Using the detailed HEMP as appropriate, outline and write the text, prepare tables and figures.

c. Environmental Assessment Report--Provide data to environmental section. Supply text, figures, plates, as needed.