Medina River Regional Flood Protection Planning Study

Prepared for:

Texas Water Development Board
Bexar-Medina-Atascosa Counties WCID No. 1
San Antonio River Authority
Medina County
City of Castroville
City of La Coste

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In Cooperation With:

Bandera County
Bandera County River Authority and Groundwater District

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URS responses to the following Texas Water Development Board comments on the Draft Final Report entitled **"Medina River Regional Flood Protection Planning Study"** are shown in red below.

Flood Forecasting Modeling

1. The report should include sufficient explanation in table 2-3 to help readers understand if this table is about volume, peak, peak time, or combination of them. Text has been added to section 2.3.4 (Item 1), to explain the application of the table. In addition, an explanation for the units presented in the table has been added as a footer to the table. This change accompanies these comments.
   Many of the comments provided by TWDB deal with providing more detail concerning the documentation of the model's calibration. The objective of the report is to document the process and parameters used to develop a refinement of the current NWSRFS model for the Medina River corridor. The prime focus of the report is to have the revised model accepted and used by the NWS. For this reason, the report is focused upon meeting NWS-defined standards of model accuracy and demonstrating use of NWS modeling procedures. The revised model and report were developed in close coordination with staff of the West Gulf River Forecast Center (WGRFC). The reader is referred to the documentation provided by the authors of NWSRFS for an explanation of the calculation of each statistic and its meaning. URS followed the recommended procedures for calibration of NWSRFS models including the determining the goodness of fit for the calibration. The objective of the report is to discuss the results of these procedures not the procedures themselves.

2. The report should explain the meanings of the abbreviations in table 2-3 and how the statistics were calculated to help readers understand the statistics. The abbreviations are explained in a new table footer. The statistics have not been explained in detail, as this would require providing complex statistical definitions and applications specific to NWS calibration procedures. These procedures are defined in the NWS River Forecast System User's Manual, available on-line.
3. The report should include a distance scale on figures 2-1 and 2-2. These figures have been corrected.
4. The report should provide more and better information to help the readers assess the model accuracy. It is recommended that the report include more hydrographic comparison of modeled and observed runoff when discussing model accuracy. Per the response to comment 1, URS followed NWS procedures to meet model calibration standards, met those standards, and wrote the report in a manner to facilitate NWS model acceptance. URS agrees that providing the observed and simulated hydrographs for the entire period of record would be beneficial. However, when calibrating this type of hydrologic model the entire period of record is used to find a reasonable calibration. For many NWSRFS models the period of record can be as large as 60 years. Tools have not been developed for integrating these large datasets into a concise report form. URS determined the most practical way to disseminate the information would be to provide example figures such as those shown in Figures 2-6 and 2-7 and 2-9 thru 2-11. These representative examples along with quantitative measures of goodness of fit for the model were deemed appropriate to illustrate model calibration. Furthermore,

model files were made available for those who would like to further investigate other events in the period of record.

5. The No. 1 calibration goal is to "produce a good reproduction of the observed hydrograph" (page 2-9, point 1), but the report does not provide enough data to demonstrate to what extent this goal has been achieved.
   - The statistics in table 2-3 indicate improved model accuracy on water volume, but not significant enough to make the new model a tool for real flood predictions. For example, the Percent Average Absolute Error (50.43 ~ 61.86%) and the Percent Monthly Volume RMS Error (56.63 ~ 124.65%) are still very high. The values presented show a significant improvement in quantitative calibration parameters. Guidance provided by NWS for calibration of NWSRFS indicates that percent volumes errors in the range that we achieved are acceptable.
   - The report does not provide statistics on peak value accuracy. Instead, it provides a comparison of modeled and observed flood hydrograph of June 21-23 of 1997 (Fig. 2-7). The accuracy for this particular event (peak) is not good, only about 66%. No other data was found to judge the model performance on the rest of calibration period (1995 – 2002).
     We understand that the peak flow in the case given is not exact. However, the objective of this project was explained in the section titled "Defining Calibration Goals" as "...attain an unbiased reproduction of historical conditions and a higher level of predictive capability." The unbiasedness of the results are illustrated with quantitative metrics (e.g. Percent Bias, Monthly Bias) listed in Table 2-3. Figure 2-7 shows an example of the latter objective; to show a higher predictive capability. While the results peak flow is not matched, the new model provides a better match than the previously used model.

     In response to the fact that only one event was shown from the seven year period of record, URS believes that for simplicity a representative example event would illustrate the concepts that were used in the calibration process. The quantitative measures given in Table 2-3 are included to represent how the model matches the data over the entire period of record. Model files were submitted along with the report to allow investigation of the entire period of record. Developing a method for including hydrographs from the entire period of record was not practical for this project.
   - The report does not provide statistics on peak time accuracy. Instead, it provides a comparison of modeled and observed flood hydrograph of June 21-23 of 1997 (Fig. 2-7). The accuracy for this particular event (peak) is good. However, no other data was found to judge the model performance on the rest of calibration period (1995 – 2002). See response to previous comment.

6. In general, the accuracy of a flood model should be verified by the runoff data other than used in the calibration. This study does not include model accuracy verification. Therefore, I cannot judge the model accuracy. NWSRFS calibration is not the same as calibration of traditional hydrologic models. Calibration of an NWSRFS model includes all available data. Any knew data that may be used for verification runs

would be assimilated for use with the calibration process. In modeling with NWSRFS the verification process is completed when the model is used in predictive mode and used to predict floods according to established river forecasting center operations. Implementing the predictive mode was not in the scope of the project. This is currently being completed by WGRFC. The objective of this report was to discuss the calibration process not the implementation of the model into use as part of WGRFC operations.

Dam Break Inundation Mapping

1. Add a diagram to show all the parameters in table 3-3 to help the understanding. This diagram has been added (as Figure 3-4a), and replacement pages provided with this response to comments.
2. The Medina dam is 1,580 feet long, but the breach center is at 1,900 feet (table 3-3). Explain. HEC-RAS defines the center of the breach as the distance from the left end of the cross-section to the center of the breach not the left end of the dam. The cross-section used to define the dam location is much wider than the dam itself. 1900 feet from the edge of the cross-section is located approximately half way between the left side of the dam and the emergency spillway. Table 3-3 has been changed to explain this.
3. The table 3-3 should also include all dimensions of the opening of the breach, i.e., height, top width, slopes, and bottom width. Breach height and top width have been added to the table.
4. Should include the arrival time of the dam failure flood peak for the fair weather, 500-year, and PMF scenarios in table 3-4, too. These values have been added to the table.

An Application for Approval of Reclamation Project need not be filed with the Texas Commission on Environmental Quality for the referenced proposal. It was determined from the review that the proposed project is located within communities that participate in the National Flood Insurance Program (NFIP). As a result, any work would require permitting by the local jurisdiction by virtue of its participation in the NFIP, and in accordance with Section 16.236 (d) (3&4) of the Texas Water Code. If the City or County has not already done so, they should insure that the proposed construction is documented and permitted in accordance with their Flood Hazard Prevention Ordinance or Court Order. This documentation should also be submitted by the local jurisdiction to the Federal Emergency Management Agency to obtain a Letter of Map Revision (LOMR) for the affected panels of the appropriate Flood Insurance Rate Maps. Understood.

Concerning Flood Emergency Communications Procedures for the Public, experience within the past 2 years has led the GDEM to think that a Reverse Call Back System is the most cost-effective way of notifying the public of developing emergency flood conditions. However, GDEM also recognizes that a Reverse Call Back System only works to warn people at home or those people that have cell phones. Therefore, this type of Public Warning System is not effective for all areas. Understood.

URS responses to the following San Antonio River Authority comments on the Draft Final Report entitled **"Medina River Regional Flood Protection Planning Study"** are shown in red below.

1. Section 1.1 – Background/Description of Project Area: Could not find Figure 1-1. Please place right under text that references this Figure or no less than a page from its text reference. Figure 1-1 has been inserted.
2. Section 1.3 – The first paragraph states "TWDB approved the grant application under its Regional Flood Planning program and became a 50 percent financial partner in the study." Please make this sentence reflect that they only participated in the Regional Early Warning Study and Dam Break. This change has been made.
3. Section 2.1 – Project Background: Define Stage 3 NEXRAD data. Explanatory text was added to this section.
4. Section 2.2.1 – Subdivide segment: Label BDAT2 and LACT2 sub-basin, as well as further divisions (WMPT2, NPM72, CSRT2) on Figure 2-2. This labeling was performed.
5. Section 2.3.4 – Calibration Results: Table 2-3 explain some of the statistical results. You state that the quantitative measurement parameters are relatively similar and in some cases improved, but you don't give examples of what has been improved. The following text was added:

> For example, the *Percent Bias*, *Monthly Bias,* and *Percent Monthly Volume RMS Error* for both the La Coste and Bandera gage locations were each significantly reduced. Also, the *Daily RMS Error* was reduced for the La Coste gage and for the Bandera gage when the July 2002 storm was not considered in calculating the statistics.

6. Section 4.1 – Background: Correct misspelling of "which" in BMA section. Corrected.
7. Appendix 4C: Could we move this appendix to Chapter 4 and really bring it out in the table of contents. It is very important that this be found in a relatively easy manner. Section 4.4.1 was expanded to include the Appendix 4C information as requested.

1.0 INTRODUCTION

1.1 Background/Description of Project Area

The Medina River originates within Bandera County, and flows through Medina County, then Bexar County where the river joins the San Antonio River. The Medina River watershed upstream of the river junction is mostly situated within Bandera County, Medina County, and Bexar County, with some minor area within Kerr County and Atascosa County (see Figure 1-1). Lake Medina, on the boundary between Bandera and Medina County, is a major reservoir (254,000 acre-feet capacity at the spillway) that has a significant effect on river flooding. A number of municipalities are located along the Medina River and Lake Medina, the largest being Bandera and Castroville. The Medina River watershed above Bandera, Lake Medina Dam, La Coste (near the Bexar County/Medina County border), and the San Antonio River junction covers 427 square miles, 634 square miles, 805 square miles, and over 1,300 square miles, respectively.

Lake Medina Dam, the focus of this study, was constructed between 1911 and 1913. The dam has a crest length of 1,580 feet, a maximum structural height of 165 feet, and, as noted before, 254,000 acre-feet of capacity when full to the elevation of the spillway. The dam is owned and operated by Bexar-Medina-Atascosa Counties Water Control and Improvement District No. 1 (BMA).

1.2 Purpose of Study

During the flood events of July 4 through 6, 2002, severe flooding occurred throughout the Medina River watershed in Bandera, Medina, and south Bexar Counties. In addition, the Texas Commission on Environmental Quality (TCEQ) inspected Lake Medina Dam and declared the dam conditionally unsafe (ref: letter from Chau Vo, TCEQ to BMA Oct 22, 2002) for a flood event that overtopped the dam crest. The flood, the State declaration, and the public events that followed identified a number of issues concerning regional emergency flood response and the operation of Lake Medina Dam which could benefit from further study and regional coordination. These included:

Flood Prediction. The existing flood prediction methodology has significant limitations in prediction of flood peaks and timing upstream of Lake Medina Dam and did not include prediction of maximum lake stage at the dam or downstream of the dam. This complicated emergency response (particularly within Bandera County) and the assessment of whether the dam would overtop, given projected rainfall and upstream runoff conditions.

Inundation Mapping. The existing dam break inundation mapping for Lake Medina Dam could be improved. The existing mapping has the following traits:

- The modeled failure is for a "fair weather failure" (i.e., an instantaneous failure, not concurrent with a flood).
- The mapping terminates 42 miles downstream at a point where, per the 1988 study, "no houses or improvements were in the inundated area" (Willard-Swift Engineers, 1988).

This termination point is in mid-Bexar County, upstream of Von Ormy and the intersection of the Medina River with Potranca Creek.

- The mapping is at a small scale (1:50,000).
- The modeling appears to have been based upon USGS scale (1:24,000) topography.

Regional Emergency Preparation. The 2002 flood event showed the advisability of stronger coordination between emergency management staff at BMA, potentially affected cities (Bandera, Castroville, La Coste) and counties (Bandera, Medina, Bexar, and, less likely, Karnes, Wilson, and Goliad), the regional flood planning agency (San Antonio River Authority), relevant state agencies (State Office of Dam Safety, Department of Transportation, Division of Emergency Management), and the relevant federal agencies (FEMA, National Weather Service River Forecast Center). Improvements could potentially be made in flood prediction and dam safety status information interchange between the agencies and with the public.

1.3 Organization of Study

A grant application was submitted to the Texas Water Development Board (TWDB) in December, 2002 to address the above three issues. Financial sponsors of the application included BMA, the San Antonio River Authority (SARA), Medina County, City of Castroville, and City of La Coste. TWDB approved the grant application under its Regional Flood Planning program and became a 50 percent financial partner in the study. Additional public participants include Bandera County and the Bandera County River Authority.

This study is organized in three sections, described below.

- **Section 2**. This section provides the documentation of procedures used in the development and calibration of a revised River Forecast Model for the Medina River.
- **Section 3**. This section provides the documentation of procedures used and results obtained in mapping the extents of inundation associated with a dam break of Lake Medina Dam.
- **Section 4**. This section deals with discussion of and recommended improvements to regional flood planning and associated emergency management procedures.

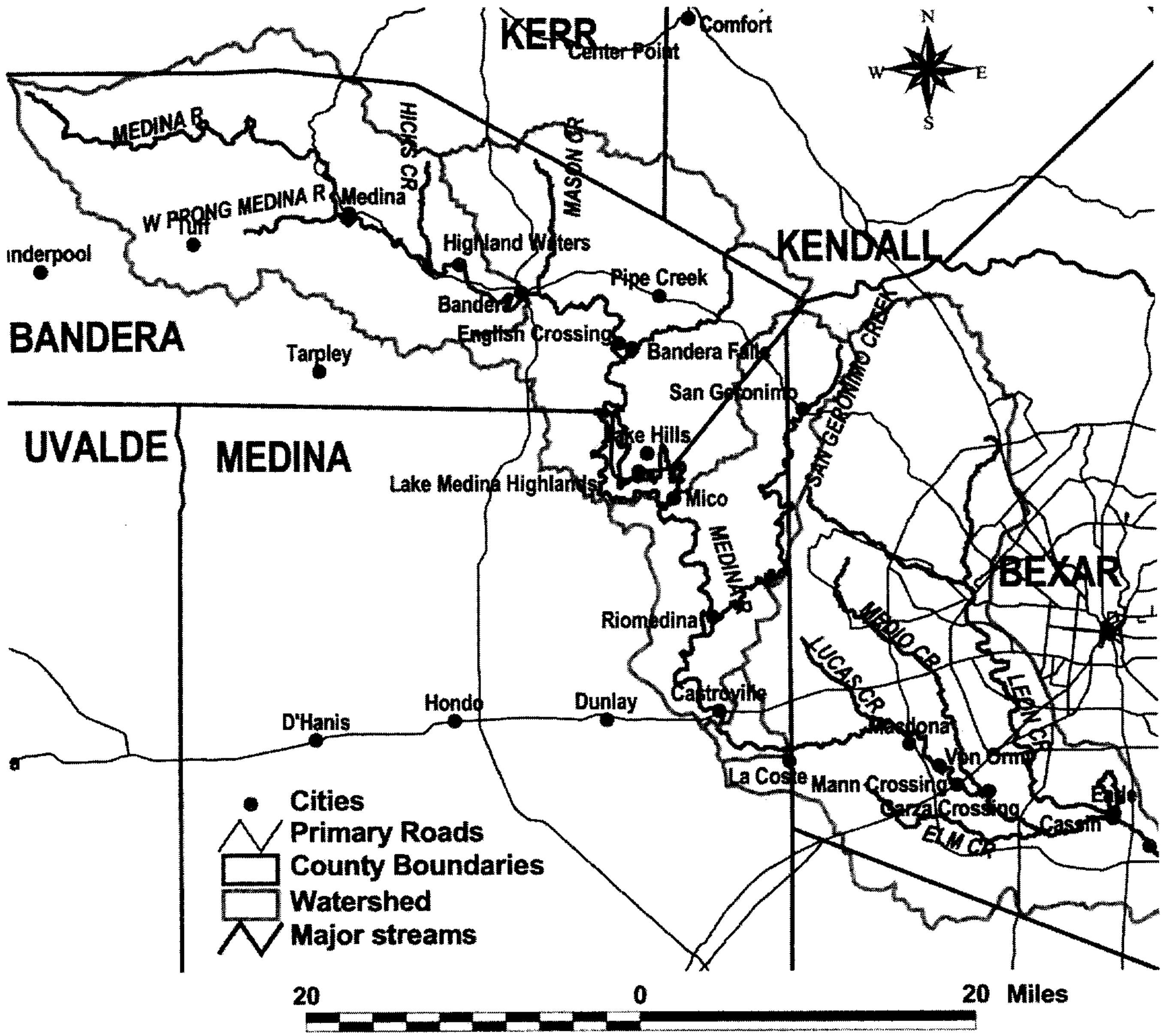

Figure 1-1
Project Area

2.0 REVISED RIVER FORECAST MODEL FOR MEDINA RIVER

As part of the Regional Flood Planning, Medina River Project (BMA Work Order 21, Project 80871221), URS Corporation was tasked with the assignment of modifying the National Weather Service River Forecasting System (NWSRFS) model for Bandera, Medina, and La Coste watersheds to run on hourly timesteps and calibrating the model using hourly XMRG data. The object of this report is to outline the methods and parameters used to accomplish this task. The report is broken up into the following sections:

- Project Background;
- NWSRFS Model Setup at URS Austin;
- Updating Model Inputs; and
- Model Calibration.

These topics are discussed below.

2.1 Project Background

The West Gulf River Forecast Center (WGRFC) of the National Weather Service (NWS) operates the NWSRFS model to make river forecasts for major river systems within the WGRFC boundaries. Figure 2-1 shows the extent of the WGRFC boundaries. It includes a close-up of the boundaries of the current sub-basins above the Bandera gage (BDAT2), at Medina Lake (MDLT2), and above the La Coste gage (LACT2). These sub-basins comprise the NWSRFS for the Medina River above Bexar County.

The current NWSRFS predicts streamflows and stage at these locations on a 6-hour timestep based on hourly rainfall data from the Stage 3 NEXRAD data. Stage 3 NEXRAD data consist of precipitation measurements for each 4 x 4 km^2 of the model domain. The measurements are a composite of radar data that have been compared and adjusted to more closely match measurements taken at rain gaging locations. The 6-hour timestep is potentially a significant limitation of the model, particularly for Bandera, which is located at the headwaters for the Medina River with an approximate lag time (i.e., time for water to run from the edge of the watershed to the gage) between 4 and 6 hours. For this reason, the existing model potentially underestimates the predicted peak at Bandera. Model timesteps typically should be less than one-fourth of the lag time, to ensure that the predicted peak is not averaged over too long a time period. The 6-hour timestep is also a significant limitation to the model's usefulness in predicting the peak reservoir stage at Lake Medina Dam, for the same reason. The significance is increased because of the relatively short estimated travel time of a dam break wave from Lake Medina to Castroville (2 hours).

Decreasing the model timestep to a 1-hour timestep would benefit the usefulness of the model as a predictive tool for residents within these watersheds. For this purpose, the process of model upgrading and recalibration was undertaken.

2.2 Updating Model Inputs

The next step to enhance the NWSRFS model for the Medina River above the La Coste gage is to update the NWSRFS input files for operating on an hourly timestep. The primary tasks to accomplish this are: 1) subdivide the segments where desired; 2) generate 1-hour unit hydrographs for all segments and recalculate routing parameters where necessary; and 3) recalibrate the segments along the Medina River including adjustment Sacramento soil moisture accounting (SAC-SMA) parameters and adjustments to unit hydrographs and routing parameters.

2.2.1 Subdivide Segments

Figure 2-2 shows the location of existing and new boundaries and outlet locations for sub-watersheds on the Medina River above Bexar County. Two sub-watersheds were added within the BDAT2 sub-basin (WMPT2 and NPMT2), and a sub-basin was added within the LACT2 sub-basin (CSRT2) with an outlet at the city of Castroville. Subdividing BDAT2 will enhance the ability of NWSRFS to improve flood prediction at the BDAT2 gage. Also, adding a gage location at the city of Castroville (CSRT2) would give the model the ability to predict floods in this area where predictions have not been carried out prior to this update. Figure 2-2 shows a comparison of the sub-basin areas between the current and enhanced models.

Where possible, existing watershed boundaries were used to remain consistent with previous modeling efforts of the WGRFC. New sub-basin boundaries were located based on USGS 10-ft contours of the area. All boundary coordinates were exported to text files and used to update sub-basin boundaries in the operational side of NWSRFS.

2.2.2 Calculate 1-Hour Unit Hydrographs and Routing Parameters

The SCS unit hydrograph method was used for creating 1-hour interval unit hydrographs based on the basin areas computed in the previous task. A detailed description of this process is included in the "Unit Hydrograph Calculation File" and the "Routing Calculation File" included in Appendices 2B and 2D, respectively. The SCS unit hydrograph method requires basin area and time of concentration to produce a unit hydrograph. Lag times for each sub-basin were derived from rainfall and runoff hydrographs. Figure 2-3 shows an example hydrograph that was used for determining lag time for the Bandera sub-basin.

Figure 2-4 shows the initial unit hydrographs created for use with the NWSRFS model. It was anticipated that changes would be made to these hydrographs during the calibration process, especially in the new sub-basins where no observed hydrographs are available. The final unit hydrographs used for the calibrated models are presented in the "Model Calibration" section.

2.2.3 Gather Historical Data Time Series

Several historical data sets were needed to perform a calibration on an hourly timestep. These data sets include:

- Rainfall Data;
- Stream Flow Data; and
- Evaporation Data.

Acquiring and creating these data sets are discussed in the following sections.

Rainfall Data

Rainfall data used for the calibration of NWSRFS are stored in files called MAPX time series files. The MAPX time series is comprised of rainfall data developed from XMRG data. XMRG is a type of file format that stores variable precipitation amounts over a large region. In our case, XMRG files store all precipitation amounts for the entire WGRFC region. This is over 100,000 measurements for each 1-hour time period. NWSRFS contains programs that will develop MAPX time series files based on XMRG rainfall data. To create these datasets, the basin boundaries and the XMRG data for the desired period are needed. XMRG data were received from NWS WGRFC for the period from January 1995 to December 2002. Basin boundaries used for creating the data sets were taken from steps previously discussed in "Subdividing Segments". The 'mapx' executable was used to create the historical MAPX time series used for the calibration.

Stream Flow Data

URS received hourly stream flow data for both the Bandera and La Coste gages from the San Antonio office of the USGS. The timeframe of the Bandera gage is January 1995 to September 2003 and the La Coste gage is January 1995 to September 2000. Measurements at the La Coste gage were discontinued after water year 2000. These data sets were converted to NWS CARD format using Microsoft Excel Macros for use with NWSRFS.

Evaporation Data

Evaporation data for NWSRFS are stored in time series file titled MAPE time series. The current calibration was completed using daily evaporation data. However, the MAPE time series used in the current model did not span the timeframes of hourly data obtained for the updated model. URS determined the best available MAPE data could be found from the Texas Water Development Board (TWDB, 2002). Selecting this dataset is described in detail in Appendix 2C "PET Development". The TWDB maintains a website that lists historical monthly evaporation data. The data were obtained from the TWDB for the period from 1991 through 2002. The monthly values were distributed evenly throughout each month to produce daily values of evaporation. These values were converted to NWS CARD format using Microsoft Excel Macros for use with NWSRFS.

Water Balance

The datasets described in this section were used to compute a water budget for the BDAT2 sub-basin. This water balance is included in Appendix 2A. The water balance provided insight into possible data gaps and time periods where the water balance was not reflected by the collected data sets. This was used to assist in developing a strategy for calibrating the NWSRFS model.

2.2.4 Edit/Create MCP3 Input Decks

Manual Calibration Program (MCP3) and Interactive Calibration Program (ICP) are the pieces of NWSRFS used for calibrating sub-basin parameters. MCP3 and ICP use input files called decks, one for each calibration point, that contain all of the model parameters that will be changed as part of the calibration process. Some example parameters included in the input decks are the Sacramento soil moisture accounting parameters, routing information, and sub-basin connectivity. The current model input decks were used as a starting point for this task. These input decks were altered to include parameters and connectivity for the new sub-basins and changes to the primary time interval from a 6-hour interval to a 1-hour interval. A printout of the input decks used for calibration are located in Appendix 2E.

2.3 Model Calibration

Model calibration is the process of altering model input parameters until a reasonable match between observed data and model predicted data has been achieved. The goal of this section is to discuss the steps taken to achieve a reasonably calibrated model for the NWSRFS model on the Medina River above Bexar County and compare it to the previous calibration. This is discussed in the following sections:

- Defining Calibration Goals;
- Calibration Approach;
- Parameter Changes; and
- Calibration Results.

2.3.1 Defining Calibration Goals

The main goal of the calibration process is to attain an unbiased reproduction of historical conditions and a higher level of predictive capability. Comparison of field observed measurements and simulated output can be accomplished by quantitative and qualitative methods. Some of the quantitative approaches include: bias, volume error, correlation coefficient, root mean squared error (RMS), and graphical methods. Further, qualitative methods include visual inspection of observed and simulated hydrographs and comparing model input parameters to acceptable limits. Following guidance provided to URS by WGRFC personnel, several of these methods were used in the calibration of the new model. They are:

1. Produce a good reproduction of the observed hydrograph.
2. The model parameters should function as they are intended.
3. There should be a realistic variation in parameter values from one area to adjacent areas.
4. Obtain a near zero water balance, that is, an overall bias for the calibration period of less than 5%.
5. Obtain a reasonable estimation of baseflow.
6. Adjust parameters to give a good simulation for major rises.

These metrics were defined to address any concerns that might hinder acceptance of the calibrated model.

2.3.2 Calibration Approach

Guidance for calibrating NWSRFS models using the Sacramento Soil Moisture Accounting parameters was obtained from North Central River Forecast Center (NCRFC). The document, found in Appendix 2B, outlines a systematic approach for calibrating NWSRFS models. The calibration utilized this approach in the following steps:

- Step 1 – Model input data sets should be checked and rechecked until the "Year Average Percent Bias" is within 10 percent. Parameter fine tuning should not begin until this is accomplished
- Step2 – Adjust parameters that affect the baseflow.
- Step 3 – Adjust snow parameters if they are significant. Since snow is insignificant for our sub-basins, this step was skipped.
- Step 4 – Adjust the tension water capacities.
- Step 5 – Adjust parameters that affect storm runoff, including the additional impervious percent (ADIMP).
- Step 6 – Final adjustments to the unit hydrograph and riparian vegetation parameters can be made to improve the match of predicted and observed flow data.

These steps were followed to achieve the calibration results discussed in the next two sections.

2.3.3 Parameter Changes

Adjustment to input parameters is the manner to obtain a more reasonable calibration. For calibration of a numerical model, the adjustments are carried out in an iterative process until a "best fit" is found. For calibration of NWSRFS, several adjustments were made to model input parameters to obtain the "best fit". These adjustments included changing:

- Rainfall Data;
- Unit Hydrographs and Routing;
- Evapotranspiration; and
- SAC-SMA Parameters.

The changes made to each of these datasets are discussed below.

Rainfall Data

MAPX time series created for calibration of NWSRFS were discussed in the section "Model Parameters – Rainfall Data". During calibration, a discrepancy was discovered concerning rainfall totals reported using XMRG data and totals collected from rainfall gage stations near and within the watershed. This was discovered due to a difference in the observed and predicted hydrographs at the BDAT2 prediction point for a storm event that occurred from June 21- 23, 1997.

Initially, when the difference in the observed and predicted hydrographs was discovered, model parameters such as unit hydrographs and SAC-SMA parameters were adjusted to produce a more reasonable fit between the hydrographs. These attempts were unsuccessful. Finally, the totals from the XMRG data and the rainfall gage stations were compared. The locations and rainfall totals of the rainfall gage stations are shown in Figure 2-5. The observed rainfall at the gage locations shows that total rainfall in the basin was more likely greater than shown by XMRG data.

Based on these findings, the MAPX time series were adjusted to reflect the larger amount of rainfall over the three-day period. However, the percent distribution of the rainfall was not altered. The same comparison was completed for the XMRG and rain gage data for the MDLT2, CSRT2, and LACT2 basins. However, the rainfall totals for these basins were reasonably close to the gaged values and were left unaltered.

Unit Hydrographs and Routing

The unit hydrographs and routing parameters used initially for running the NWSRFS were altered to produce runoff hydrographs that more closely resembled the observed hourly runoff hydrographs. Figure 2-4 shows the initial unit hydrographs and routing parameters used. Figure 2-6 shows the observed and predicted runoff hydrographs calculated using the unit hydrographs shown in Figure 2-4. The volume of runoff is approximately the same; however, the observed runoff hydrograph shows a quicker response with higher peaks. To match this response, the unit hydrographs were regenerated using shorter lag times. This is consistent with NWSRFS (NWS, 19XX) User's Manual, Part 2, Section 4. It states that a shorter duration and higher intensity unit hydrograph may be more appropriate than a traditional unit hydrograph when it is used with the SAC-SMA model. Figure 2-6 shows the unit hydrographs and lag times used in the final calibration of NWSRFS. Figure 2-7 shows the resulting predicted runoff hydrograph at BDAT2. The use of the new unit hydrographs improved the match to the observed runoff hydrograph.

Evapotranspiration

During calibration, the amount of simulated evapotranspiration occurring was too great for the model to produce the observed runoff. Appendix 2A, "Water Balance" contains a detailed water balance of the BDAT2 sub-basin runoff hydrograph. It discusses actual evapotranspiration (AET) versus PET. The water balance found that, on average, the AET is only 31 percent of the PET. Therefore, the PEADJ parameter was altered to decrease the amount of simulated evapotranspiration. The final PEADJ factor used for BDAT2 was 0.595.

SAC-SMA Parameters

Table 2-1 and Table 2-2 show a summary of the changes made to model input parameters during the calibration process. The table includes the parameter name, a parameter description, the

Table 2-1. SAC-SMA Parameter Comparison of Current and Updated NWSRFS Models for Subbasins BDAT2, NMP2, and WMPT2

Parameters	Description	Acceptable Range	Current Model Values	Updated Model Values	Explanation
PXADJ	Precipitation Adjustment Factor	0.8-1.3	1	1	
PEADJ	Potential Evaporation Adjustment Factor	0.8-1.1	1	1	This accounted for the ratio of AET/PET discussed in the water balance calculation sheet.
PCTIM	Precent Impervious	0.0-0.1	0	0	
ADIMP	Additional impervious for wet conditions	0.0-0.2	0	0.005	Lowered to decrease runoff from smaller storm events
UZTWM	Upper zone tension water maximum (mm)	10-150	81	25	Increased the amount of runoff after dry periods
UZFWM	Upper zone free water maximum (mm)	10-100	57	61	Raised to increase the amount of percolation and slow recession of hydrograph
UZK	Upper zone free water depletion coefficient	0.1-0.6	0.2	0.1	Lowered to slow the recession of the flow hydrograph
ZPERC	Percolation demand factor	5-200	213	13	Adjusted percolation rates
REXP	Percolation demand exponent	1-5	2.37	1.01	
PFREE	Fraction of direct percolation	0.0-0.6	0.02	0.4	Increased the amount of percolation
LZTWM	Lower zone tension water maximum (mm)	50-700	410	55	Slowed recession of flow hydrographs
LZFPM	Lower zone primary free water maximum (mm)	5-1000	125	325	Increased the volume of baseflow
LZPK	Lower zone primary free water depletion coefficient	0.001-0.2	0.044	0.003	Improved match to baseflow portion of hydrograph
LZFSM	Lower zone secondary free water maximum (mm)	10-300	45	50	
LZSK	Lower zone secondary free water depletion coefficient	0.02-0.25	0.122	0.121	Improved match to baseflow portion of hydrograph
RSERV	Fraction of reserved lower zone free water	0.25-0.3	0.3	0.3	
RIVA	Riparian vegetation factor	0-0.1	0	0.008	Baseflow portions of the observed hydrograph showed signs of riparian evapotranspiration.
SIDE	Ratio of unobserved to observed baseflow	No Value	0	0.2	Represents amount of water that supplies deep recharge. This accounts for water that recharges deep aquifers.

Table 2-2. SAC-SMA Parameter Comparison of Current and Updated NWSRFS Models for Subbasins MDLT2, LACT2, and CSRT2

Parameters	Description	Acceptable Range	Current Model Values	Updated Model Values	Explanation
PXADJ	Precipitation Adjustment Factor	0.8-1.3	1	1	
PEADJ	Potential Evaporation Adjustment Factor	0.8-1.1	0.935	0.595	This accounted for the ratio of AET/PET discussed in the water balance calculation sheet.
PCTIM	Precent Impervious	0.0-0.1	0	0	
ADIMP	Additional impervious for wet conditions	0.0-0.2	0.2	0.05	Lowered to decrease runoff from smaller storm events
UZTWM	Upper zone tension water maximum (mm)	10-150	28	35	Decreased the amount of runoff after dry periods
UZFWM	Upper zone free water maximum (mm)	10-100	51	64	Raised to increase the amount of percolation and slow recession of hydrograph
UZK	Upper zone free water depletion coefficient	0.1-0.6	0.399	0.15	Lowered to slow the recession of the flow hydrograph
ZPERC	Percolation demand factor	5-200	38	13	Adjusted percolation rates
REXP	Percolation demand exponent	1-5	1.01	1.01	
PFREE	Fraction of direct percolation	0.0-0.6	0.3	0.4	Increased the amount of percolation
LZTWM	Lower zone tension water maximum (mm)	50-700	327	71	Slowed recession of low hydrographs
LZFPM	Lower zone primary free water maximum (mm)	5-1000	195	325	Increased the volume of baseflow
LZPK	Lower zone primary free water depletion coefficient	0.001-0.2	0.027	0.007	Improved match to baseflow portion of hydrograph
LZFSM	Lower zone secondary free water maximum (mm)	10-300	49	50	
LZSK	Lower zone secondary free water depletion coefficient	0.02-0.25	0.161	0.121	Improved match to baseflow portion of hydrograph
RSERV	Fraction of reserved lower zone free water	0.25-0.3	0.3	0.3	
RIVA	Riparian vegetation factor	0-0.1	0	0.011	Baseflow portions of the observed hydrograph showed signs of riparian evapotranspiration.
SIDE	Ratio of unobserved to observed baseflow	No Value	0	0	

initial parameter value, the final parameter value, and an explanation of the changes made during the calibration.

2.3.4 Calibration Results

The goals of calibration were to improve the match between the predicted runoff hydrograph and the observed runoff hydrograph. The goals of the calibration were defined in "Defining Calibration Goals". The results will be discussed in terms of the listed goals described in this section.

1. *Produce a good reproduction of the observed hydrograph.* – Table 2-3 contains a listing of quantitative measurements of the reproduction of the observed hydrograph by the current and updated NWSRFS. The parameters are relatively similar and in some cases improved. For example, the *Percent Bias, Monthly Bias,* and *Percent Monthly Volume RMS Error* for both the La Coste and Bandera gage locations were each significantly reduced. Also, the *Daily RMS Error* was reduced for the La Coste gage and for the Bandera gage when the July 2002 storm was not considered in calculating the statistics.
2. *The model parameters should function as they are intended.* – Table 2-1 and Table 2-2 have a listing of the SAC-SMA parameters, including a range of reasonable values for each parameter. Only one parameter is outside the "reasonable" range. This is PEADJ for the BDAT2, NMPT2, and WMPT2 sub-basins. This parameter was calibrated based on the discussion found in the previous section.
3. *There should be a realistic variation in parameter values from one area to adjacent areas.* – The SAC-SMA parameters listed in Table 2-1 and Table 2-2 show little variation in parameters from sub-basin to sub-basin. This is different from the current model. The initial parameters listed for BDAT2, MDLT2, and LACT2 vary greatly between the two basins. Less variation would be expected of similar basins. The updated calibration shows less variation between similar types of basins.
4. *Obtain a near zero water balance, that is, an overall bias for the calibration period of less than 5 percent.* - Table 2-3 shows the measure of water balance in the "Year Average Percent Bias" column. For BDAT2 and LACT2, the percent bias is approximately 1 percent in both cases.
5. *Obtain a reasonable estimation of baseflow.* – Figure 2-8 shows identical portions of the predicted and observed runoff hydrographs for the current and updated NWSRFS model SAC-SMA parameters. They are plotted on a semi-log scale for better comparison of the baseflow portion of the hydrograph. Based on visual inspection, the updated model produces a reasonable match of the baseflow.
6. *Adjust parameters to give a good simulation for major rises.* – Figure 2-9 and 2-10 show major rises within the calibration period of record for the BDAT2 and LACT2 runoff hydrographs, respectively. Each shows a major rise in the predicted hydrograph that corresponds to the observed hydrograph.

Based on the discussion above, URS believes the calibration of the BDAT2, NMPT2, WMPT2, LACT2, MDLT2, and CSRT2 sub-basins is reasonable.

Table 2-3. Comparison of Current and Updated NWSRFS Model Quantitative Calibration Statistics

	La Coste Gage Year Average		Bandera Gage Year Average		Bandera Gage w/o 7/2002 Year Average	
Parameter	Current	Calibrated	Current	Calibrated	Current	Calibrated
Year Average Statistics						
Simulated Mean (CMSD)	1.097	2.576	3.591	4.853	2.026	3.293
Observed Mean (CMSD)	2.552	2.552	4.79	4.79	3.452	3.452
Percent Bias	-57.02	0.94	-27.41	1.31	-42.74	-4.61
Monthly Bias (MM)	-167.464	2.627	-38.487	1.209	-42.823	-5.281
Maximum Error (CMSD)	-293.688	-176.686	-293.688	469.507	-442.941	-144.452
Percent Average Absolute Error	65.35	61.84	65.35	50.43	60.31	52.29
Percent Daily RMS Error	440.39	266	440.39	266.99	307.89	156.09
Max Montly Volume Error (MM)	-386.41	-196.21	-386.41	-29.839	-65.317	-29.839
Percent Average Absolute Monthly Volume Error	62.98	50.59	62.98	35.08	53.98	46.1
Percent Monthly Volume RMS Error	206.82	124.65	206.82	56.63	110.05	75.84
Period of Record Statistics						
Daily RMS Error (CMSD)	11.2	6.811	11.2	12.788	10.896	5.388
Daily Average Absolute Error	1.668	1.578	1.668	2.415	2.134	1.805
Average Absolute Monthly Error	15.54	12.484	15.54	3.995	4.542	3.784
Montly Volume RMS Error (MM)	51.035	30.7	51.035	6.45	9.26	6.225
Correlation Coeficient Daily Flows	0.1455	0.8045	0.1455	0.8925	0.4818	0.9033

Current = statistics for existing NWS model for Medina River
Calibrated = statistics for updated NWS model for Medina River
MM – millimeters of depth of runoff volume over entire watershed
CMSD = Cubic meters per second per day
RMS = Root Mean Square

Table 2-3. Comparison of Current and Updated NWSRFS Model Quantitative Calibration Statistics

	La Coste Gage		Bandera Gage		Bandera Gage w/o 7/2002	
	Year Average		Year Average		Year Average	
Parameter	Current	Calibrated	Current	Calibrated	Current	Calibrated
Year Average Statistics						
Simulated Mean (CMSD)	1.097	2.576	3.591	4.853	2.026	3.293
Observed Mean (CMSD)	2.552	2.552	4.79	4.79	3.452	3.452
Percent Bias	-57.02	0.94	-27.41	1.31	-42.74	-4.61
Monthly Bias (MM)	-167.464	2.627	-38.487	1.209	-42.823	-5.281
Maximum Error (CMSD)	-293.688	-176.686	-293.688	469.507	-442.941	-144.452
Percent Average Absolute Error	65.35	61.84	65.35	50.43	60.31	52.29
Percent Daily RMS Error	440.39	266	440.39	266.99	307.89	156.09
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Percent Monthly Volume RMS Error	206.82	124.65	206.82	56.63	110.05	75.84
Period of Record Statistics						
Daily RMS Error (CMSD)	11.2	6.811	11.2	12.788	10.896	5.388
Daily Average Absolute Error	1.668	1.578	1.668	2.415	2.134	1.805
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Current = statistics for existing NWS model for Medina River
Calibrated = statistics for updated NWS model for Medina River
MM = millimeters of depth of runoff volume over entire watershed
CMSD = Cubic meters per second per day
RMS = Root Mean Square

2.3.5 Conclusion

The purposes of updating the NWSRFS model for the Medina River above Bexar County were to change the 6-hour operating timestep currently used to a 1-hour timestep and to update the input parameters to improve the flood prediction at locations along the Medina River. Through a combination of adding forecasting locations and updating model parameters, the project was able to accomplish both tasks.

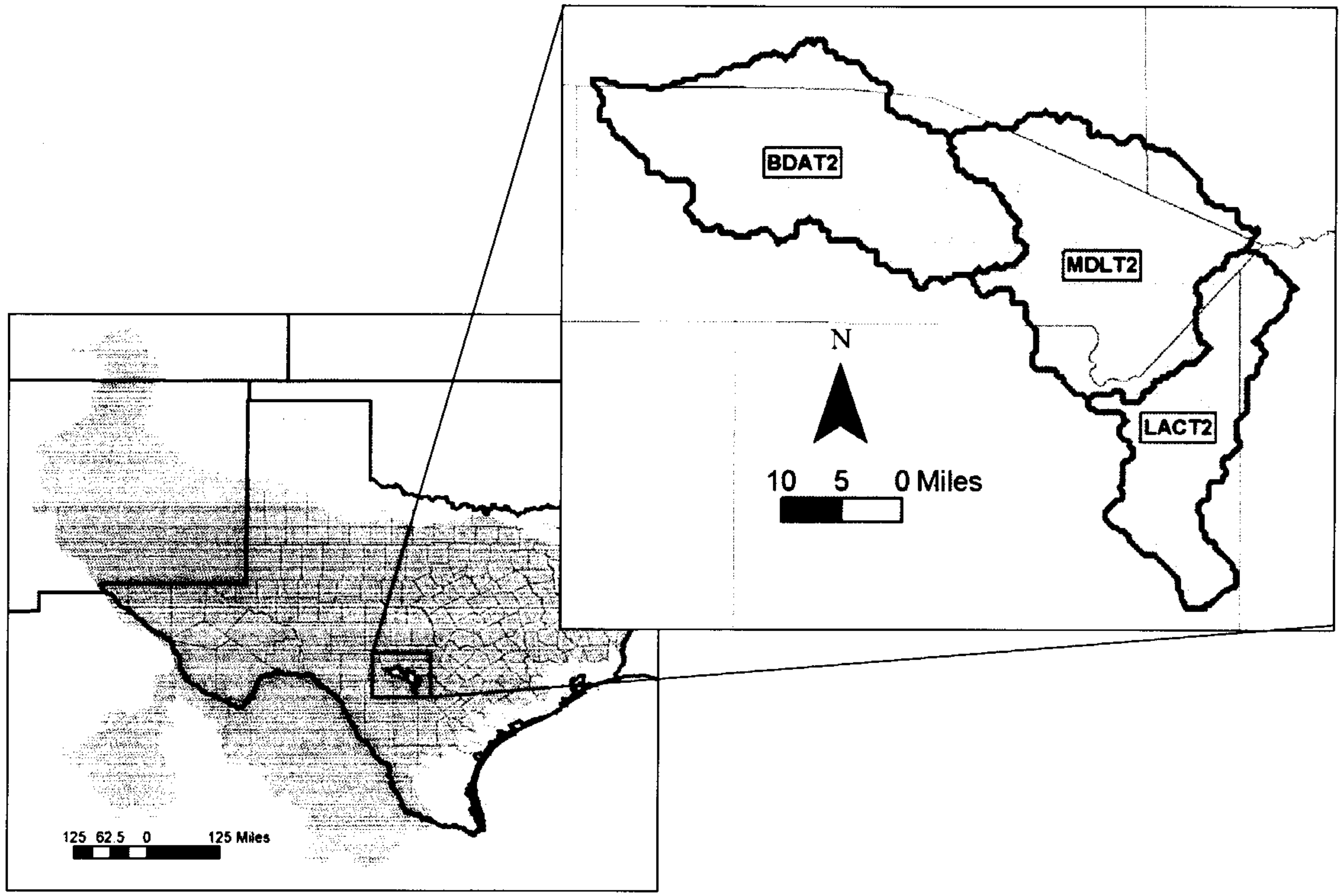


Figure 2-1 – Extent of West Gulf River Forecast Center NWSRFS modeling responsibilities. The scope of this project includes the BDAT2, MDLT2 and LACT2 sub-basins of the NWSRFS model.

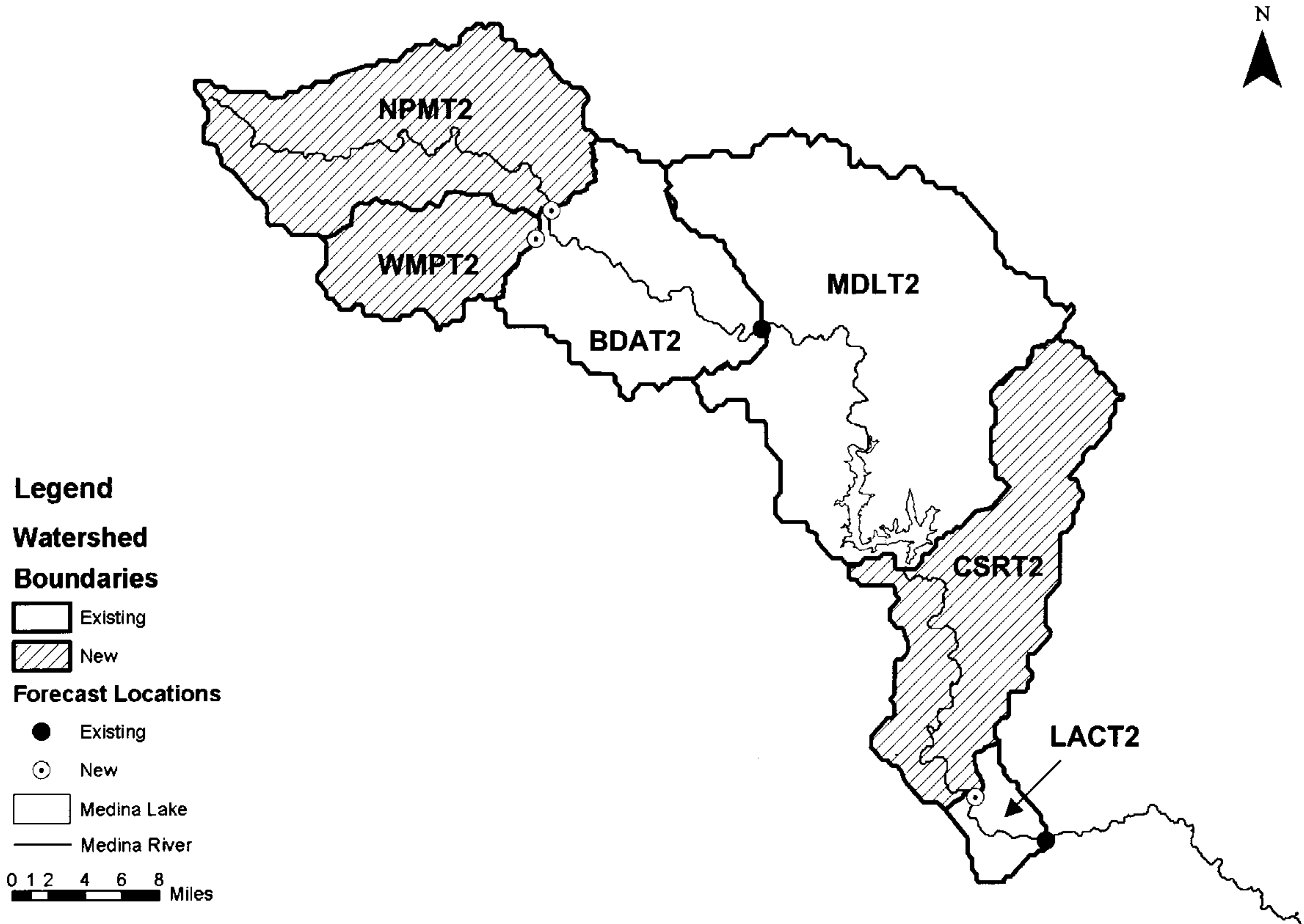


Figure 2-2. Boundary and outlet locations of existing and new sub-basins used for predicting flow in the Medina River with NWSRFS.

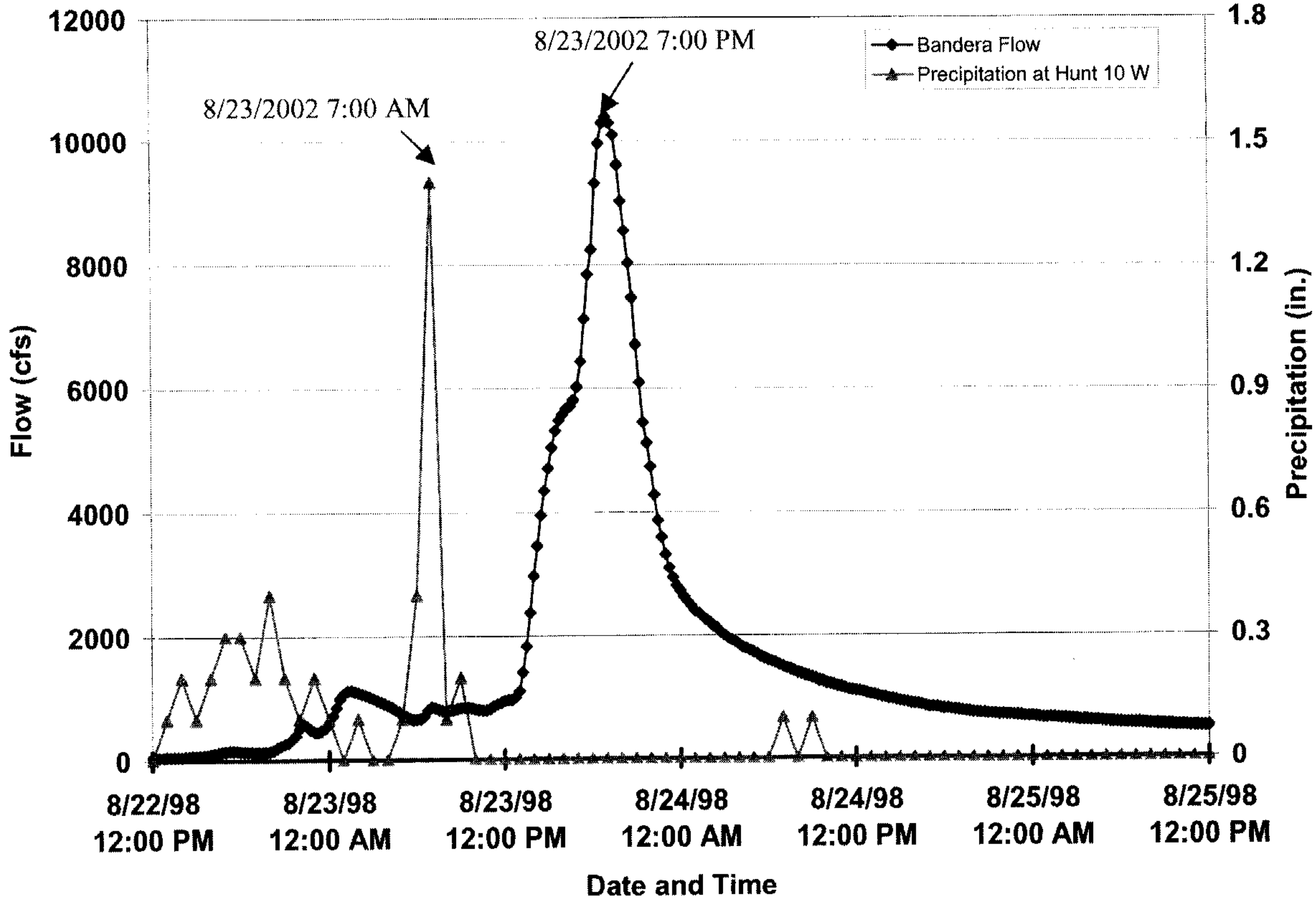
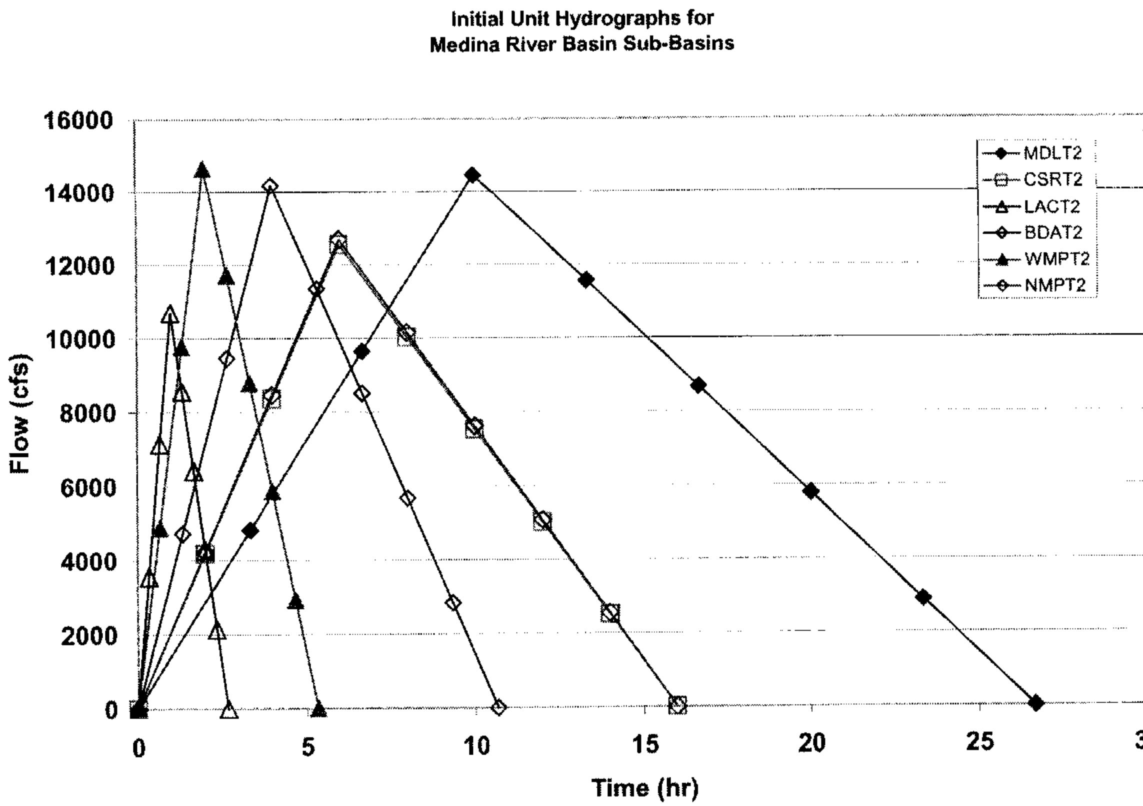
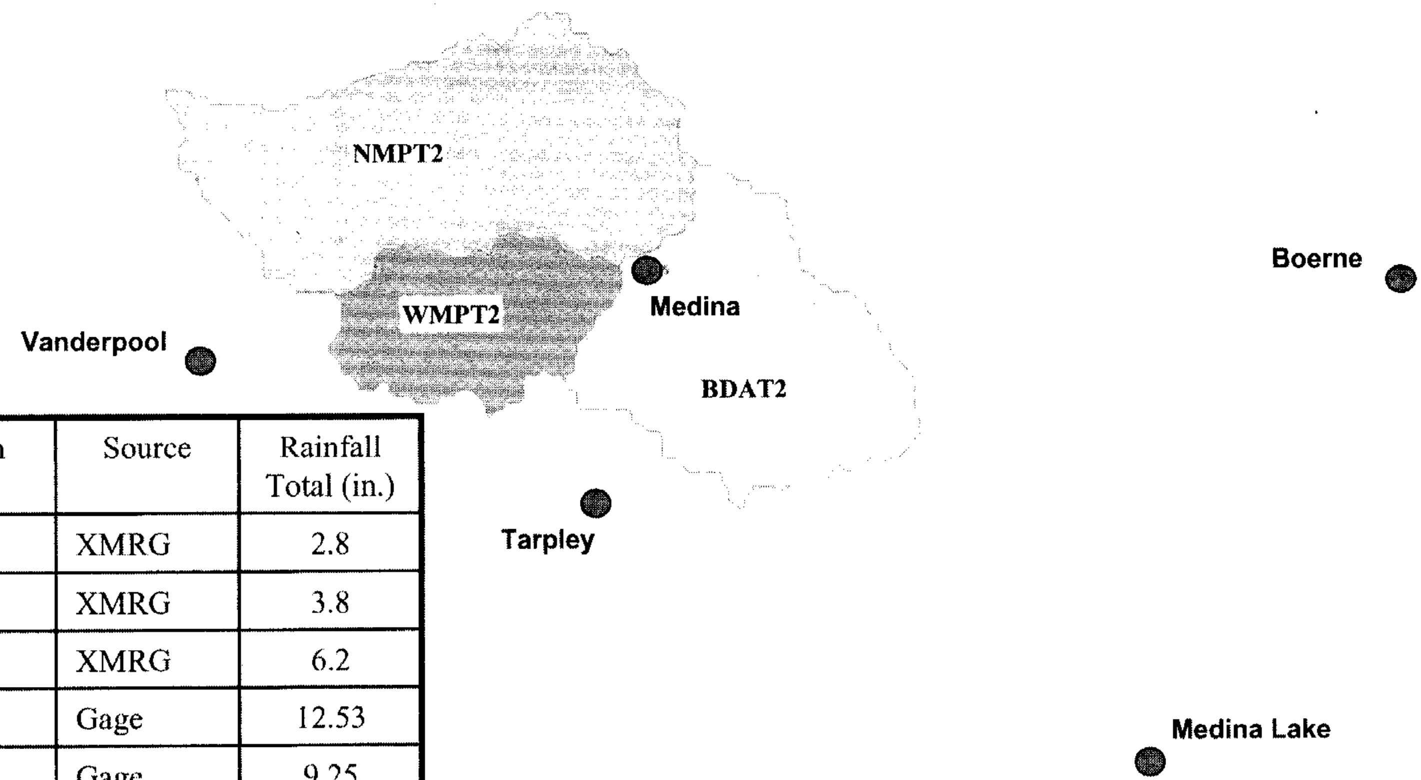


Figure 2-3. Precipitation and Streamflow hydrographs used to determine lag time of the Bandera sub-basin.



Basin	Stream Length (m)	Muskingum	
		K (hrs)	x
BDAT2	32861	9	0.2
MDLT2	46384	13	0.2
CSRT2	37335	10	0.2

Figure 2-4. Unit hydrographs developed from lag time estimates of BDAT2 for initial inputs into NWSRFS.



Location	Source	Rainfall Total (in.)
NMPT2	XMRG	2.8
WMPT2	XMRG	3.8
BDAT2	XMRG	6.2
Boerne	Gage	12.53
Medina	Gage	9.25
Medina Lake	Gage	9.99
Tarpley	Gage	10.46
Vanderpool	Gage	5.46

Figure 2-5. Comparison of rainfall for the June 21-23, 1997 storm event above the BDAT2 gage.

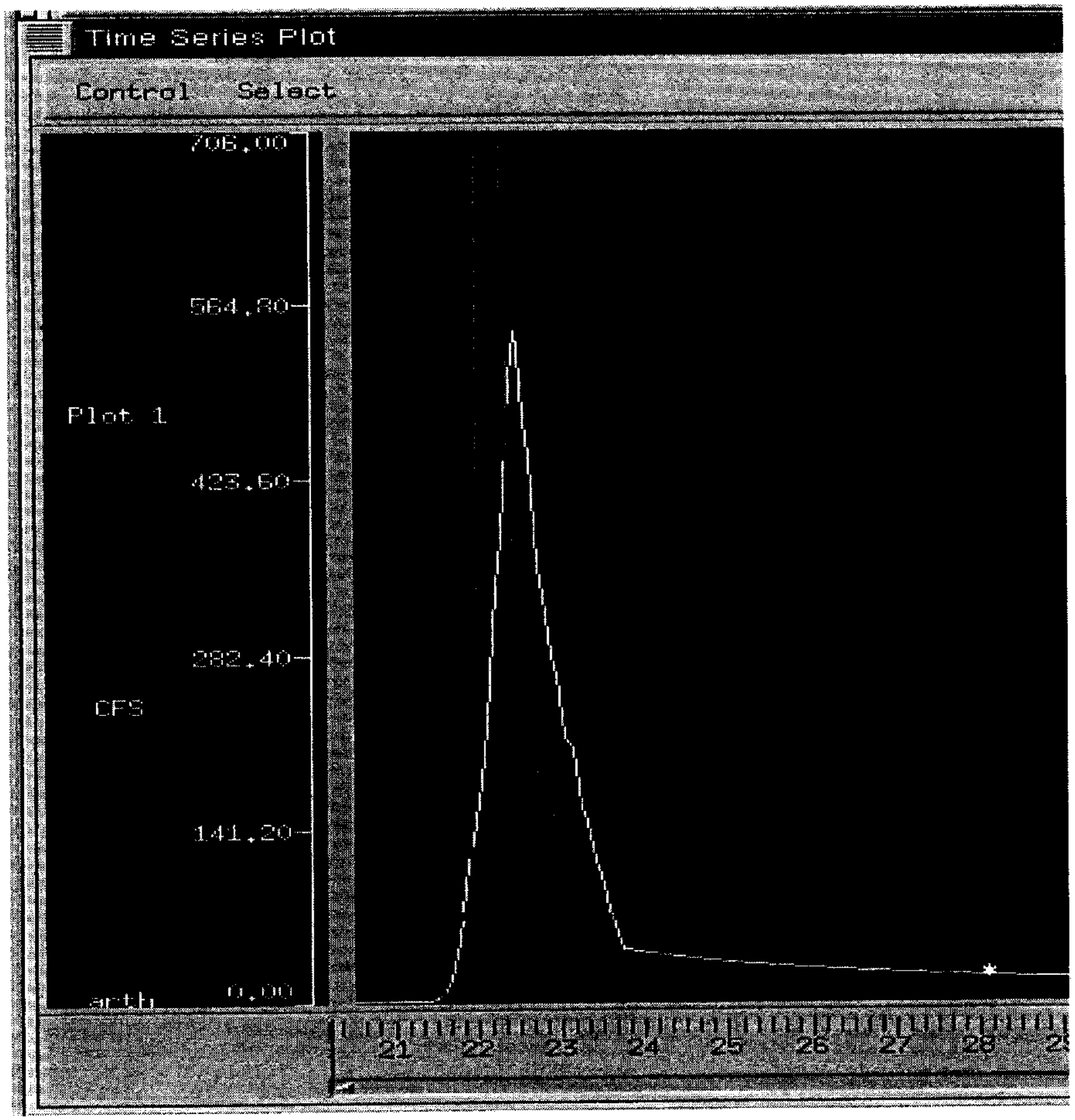


Figure 2-6. Comparison of predicted and observed runoff hydrographs using initial unit hydrographs.

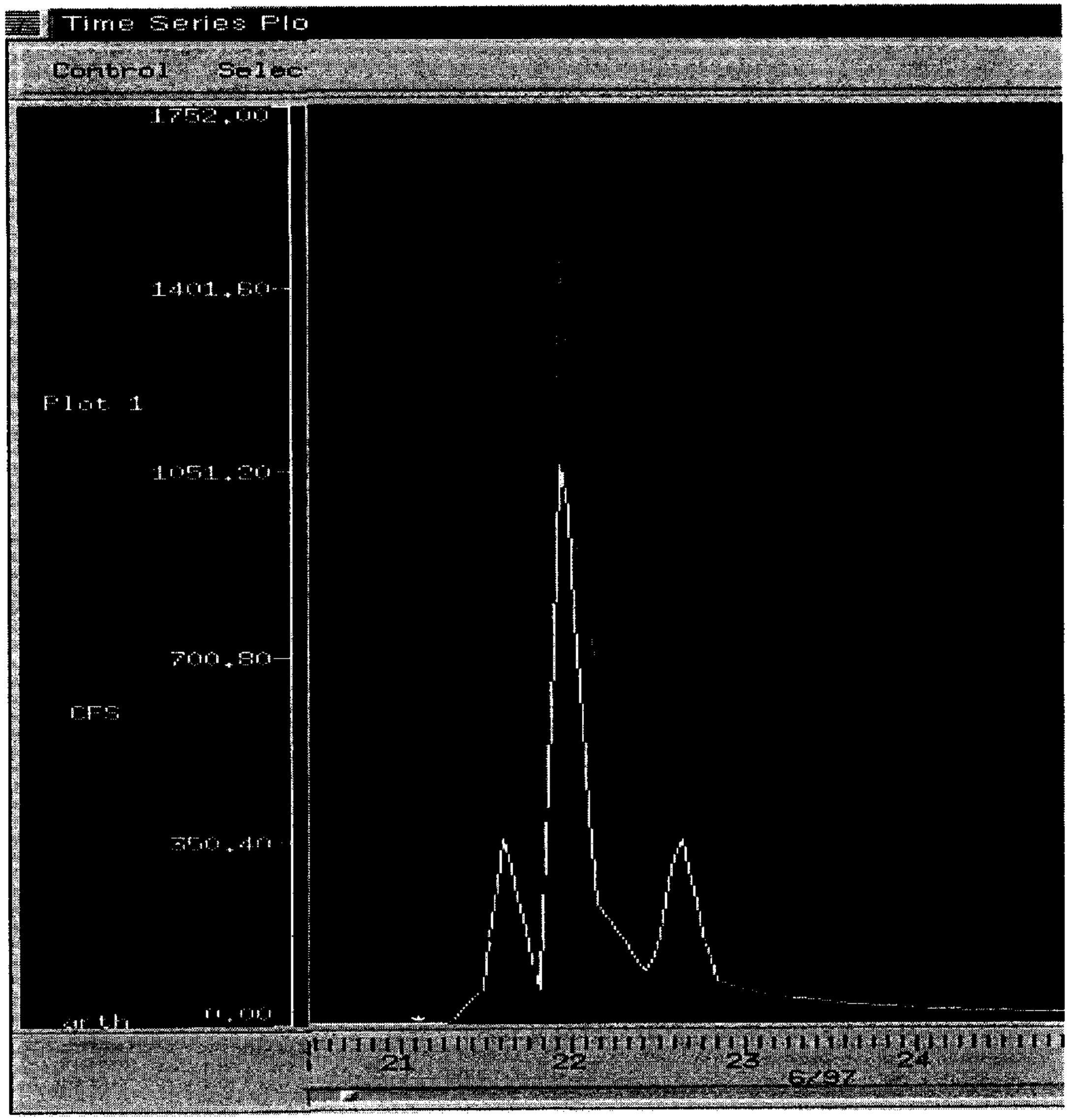
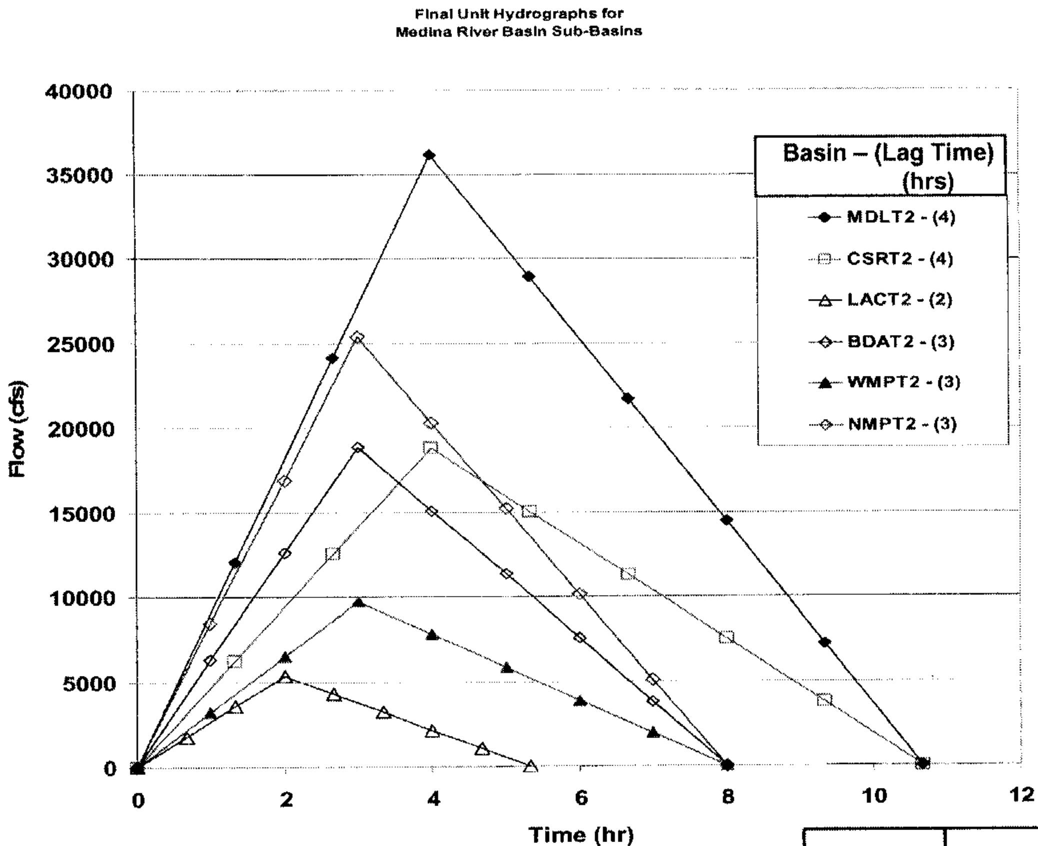


Figure 2-7. Comparison of predicted and observed runoff hydrographs using final unit hydrographs.



Basin	Stream Length (m)	Muskingum K (hrs)	Muskingum x
BDAT2	32861	7	0.2
MDLT2	46384	4	0.2
CSRT2	37335	1	0.2

Figure 2-8. Final unit hydrographs developed during calibration phase of NWSRFS.

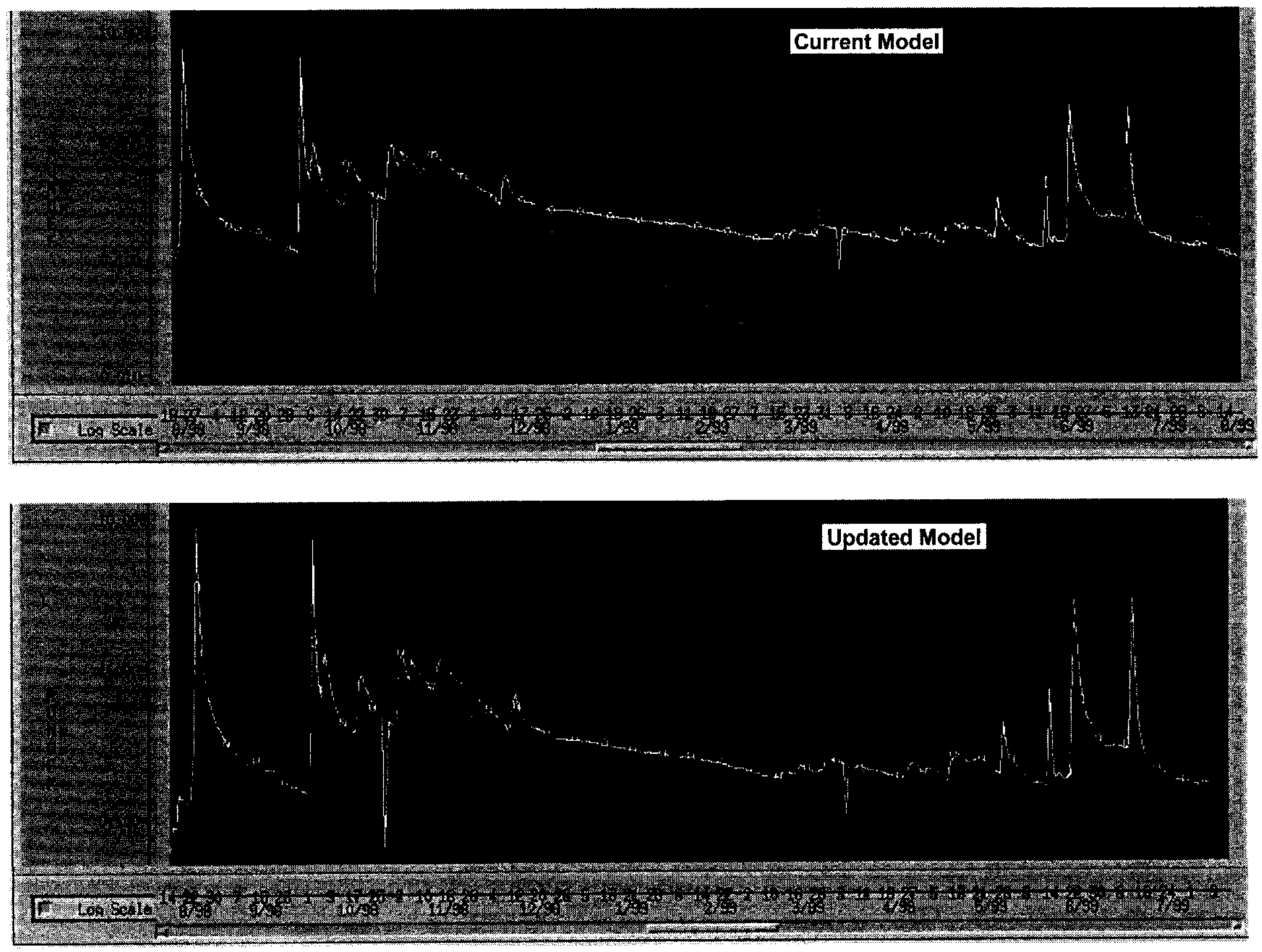
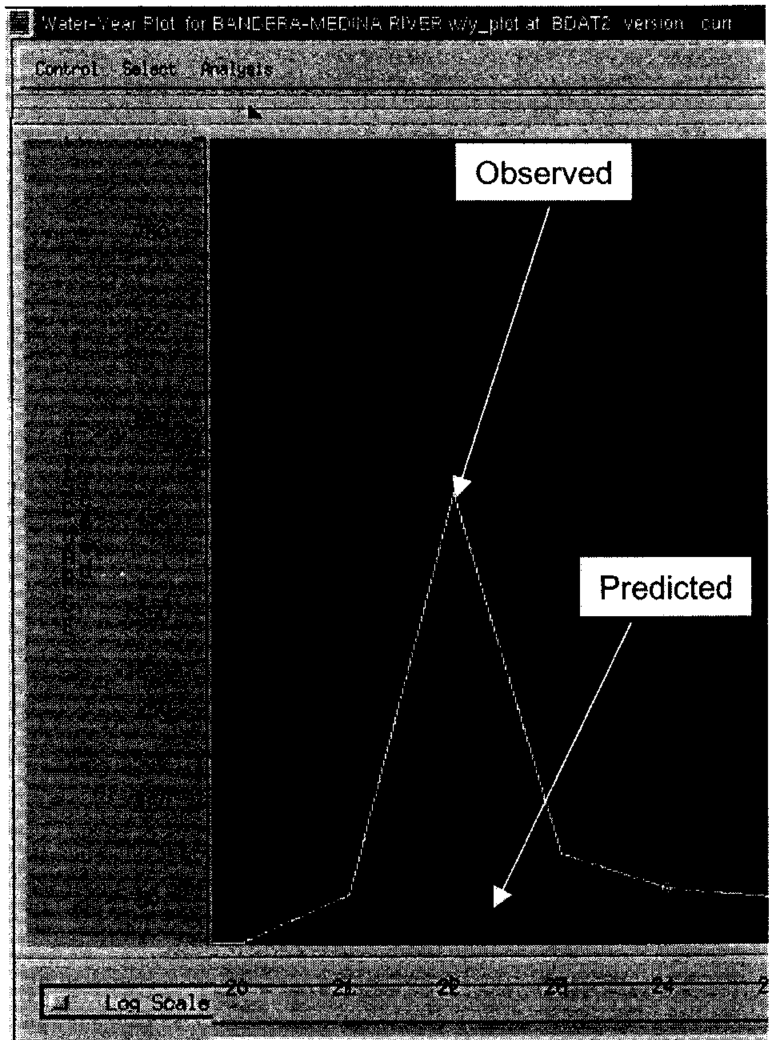


Figure 2-9. Comparison of current and updated NWSRFS model and prediction of baseflow at BDAT2.

Current NWSRFS SAC-SMA Parameters



Updated NWSRFS SAC-SMA Parameters

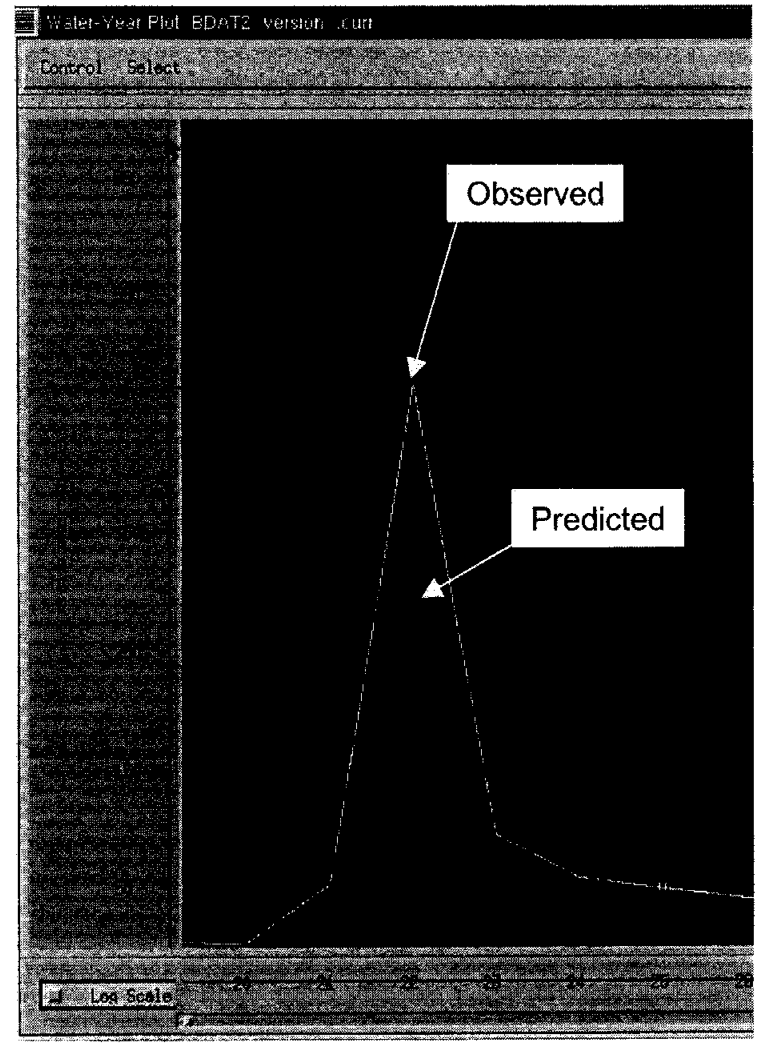


Figure 2-10. Comparison of current and updated NWSRFS model and prediction of major hydrograph rises at BDAT2.

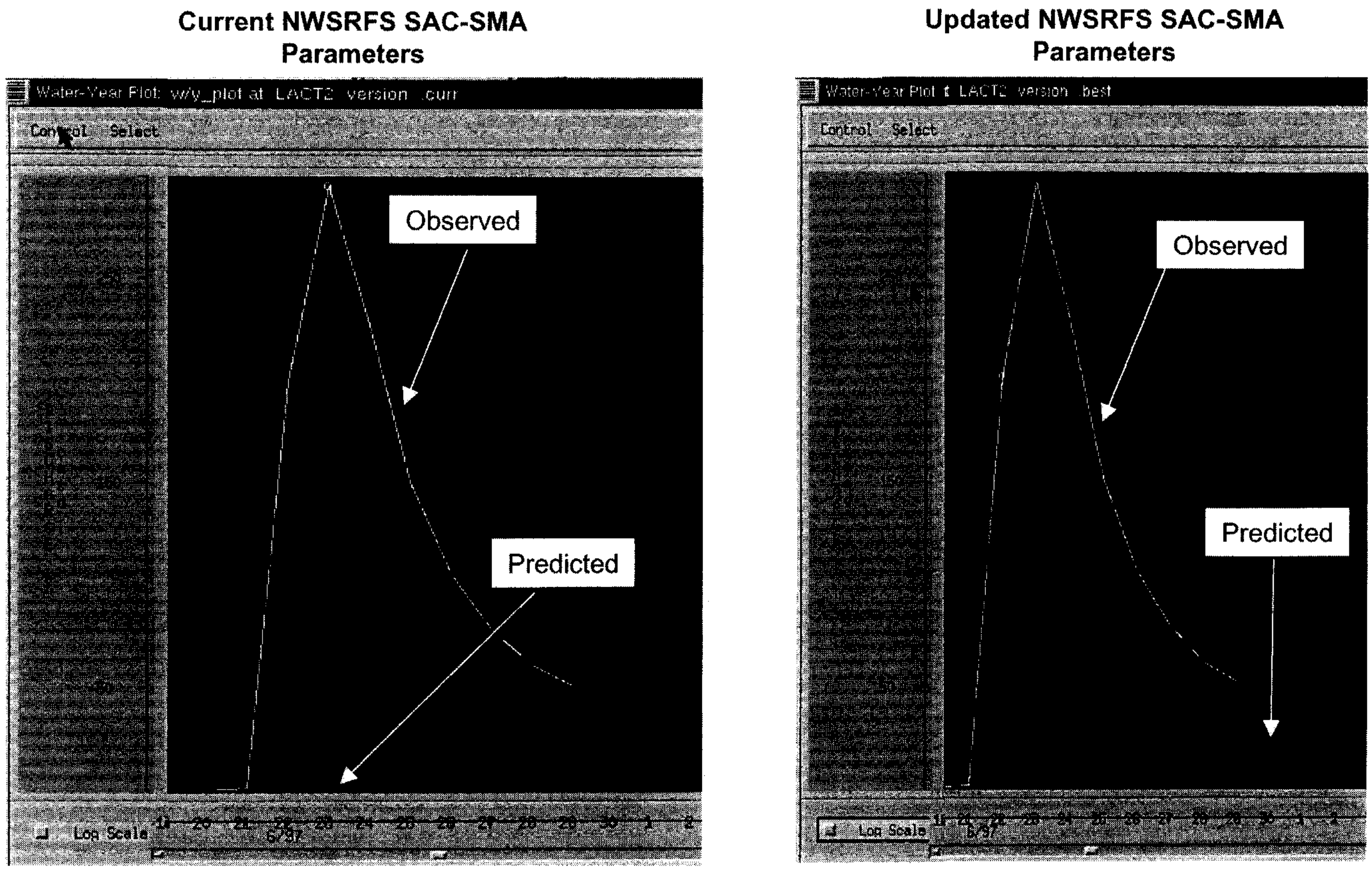


Figure 2-11. Comparison of current and updated NWSRFS model and prediction of major hydrograph rises during June 1997 at BDAT2.

3.0 REVISED INUNDATION MAPPING FOR MEDINA RIVER

3.1 Background

Lake Medina Dam is classified by TCEQ as a High Hazard structure. As noted in Chapter 299 of the Texas Administrative Code (§299.13), "hazard classification does not indicate any condition of the dam itself." To classify hazard, an estimate needs to be made of the area inundated by a dam failure induced flood wave. A dam is classified as "High Hazard" if the estimated inundated area (and estimated time between failure and inundation) shows loss of human life could be expected. The test, per Chapter 299, is whether there is "urban development or large number of inhabitable structures" in the potentially inundated area downstream. A dam is also classified as "high hazard" if the estimated inundated area shows the potential for excessive economic loss (i.e., there is "extensive public, industrial, commercial, or agricultural development").

The existing dam break flood inundation maps for the Lake Medina Dam were derived in 1988 (Willard-Swift Engineers, 1988) and have the disadvantages of being based upon outdated topography, of only addressing a "fair weather" failure scenario, and of being presented in a large-scale format that makes it difficult to ascertain the extent of the predicted flood area.

This study provides inundation maps for a variety of scenarios for fair weather and a series of extreme natural floods. In addition, the mapping is presented in large (small-scale) hard copy format and in digital format. The latter format will allow the maps to be used within agency Geographic Information Systems (GIS), aiding flood emergency planning.

The modeling for this study was performed using HEC-RAS, the river analysis system software developed by the U.S. Army Corps of Engineers Hydrologic Engineer Center (USACE, 2002). The development of the HEC-RAS simulations was carried out in four phases. First, pertinent data concerning topography and geometry of the study area were gathered. Second, initial model inputs were developed based on field data and published values for the site. Third, the model was calibrated to the July 2002 storm event. This section also discusses limitations associated with the calibration and other storms that were considered for calibration. Last, the model was employed to estimate the extent of inundation for four dam failure scenarios:

- A "fair weather" scenario: the dam is simulated to fail on a day with no rain-induced runoff, with the lake at spillway elevation
- Three flood scenarios: 100-year flood, 500-year flood, and Probable Maximum Flood (PMF). In each of these cases, the dam is simulated to fail at the time when the flood is at its peak at the dam itself.

3.2 Data Gathering

3.2.1 Definition of Study Area

The study area was initially defined as the reach of Medina River below Lake Medina Dam where the fair weather scenario dam break flood inundation elevation exceeded that of the regulatory 100-year flood. During initial simulations, it was clear that this criterion would lead to modeling downstream of the junction of the Medina River with the San Antonio River. After review of the existing flood insurance studies for Wilson and Karnes Counties, there does not appear to be a current estimate for a 100-year flow for the San Antonio River through these counties. The nearest long-term gage downstream of these counties is in Goliad, in Goliad County, just downstream of Karnes County. The peak flow rate measured in the 71-year record of that gage is 138,000 cfs in September 1967. An estimated 100-year flow rate for this gage is likely to be somewhat higher than this value. The estimated peak flow rate from a Lake Medina dam break flood at the downstream (southern) boundary of Karnes County generated by a fair weather failure is 148,000 cfs. The study area was therefore defined as the reach of the Medina River from Lake Medina Dam past the junction with the San Antonio River into the San Antonio River itself, downstream to the southern boundary of Karnes County.

Input data gathered for the study area for use in the modeling included topographic and bathymetric data, observation data from the July 2002 flood event, and geometric descriptions dam structures. The following sections describe each of these data sources.

3.2.2 Topographic and Bathymetric Data

Table 3-1 shows the sources of topographic and bathymetric data used for creating the river channel and floodplain for the HEC-RAS modeling. A variety of sources and data were used for the surveys in the list. This section will discuss the following topics:

- Survey data;
- Survey extents and descriptions; and
- Common datum conversion.

Table 3.1 – Listing of Survey Data Used for Developing the Cross Section of Medina River Floodplain for HEC-RAS Modeling

Survey	Description	Datum
TWDB Bathymetry	Bathymetry survey of Medina Lake carried out by Texas Water Development Board in 1995	BMA Datum
Stewart Geotechnology	Survey of shoreline for Medina Lake completed by Stewart Geotechnology for BMA in 2003 (the survey boundary was approximately ¼ mile from the water's edge)	BMA Datum
Stewart Geotechnology	Survey of shoreline of Diversion Lake and Medina River from Medina Lake Dam to the Bexar County line	NGVD 1929
USGS Benchmark	Survey that establishes benchmark that resides on Lake Medina Dam	NGVD 1929
USGS Diversion Dam Survey	Surveys of spillway and diversion intake for Diversion Dam, includes survey of spillway and establishment of benchmarks on the dam	NGVD 1929
Smythe Survey	Survey of spillway for Medina Lake Dam completed for this project (2003)	NGVD 1929

Table 3.1 – Listing of Survey Data Used for Developing the Cross Section of Medina River Floodplain for HEC-RAS Modeling

Survey	Description	Datum
NGS Data Sheet	Survey information for National Geodetic Survey benchmarks within Medina county	NAVD 1988
BMA Datum Summary	Description of how the BMA datum was first established for Medina Lake Dam	BMA Datum
USGS Mapping	Elevation contours on USGS Quadrangle Maps	
	20 ft Contour interval above Diversion Dam	NGVD 1929
	10 ft Contour interval from Diversion Dam to La Coste	NGVD 1929
USGS National Elevation Dataset	30 m resolution DEM from the National Elevation Dataset from the USGS	NGVD 1929
Bexar County 2-ft Contours	2-ft contours of Bexar county received from SARA	NAVD 1988

Survey Data

Various data have been used as the base reference elevations from which to measure topographic and bathymetric elevations in the Medina River Corridor. These data include the BMA vertical datum, National Geodetic Datum of 1929 (NGVD 29), and the North American Vertical Datum of 1988 (NAVD 88). Each of these is discussed in the following paragraphs.

Holland and Yost surveyed the BMA datum in 1948 (Holland, et al., 1948). They established the top of the dam to be 1084 ft msl. They also established the elevations for benchmark locations on the crest of the dam. The benchmark on the east side chiseled into the curb of the roadway was surveyed at 1083.92 ft. The benchmark in the concrete roadway (i.e., not including the curb) to the extreme west side of the dam was surveyed at 1082.94 ft.

NGVD 29 and NAVD 88 are standard geodetic survey data used for measuring elevations throughout North America. Use of these data are the norm for projects where vertical discretization is necessary. A USGS survey conducted in 1963 showed a discrepancy between the BMA datum and NGVD 29 (USGS, 1963). The calculated difference between the two data was found to be 7.8 ft, such that a 1084 feet elevation under the BMA datum is 1076.2 feet in elevation under the NGVD 29 datum. This value is used as a conversion factor between the BMA and NGVD 29 data.

Survey Extents and Descriptions

This section contains a brief description of the source and extents of the data from each of the sources listed in Table 3-1. These surveys can be broken into two groups. The first discusses surveys used to delineate the river basin and floodplain. The second section concerns surveys used to describe geometry of structures used with the modeling.

River Basin Surveys

Figure 3-1 shows an overview of the different surveys used to produce cross sections for the HEC-RAS model. These surveys include the Stewart Geotechnology survey, the TWDB Bathymetry survey of Medina Lake, the 2-foot contours of Bexar County, and USGS DEM data. Each of these is discussed below.

Stewart Geotechnology collected topographic data for the study area above La Coste, Texas to the upstream side of Medina Lake. The data was transferred to URS Corporation via CD-ROM. URS received 2-foot contours of the area in AutoCAD format. The survey was completed in two parts. First, a survey of the Medina Lake shoreline was completed in the BMA Datum. The contours did not include lake bathymetry for Medina Lake. Also, the Medina River corridor was surveyed beginning at Medina Lake Dam downstream to the Bexar County Line. This survey was completed in NGVD 29.

Bathymetry data for Medina Lake was taken from a study completed by the TWDB in 1995 (TWDB, 1995). These elevations were used up to the 1072-ft contour (BMA Datum). Above the 1072-ft contour elevation the Stewart Geotechnology survey was used. No bathymetry survey for Diversion Lake is believed to exist. Bathymetry of Diversion Lake was inferred from available storage elevation curves for Diversion Dam assuming a constant slope from Medina Lake Dam to Diversion Dam.

Where elevation data from more current surveys were not available or if cross sections extended beyond the extent of surveys mentioned previously, the USGS Quadrangle maps were used to estimate elevations. The available maps consisted of 20-ft contour lines above Diversion Dam and 10-ft contour intervals below Diversion Dam to La Coste.

Topographic data within Bexar County was taken from 2-ft contours received from Bexar County through SARA. The data were entered into GIS for processing to create continuous contours of the Medina River Basin within Bexar County.

The elevation data set used downstream of the Bexar county line was obtained from the USGS National Elevation Dataset. The data consist of 30-meter resolution digital elevation model (DEM) covering both Wilson and Karnes counties. The dataset was received in the NAVD 88 vertical datum.

Dam Structure Surveys

The dam structure surveys consist of surveys that were used to locate the position, size, and dimensions of the crest and spillway of Medina Lake and Diversion Lake Dams. These include the USGS benchmark surveys for Medina Lake and the Diversion Dams and the Smythe survey of Medina Lake Dam.

The USGS benchmark survey for Medina Lake Dam was completed in 1963. The survey establishes the Medina Lake Dam elevations in NGVD 29 based on the historic benchmark installed on the eastern side of the dam. This survey was used to verify datum conversions between NGVD 29, NAVD 88, and the BMA vertical data. According to the survey, the benchmark on the extreme right of the dam is located at 1074.951 ft msl NGVD 29. Additionally the Smythe survey, conducted in 2003 as part of the Medina Dam safety analysis, confirmed the elevations of the benchmarks and contributed measured points of the emergency spillway of Medina Lake Dam (URS, 2003).

The Diversion Dam survey was conducted by the USGS in 2003. This survey established the dimensions of Diversion Dam. The surveyed elevation of the dam crest was reported as 918.97 ft msl NGVD 29.

Common Datum Conversion

To use each of the data sets for the purpose of HEC-RAS modeling, a common datum was selected to merge the surveys. The datum consisted of both vertical and horizontal components. The NAVD 88 and UTM 1927 Zone 14 data were selected as the vertical and horizontal data, respectively, for this project.

All elevation survey data were converted into NAVD 88 for use in the HEC-RAS simulations. Converting from NGVD 29 to NAVD 88, the selected project vertical datum, can be done using GIS and established techniques such as the Army Corps of Engineers software CorpCon or the National Geodetic Survey software VERTCON. NAVD 88 is approximately 0.4 ft higher in elevation than NGVD 29 throughout the domain of the study. Conversion from the BMA datum to NAVD 88 is more involved. According to the USGS the BMA datum is measured at 7.8 feet above NGVD 29 (Reference USGS). To convert from BMA datum to NAVD 88, the data were first converted from BMA datum to NGVD 29 using the USGS conversion factor, then subsequently converted from NGVD 29 datum to NAVD 88 datum as discussed previously.

Horizontal projection of the data into the common datum was completed using ArcGIS software and standard data projection utilities. Using this software, merging the data is a straightforward process. However, at survey boundaries, the potential existed for discontinuities in the elevation data set. Two practices were implemented to ensure that discontinuities were not entered into the model. First, surveys were clipped so that elevation data at a given location were based solely on the best available data source. Second, cross sections did not intersect boundaries between surveys. Cross sections located on either side of survey boundaries were inspected to verify a reasonable change in elevation.

3.3 Development of Model

3.3.1 River Analysis System HEC-RAS Model

The most common application of the HEC-RAS model is for estimation of floodplain elevation for extreme natural floods. In natural floods, the slope of the water surface and flow velocity change gradually from point to point along the channel reach. The HEC-RAS model used in this situation is a gradually varied flow model, sometimes called a backwater model, because the calculation of water surface (under the usual subcritical conditions) progresses cross section by cross section from downstream to upstream. The model inputs include peak flow rates within each reach, not the full flood hydrograph, and the results show flood elevations associated with each peak flow. The model is termed a steady-state model, as the change in stage over time is not modeled. The model is based upon an assumption that the acceleration components of flow are negligible.

A dam break flood, in contrast to a natural flood, involves a rapid change in water surface and flow velocity over a very short reach. The acceleration components of flow are not negligible, and strongly influence the flow rate, flow depth, and flow velocity. For this situation, an unsteady flow model is required. HEC-RAS includes an unsteady flow model and is a standard model used for this purpose. The HEC-RAS unsteady flow model is a finite difference model with an intrinsic solution scheme. All of the cross sections of the model are linked by finite difference equations, all of which have to be solved simultaneously within each timestep. This is in contrast to the much simpler backwater model that solves each cross section individually in the calculation scheme. An intrinsic solution scheme depends upon the model timestep duration being consistent with the distance between cross sections and the velocity of the flood wave. If these parameters and wave characteristic are inconsistent during any timestep in any cross section throughout the modeled passage of the flood wave, then the model becomes unstable, and a simultaneous solution of all the finite difference equations cannot be found.

Achieving model stability (model convergence) can involve a number of model setup steps not associated with a steady-state model, including:

- Setting pre-flood baseflows above historic values (but insignificant relevant to dam break flood flows);
- Using cross-section interpolation within similar reaches to match reach distance to flood wave velocity; and
- Adjusting timesteps to values much lower than used in typical hydrologic modeling (e.g., HEC-HMS).

An additional step undertaken for this project to maintain model stability was dividing the HEC-RAS simulation into two sections. The upper and lower sections of the HEC-RAS simulation are shown in Figure 3-2. Each section was comprised of an independent HEC-RAS simulation. The upper section was run to compute outflows from the dam failure and stages and flow through Medina County. The lower section was run to compute the stages and flows through Bexar, ,Karnes and Wilson counties. The two independent models were linked using flow hydrographs from cross sections located at the Bexar County line from the upper section as the inflow hydrograph of the second section. Simulating the dam failure in two sections provided equally reasonable model results while enhancing model stability.

It should be noted that the upper section of the model contains cross sections past the Bexar County line. These cross sections were entered into the model for proper estimation of flows and stages near the Bexar County line. This follows guidance in the HEC-RAS User's Manual that states downstream boundary conditions should be placed far enough downstream to not affect flows and stages at points of interest in the model (USACE, 2002). The added cross sections allowed for flood predictions near the Bexar County line.

3.3.2 Model Input Values

Model inputs used for the HEC-RAS simulation included cross-section location, Manning's roughness coefficients, expansion/contraction coefficients, dam geometries and coefficients, dam breach parameters, input flow rates, and model initial conditions. These items will be discussed in the following sections.

Cross-Section Location

Figure 3-3 shows final cross-section locations for the entire domain of the model. The cross sections were oriented to lie perpendicular to expected flow paths through the channel. The cross-section elevations were derived from both the topography and the bathymetry data discussed in Section 3.2.2. It should be noted that the model was developed for dam break flood inundation map creation. This resulted in much wider and deeper cross sections than in previous 100-year flood HEC-RAS simulations created for the same river basin.

In some areas of the model, cross sections were interpolated to increase the efficiency of computation for the HEC-RAS model. These locations were selected where terrain changes between cross sections could be approximated to vary linearly. This was done according to guidance presented in the Army Corps of Engineers HEC-RAS User's Manual (USACE, 2002).

For dam failure analyses in HEC-RAS, the volume of water escaping the dam is determined by the placement and shape of cross sections upstream of the dam. The placement of these cross sections must be completed to produce a reasonable match to the storage-elevation curve for the dam. To verify that the placement of cross sections produced a reasonable match to the storage elevation curve, URS compared the volumetric budget of the calibrated HEC-RAS simulation. For example, the 100-year calibrated simulation used an initial stage of 1073.1 ft msl NAVD 88. This corresponds to an approximate storage of 310,000 acre-feet based on the TWDB (1995) storage-elevation curve. According to the HEC-RAS volumetric budget, a volume of 300,195 acre-feet entered the stream due to the dam failure. This is within 3 percent of the TWDB estimated curve. Based on these findings, the placement of cross sections above the dam was deemed reasonable.

Manning's Roughness

To estimate Manning's roughness, aerial photography of the study area was used to determine possible ground cover variabilities. The overbank floodplain roughness coefficient of 0.04 was taken from published values for an agricultural area, assuming "mature field crops" (Chow, 1959, Table 5-6, D-2b3). The channel roughness factor of 0.047 was estimated during the calibration process (see Section 3.3.4 below) and can be considered a composite roughness for the channel itself (which should by itself be on the order of 0.030) and for the heavily wooded strip that appears on the immediate channel banks (which should by itself be on the order of 0.1).

Expansion/Contraction Coefficients

The model assumed HEC-RAS default values of 0.1 and 0.3 for expansion and contraction coefficients, respectively.

Dam Structure and Weir Coefficient

The Medina Lake and Diversion Dams were modeled as inline weirs in the HEC-RAS simulation. Table 3-2 displays the values used to define the structure for both Medina and Diversion Dams. Crest and spillway elevations and width were taken from the survey data discussed in Section 3.2.2. The weir coefficients used to model the outflow of the Dam were 3.163 and 2.6 for Medina and Diversion Dams, respectively. The values for both dams were based on the values calibrated for hydrologic/hydraulic modeling using HEC-HMS and HEC-RAS by URS as part of the Lake Medina Dam Stability Analysis (URS, 2004).

Table 3-2. Dam Structure Parameters for Medina Lake and Diversion Dams

Parameter	Medina Lake	Diversion
Crest (ft msl NAVD 88)	1076.6	919.3
Spillway Crest (ft msl NAVD 88)	1064.6	N/A
Width (ft)	10	5
Weir Coefficient	3.163	2.6

Dam Breach Parameters

The rate at which a lake empties following failure of the dam creating the lake is a function of the size of the initial breach in the dam and the rate at which that initial breach opening expands. For embankment dams, the estimation of initial breach width and the rate of expansion of that opening both vertically and horizontally can involve complex analysis of soil erodibility. For large concrete gravity structures like Lake Medina Dam, the primary failure modes consists of potential concrete overstressing or instability along the dam/foundation interface. Figure 3-4 shows the basic forces acting upon a dam cross section. The primary force that thrusts the dam in the downstream direction is the reservoir load, which is due to the linear hydrostatic pressure on the upstream dam face. The frictional force that develops along the dam/foundation interface dam resists the thrust from the reservoir and is directly proportional to the effective weight of the dam. The effective weight of the dam is equal to the gross weight of the concrete minus the uplift force that develops along the interface. If the effective weight of the dam is reduced, then the frictional force along the dam/foundation interface is also reduced, which can result in reduced safety, or even instability.

Typically for concrete gravity dams, the sliding failure develops quickly once the thrust force due to the reservoir has exceeded the frictional resistance at the interface. For this reason, failure of a concrete dam is considered to be instantaneous, and the release of the reservoir is assumed to occur over a very short period of time. This is in contrast to an embankment dam, which has a progressive (and slower) failure, limited by the rate of soil erosion.

There are two typical cross sections that make up the dam. The main section, which has a maximum height of 165 feet, is located in the central portion of the dam. The abutment sections are located on both the right and left (the abutments are identified looking downstream) and have a maximum height of about 75 feet. The main section of the dam contains foundation drains to reduce the uplift pressure along the dam/foundation contact. The abutment sections of the dam do not contain any drains; thus, the uplift pressure varies from full reservoir pressure at the upstream heel to tailwater at the downstream toe. Because the abutment sections do not contain foundation drains to reduce the uplift pressure, the computed sliding factor of safety is less than the main section of the dam, which does include drains. The purpose of this dam breach modeling is to provide Emergency Managers with a worst-case area of potential inundation; therefore, the assumption is made in this modeling that the entire dam fails catastrophically, either by overturning or by sliding. This failure is estimated to occur essentially instantaneously, i.e., within 4 minutes, which is correct for these modes of failures, and is the typical assumption for breach modeling of this type of structure. Dam breach parameters used in the model are shown in Table 3-3.

Table 3-3. Dam Breach Parameters for Medina Lake Dam

Parameter Name	Parameter Value	Description
Breach Center	1900 ft	Distance in feet from left (of cross-section, which is longer than the dam) looking downstream
Final Bottom Width	5 ft	Width of failure at its lowest point in the structure
Final Bottom Elevation	905 ft msl NAVD88	Elevation at the bottom of the dam breach
Final Top Width	1378.5 ft	The width of the breach along the dam crest
Final Breach Height	171 ft	The vertical distance from the dam crest to the bottom of the breach
Left Side Slope	3 ft/ft	Slope of the left side of the trapezoidal breach shape
Right Side Slope	5 ft/ft	Slope of the right side of the trapezoidal breach shape
Full Formation Time	4 minutes	Time for the breach to start from no damage to fully breached
Failure Model	Overtopping	Method for dam breach

Input Flow Rates

Input flow rates for the model were estimated for fair weather conditions, the 100-year flood, the 500-year flood, and the PMF flood event. The fair weather scenario input flow rate was estimated to be 8,000 cfs. This was selected as the lowest input flow rate possible that also produced efficient model convergence. The 100-year and 500-year flow rates were taken from the flood insurance study for Bandera County published by FEMA. The values were 66,500 cfs and 120,000 cfs, respectively. The peak PMF flow rate was obtained from HEC-HMS modeling carried out as part of the Medina Lake Dam Stability analysis (URS, 2004). The peak PMF flow rate was estimated at 501,053 cfs.

Initial Conditions

Initial conditions for the HEC-RAS modeling were assumed to be at peak conditions throughout the length of the model for the given scenario's peak flow rate. For example, for the simulation of dam failure with a 500-year flood event, the initial condition was the peak flow of 120,000 cfs throughout the length of the model. Using constant peak flow rates throughout the model domain for the entire simulation provided a conservative estimate of the effect the hydrologic conditions coinciding with the dam failure would have on the inundation zones.

3.3.3 Model Calibration, July 2002 Storm

The HEC-RAS model was calibrated against the July 2002 storm event using two metrics. First, the high water mark measured below the Medina Lake dam for the July 2002 flood, and second, the maximum water level above Medina Lake dam. These metrics are discussed in the following sections.

High Water Mark

Watershed Concepts collected high water marks after the July 2002 flood event within the Medina River Corridor. According to a measurement taken just below Medina Lake Dam, the maximum water level below the dam reached 943.1 ft. NGVD 88 (Watershed Concepts, 2002). Using steady-state analysis mode, the roughness coefficient was iteratively changed from its initial value until the simulated water surface elevation matched the observed elevation at the location of the high water mark. The final roughness coefficient was 0.047.

Maximum Stage Above Medina Lake Dam

During the July 2002 storm event, the lake level was measured at approximately 0.5 foot below the curb top on the dam crest. The calibrated HEC-RAS model was run in unsteady mode to simulate the storm event. The inflow hydrograph for the upstream boundary condition was extracted from HEC-HMS modeling of the July 2002 storm event previously completed by URS as part of the Dam Stability Analysis (URS, 2004). The simulation showed that lake elevation above Medina Lake Dam reached approximately to the crest of the dam as observed in the storm event. This gave reasonable confidence in the model construction.

3.4 Application of the Calibrated Model

The calibrated HEC-RAS model was used to simulate the hypothetical failure of Medina Lake Dam and the flood wave that would result from such a failure. This was completed to produce flood inundation maps for the area below the dam and travel times for the flood wave to reach specific locations within the inundation maps. Exhibits X thru X display the flood inundation maps created for the affected area of a hypothetical dam failure at Medina Lake Dam. These maps were produced using HEC-GeoRas 3.1.1 for ArcView 3.X and ArcInfo 8.3. The steps for creating the inundation maps and a discussion of the maps and flood wave arrival times follows.

3.4.1 Creating Inundation Maps

Flood inundation maps are created from HEC-RAS simulation output and digital terrain models either in TIN of DEM format. HEC-RAS generates the water surface elevations for the entire reach based on the simulation input parameters. HEC-RAS outputs the data in a geo-referenced format that can be superimposed on the terrain models. Using HEC-GeoRas 3.1.1, the elevation model is subtracted from the water surface. The subtraction creates a geo-referenced raster data set of water surface depth. If, for a given location, the water depth is greater than zero, this area is approximated to be inundated for the given dam failure scenario. HEC-GeoRas 3.1.1 then creates a boundary surrounding the entire area that is inundated with water according to the HEC-RAS simulation.

is approximated to be inundated for the given dam failure scenario. HEC-GeoRas 3.1.1 then creates a boundary surrounding the entire area that is inundated with water according to the HEC-RAS simulation.

3.4.2 Inundation Map Discussion

Flood inundation maps approximate the area that will be covered by any depth of water due to a dam failure event. Figures 3-5 and 3-6 show the approximate boundaries for the fair weather, 100-year, 500-year, and PMF dam failure scenarios over the upper and lower sections of the model, respectively. Included in the figure is an approximate time marker that represents the arrival time of the flood peak in hours after a dam failure during a 100-year flood event. A detailed set of inundation maps is included as part of Section 4.

Figure 3-7 shows the confluence of the San Antonio and Medina Rivers. The inundation boundary crossing the San Antonio River is a straight line. Straight-line boundaries where tributaries are located denote and approximate inundation boundaries. The study scope did not include modeling of each tributary of the Medina and San Antonio river basins. Therefore, the magnitude and extent of flooding that occurs upstream for tributaries along the river basins are not delineated.

3.4.3 Flood Wave Arrival Times

Table 3-4 contains information regarding the peak arrival time of the flood wave at several key locations throughout the study area. The peak arrival time approximates the amount of time from the beginning of dam failure to when the highest flow is achieved at the given location.

Table 3-4. Flood Wave Peak Arrival Times for Dam Failure Associated with a 100-Year Storm Event for Selected Municipalities Along Medina River

Municipality	Arrival Time of Flood Peak (hrs)			
	Fair Weather	100-yr	500-yr	PMF
Riomedina	1.4	1.4	1.3	1.2
Castroville	2.5	2.3	2.3	2.0
La Coste	3.3	3.0	2.9	2.6
MacDona	5.3	4.7	4.6	4.0
Mann Crossing	5.9	5.4	5.2	4.2
Van Ormy	6.6	6.2	5.6	4.4
Garza Crossing	7.0	6.6	6.0	4.6
Earle	10.0	9.1	8.3	6.2
Cassin	10.0	9.1	8.3	6.2
Losoya	11.0	9.7	8.9	7.2

The arrival times vary depending on which scenario is modeled concurrently with the hypothetical dam failure. When higher initial flow rates are used, the peak arrival times decrease. This is due to less attenuation of the flood wave as it travels through the floodplain at high initial condition flow rates.

3.5 Recommended Application for Inundation Maps

The inundation maps have been prepared by this study for the purpose of providing guidance to emergency managers as to the estimated extent of flooding (and timing of flooding) that could occur downstream of Lake Medina Dam in the event of a failure of that structure. Any other use of these maps should note the observations and qualifications that have been made previously in this report, notably:

- The assumptions made in the map preparation are very conservative, in particular the assumption that the entire dam fails within 4 minutes. The failure mode modeled is a worst-case scenario, appropriate for emergency management use. The model used is not a model of the most likely failure.
- This mapping is performed because of the status of the dam as a High Hazard dam. Per state regulation, "hazard classification does not indicate any condition of the dam itself."

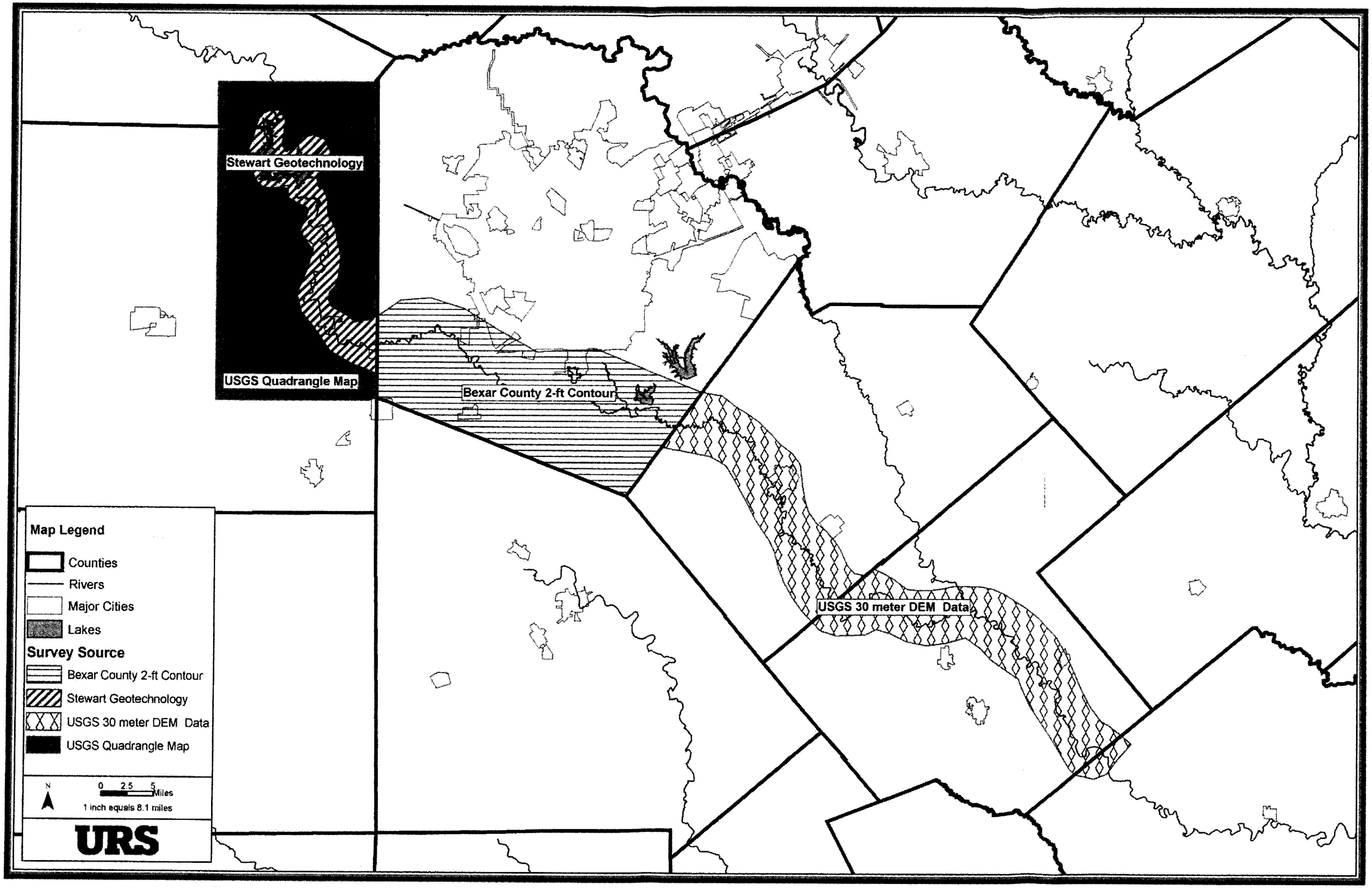


Figure 3-1. Survey sources used for creating cross-section data incorporated into HEC-RAS simulations

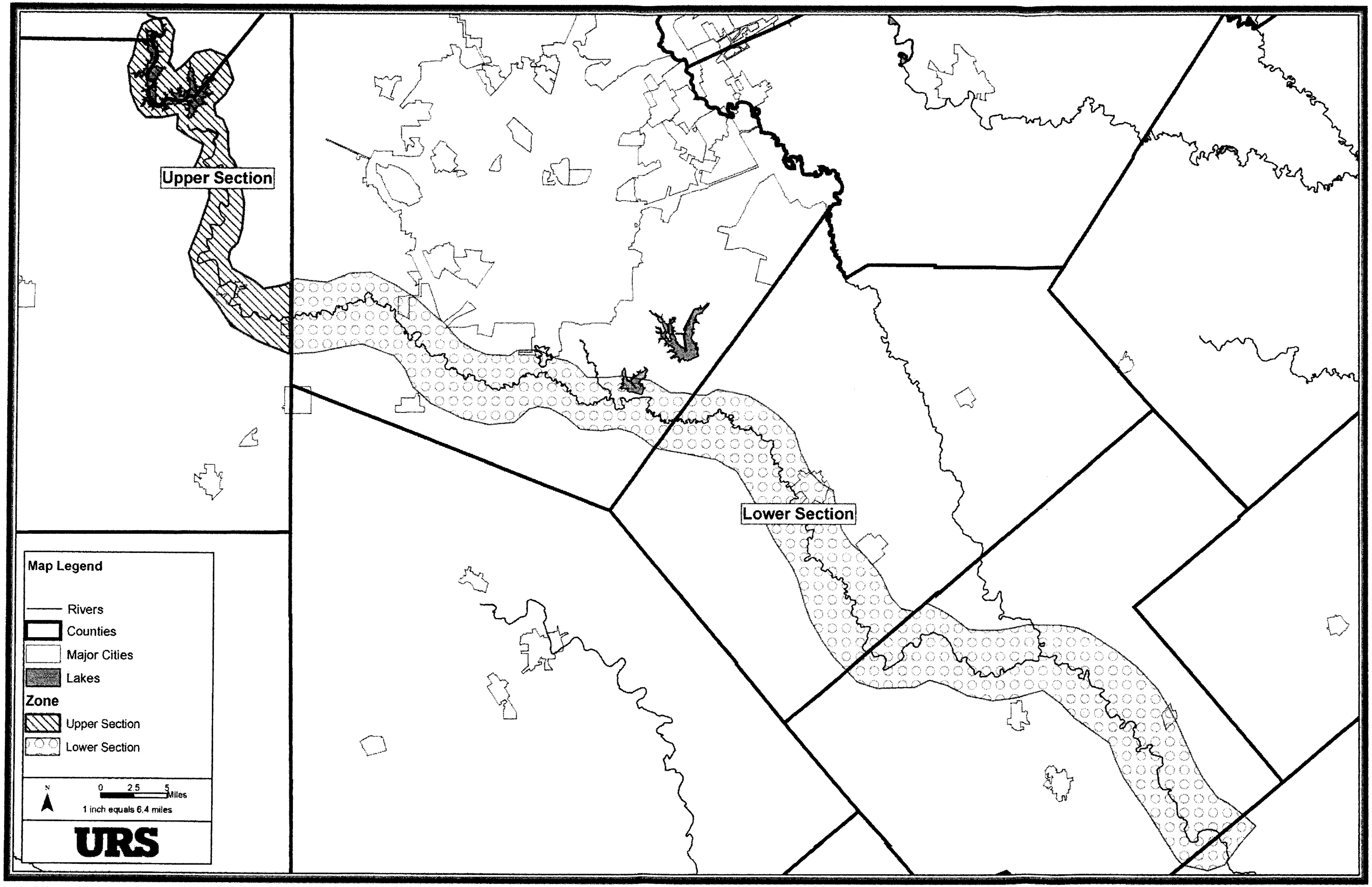


Figure 3-2. HEC-RAS simulations were broken up into the upper and lower sections shown in the figure. Using two sections improved model stability during calibration phase of modeling.

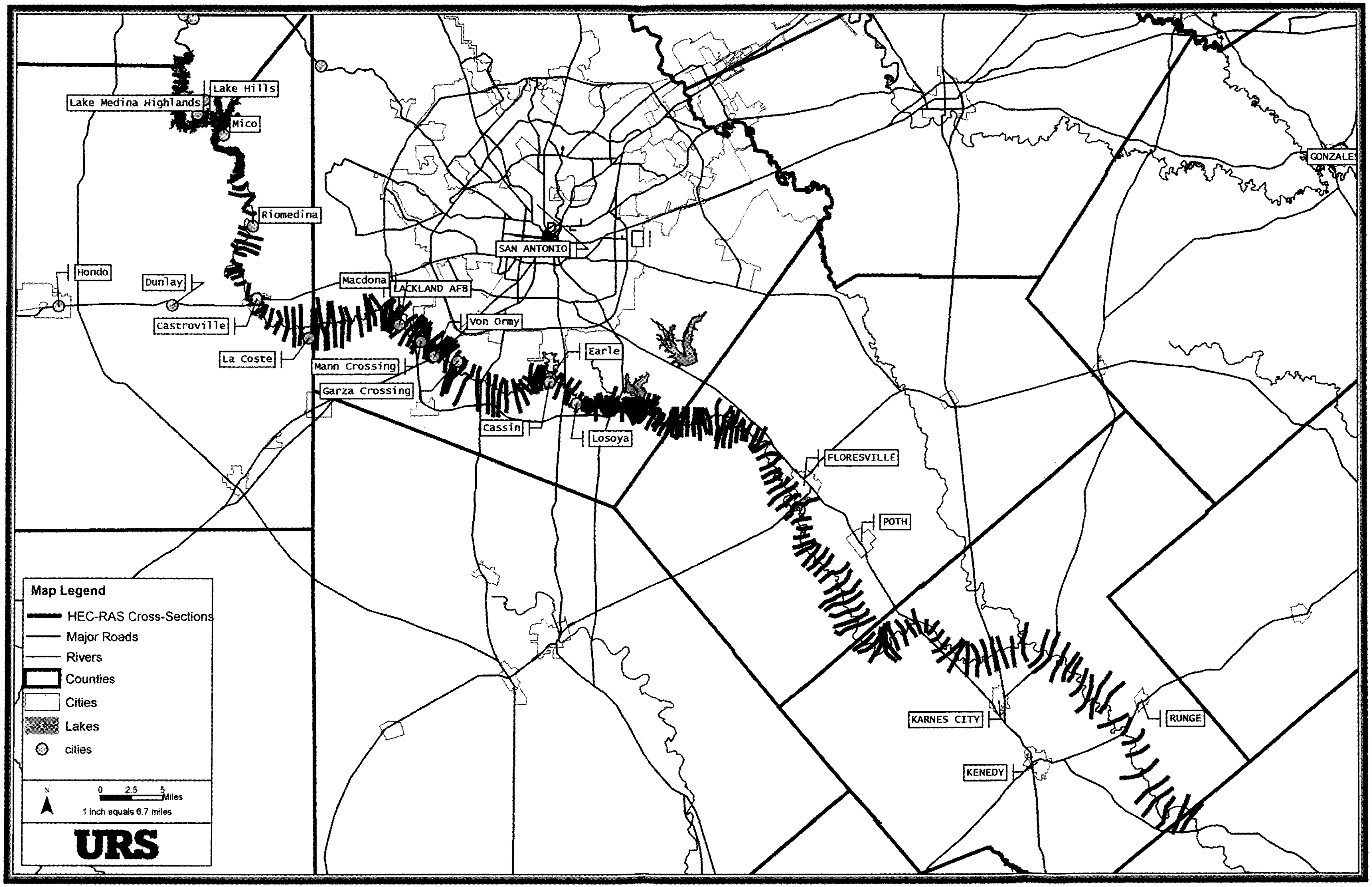


Figure 3-3. Cross-section locations for HEC-RAS simulation over the entire model domain.

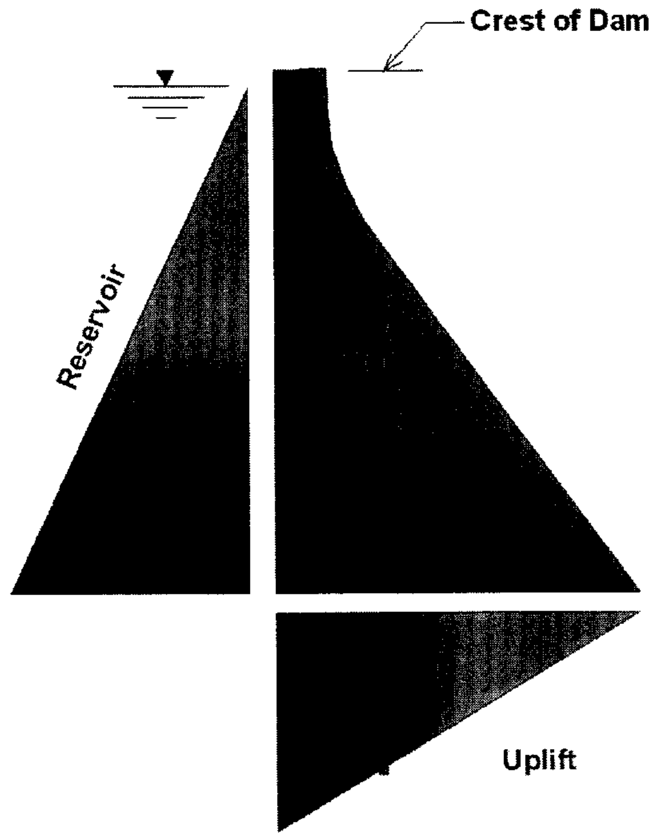


Figure 3-4. Primary Forces Acting on a Gravity Dam

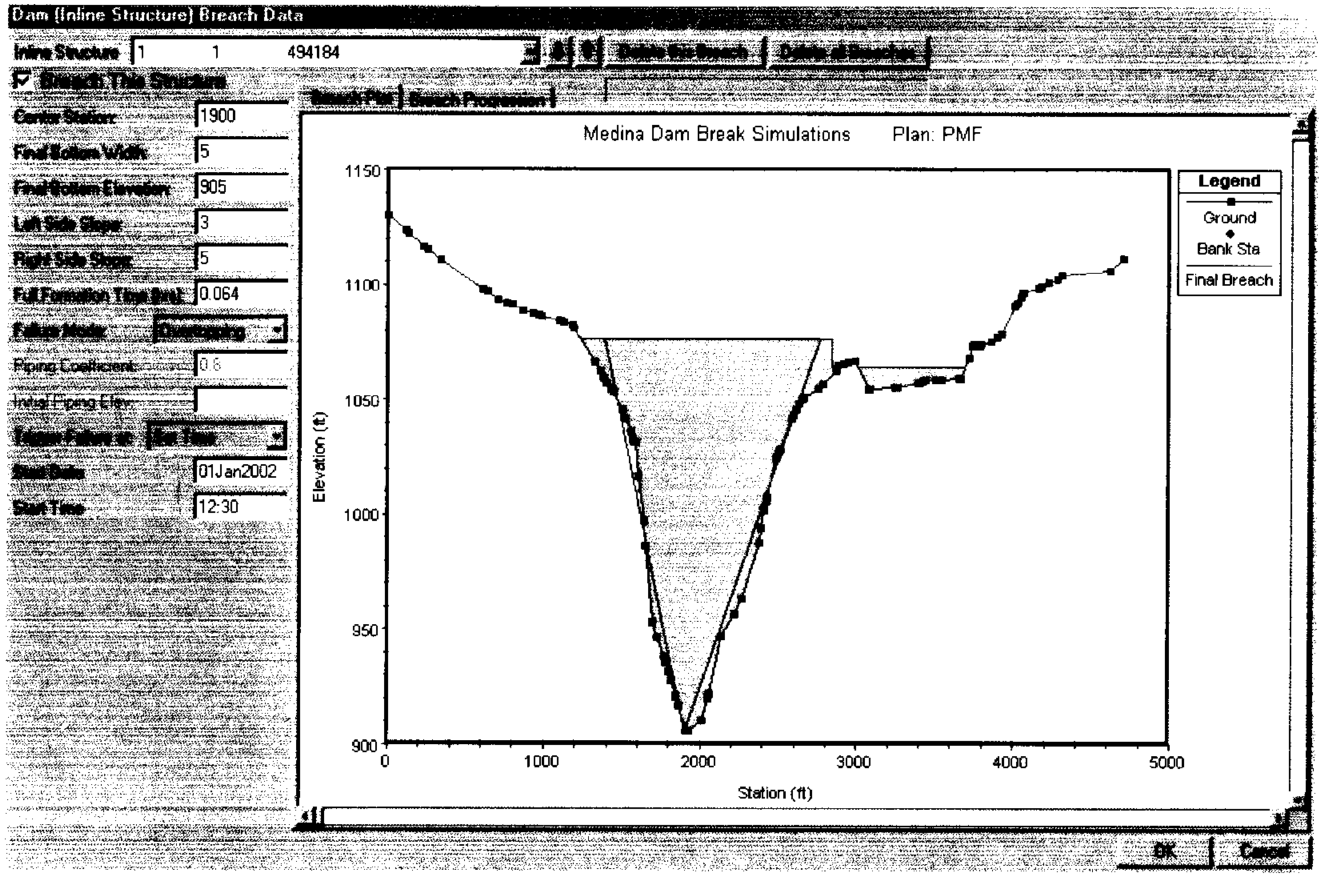


Figure 3-4a – Diagram of Dam Breach Parameters used for Simulation of hypothetical failure at Medina Lake Dam

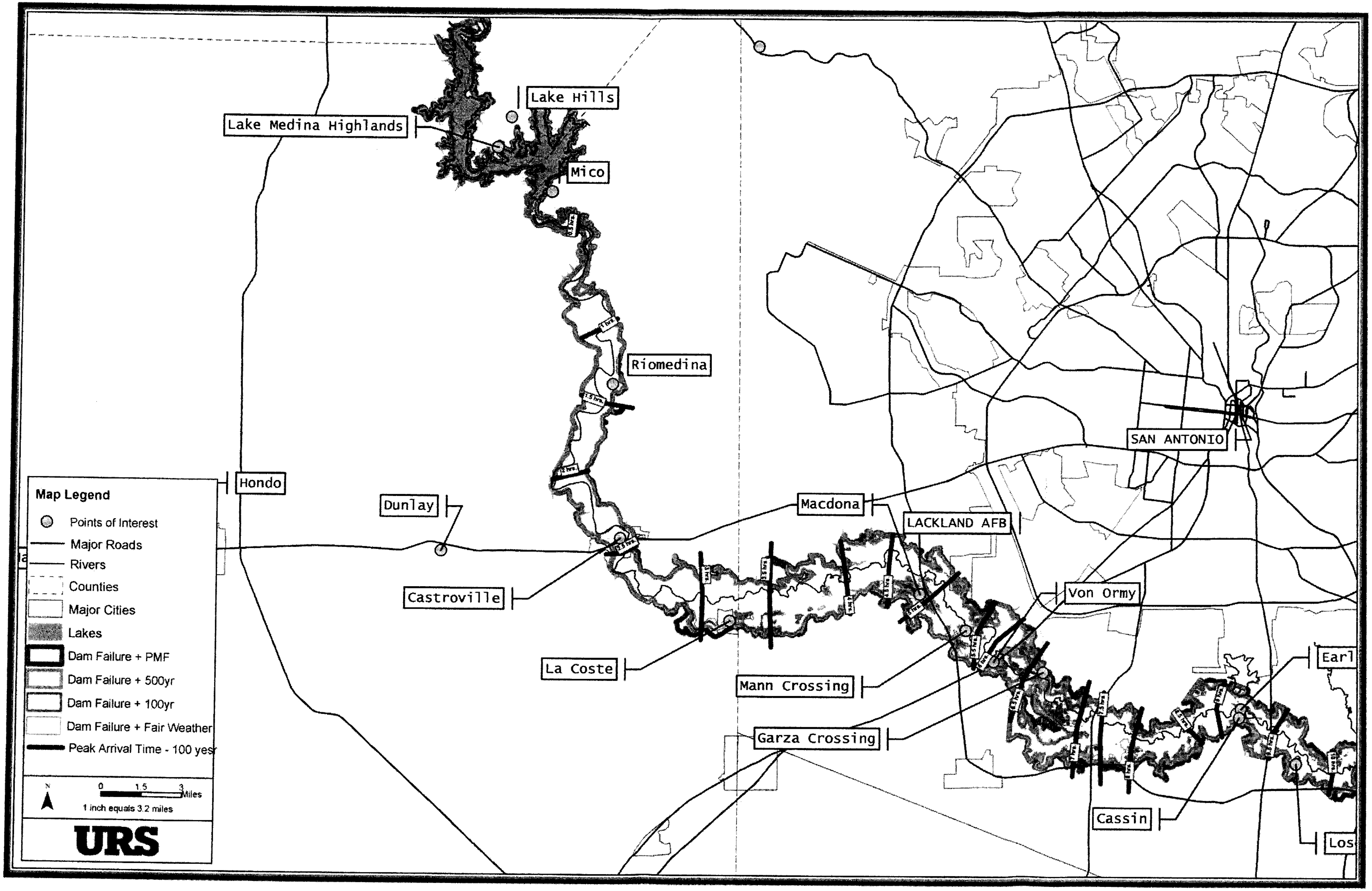


Figure 3-5. Flood inundation maps for dam failure combined with the Fair Weather, 100-year, 500-year and PMF flood event. Arrival times for the flood wave peak are posted along the Medina River for dam failure during the 100-year flood event.

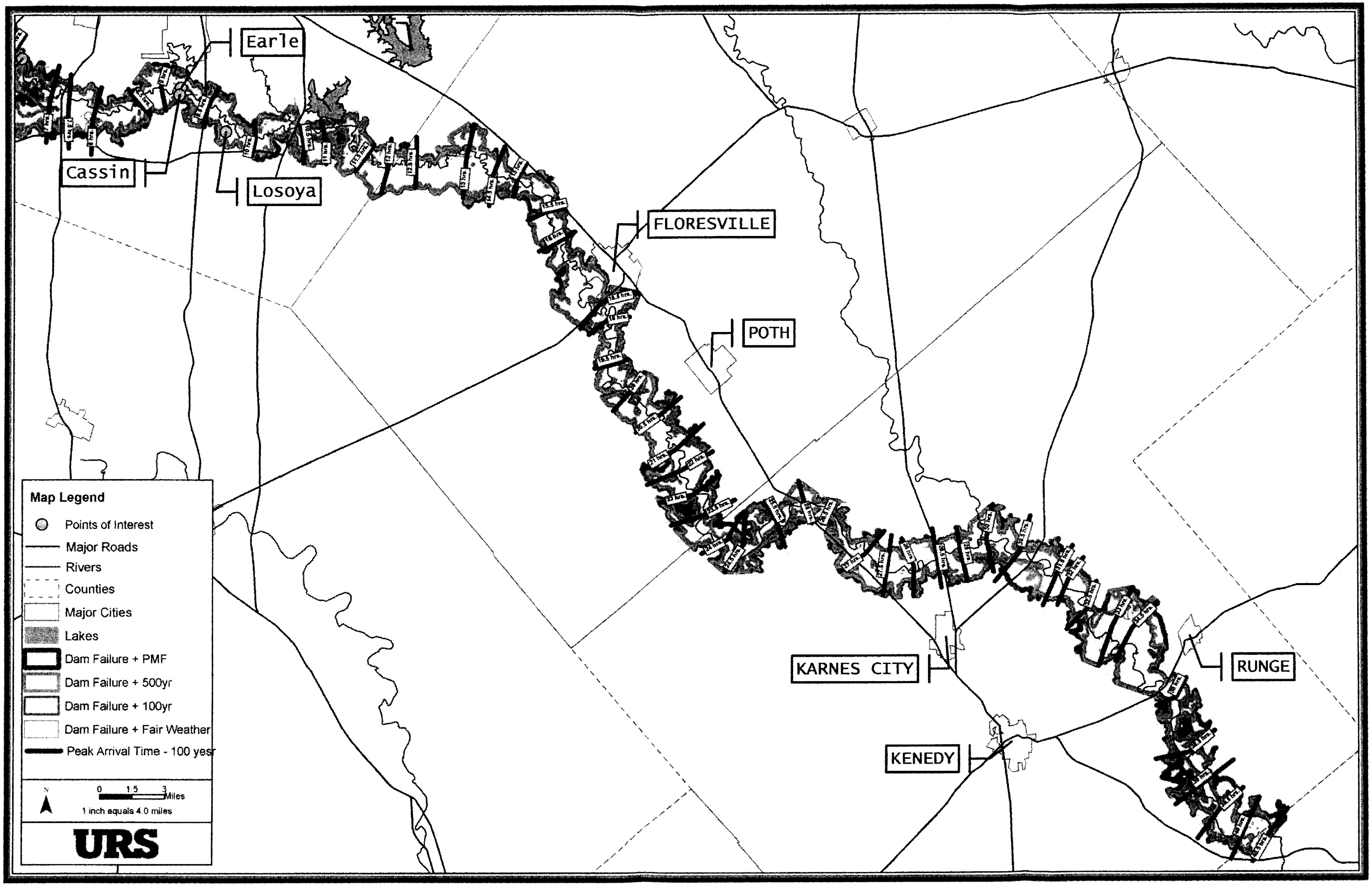


Figure 3-6. Flood inundation maps for dam failure combined with the Fair Weather, 100-year, 500-year and PMF flood event. Arrival times for the flood wave peak are posted along the Medina River for dam failure during the 100-year flood event.

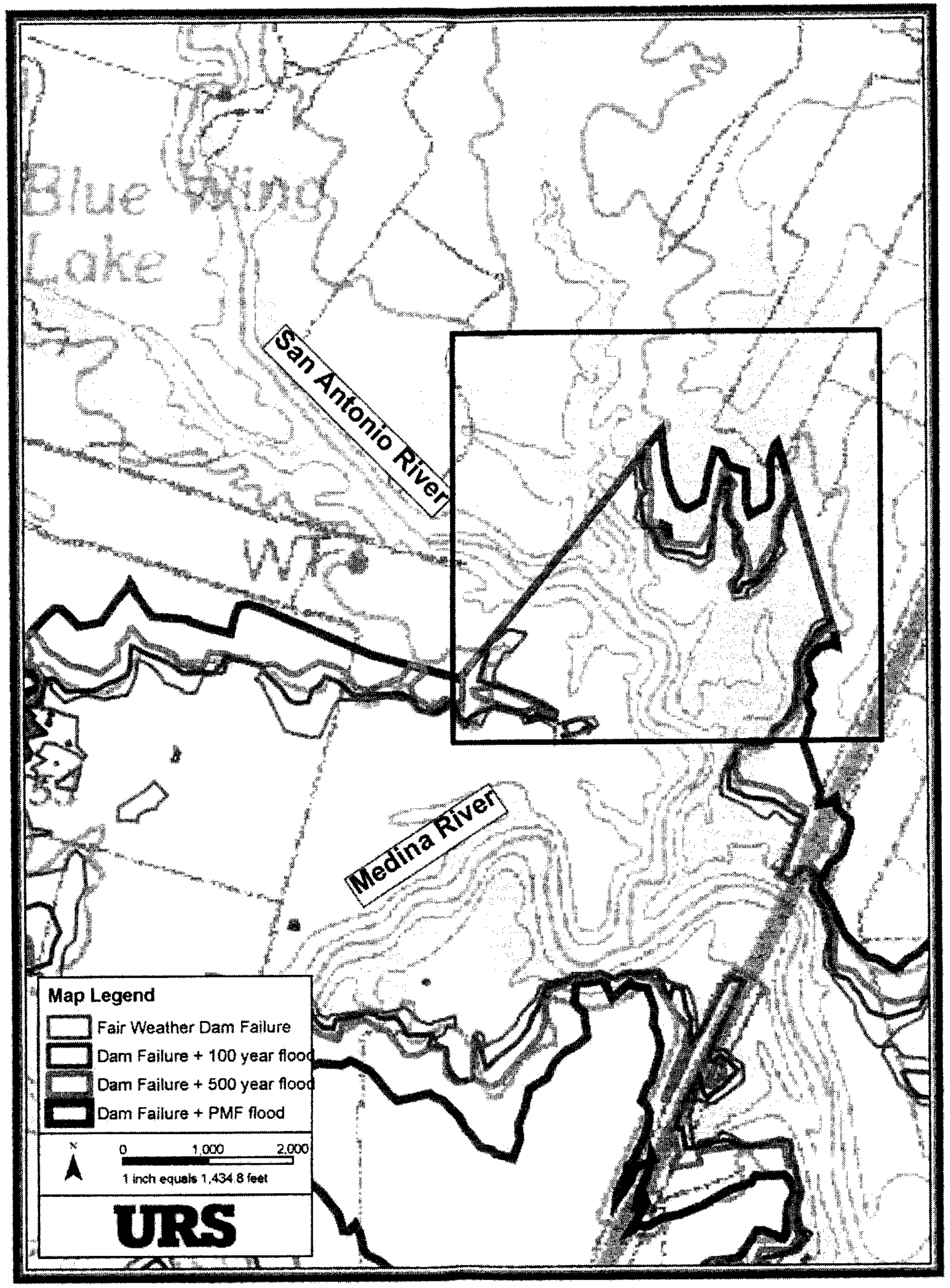


Figure 3-7. Close-up of flood inundation boundaries near the confluence of the Medina and San Antonio Rivers. This figure shows an example of an approximate boundary where tributaries join the main river channel.

4.0 REGIONAL FLOOD EMERGENCY PLANNING

4.1 Background

The river reaches for this portion of this study extend from the upper reaches of the Medina River within Bandera County, through Medina Lake (in Bandera and Medina Counties), through Diversion Lake (in Medina County), and downstream into the Medina River as it flows through Medina County and Bexar County (see Figure 4-1). The larger municipalities within this reach are the City of Bandera, City of Castroville, and City of La Coste, but there are smaller communities along the river in Medina, Highland Waters, English Crossing, Rio Medina, Macdona, Mann Crossing, Garza Crossing, Losoya, Von Ormy, and Cassin. There are additionally small communities and subdivisions located around the periphery of Lake Medina, including Mico.

The planning and performance of emergency management activities are led by the three counties of the region: Bandera County, Medina County, and Bexar County. Each of these counties has the responsibility to set up Emergency Operations Centers (EOCs) in the event of extreme flooding, under the supervision of the County Judge and County Sheriff. Each county has designated an Emergency Management Coordinator. Other entities that have a major role in emergency management activities in the region include:

- *Alamo Area Council of Governments (AACOG).* The AACOG area includes the three counties that are the focus of this study. AACOG supports the County EOCs in numerous ways, to include maintaining selected types of emergency vehicles and equipment which can be provided upon request, according to priority of need;.
- *Bandera County River Authority and Groundwater District.* This agency provides selected emergency management support in the Lake Medina area within Bandera County.
- *BMA.* BMA has the responsibility for the operation of Lake Medina Dam, and for its periodic safety inspections and maintenance. BMA also has the responsibility to maintain the Emergency Action Plan (EAP for Lake Medina dam, which includes responsibilities for close coordination during floods with regional EM staff, and issuance of dam safety warnings, as needed.
- *Emergency Services District No 1 (ESD No 1) of Medina County.* This district is the taxing authority that funds local fire departments and Emergency Medical Services (EMS) within the Medina River Valley within Medina County. The Medina Valley EMS, based in Castroville, is one of the entities funded by ESD No 1, and serves the Medina River valley downstream of Lake Medina, through and including Castroville.
- *City of Castroville.* The City of Castroville has an Emergency Management Coordinator.
- *City of La Coste.* City of La Coste emergency management is a duty of the City Adminstrator.
- *City of San Antonio.* City of San Antonio has an Emergency Management coordinator.
- *San Antonio River Authority (SARA).* SARA directs aspects of flood management planning for Bexar County and the City of San Antonio, and for the San Antonio River floodplain through Wilson and Karnes County.

- *Local fire departments.* The local fire departments participate in local and regional emergency planning and management. The Mico fire department has been an active participant in this study.

One private organization will be noted: the Medina Ranch Property Owner's Association. This association represents the owners of property immediately downstream of Lake Medina Dam and upstream of Diversion Dam, as such, has one of the most critical interests in notification procedures developed for flood-threatened properties downstream.

Table 4-1 shows the current names and contact numbers for the individuals representing these organizations.

Table 4-1. Contact Information

Affiliation	Contact Name	Phone	E-Mail
Alamo Area COG (AACOG)	Don McFarland	210-362-5296	dmcfarland@aacog.com
BMA	Brian Sullivan	830-665-2132	bmabrian@devtex.net
Bandera County EMC	Ralph Dresser	830-612-3335	rdresser@texas.net
Bexar County EMC	Scott Lampright	210-335-0300	slampright@co.bexar.tx.us
Bandera County River Authority and Groundwater District	David Jeffery	830-796-7260	djeffery@indian-creek.net
Castroville EMC	Timothy Fousse	830-931-0234	Tim.fousse@castrovilletx.us
City of La Coste	Reggie H. Winters (City Administrator)	830-985-9494	cityoflacoste@sntrrr.com
City of La Coste	Henry A. Seay, Jr. (Mayor Pro Tem)	830-985-9437	hankseay@aol.com
City of La Coste	J. Medellin	830-985-3780	Hadrian554@yahoo.com
City of San Antonio	Rey Lujan	210-335-4600	rlujan@bexar.org
ESD#1 Medina County	Polly Edlund	830-931-3358	edlund@stic.net
Medina Ranch – Diversion Lake	John (Jack) Williamson	210-805-8059	jmbwmson@swbell.net
Medina County EMC	Brian Dopp	210-381-3455	
Medina County Sheriff's Department	Gilbert Rodriguez	830-741-6150	sheriff@devtex.net
Mico Volunteer Fire Department	Wayne E. (Ed) Eades	830-612-2227	hceades@aol.com

4.2 Study Methodology

The study proceeded performing the following tasks:

- Regional meetings for emergency managers. Two meetings were held at the BMA office in Natalia on February 17 and 18, 2004. The agenda for these meetings was primarily to solicit input from regional EM staff as to regional EM issues and needs. Input was solicited via a questionnaire prepared for the meetings. Questionnaire responses received are provided in Appendix 4A.

- Development of response to meeting input. URS performed selected tasks as a response to the input received during the EM staff meetings. These tasks included:
  - Development of recommended guidance for specific issues of interest to EM staff: preparation or review of existing EM plans, pre-disaster activities, prepartion of a debris management plan, preparation of a recovery plan, and other issues. This guidance was developed by a senior URS engineer familiar with EM practices in several regions nationwide. This guidance is provided in Section 4.3.
  - Development of recommended EOC actions associated with dam safety warnings issued by BMA (Section 4.4).
  - Development of a summary of current communications procedures (including current notification lists) among regional EM staff for flood situations. Recommendations for potential improvement of these procedures are also provided (Section 4.5).
  - Development of Early Warning System (EWS) guidance. Basic FEMA guidance for warning siren design is provided as Appendix 4B. Sample vendor information for cameras, lighting, and sirens used successfully by URS is provided in Appendices 4E and 4F. A site-specific concept design for lighting and a video camera at Lake Medina Dam is provided, as is a generic design for a siren (Section 4.6).
  - Other Tasks Identified During the EM meetings (Section 4.7). These tasks include 1) providing a summary of information available for relating Medina Lake stage (at the dam) to elevations in subdivisions lakeside upstream, and in Castroville downstream; and 2) providing a base map for identification of roads that flood during major flood events (Section 4 Plates).
- Summary of Recommendations (Section 4.8).

4.3 Guidance for Emergency Management Planning

4.3.1 Introduction

Every community needs a roadmap of what to do at the time of an emergency. The emergency might be a natural disaster such as a flood or tornado or a technological hazard such as a tank truck incident on a local highway. The disaster might affect most or all of the community or it might only affect a neighborhood. It might last for days or occur and be cleaned up in a matter of hours. However in any of the scenarios, community leaders must know who to contact and solicit help from, who to inform of the incident, and where to shelter those who need to be moved from their residence, business or school. They must have an idea of which travel corridors might be affected, how long will it take to get people out of harm's way, and what resources are needed to weather the disaster.

This information cannot be obtained in a hurry while the disaster is occurring or even a few hours before it begins if it's the type of event where there is some warning (usually floods are this type). Actions must be thought out well in advance of an event. Various scenarios must be developed and the effects of those scenarios played out to develop the consequences so that plans can be made to deal with the various effects from the possible scenarios.

The counties and municipalities that are participants in this study have existing Emergency Management Plans at various levels of completion and complexity. This report is intended to enhance existing planning and is included as a supplement to what has already been developed. URS and/or the project participants and sponsors may wish to include some pieces of this supplement into individual plans thus this information is developed in a way that will hopefully make this incorporation an easy process.

4.3.2 General Guidance for an Emergency Management Plan

Important Contents for an Emergency Management Plan (EMP)

In general, an Emergency Management Plan (EMP) should address:

- The question of who is in charge. In the community, when decisive action is required to reduce both human and economic losses, someone must be in charge, direct others to take care of elements of community protection, and act as the Point of Contact (POC) for the media, the state, and surrounding communities. The EMP should identify who is in charge and include those who will provide certain types of backup.
- The EMP should be established to deal with a variety of emergencies however; the focus here is on the flood emergency.
- The EMP should define the operation of the EOC including specific location, how and when the EOC should be activated, who should be involved in the EOC in terms of support functions and how assets will be communicated with from the EOC and how they will be deployed.
- How counties or agencies within counties are expected to function with each other .
- How will warnings occur and who is expected to respond to the warnings.
- How the public education will be notified including, who must receive information about how to respond, and how local officials will know the message is being received.

The plan should provide a roadmap for future actions that should be taken or for additional plans that should be developed. The plan must include a provision for updating as no plan can remain static if it is to be effective at the time of use.

The important tasks that need to be performed during a flood emergency include:

- Notifying of the public about flood status and seeing that the public responds appropriately at the various warning levels
- Directing traffic such that impassable roads are not attempted and the most direct passable roads are used
- Opening of shelters as required
- Providing temporary supplies as required including bottled water, portable toilets, dry or canned food goods, fuel for generators or automobiles
- Coordinating efforts of the local utility providers, law enforcement, Department of Transportation, and citizens to remove downed power lines, secure floating hazardous debris, shut down waste water treatment plants, etc.
- Communicating with the media to help disseminate various public messages

- Coordinating with other public services such as fire, rescue, EMS, hospitals, schools, nursing homes, etc.

Recommended Predisaster Activities

The following activities are recommended for consideration as preparation for a future flood.

Education. Ensuring that the citizens in the areas potentially affected by flooding from either an overflowing river or a dam break react in a pre-determined way when they are told to evacuate is critical during a flood event. The citizens must know:

- Am I in an area that could be inundated with water.
- If I am in a potentially inundated area, how deep will the water be.
- How will I travel to get out of harms way.
- Will any roads I try to leave on be covered with water.
- If I have to leave during the day, how can I get my children from school.
- Where can I go for safety in a dam break scenario.
- Where should I go in a flood scenario when there is some warning time.
- What do the various warnings mean and what action am I supposed to take at each warning stage.
- How will I be alerted that there is a potential flood situation – will I be called, will someone drive by my house and warn me to leave, will a siren sound, will there be an alert on a radio or television station, etc.
- If I have to evacuate, what should I take with me and how long might I have to be gone from my home.

An education campaign and message should be planned so that irrespective of the medium used to distribute the message, it is the same message. The citizens will be confused if messages are developed and distributed by numerous organizations who will distribute the messages and they are even slightly different. An effective educational campaign could include:

- Printing flyers or brochures describing the potential threats, the possible inundated areas, and what citizens need to do if warned to leave.
- Mailing fliers that go to a targeted audience identified by zip code or telephone exchanges.
- Altering the message in various mailings to help insure readership. If every mailing looks the same, it will soon be ignored by those receiving them.
- Meeting citizen groups, clubs, etc where members live in the potential inundation area and discussing how citizens should be prepared.
- Meeting with ham radio operator clubs and soliciting help in formulating a message and a message dissemination campaign when it is time to issue flood or dam break watches or warnings.
- Printing material in multiple languages.

- Providing materials and speakers for public schools, especially lower grades. Children can do a lot of message sending to their parents, and parents seem to listen to their children.
- Distributing messages in local utility bills, telephone book inserts, and fliers in grocery stores.
- Announcing public messages over radio and television (Note: these outlets may cover too broad an audience, and thus there may be an overload of questions from citizens who are not likely to be affected and who should not have to take any action during a flood event).

Debris Management Plan

A substantial amount of debris can be created by either a flood or dam break. The higher the water velocity and the more bank overflow there is, the more debris will be created. Every community potentially affected by such an event should have a plan for dealing with the debris.

The plan should include locations for the permanent disposal of debris. Any environmental or other issues of public concern relating to the planned site should be resolved. There are numerous advantages to having a plan detailing sufficient pre-selected landfill sites of adequate capacity, notably: unnecessary site disturbance is minimized, costs are greatly reduced, and public acceptance is facilitated.

Appendix 4B is a sample Debris Management Plan template for possible use by the three-county areas.

Recovery Plan

A recovery plan deals with the many aspects of recovering from a disaster. Such a plan could guide the community on how to rebuild elements of the infrastructure (roads, bridges, sewer and water service, railroads, power grid, etc.), how to provide temporary and permanent housing, how to get children back in school, etc.

Developing a recovery plan is an excellent time to involve many other public and private entities in the thinking about how to rebuild. Many questions must be dealt with and many may require engineering, architect, planner, accountant, or legal input. Questions about how badly damaged an element must be before replacement is considered the only viable option must be answered. This question must be asked and answered for many of the systems noted above.

Issues of contamination of water supplies, landfills being filled with hazardous materials or other means of disposal, restocking items in critical facilities, all must take some high priority so that these very necessary functions can be brought back on-line as quickly as possible.

Financial planning is another important element of recovery, so the plan should address funding opportunities for both disaster-related relief and rebuilding, or identify some elements of the infrastructure that could be rebuilt better to reduce future disaster costs. There will be people who live and work outside the area inundated by flooding who will lose service – power, water, waster disposal, telephone, etc. It will be important to consider these people in any recovery and rebuilding plan as the number of people affected by this event could be many times the number of those who lost everything.

Installing Early Warning/Notification System

It is very important to get word or a signal of some sort to the citizens warning them of impending danger as far in advance as possible to minimize deaths and injuries from the flood or dam break event. There are numerous options for warning systems. A dam break event is similar to a tsunami in that a large wave or wall of water will flow into the inundation area very quickly, perhaps with little warning. Several warning methods are already in place in the three-county affected area. These systems include:

- Tone alert (weather) radios;
- Reverse 911;
- Sirens;
- Mobile announcement;
- Wireless announcement through metro call paging system;
- Door-to-door canvassing; and
- Surveillance.

At this time, when each of these systems is put into effect can vary depending on the flood or dam break scenario and on which county issues the warning. The chart below suggests the most effective warning system(s) for each condition. In some conditions, multiple warning systems may be required to create a fully effective warning network.

Table 4-2. Applicability of Warning Systems

	Tone Alert Radio	Reverse 911	Sirens	Mobile Announcement	Wireless Announcement	Door-to-Door	Surveillance
Flood watch	****				***		**
Flood warning	****		***	***	***	**	**
Dam watch							**
Possible dam failure	**	****			***		**
Imminent dam failure	****	****	****	**	***	*	
Dam failure	****	**	****	*	**		

No designation suggests warning system would not be effective for a particular watch/warning.
* Minimally effective strategy.
** Somewhat effective strategy.
*** Effective strategy.
**** Very effective strategy.

The least expensive method is tone alert radios since the citizens pay for the communication medium. Effectiveness of this strategy depends upon having a sufficient number of citizens listening to the radio. Surveillance, door-to-door canvassing, and mobile announcement systems require some manpower on the part of the counties but no significant equipment. Wireless announcement systems such as paging will only cover a small number of citizens and will require some funds for equipment and service. Reverse 911 systems will require funding, and if telephones are frequently cellular phones, then the system will not be very effective. Sirens will probably be the most costly, but the most effective. Coverage can be focused on those areas in the probable inundation zone and can be used for a number of different emergencies by using different signals.

Temporary Housing, Cooperative Agreements for Utility Service Repair

While temporary housing should be included in recovery plans, it is very important to understand the dynamics of people not having their own permanent housing for an extended period of time. Recovery occurs faster when people can put their children back in school, people can go back to work, and life seems more normal.

For housing to be replaced, even temporarily, services must be available. Water supply, waste disposal, power, and telephone service all must be hooked to the temporary housing so that people can operate normally. If services are lost due to the event, temporary services must also be provided. For these services to be ready to supply needs, contracts must be in place for bottled water, portable toilets, generators, portable phone banks, and mobile homes. Extensive effort is required to make arrangements for these services well in advance of an event, especially without knowing that any specific event will actually occur.

Practice and Exercises

Practicing elements of the plan helps insure citizens will do what is expected of them when the emergency occurs. Practice also gives emergency management, law enforcement, fire, rescue, and volunteer groups a chance to practice a response to various type and magnitude events.

Exercises must be carefully designed to achieve the maximum usefulness. They should include roles for as many important players as possible. The exercise should include ‘exercising’ many of the emergency support functions so the interaction and required communication between various agencies can be tested. The exercise should include a test of the citizens response to the warning systems used during the exercise.

Practice or exercises should be conducted on a frequency that provides sufficient testing but not so often that the practice is meaningless. A frequency of 6 – 12 months is probably about the right time frame at least for the first 2 – 3 exercises until the roles of various important players are clear. As new players come on the scene in various roles, an exercise should be conducted so these new players understand their part in the overall success of managing a significant disaster event. Different types of disasters should be used in the exercises as well as this will test different elements of the plans. Exercises for floods, dam breaks, tornadoes, and a technological and man-made hazard event should be considered.

Funding Opportunities

There are some federal opportunities for funding some of these programs and projects. FEMA's web site http://www.fema.gov/fima/ has information about many of the mitigation programs including the type of planning or project activity that might qualify. All of FEMA's programs must be submitted through the state to the Region (Region VI located in Denton, TX). Some of the funding programs are:

HMGP – Hazard Mitigation Grant Program provides funds for planning and projects that reduce the costs of future disasters. The funds are provided as a percentage of a federally declared disaster. Projects must be cost-effective where the project benefits are greater than the project costs.

PDM – Pre-Disaster Mitigation funds are competitively awarded. Planning and project grants compete with other projects from across the nation. All projects must be cost-effective. Project grants usually have cost ceilings to them. For 2003, the maximum award was $3,000,000. The 2004 PDM program has been authorized by Congress and project grant applications will be requested soon by FEMA.

Some funds have also been distributed through the Homeland Security Department for the improvement of communication between regional and local emergency management offices, and also for the procurement of emergency vehicles and equipment. The regional entity with the most experience with these programs is the Alamo Area Council of Governments (contact provided in Table 4-1).

In some locations along the Medina River, notably upstream of Castroville, severe flooding can lead to debris accumulation which raises local water levels or which can largely block the channel and force some flow diversion into areas not otherwise flooded (discussion with Tim Fousse, Castroville EMC at February 18 neeting). Funding may be available under the NRCS Emergency Watershed Program (EWP) to perform channel restoration to address channel damages associated with erosion and debris issues.

4.4 Lake Medina Dam Safety Warnings and Regional Response

4.4.1 BMA Dam Safety Warning Procedures

Lake Medina Dam is classified by the State as a High Hazard structure. As explained in Section 3, this classification is unrelated to the condition of the structure and is set only by the possible consequences of dam failure. The inundation maps presented in Section 3 demonstrate that a dam could result in loss of life and would certainly result in major economic loss in Medina and Bexar Counties, and these effects would likely extend into Wilson and Karnes Counties.

BMA has prepared an Emergency Action Plan (EAP) which explains BMA's procedures for issuing dam safety warnings during a severe flood. These warnings follow the guidance and format presented in Chapter 8 of "Guidelines for Operation and Maintenance of Dams in Texas" (TWC [now TCEQ], 1990). Guidance per the current EAP is provided in the following sections and in Appendix 4C.

Emergency Conditions. Once an emergency has been identified, it must be classified according to its urgency. The following five classifications shall be used.

Situation		Examples of Condition
Watch Condition	A problem has been detected which requires constant monitoring or immediate action to repair or correct, or a potentially hazardous situation is developing.	Medina River Flood Warning Issued by National Weather Service (NWS) for Bandera or Medina County watersheds upstream of Medina Lake.
		Flow at elevation 1068 ft Mean Sea Level (not BMA datum) overtopping Emergency Spillway by 4 ft with water rising or additional major short term rainfall predicted.
		Significant changes noted in dam, foundation, or abutment seepage rates, without evidence of erosion or rock spalling.
Possible Dam Crest Overtopping	A Watch Condition providing warning of potential dam crest overtopping.	USGS Gage 08178880 at Bandera with stage exceeding 38 ft (elevation 1228 ft Mean Sea Level), while Medina Lake level exceeds 1069 ft Mean Sea Level (not BMA datum).
		If Medina Lake level exceeds 1071 ft Mean Sea Level (not BMA datum) (7 ft over the spillway crest), use rate of rise (calculated every 15 minutes) to estimate time to rise to elevation 1076 ft. A possible dam crest overtopping condition exists if flood reaches this elevation within 6 hours.
		If the NWS predicts overtopping of the Dam Crest to occur.
Dam Crest Overtopping	A Watch Condition providing notice that dam crest has been overtopped.	Water is going over the dam crest at any location.
Possible Dam Failure	A Watch Condition that is getting progressively worse.	Use rate of rise (calculated every 15 minutes) to estimate time to rise to elevation 1079.3 ft. A possible dam failure condition exists if flood reaches this elevation within 6 hours.
		Further increases in dam, foundation, or abutment seepage rates, without evidence of erosion or rock spalling.
Imminent Dam Failure	The Field Foreman has determined that conditions at the dam will progress to a failure of the dam and an uncontrollable release of the reservoir.	Overtopping of Dam Crest by 3.3 ft (1079.3 ft msl).
		Movement of Dam (crest or abutment)
		Rock spalling, plucking, or erosion in foundation or abutment from impact of overtopping.
		Abutment or foundation seepage with rock erosion, spalling, or plucking.
Dam Failure	A failure has occurred and a flood wave is now heading downstream.	A failure has occurred and a flood wave is now heading downstream.

Emergency Actions. Once the emergency has been classified, the following actions are recommended.

Situation	Recommended Action	Responsible Person
Watch Condition	1. Issue Watch Condition Warning Message (p. 4-7) per Notification Plan	Board President
	2. Instigate continuous monitoring of structure	Field Foreman
	3. Obtain assistance from expert consultants, as needed	Board President
	4. Initiate calculation of lake level Rate of Rise (Eqn #1) every 15 minutes after lake level reaches 1072 ft mean Sea Level (not BMA Datum)	Field Foreman
	5. Issue cancellation of Watch Condition when condition no longer exists	Board President

Situation	Recommended Action	Responsible Person
Possible Dam Crest Overtopping	1. Issue Possible Dam Crest Overtopping Warning Message (p. 4-7) per Notification Plan	Board President
	2. Obtain assistance from expert consultants, as needed	Board President
	3. Issue cancellation of Possible Dam Crest Overtopping Warning when condition no longer exists	Board President
Dam Crest Overtopping	1. Issue Possible Dam Crest Overtopping Warning Message (p. 4-7) per Notification Plan	Board President
	2. Issue cancellation of Dam Crest Overtopping Warning when condition no longer exists	Board President
Possible Dam Failure	1. Issue Possible Dam Failure Warning Message (p. 4-7) per Notification Plan	Board President
	2. Issue cancellation of Possible Dam Failure Warning when condition no longer exists	Board President
Imminent Dam Failure	1. Issue Imminent Dam Failure Warning Message (p. 4-7) per Notification Plan	Board President
	2. Issue cancellation of Imminent Dam Failure Warning when condition no longer exists	Board President
Dam Failure	1. Issue Dam Failure Warning Message (p. 4-7) per Notification Plan	Board President

Emergency Conditions Based on Water Levels. Note: All other conditions of the Dam (structural, foundation, etc.) should be monitored and evaluated with the water levels during an emergency situation. This table is consistent with the table on page 4-10 and is intended as a further clarification of that table.

Water Level (ft MSL)	Description	Resulting Action
1064	Water begins to overtop Spillway	No emergency condition, continue to periodically monitor.
1068	Water is overtopping Spillway by 4 ft	Go to ***Watch Condition.***
1069	Call National Weather Service for water level at Bandera USGS Gage, which is 6 hours upstream of Medina Lake Dam.	If Bandera USGS Gage is <u>below</u> 1228 ft MSL, remain at ***Watch Condition.***
		If Bandera USGS Gage is <u>at or above</u> 1228 ft MSL, go to ***Possible Dam Crest Overtopping.***
1072	Calculate Estimated Time to Overtop Dam Crest (Eqn #2) using Rate of Rise (Eqn #1), every 15 min.	If water is predicted to overtop elevation 1076 in <u>more</u> than 6 hours, remain at ***Watch Condition.***
		If water is predicted to overtop elevation 1076 in <u>less</u> than 6 hours, go to ***Possible Dam Crest Overtopping Condition.***
1076	Water begins to overtop Dam Crest	Go to ***Dam Crest Overtopping Condition.***
	Continue to Calculate Estimated Time to reach elevation 1079.3 (Eqn #3) using Rate of Rise (Eqn #1), every 15 min.	If water is predicted to overtop elevation 1079.3 in <u>more</u> than 6 hours, remain at ***Dam Crest Overtopping Condition.***
		If water is predicted to overtop elevation 1076 in <u>less</u> than 6 hours, go to ***Possible Dam Failure Condition.***
1079.3 or higher	Water is more than 3 feet over dam crest.	Go to ***Imminent Dam Failure.***

Appendix 4C also contains information on water level rate of rise calculations, water level monitoring log guidance, and sample notification messages. The emergency notification flow chart is provided below. A more detailed explanation of how the communication will be made between BMA and the entities on the Notification Chart is explained in Section 4.5.

EMERGENCY NOTIFICATION FLOWCHART FOR MEDINA LAKE DAM

Emergency Condition

↓

Observer

↓

BMA Field Foreman
Brian Sullivan
Shop office 830-985-3271
Mobile 210-825-9869

↓

BMA Board President
Tommy Fey
Office 830-709-4733
Mobile 210-508-9957

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BMA OFFICE

1. BMA Business Manager		830-665-2132
Ed Berger		
2. BMA Dam Caretaker	home:	830-612-2294
J.R. Gulley	mobile:	210-287-0933

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DOWNSTREAM RESIDENTS
From Medina Lake Dam to Diversion Dam

1. Medina Ranch, Inc.
Primary contact will call 22 vacation residents
Ranch Foreman,
Tony Sammis mobile 210-213-5729
President,
Dr. John Williamson mobile 210-213-0465

2. David Zinsmeister 830-612-3704

3. James Calvert (phone # N/A)

4. Nancy & Bob Wallace 830-612-2536
210-764-0797

5. Irene Kocurek 830-612-2842

6. Residents below Diversion Dam will be contacted by Sheriff's department.

-1-

1. **PRIMARY CONTACT - (Will coordinate all local agencies listed in this section below)**

Medina County Sheriff Department		
Emergency Dispatch	24 hr	830-741-6153
Sheriff Gilbert Rodriquez		830-741-6150
ALTERNATE CONTACTS – in order (If unable to contact Sheriff)		
Medina County		
EMC, Brian Dopp		830-741-6021
Judge James E. Barden		830-741-6020
Medina County Sheriff/ EMC to contact:		
Texas Dept of Public Safety		
DPS Dispatch Center	24 hr	210-531-2280
Bandera County		
Sheriff James MacMillan	24 hr	830-796-3771
Judge Richard Evans		830-796-3781
Bexar County		
EMC, Carl Mixon		210-335-0300
Sheriff Ralph Lopez	24 hr	210-335-6000
Judge Nelson Wolf		210-335-2626
San Antonio Dispatch	24 hr	210-207-7744
City of Castroville		
EMC, Tim Fousse		830-931-0234
Police Dept		830-931-2222
Mayor Robert Hancock		830-931-4070
ESD #1, Medina County		
Polly Edlund		830-931-3358

2. **NATIONAL WEATHER SERVICE**

San Antonio/Austin Office
24 Hours 830-606-3600, Press 3
8-4 pm 830-606-3617 x206
Primary Contact – contact periodically for updated river information:
Hydrologist, Mark Lenz x228

River Forecasting Center 817-831-3289

3. **URS ENGINEERING**

Project Manager, Jeff Irvin Office 512-419-6523
Austin Office Cell 512-658-0856

4. **TEXAS COMMISSION ON ENVIRNMENTAL QUALITY**

Emergency Response Hotline- Austin, Texas 1-800-832-8224
Dam Safety Team
Coordinator, Warren Samuelson Office 512-239-5195
Home 512-238-6660

5. **TEXAS DEPT OF TRANSPORTATION**

Hondo Area Office 8-5pm, 830-426-2522 (Mtce.) or 830-741-8024 (Main)
Primary Contact
Area Engineer, Carl Friesenhahn Mobile 830-426-1923
Home 830-538-2713

Secondary Contact
Asst. Area Engr, Greg Biediger Home 830-612-2464
Mobile 830-426-1924

4.4.2 Regional Response to National Weather Service and BMA Dam Safety Warnings

The National Weather Service (NWS) issues warnings concerning actual and predicted flood levels in the Medina River corridor. The status of the current River Forecast Model for the corridor is described in Section 2 above. The NWS office in San Antonio currently issues a river flood statement when the Medina River's banks are full (a depth of 10 ft). The flood statement is good for the river depths of 10 ft to 12 ft. When the flood depth at the Bandera USGS Gage No. 08178880 is 13 ft and the river is over its banks, a flood warning is issued. The warning will extend for 12 to 24 hours, and the warning is issued by the local NWS office. Flood watches are experimental at this point; however it seems that flood statements provide the same information to the community. The information from the NWS should be used in addition to lake levels to anticipate conditions some hours in the future.

This section addresses the currently planned regional actions associated with NWS warnings and with each of the dam safety warnings described in Appendix 4C. The actions noted below were provided by EMS leadership for each of the three counties (Bandera, Medina, and Bexar) at and following the EM staff meetings in February, 2004. Bandera County is above the Medina Lake Dam and thus will be more affected by Medina River flooding until there is a possible dam break scenario, and then counties below the dam (Medina and Bexar) will be more affected by a possible dam break.

- "Flood watch" (currently the NWS issues flood statements, not flood watches)
  - Bandera County might activate EOC;
  - Medina County would monitor conditions; and
  - Bexar County would notify EOC staff and volunteers, Bexar County would consider evacuation procedures including deciding what areas might need to be evacuated.

- "Flood warning" – issued by the NWS when river is 13 ft in depth and over its banks at the Bandera gage
  - Bandera County would alert first responders and local agencies;
  - Medina County would activate EOC – ready for a possible evacuation; and
  - Bexar County would activate EOC – ready for a possible evacuation.

- "Dam watch"– issued by BMA, occurs when water is 4 ft deep going over the dam spillway or water surface elevation of 1068 feet MSL (USGS datum, not BMA datum)
  - Medina County monitors water level and spillway discharge; and
  - Bexar County notifies EOC staff and volunteers, prepares for evacuation and sheltering.

- "Possible dam failure" – issued by BMA, lake water surface elevation at dam is 1071 feet (USGS datum, not BMA datum) (7 feet over spillway) and current rate of rise would reach elevation 1074.5 feet within 6 hours.
  - Medina County evacuates and shelters, calls state for required assistance, and prepares for search and rescue; and
  - Bexar County activates EOC and considers evacuation.

- "Imminent dam failure" – issued by BMA, water is overtopping dam crest of 1076 by 3 ft or more, or site observations show stress.
  - Medina County evacuates and helps to transport residents from downstream area; and
  - Bexar County evacuates and shelters, calls state for required assistance, and prepares for search and rescue.

- "Dam failure" - issued by BMA if dam fails.
  - Medina County works with Red Cross to open shelters, provides support to fire and EMS personnel, assists with law enforcement; and
  - Bexar County evacuates, shelters and prepares for mass care, performs search and rescue, asks for state assistance as required.

The one action that could cause confusion is at the Possible Dam Failure stage where the water surface elevation at the lake is 1071 MSL. At this action, Medina County says the emergency evacuation plan is being initiated and Bexar County is activating their EOC. If Medina County activates their EOC at this warning stage, and BMA sends a representative to the EOC to help coordinate information about the event, then there is less chance for confusion and mixed messages to be sent to the public. However, if one county is activating their evacuation plan and another county is not activating their evacuation plan, this will send a confusing message about the seriousness of the possible event. It is recommended that both Medina County and Bexar County activate their evacuation plans upon receipt of the "possible dam failure" warning from BMA.

4.5 Flood Emergency Communications Procedures

Based on interviews conducted with the Bandera County EMC, Medina County EMC, Medina County Sheriff, and the Medina County ESD#1, there appear to be two types of communication networks regarding flooding conditions along the Medina River. The first communication network is based upon an informal agreement among local entities that has been established as a means to provide an early alert to residents immediately downstream of Medina Dam and to alert volunteers and paid local government employees responsible for assisting these residents of the need to be on stand-by status. The second communication network is more formal and is designed to mobilize government and volunteer personnel for a pending evacuation and notify the general public that an evacuation is needed.

A summary of the formal and informal communication networks and the communications technologies used to convey information during flooding conditions follows. The information presented is based on a series of interviews conducted by URS.

4.5.1 Formalized Communications Networks

BMA

BMA is notified of flood watch conditions via a cell phone call from the NWS. Brian Sullivan, the BMA field manager, is responsible for emergency management for BMA and has both a work cell phone with service provided by Nextel and a personal cell phone with service provided by Cingular. Notification of flood conditions is also received via a cell phone call from both a resident located at Medina Dam and a BMA contract employee who is also employed by the Medina County Sheriff and is dispatched to the Medina Dam by the Sheriff when the NWS issues a flood watch notice. Once alerted of flood watch conditions, Mr. Sullivan places a cell phone call to the following:

- Diversion Lake
  - Tony Sammis;
  - Dr. John Williamson;
  - David Zinsmeister;
  - James Calvert;
  - Nancy and Bob Wallace; and
  - Irene Kocurek .
- URS (or other entity in charge of piezometer monitoring) to initiate frequent readings of piezometer levels.

After notifying Diversion Lake residents, Mr. Sullivan drives to Medina Dam and remains at that location until the Medina River and Bandera River have crested. Although not a formal policy, if flooding conditions last for an extended period of time, Mr. Sullivan can contact another BMA employee to provide relief. During the 2002 flood, both the Manager and Director were physically located at Medina Dam to monitor flood conditions.

Bandera County

The first point of communication regarding flooding conditions along the Medina River is the Bandera County Emergency Management Coordinator (EMC). The Bandera County EMC has a National Oceanic and Atmospheric Administration (NOAA) radio at his residence that sounds an alert tone when significant rainfall is occurring. A secondary form of notification comes from local residents that have agreed to be "spotters" and contact the EMC via telephone (land line or cell) when water conditions become a concern. Once the Bandera County EMC has received notification of significant rainfall, the Bandera County Emergency Operations Center (EOC) is opened. At this point weather conditions are monitored by calling the National Weather Service (NWS) on the land-line telephone, monitoring radio traffic throughout the County (Police Department, Fire, EMS, and Game Warden), and monitoring the USGS water gage data available via the internet.

As a general rule of thumb, if Bandera County receives three inches or more of rain[1], the Bandera County EMC will notify the following of rainfall totals and predicted flood level information:

- Bandera County Deputy (radio);
- Bandera County Judge (land-line or cell phone);
- Castroville EMC (cell phone and pager); and
- Hondo Sheriff Department (via radio) – most recent rainfall event only.

[1] If the ground is already saturated, the EOC may be opened when 2 inches of rain has fallen.

Medina County

Notification of potential flooding conditions is received by the Medina County Sheriff's office by tele-type from the NWS. If the flood situation is severe, the NWS will follow-up with a telephone call to ensure that the information has been received. Once the notification is received, the Medina County Sheriff contacts the following:

- Medina County Judge (via telephone);
- Medina County EMC (via telephone);
- Castroville EMC (via telephone, pager, or radio);
- La Coste City Manager, Mayor, and Police Chief (via cell phone);
- BMA (via telephone)(if BMA has not already notified the Sheriff);
- County Commissioners; and
- Volunteer Fire Departments.

The Sheriff disseminates information to the County Commissioners via cell phones and pager so that road crews can be organized to provide assistance as needed. In addition, the Medina County Sheriff will send a Deputy to monitor and report on water conditions at Medina Dam via cell phone, radio, or pager. The Medina County Deputy currently rents property at Medina Dam and is paid by the BMA to be the Medina Lake Caretaker. The Medina County Deputy remains at Medina Dam until the flooding conditions have passed or he needs to leave to ensure his own safety. Another police official replaces the Deputy after 10 hours. The Sheriff also notifies Volunteer Fire Departments in the area via pagers that have specific tones to identify the type of danger and the specific location where assistance is needed. The San Antonio television media (ABC, CBS, NBC, and FOX) and Medina County radio station (KCWM) are also notified via telephone.

To date, the Medina County Sheriff's office has not experienced problems with the functionality of the existing communications systems when needed to convey information about flooding conditions. Medina County police officers have routine patrol routes around Medina Dam, and therefore the communication systems are continuously being used and periodic testing is not required. When the County Judge or Sheriff determine that the general public needs to be notified, a telephone call is made to residents in local subdivisions and squad cars are dispatched to notify residents via a public address system. The VFD and police officials will also conduct door-to-door notifications.

4.5.2 Informal Advance Warning Communications

The existing Lake Medina Dam Emergency Management Plan calls for initiating a series of dam safety warnings when flow is 4 feet deep over the spillway. The Medina County Sheriff begins notifications when the water flow is 1 foot deep over the spillway. These notification triggers are based upon current water levels. However, information on both the current water levels and the rate of rise is essential for communities downstream of Medina Dam that need more lead time to inform residents and emergency personnel of a potential flood hazard in Medina Ranch, Rio Medina and Castroville.

Most of the water that enters Medina Lake comes from the Medina River. Therefore, the amount of water in the Medina River and the rate at which the river is rising is a good indicator of the potential for flooding conditions downstream of Medina Dam. There is currently a USGS water level gage on Medina River in the City of Bandera. However, the USGS only updates the agency website with water level readings taken from this gage every 4 to 6 hours, during which time a significant change in conditions may have occurred. In Bandera County, individuals monitor the water level gage and report the data real time to the Bandera County EMC. This real-time information is used to make predictions about the rate of rise downstream and can assist communities downstream to better prepare for potential flooding conditions.

Over the past few months, the Bandera County EMC and the Castroville EMC have been working closely to better communicate information on the potential for flood conditions downstream of Medina Dam. In the recent past, during heavy rainfalls several courtesy calls have been made from the Bandera County EMC to the Castroville EMC that have assisted in alerting emergency entities downstream of the need to be on stand-by status. These courtesy calls were initiated as soon as the Bandera County EOC was opened. The Bandera County EMC courtesy calls to Castroville were also supplemented by courtesy calls from BMA prior to the water reaching 4 feet above the spillway.

Once the Castroville EMC is notified, that EMC contacts the following via cell phone or land-line telephone:

- Castroville Mayor;
- Castroville City Administrator;
- Castroville Police Chief;
- Medina County EMC; and
- ESD #1 (depending on the severity of the situation).

The Bexar County EMC is also the Chief of the La Coste Fire Department, which is one of the Volunteer Fire Departments within ESD #1. Therefore, once ESD#1 is notified, the Bexar County EMC is aware of the potential for flooding conditions. The ESD #1 also notifies residents in Medina Ranch via land-line telephone or e-mail. Typically, e-mail is only used as a method of communication when there is at least 2 days of lead-time between notification and predicted flooding conditions.

4.5.3 Discussion of Communications Issues and Recommendations

Problems Encountered With Current Means of Communication

One of the problems that has been encountered in Bandera and Medina Counties in the past as a result of communicating flood conditions by way of radio is that there are a significant number of private citizens that have scanners and are able to intercept radio communication. In the past, private citizens have misinterpreted the information conveyed and then disseminated inaccurate information to the public. To address this problem and the problem of having black out areas where radio coverage is incomplete, Medina County has been evaluating the cost of transitioning from a VHF high-band radio system to a 900 MgHz radio system. Because all County radios would need to be replaced, converting to a 900 MgHz radio system is likely to be cost prohibitive.

Recent Communication Enhancements

The Medina County Sheriff's office recently purchased, through a Homeland Security Grant, a travel trailer that includes 30 to 40 portable radios and a computer with internet access. This trailer can be located as needed to facilitate communications during emergency conditions.

Planned Communication Enhancements

1. **Radar Gage** - Castroville has included in their next year's pre-approved budget costs to install an ultrasound radar gage on the river in Castroville that reads continuously through SCADA. Essentially, this device is similar to a radar gun that sits above the river and then automatically sends a radio signal through a computer to notify Castroville that the water has reached a specific level. The gage data feeds into the same SCADA system used for monitoring of city utilities: water, wastewater facilities, etc. Funding for this system has been requested in the current budget, which is to be approved this month. If approved, the radar gage would likely be installed in November. Other municipalities can install a similar device that can link to the one set up in Castroville. The cost would likely run about $6,000 for the equipment and then an additional $1,000 to $2,000 to set up the computer linkages.

2. **Siren System** - Medina County is considering (and has included in their proposed budget) a County-wide Emergency Siren System that would notify residents to turn on their televisions or local radio station to obtain information about flooding conditions. This would provide an expeditious way to disseminate information to the general public. Medina County is planning to fund the cost of installing sirens in smaller communities and Castroville, Devine, LaCoste, Natalia, and Hondo have agreed to purchase sirens for their own communities that would be part of the County-wide system. The main siren control will be operated by Medina County. However, individual communities have the option to purchase a second control that would activate the siren for their community only. The current proposed budget also includes funding for a localized AM radio station that would provide general community information during non-emergency situations and emergency information when the County-wide Emergency Siren System is activated.

3. **Ham Radios** - The Medina County Sheriff's office is evaluating the use of ham radios as an additional method of back-up communication. There are currently a number of private citizens that are ham radio operators in the local area. Therefore, the only requirement to implement this option is the purchase of hand radios so that County Sheriff staff can communicate with the ham radio operators. Due to funding limitations, purchase of these hand radios has not been finalized.

Recommended Communication Enhancements

1. **Land-Line Telephone at Medina Dam** – Currently, cell phones are the only communication option for BMA employees located at Medina Dam. Installation of a land-line telephone in the weatherproof building where the gate operator is housed would provide a reliable back-up method of communication should the cell phones be inoperable.

2. **Coordination with Medina County EMC** – Currently the Medina County Sheriff is receiving information about flood conditions primarily from the NWS and a Deputy dispatched to Medina Dam. Given the recent hire of a Medina County EMC, there is an opportunity for parallel communication between the three county EMCs, which can provide more advanced warning of the potential for flooding conditions. To ensure that the Medina County EMC receives courtesy calls currently provided other entities downstream from the dam, the Medina County EMC needs to work with the Bandera County and Bexar County EMCs to be included in any EMC notification charts. Contact information for the new Medina County EMC is included in Table 4-1 above.

3. **Water Gages** – The key to protecting the public during flooding conditions is ensuring that adequate lead time is available for emergency responders to be mobilized and ensure the safety of local residents. While the USGS has installed a water level gage in the lake immediately upstream of Medina Dam that takes readings every 15 minutes, information transmitted to the USGS website is only updated every 4 to 6 hours. More frequent updates during flooding conditions would enable emergency management personnel to better predict water levels and ensure adequate lead time is available to protect the public and their property. Another recommendation that would increase the amount of lead-time available is the installation of additional USGS gages upstream from the community of Medina where the north and west prongs of the Medina River join together and where Highway 16 and Highway 2107 merge. This issue is discussed in more detail in Section 4.7.1.

4. **Back-up Generators** – Many of the communications technologies currently being used by EMCs rely on electrical power (telephones, television, radio, internet). Should there be an extended power outage during a flood situation, communication about flooding conditions would be severely restricted. Ensuring that the EOCs have adequate back-up generators (if not already present) would reduce the risk of communication problems should a power outage occur.

5. **Review of Notification Chart** – Figure 4-2 provides a summary of the notifications discussed above. It is recommended that this figure be incorporated in existing Emergency Management Plans, and that edits be communicated to all agencies listed in Table 4-1.

4.6 Overview of Early Warning System

This section provides selected guidance on early warning systems for the Medina River corridor. Gudiance is provided on the following topics:

- Warning Sirens. Section 3 has demonstrated that a failure of Lake Medina would inundate a substantial populated area downstream of the dam, and that warning time is minimal. Installation of sirens in areas of concentrated population are recommended, and is currently in the planning stage in parts of the corridor (see Section 4.5). This section provides some selection guidance for sirens.
- Video surveillance system for Lake Medina Dam. This section provides a concept design for a video surveillance system for the dam.
- New flow gages. This section provides some recommendations as to the locations of new gaging stations for the corridor.

4.6.1 Warning Sirens

General Guidance

The use of outdoor warning sirens for evacuation of downstream residents is becoming more prevalent in recent years. Advances in siren technology coupled with flood forecasting and dam safety automated data acquisition system capabilities now provide reliable and cost-effective means to warn downstream residents of a pending or imminent safety event. Warning sirens come in a variety of styles and formats, there are mechanical sirens, electro-mechanical sirens and more recently solid-state sirens. Until recently, sirens operated primarily by using a variety of tones that could be used to designate different safety events such as tornadoes, flood warning or some other type of natural disaster. Sirens available in the marketplace today now include the ability to broadcast voice messages, in addition to tones, using pre-recorded messages or through direct voice broadcast in real-time. Appendix 4D provides a copy of FEMA's Outdoor Warning Systems Guide (CPG 1-17). Although this guide was published in 1980 it provides a good overview of sirens, properties of sound and provides a means of designing the layout of a siren network for a given community. We understand that this document is currently being revised and may be officially updated soon. Depending upon the timing of this project you will need to check to make sure that the most recent guidance is being used.

Essentially the design goal of a siren warning system is to broadcast siren tones and/or voice messages to the population within the anticipated evacuation zone(s). Prevention of false alarms in the event of equipment malfunction, providing manual override control, and the ability to run daily diagnostic checks on the siren network are critical system capabilities. The siren warning system should be incapable of activation in the absence of an instruction from an operator.

The installation of a siren warning system needs to be coupled with both an evacuation plan and a community outreach program. Basically the downstream community needs to know what the sirens mean and where they should go for safety. This can only be provided through the use of an evacuation plan and community outreach campaign to educate both the emergency operations personnel and affected residents of the community. An issue associated with dam safety early warning systems is that most of us have been trained to head for the basement when the sirens go off. This is not the place to be during a potential flood event. The community needs to be able to clearly differentiate between a storm warning siren and flood warning siren tone/voice message.

The determination of the type and number of sirens required to properly alert a community is a function of population density, area-wide topography and ground cover. If urban areas are in the evacuation zone the number and size of commercial buildings is important. The previously mentioned FEMA document CPG 1-17 can be used as a guide to determine the type of sirens required, the number of sirens required and approximate location of the sirens in a given area. Other issues to consider in designing a siren system include availability of AC power at siren locations, communications options and who will control activation of the siren system (i.e., where will the siren control console be located).

A very basic rule-of-thumb, to get an initial count on the number of sirens that might be required, is to assume one siren per square mile of evacuation zone. This can vary a lot depending upon population density, topography (hilly versus flat terrain), and ground cover (grasses versus dense tall trees, etc.).

Siren Components

Generally siren installations use the same configuration and component set. The foundation support and other location-specific items such as solar panel locations (if required) and orientation of antennas will be adjusted for each location. A typical siren location consists of the following components:

- Speaker Cells
- Mounting Pole or Tower
- Power Supply
- Siren Control Unit
- Radio Transceiver

Each of these components are described in the following sections. Appendix 4E provides vendor information for several siren manufacturers.

Speakers. Every siren has at least one speaker cell. Generally individual speaker cells are banked or grouped together to increase the sound output at a specific siren location. Although mechanical (rotating sirens) use fewer speakers the mechanical nature of these types of systems can increase long-term maintenance costs. Therefore, we suggest that you consider solid-state sirens for this specific application. The solid-state sirens can consist of either omni-directional or directional units or both.

The speaker is a stack of two to ten identical electromagnetic compression driver/folded exponential horn units called speaker cells that generate the sound pressure waves heard as tones or voice messages. The drivers produce sound pressure levels (SPLs) that are directed in a

360-degree radial pattern and are controlled by the speaker housing for loudness, clarity and intelligibility within the zone of influence of the siren.

Performance of a siren acoustic survey can provide site-specific information to refine the design of a siren network.

Mounting Tower. The siren can be mounted on either existing facilities, wood or steel monopoles. The mounting requirements are unique to the size of siren required and the local foundation conditions.

We prefer the use of a hollow steel monopole mount to support the speaker cells, and the radio antenna (refer to Figure 4-3). The galvanized steel poles are supplied in two 20-foot sections. All wiring is run inside the pole to reduce the potential for vandalism and general long-term degradation of wiring and connectors from sunlight exposure. The use of Class 2 wood poles can be considered for this application. However, this requires exterior cabling that can increase future maintenance costs.

Foundations for each monopole need to be designed based on ground conditions at or near each mounting pole location. There are two general classes of foundations: (1) a spread footing for areas with shallow bedrock at or near the ground surface or stronger soils; and (2) a deep foundation consisting of drilled shafts.

The mounting poles are typically 30 to 40 ft tall. The height of the pole is governed by the size and output power of the speaker cells. Louder sirens require higher mounting poles.

Power Supply. Sirens can be connected to AC power when available. If local power is not available then the sirens will require solar powered battery backup units. The size and number of solar panels and required batteries is a function of the number of speaker cells at each siren location.

Siren Control Unit. A siren control unit is located at each siren and it interprets the radio messages sent out by the central station control unit (usually located at the local emergency operation center or sheriff's department) and activates the warning signal tones and/or voice messages if the incoming coded radio message satisfies security coding requirements. Amplifiers in the siren control unit drive the speaker cells mounted on or adjacent to the siren pole. The amplifier is controlled by electronic circuitry in the control unit and plays pre-recorded digital files that are "burned into" an electronic programmable read only memory chip (EPROM). The siren control unit provides other important functionality as well. The system's voice capabilities will allow the sirens to broadcast public address messages when necessary to assist with evacuations.

The siren control unit also provides system health status and diagnostic information back to the central station siren control console. Each siren can be interrogated and status of all functional blocks reported back to the siren control systems either on schedule or when requested by an operator. Message security is high since the control codes are based on a key developed by the network controller at the base location. Accidental or coincidental activation of all the sirens is unlikely since each siren has a unique control code not known to the other sirens.

Radio Transceivers. Radio transceivers are typically voice-capable radios housed in the same NEMA-4X case as the siren control unit. The operating frequency selected will likely be in the VHF (136.00 to 151.00 MHz) band. Final selection of the frequency will depend on local site conditions, path conditions, and radio traffic considerations. The radio provides full two-way communication with the central station control. A detailed siren design will require radio path and signal strength surveys for a single or multi-siren network.

Activation Acknowledgement and Remote Diagnostics. A radio network typically provides siren activation acknowledgement from each siren during an activation event. The operation of each siren and the conditions of operation will be reported back from each siren. Sirens can also report back diagnostic system status according to an established schedule on a regular basis. This status information can be logged to a PC connected to the siren interface controller running a software package specifically developed by the siren vendor for this functionality.

The overall cost of a siren warning system is dependent on the type and quality of sirens purchased, the number and size of sirens required and installation costs. There is also a long-term operation and maintenance cost associated with siren systems. There are a number of siren manufacturer's and siren system installers throughout the US. For this project we suggest identifying one or more local siren vendors/installers that cover the affected area. They can then provide specific information regarding types of siren manufacturer's equipment that can be supported locally and offer specific operational and maintenance issues in the Medina Dam area. For initial consideration and preliminary budget level pricing siren costs typically range between $20,000-$60,000 per location. These prices include installation, setup and startup fees. We would expect sirens for this application to be near the lower end of the cost range.

Indoor Alert Units for Special Use/Critical Facilities. A number of special use/critical care facilities may be located within the siren notification area. Since these facilities are likely to require significantly higher effort to evacuate residents, direct notification to these facilities using the same radio activation transmissions as the sirens is recommended. Several vendors offer indoor alert units. These units range in cost from about $500 to $1500 each.

4.6.2 Video Surveillance Concept Design for Lake Medina Dam

The primary components of an early warning system consist of an automated data acquisition system for instrumentation, remote video surveillance to confirm a safety event and a siren warning system for the downstream evacuation zone. This conceptual design report section will focus on the video surveillance system.

A video camera is recommended at Lake Medina Dam for two reasons: 1) to visually monitor the structure and the water levels during times of severe flooding, and 2) to provide additional security. Additionally, since Lake Medina Dam does not have any lighting for both security and viewing conditions after dark, lighting will be added to the concept design. Finally, the video system will need to have a method of communication to send the video images to one or more remote locations.

Lighting

After reviewing the lighting patterns of several overhead lighting systems, a general device type was chosen that provides lighting in two directions from one pole: both an upstream arm and light and a downstream arm and light. The poles would be located at the top of the dam at the downstream edge (refer to Figures 4-3 and 4-4) so that the downstream arm can overhang the downstream face to provide light on the critical downstream face of the dam. This provides light for personal observation as well as for video viewing of the downstream face. The upstream arm and light will direct its light on the crest and the upstream reservoir level. Based on previous discussions with Medina personnel, light will be concentrated in the center section of the dam and not at the abutments. The upstream and downstream lamps will contain different reflector patterns to provide general floodlight on the upstream crest and more of a concentrated pattern on the downstream face.

Video Surveillance System

The word video can describe a wide range of results. It can mean full- time, full- motion video that is nearly television quality, all the way down to a simple inexpensive black and white still image that is updated periodically. For Medina Dam, two approaches were considered. Both approaches are in the middle of the range based on complexity and cost. Both approaches transmit still jpeg file images. Jpeg images are most familiar to those who use the Internet as most still pictures on the Internet use the jpeg format. One approach, the most demanding in terms of bandwidth, includes video images that would be updated and transmitted about once per second. These images are best used for small, low-resolution images without much movement. In the second approach the video image seen at another location would only be updated when requested by the viewer. The preferred approach for Medina Dam would be a combination of the two approaches balanced for resolution, cost, simplicity, and bandwidth required for transmitting the images. That is, for general pictures the image would be smaller and lower in resolution, but when a high-resolution image is required, a larger and slower to update image could be transmitted.

There are several aspects to consider in selecting a video system. The major items are:

- Camera;
- Resolution;
- Mounting;
- Pan, tilt, aoom;
- Day/night viewing; and
- Video output.

Camera. The camera needs to be designed for operation outdoors in heat, cold, rain, sun, ice and wind. Most camera vendors have models designed for such applications. All vendors have color cameras designed for rugged outdoor applications. Since the camera is the heart of the system, the vendor needs to have considerable experience in servicing the industrial market place with reliable and serviceable equipment. Two major vendors fit the criteria listed: Cohu and Pelco. Refer to Appendix 4F for vendor information.

Resolution. For Medina Dam, the resolution of the video image needs to be high enough to view small details at far distance (refer to Figure 4-4). This is a function of the design of the lens and the design of the imager. A camera with a higher resolution and a good zooming power lens will be able to provide larger and clearer images, especially when it is important to view small detailed areas of the downstream face of the dam.

Mounting. The mounting of the camera needs to be rigid and secure and be able to withstand winds and heavy rain to provide clear images during times of severe weather. Besides being a function of the camera, this is also a function of the mounting method used. For Medina Dam it is desired to be able to clearly see as much of the downstream face as possible and be able to view, although with more limited resolution, as far away as the spillway. This will require a mounting location and mounting height that will place the camera at least above the dam crest. This will require a rigid tower of approximately 20-30 feet in elevation (refer to Figure 4-3).

Pan, Tilt, and Zoom (PTZ). For Medina Dam, being able to zoom in on a particular area of concern is a key required function. Part of the zooming function must also include the ability to pan and tilt to more closely observe the areas of interest. The camera must have a PTZ mechanism that will provide a range of viewing and that can be preset to automatically scan various areas on a regular basis. Most vendors offer a software package and memory in the camera to pre-program the PTZ to give a "tour" of pre-selected locations. This feature will allow less experienced operators to use the camera, especially in times of critical weather conditions.

Day/Night Vision. Most modern cameras operate adequately in day light conditions. However, not all cameras operate adequately at night. The added lighting, outlined above, will help the camera "see" adequately during non-daylight conditions. If ambient light is low, some cameras can automatically switch from color to black-and-white to provide a clearer image under low light conditions.

Video Output. To view the images at a remote location, the video must be transformed into a signal file format that is easy to use. The preferred method of viewing high-resolution images on a remote computer is via the conversion of the image to a jpeg picture format. The jpeg format allows a high-resolution image to be compressed for transmission. Each image represents one still picture and the picture can be updated as often as necessary for a given application. Some cameras have this conversion provided as part of the camera and other cameras require a separate external device. Because of the limited number of cameras available with the internal conversion, the preferred method is to install an external conversion device at the outlet works control house. The camera will need to be located within a few hundred feet of the control house for power and communications access. An example of a vendor that provides video to jpeg conversion hardware is Axis Communications Inc (refer to Appendix 4F).

Communications

Being able to transmit the converted jpeg image to remote locations involves communications. Given the remote location of the Medina Dam site, limited communication options are available. The choices that were considered for the conceptual design include:

- Cellular telephone;
- Radio;
- Satellite;
- Cable modem (via cable TV); and
- Regular telephone lines.

Cellular telephone is limited in bandwidth and is only suitable for small amounts of data and not suitable for video or image transmission. The existing instrumentation data collection system at the site uses cellular telephone communications.

Radio can be used, has adequate bandwidth, and costs little to operate, however the installation costs will be high for this application due to hills in the area and distance to be covered. We anticipate that radio repeater sites will be required adding to the installation and maintenance costs of a radio network.

Satellite can be used, has adequate bandwidth, and has reasonable installation costs, but operational costs are estimated to be about $115-$130 on a monthly basis.

Another possible communication approach might be with a conventional cable modem, but it is currently unknown if cable access is available locally for this purpose.

That leaves regular telephone lines. Regular telephone lines can provide up to 56k bandwidth, have reasonable installation costs (using the same poles as the power uses) and has reasonable monthly costs (approximately $20-$30) to operate.

The telephone line method will allow jpeg images to be sent at the rate of about one image every several seconds to one minute depending on the size and resolution selected. There can be various resolutions used for different pictures selected. For example, a view of a specific location might want to use higher resolution for greater detail than a more general view of the dam. Associated with the telephone line, a telephone modem and a router will be required. Several vendors manufacture modems and routers that are appropriate for this application.

Summary

There are several vendor choices available for each part of the video and communication aspects of the Medina Dam project. Final design specifics, that is, models and vendor choices, will need to be determined as part of the design phase. The cost of the camera, tower and interface equipment for this application will range between $8,000-$12,000 plus installation costs. This price does not include the cost of the dam crest lighting system.

4.6.3 Gaging Needs

During the February EM staff meetings, one of the clear needs expressed was for improved communication as to current flood conditions upstream of the point of concern. The Bandera County EMC has a clear need for current information as to flooding on the north Prong of the Medina River upstream of Bandera. The BM dam tender and residents living immediately below Lake Medina Dam in Medina River Ranch have a clear need to track the state of flooding in Bandera to make decisions relating to their actions. The Medina County EMC and Castroville EMC have a clear need for current information relating to flow depth in the Lake Medina Dam spillway, and so on downstream into Bexar County. There are several potential sources for current information: the existing flow/stage measurement network maintained by the US Geological Survey (USGS), measurements taken during a flood event by local EM staff, and stage measurements from locally owned and maintained gages.

The locations of USGS gages with substantive periods of record are shown in Figure 4-5. The gages along the Medina River corridor that are currently in operation are shown those at Bandera, Riomedina, Macdona, Somerset, and San Antonio. In addition, there is a USGS stage gage currently operating within Lake Medina at Lake Medina Dam. River elevation levels for these current gages are posted in "real time" on the USGS website, which means in the case of the Bandera gage that river elevations are measured continuously, data are transmitted hourly, and the website is updated 15 minutes later following data processing. In the case of the elevation gage on Lake Medina at the dam, elevations are measured continuously, data are transmitted every 4 hours, and the website is updated 15 minutes later following data processing

The telemetered data from the USGS are supplemented within the region by local EM staff efforts. The Bandera County EMC posts deputies at three sites upstream of Bandera along the river corridor, and he has developed a set of informal rules for prediction of downstream river levels based upon upstream river levels. BMA staff at Lake Medina Dam maintain a log of lake elevation every 15 minutes in accordance with procedures laid out within the dam EAP. Medina County ESD No. 1 has developed a network of volunteers that are positioned upriver during major events. Of particular importance to Castroville is an assessment of the inflow from San Geronimo Creek, a substantial tributary which enters the Medina River below Diversion lake and above Castroville. These entities have developed an informal communication network described in Section 4.5 for the dissemination of this stage information.

The primary current hindrance to an effective use of the USGS website is that the Lake Medina elevation data is updated on the website only every 4 hours. URS has had a recent conversation (July 29, 2004) with Buddy Miller of the San Antonio office of the USGS in which Mr. Miller (telephone 210-691-9227) stated that the 4-hour transmission interval for the Lake Medina gage was previously necessitated by a lack of available satellite transmission capacity. Recently more transmission capacity has become available, and the Lake Medina gage will be reprogrammed to transmit data hourly. This change is expected to occur by the end of August 2004.

The use of EM staff and volunteers to collect and communicate river stage data during a flood has a number of disadvantages relative to having a telemetered gaging station. These include:

- EM staff, in particular county deputies, have many demands on their time during a flood emergency, and the use of staff for monitoring stage necessarily restricts the number of other tasks that can be performed by the limited staff pool.
- Data collected by EM staff and volunteers necessarily will be anecdotal and less accurate than data collected by a professionally installed and maintained gaging station. The implications of this are felt less during the event than after the event. If regularly collected and accurate stage data are available following an event, this greatly aids the updating and improvement of flood models used for real-time flood prediction (i.e,. the NWS model discussed in Section 2) or for regulatory floodplain delineation .

The most pressing needs for real-time stage monitoring within the Medina River corridor are within the upper Medina River basin in western Bandera County and on San Geronimo Creek.

The upper Medina River basin is shown in Figure 4-6. Extreme floods within this relatively steep watershed are characterized by very intense isolated rain storms leading to extremely fast rise in river stage. The rate of rise measured at the Bandera gage on the Medina River in the July 2002 storm exceeded on several occasions a rate of 5 feet per hour. This is in contrast to the peak rate of rise measured on Lake Medina, which was about 1.2 feet per hour. This exposure to sudden extreme flash flooding was one of the primary motivations for the update to the NWS model documented in Section 2. A new gage on the North Prong of the Medina River would serve several important functions: critical county EM staff would be freed for other duties during floods and scientific data would be collected from future improvement of the flood prediction model for the upper basin. The Bandera County EMC, who has in the past several years led county EM operations through several major flood events (including the 2002 flood), has a close familiarity with the nature of western Bandera County flooding and has recommended several sites as gaging sites. The highest priority of these sites, per the Bandera County EMC, are:

- 3 Mile Crossing on Highway 16 between Medina and Bandera; and
- Freeman Crossing at Highway 16 north of Medina.

The latter site has the advantage of being further upstream and providing earlier flood data. The locations of these two sites are shown in Figure 4-7.

The other priority site within the watershed is on San Geronimo Creek above the junction of San Geronimo Creek with the Medina River. An alternative is to put the gage on the Medina River below the junction of San Geronimo Creek with the Medina River. San Geronimo Creek enters the Medina River downstream of Riomedina and upstream of Castroville and has a basin area of 70 square miles. The river distance from its junction with the Medina River to Castroville is about 8.8 miles. Per discussion in the February meetings with local EM staff, the flows from the San Geronimo watershed typically form a very substantial portion of the total flow in the Medina River through Castroville during major floods. Flows from this creek are a significant unknown in the hydrologic regime of the river. During the 2002 flood for example, inaccuracies in the river flows measured and estimated appear to show very little inflow in the reach between Lake Medina and Leon Creek (URS, 2004), a conclusion contradicted by local observance (interview with Polly Edlund, EDS No 1, January, 2004). Gaging this stream or the river below the junction would greatly aid Castroville efforts to predict ultimate river stage.

There are essentially two options for establishing a gaging station. The first is for the region to pool its resources and fund a new USGS stream gage. The cost for such a gage has been provided by USGS and is a one-time $25,000 for gage construction, followed by $13,000 annually for maintenance of the gage, the telemeter system, the website, etc.

The second option is to locally fund, construct and operate an ultrasonic stage meter. This gage can be mounted on a bridge or other riverside structure and hooked up via a SCADA system to transmit real-time elevation data to a remote location. The cost for such a system is on the order of $10,000 for the gage plus SCADA system, and annual maintenance is on the order of $1,000. Sample vendor information for such a gage is provided in Appendix G. City of Castroville is currently funding such a device, to be mounted at the Medina River bridge in Castroville. The disadvantage of this type of gage versus the USGS gage is that the USGS provides the service of developing a rating curve for the gage. The rating curve allows for the conversion of the measured stage (elevation) to a flow rate. A flow rate is needed for the data to be most efficiently used in future flood modeling. The stage data alone would allow for more accurate estimation of flood travel times, and over years, provide a database which can be used for development of rule-of-thumb relationships between upstream peak stage and downstream peak stage.

The recommendation of this study is that an ultrasonic stage meter be purchased and installed at or in the vicinity of Freeman Crossing at Highway 16 north of Medina. The prime beneficiaries of this gage will be the City of Bandera and the communities on the periphery of Lake Medina. Other communities downstream will benefit to a lesser extent.

Another recommendation of this study is that an ultrasonic stage meter be purchased and installed on San Geronimo Creek above the junction with the Medina River. The reasoning for recommending that the gage be installed on the tributary is that the existing gages on Lake Medina and at Riomedina already provide information as to the magnitude of flood generated by the watershed above the junction. The prime beneficiaries of this gage will be the communities upstream of the next major tributary, Medio Creek. These communities include Castroville, La Coste, Macdona, Van Ormy, and Mann Crossing.

4.7 Other Tasks Identified in Emergency Management Meetings

4.7.1 Summary of Information Available for Existing Flood Timing

Based upon the input from emergency management staff at the February meetings, there are three priority areas for which there needs to be substantive improvements in prediction of natural peak flood stage: City of Bandera, Lake Medina Dam, and City of Castroville. Other entities, such as communities immediately upstream and downstream of Lake Medina Dam, or cities downstream of Castroville could base their estimates from the nearest of these three locations. Task 1, discussed in Section 2 above, involved the revision of the NWS River Forecast Model for the river. This improvement will allow the NWS for provide more timely and accurate estimates of peak stage at each of these three critical locations. Local emergency management staff have pointed out the need for field measurements to provide backup to and confirmation of the NWS model predictions. Currently, per the discussion in Section 4.5 above, emergency staff are sited to observe water stage at critical points within Medina County and at Lake Medina Dam. This section will summarize the information available to aid downstream EM staff in the interpretation and use of the collected data in estimating ultimate stage downstream.

USGS Flow Data

The US Geologic Survey (USGS) is the federal agency which installs and maintains flow gages on the nation's streams, and processes and publishes the data collected by these gages. The relevant gages that have been installed within the Medina River watershed are summarized in Table 4-3.

Table 4-3. Summary of Relevant Flow Gages in Medina River Watershed

Flow Gages					
Station Name	**Elevation (ft)**	**Start Date**	**End Date**	**Drainage Area (Mi2)**	**County**
Medina Rv nr Macdona, TX (8180700)	590	01/01/1981	current	885	Bexar
Medina Canal nr Riomedina, TX (8180000)	910	04/01/1922	current	0	Medina
Red Bluff Ck nr Pipe Ck, TX (8179100)	1107	04/01/1956	11/27/1981	56.3	Bandera
Leon Ck Trib at Kelly AFB, TX (8181450)	658	04/01/1969	10/18/1979	1.19	Bexar
Medina Rv bl Medina Lk nr San Antonio, TX (8179520)	1010	04/20/2001	current	635	Medina
Medina Rv at San Antonio, TX (8181500)	439	08/01/1939	current	1317	Bexar
Leon Ck at IH 35 at San Antonio, TX (8181480)	573	09/13/1984	current	219	Bexar
USGS Medina Rv nr Riomedina, TX (8180500)	858	10/01/1923	current	650	Medina
Medina Rv nr Somerset, TX (8180800)	494	10/01/1970	current	967	Bexar
Medina Rv at Bandera, TX (8178880)	1189	10/01/1982	09/30/2001	328	Bandera
Medina Rv nr Pipe Creek, TX (8179000)	1067	12/01/1922	10/19/1982	474	Bandera
Medina Rv at La Coste, TX (8180640)	667	12/19/1986	09/30/2000	805	Medina
Medio Ck at Pearsall Rd at San Antonio, TX (8180750)	597	12/19/1986	09/30/1995	47.9	Bexar
Daily Lake Volume					
Lake Medina		10/1/1947	current	635	Medina
15-Minute Readings of Lake Volume					
Lake Medina		9/1/1997	current	635	Medina

Each of the flow gages above measures water level (stage) at a 15-minute interval or less. For selected gages, notably the lake elevation gage at Lake Medina and the flow gage at Bandera, these data are plotted on the USGS website. Although these data are "real-time", the data are only updated on the website every 6 hours.

The most direct method of correlating upstream changes in stage to downstream changes in stage, and to estimate time of travel of the flood peak down the river corridor, would be to directly compare hydrographs (flow rate versus time) at gage locations for major river floods. The primary constraints on performing such an analysis are:

- The gage at the most critical location, Lake Medina Dam, started operation in September 1997;
- One of the most important downstream gages, the gage at La Coste, ceased operating in September 2000; and
- Medina Lake typically has significant available storage (i.e., the lake is drawn down to meet irrigation demands) when storms hit Bandera County, such that little or no significant flow leaves the lake for most storm events.

A thorough search of the available flow and stage dataset was performed as part of the hydrologic study performed for the recent stability analysis of Lake Medina Dam. The sole significant flood event for which there was a continuous stage record for both the Bandera gage (at intervals varying from 15 minutes to 6 hours) and the Lake Medina Dam gage (at fifteen minute intervals) was the July 2002 flood. Unfortunately, the flow gage at Riomedina failed during this event.

July 2002 Event Data

Flood elevation data were collected from four sources for this study: the USGS, the Federal Emergency Management Agency (FEMA), the Bandera County EMC (Ralph Dresser), and the EMC for the City of Castroville (Tim Fousse).

USGS Data. The elevation measurements at the Bandera gage and at the Lake Medina gage were collected plotted on the same time axis (see Figure 4-8). The rate of rise over the flood period was also calculated (see Figure 4-9). Note that for brief periods the rate of rise of the river at Bandera was over 5 feet an hour, whereas the peak rise in the lake vacillated at a rate between 0.8 and 1.2 feet per hour. Table 4-4 shows the time lag between peak stage at Bandera and the peak stage at Lake Medina Dam.

Table 4-4. Lag Time from Bandera to Lake Medina Dam, July 2002 Flood

Date	Bandera		Lake Medina Dam		Calculated Lag From Bandera to Dam (hours)	Note
	Time of Peak	Time Interval Between Measurements	Time of Peak	Time Interval Between Measurements		
7/4/2002	7/4/02 11:15	15-30 minutes	7/4/02 16:30	15 minutes	5.25	±0.5 hour
7/5/2002	7/5/02 13:30	1.5 hours	7/5/02 19:15	15 minutes	5.75	±1.5 hour

From these data, in the absence of better estimates, if the Bandera gage peaks out in the range of elevation 1222 feet to 1228 feet (per Figure 4-8) then Lake Medina can be expected to rise for 5 to 6 hours after the Bandera peak at a rate of about 1 foot per hour. CAUTIONARY NOTE: NWS model estimates, using real-time spatial rainfall data should provide a better estimate than this rule-of-thumb.

FEMA High Water Marks. Following the 2002 flood, FEMA, contracted for a survey of flood high water marks (Watershed Concepts/ Hallf Associates, 2002). This survey provides a location and surveyed maximum flood elevation, but not a time for the flood peak. High water marks of particular interest are shown in Figure 4-10.

Bandera County EMC. The Bandera County EMC provided to URS a series of hand-held GPS readings and an anecdotal estimate of maximum flood depths at those locations. The locations chosen were in the Lakeshore/Wharton Dock area within the extreme upstream end of Lake Medina, roughly 12.4 miles uplake from the dam. These locations were plotted on a recent (2003) aerial survey of the lake perimeter performed in the BMA datum, and a maximum flood elevation estimated (see Figure 4-10). Three of the four estimates were reasonably consistent, varying between elevation 1084 feet BMA datum (1076.2 feet USGS datum) and 1085.5 feet BMA datum (1077.7 feet USGS datum). The maximum elevation measured at the dam was 1074.6 feet, USGS datum. Based upon this shorthand (less accurate the FEMA survey) method, flood elevations in Lakeshore/Wharton Dock can be estimated to be roughly 1.6 to 3.1 feet higher than a maximum predicted for the dam. Other communities along the lake between Lakeshore and the dam can estimate their expected rise relative to a rise predicted at the dam based upon where the community is located between Lakeshore and the dam.

Castroville EMC. Castroville EM staff maintained a journal during the 2002 flood which noted water level locations and depths by time. These locations have been sited using a hand-held gps unit. The resulting map of Castroville showing location of peak 2002 flood elevation is presented as Figure 4-11. Figure 4-12 is a copy of Figure 4-8, with the separate 2002 flood peaks labeled as Peaks 1 through 4. Table 4-5 shows the times that these peaks arrived in Castroville, and estimates the duration between the time of a peak level in Lake Medina and the arrival of the corresponding peak level in Castroville.

Table 4-5. Lag Time from Lake Medina Dam to Castroville, July 2002 Flood

Peak per Figure 4-12	Lake Medina Time of Peak	Castroville Time of Peak		Time Lag, Lake Medina Dam to Castroville (hrs)	
	Time	Early	Late	High	Low
Peak 1b	7/2/02 20:30				
Peak 1a	7/3/02 0:45				
Peak 2	7/3/02 11:15	7/3/02 17:30	7/3/02 22:20	11.1	6.2
Peak 3	7/4/02 16:30	7/5/02 0:45	7/5/02 2:30	10.0	8.3
Peak 4	7/5/02 19:15	7/5/02 23:00	7/6/02 2:18	7.0	3.8

From these data, a reasonable estimate for the duration between the time of a peak level in Lake Medina and the arrival of the corresponding peak level in Castroville is 6 to 8 hours.

4.7.2 Mapping of Areas Subject to Flooding

During the EM staff meetings in February, 2004, a large-scale map of the Medina River corridor was posted on the wall of the meeting area. EM staff were given the opportunity to note on the map locations where flooding overtopped and forced the closure of roads. Plates 4-1 through Plate 4-4 show the locations identified. This map can be consulted when designing emergency access routes to communities and residences within the corridor.

4.8 Recommendations

This section summarizes the most significant recommendations of this study as presented earlier, according to the issues addressed in earlier discussions.

Emergency Management Plan (EMP) Recommendations

- Section 4.3.2 above provides short guidance concerning important elements of an EMP, debris management plan, and recovery plan. This guidance should be used as a checklist for review of existing plans. Appendix 4B provides a sample debris plan.
- Section 4.3.2 above provides some recommended guidance concerning an effective education campaign. It is recommended that this guidance be followed in the dissemination of selected emergency information from this study to the public. Candidate information for dissemination may include:
  - a short explanation of the natural flood warning procedure, communication channels, and connection to evacuation procedures;
  - a short explanation of dam safety warning procedure, communication channels, and connection to evacuation procedures

  URS will present the results of this study at three public meetings throughout the region, and materials developed for those presentations may be appropriate for a wider education campaign.
- Plates 4-1 through 4-8 should be included in EMPs. These plates show the potential indundated area from a flood generated by a Lake Medina Dam failure for a fair weather

scenario, a 100-year scenario (roughly similar to the July 2002 flood), and a PMF scenario. Once EMPs have been finalized, practice exercises should be performed as recommended in Section 4.3.2.7

Regional Response to Dam Safety Warnings

- Response from queries to EM staff at the February meetings show that current Bexar County procedures call for later initiation of floodplain evacuation procedures than Medina County. The study in Section 3 above notes that a dam break flood wave would reach Macdona in Bexar County approximately 4.7 hours after dam failure, and 2.4 hours after the wave reached Castroville. Given this relatively short time difference, it is recommended that Bexar County and Medina County both issue evacuation orders when a "possible dam failure" announcement is made by BMA.
- There are several sections of this study which attempt to provide a summary of planned EM staff actions at varying levels of flood and dam safety warnings. It is recommended that these texts be included as a common appendix to relevant county and municipal EMPs . These texts include:
  - Table 4-1, List of Selected Regional Flood Emergency Contacts;
  - Appendix 4C, BMA dam safety warnings, procedures, and notification chart;
  - Section 4.4.2, Regional Response to National Weather Service and BMA Dam Safety Warnings; and
  - Figure 4-2, Natural Flood Notification Chart.

Early Warning System Guidance

- Municipalities in the Medina River corridor are planning to procure sirens as part of a regional early warning network. The short time of travel for a flood wave from a Lake Medina Dam failure to numerous communities downstream (see Table 3-3) demonstrates the need for and can help provide funding justification for this system.
- Section 4.6 provides selection guidance for sirens. Municipalities considering purchase of a siren are recommended to consult the provided information prior to selection and purchase of a siren.
- Section 4.6 also provides a concept design for the lighting and video surveillance of the downstream face of Lake Medina Dam, which currently lacks such facilities. The high hazard nature of the dam is demonstrated by the inundation maps presented in Section 3. As the security of this structure is a regional concern, it is recommended that the Alamo Area Council of Governments, or other regional entity, coordinate a request for procurement of these security aids.
- The current flow gaging network on the Medina River can be materially improved by the addition of two new telemetered stage gages: 1) on the North Prong of the Medina River, and 2) either on San Geronimo Creek before its junction with the Medina River, or on the Medina River itself as close as feasible downstream of the junction. Justification and more details concerning these recommended gages are provided in Section 4.6.

Other Recommendations

- Section 4.7.1 summarizes available historic information relating to timing and size of flood peaks, particularly the peaks from the July 2002 flood. It is recommended that emergency staff utilize this information, in addition to warnings and predictions from the NWS, when planning for when to mobilize EM staff, start evacuation procedures, etc.
- Section 4.7.2 provides a series of plates which show roads which typically are closed during floods, and which also show the area predicted to be inundated by a flood caused by a Lake Medina Dam failure. These plates can be incorporated into existing EMPs. Digital copies of these maps will accompany the final report.

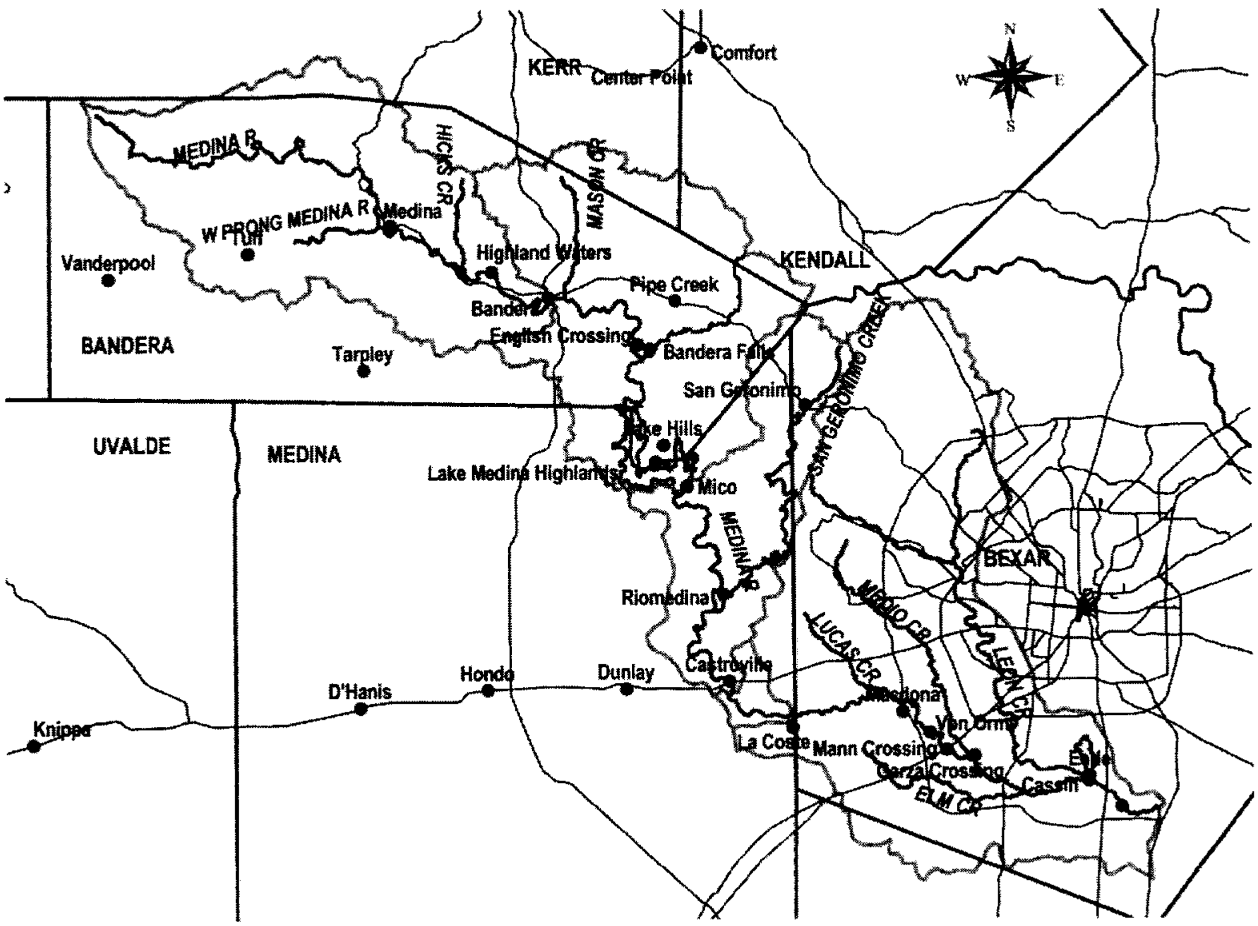


Figure 4-1. Emergency Planning Study Area

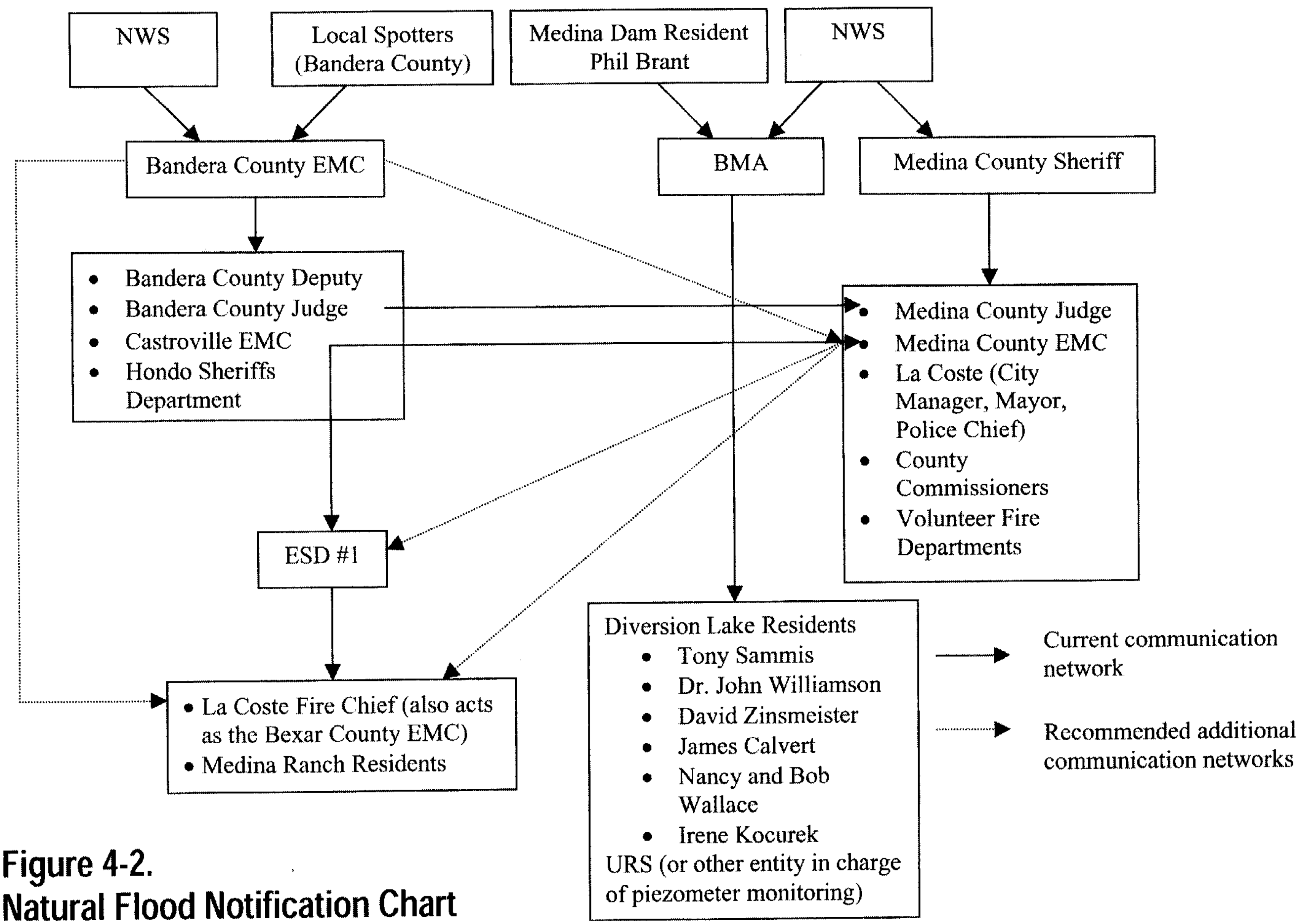
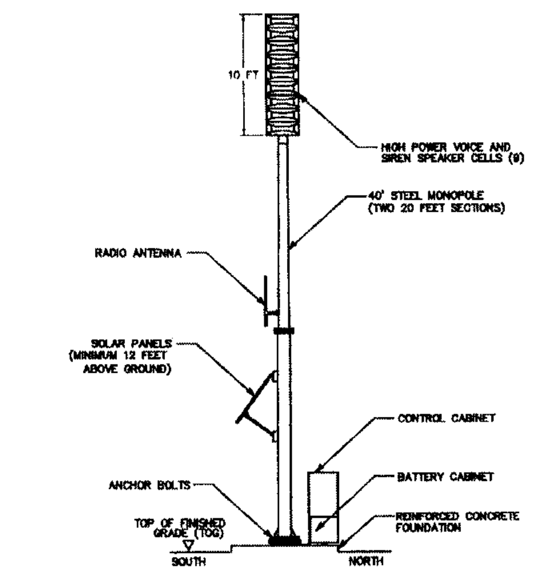
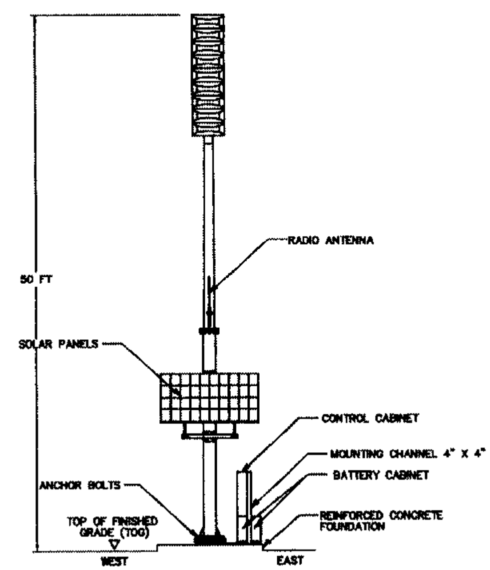


Figure 4-2.
Natural Flood Notification Chart



SIREN TOWER PROFILE
(NORTH-SOUTH SECTION-TYPICAL)



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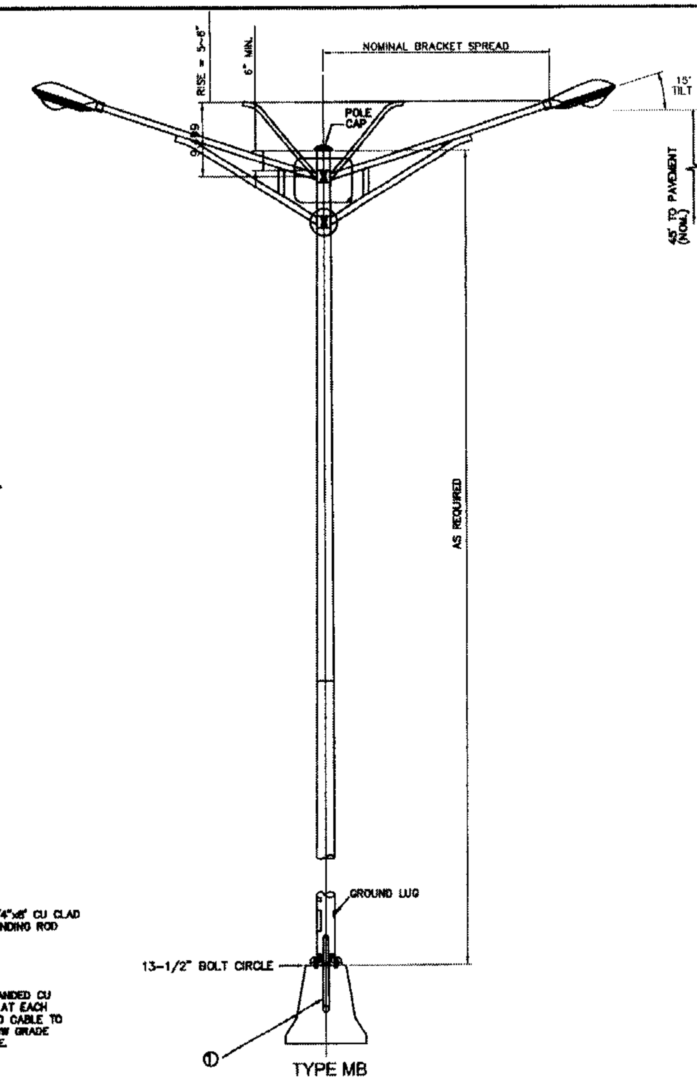
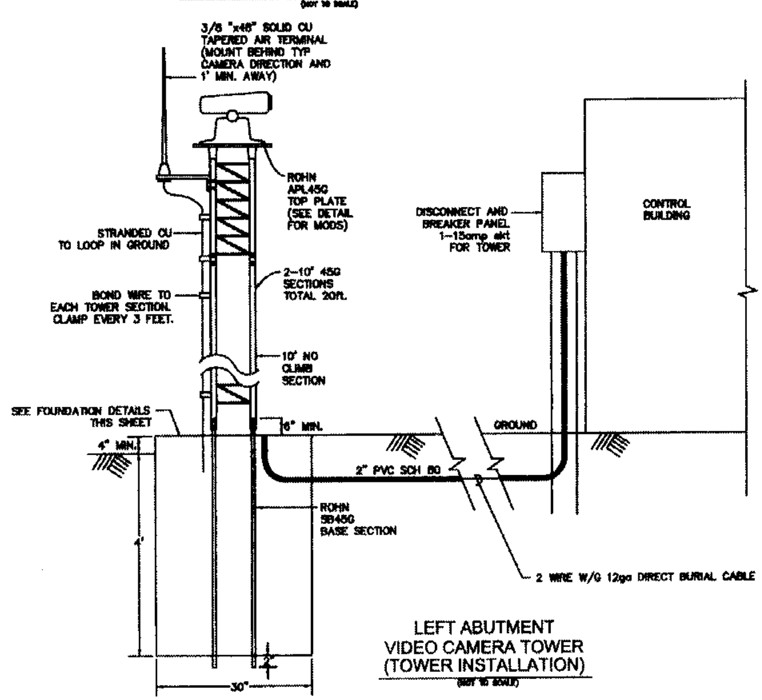
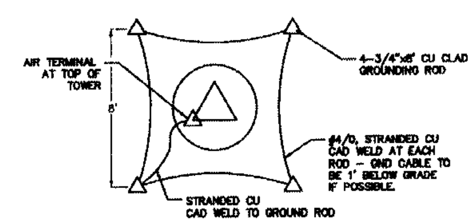
(EAST-WEST SECTION-TYPICAL)



TYPE MB



LEFT ABUTMENT
VIDEO CAMERA TOWER
(TOWER INSTALLATION)



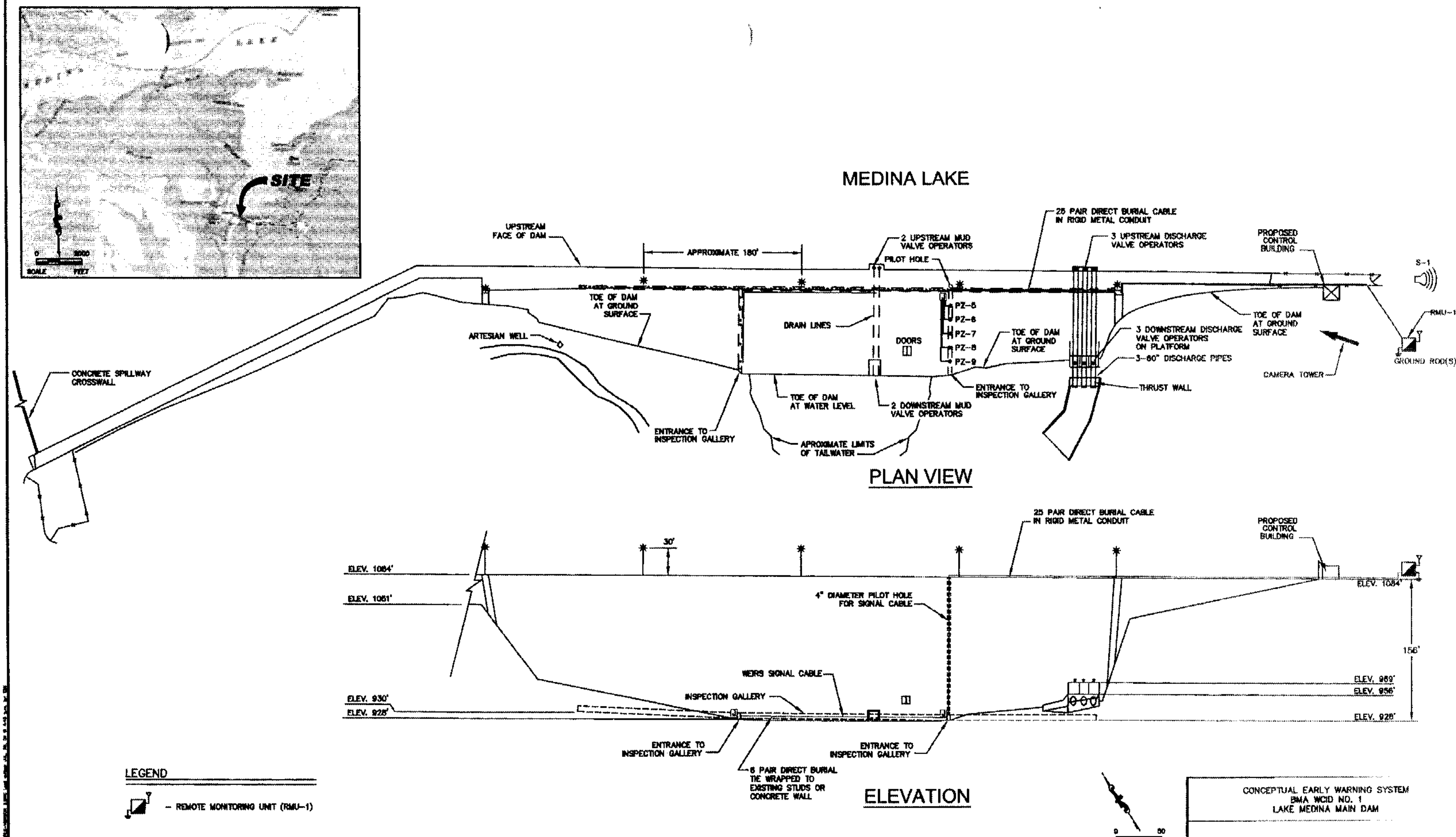
TOWER GROUNDING
FOR ALL TOWERS

CONCEPTUAL EARLY WARNING SYSTEM
BMA WCID NO. 1
LAKE MEDINA MAIN DAM

Details

Date: 1/20/04	Project Number: 41007829.01	Drawing Number: 2
Drawn by: djd	Design by: br/jh	Checked by:

URS



LEGEND

- REMOTE MONITORING UNIT (RMU-1)
- JUNCTION BOX
- PROPOSED LIGHT (STANDARD)
- PROPOSED CAMERA TOWER
- PROPOSED SIREN (S-1)

SOURCE: BASE DRAWING TAKEN FROM HEARN ENGINEERING INC. (BEXAR_MET 12/01).

CONCEPTUAL EARLY WARNING SYSTEM
BMA WCID NO. 1
LAKE MEDINA MAIN DAM

Overall Site Plan

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Drawn by: DJD	Design by: BR/JH	Checked by: JBH

URS

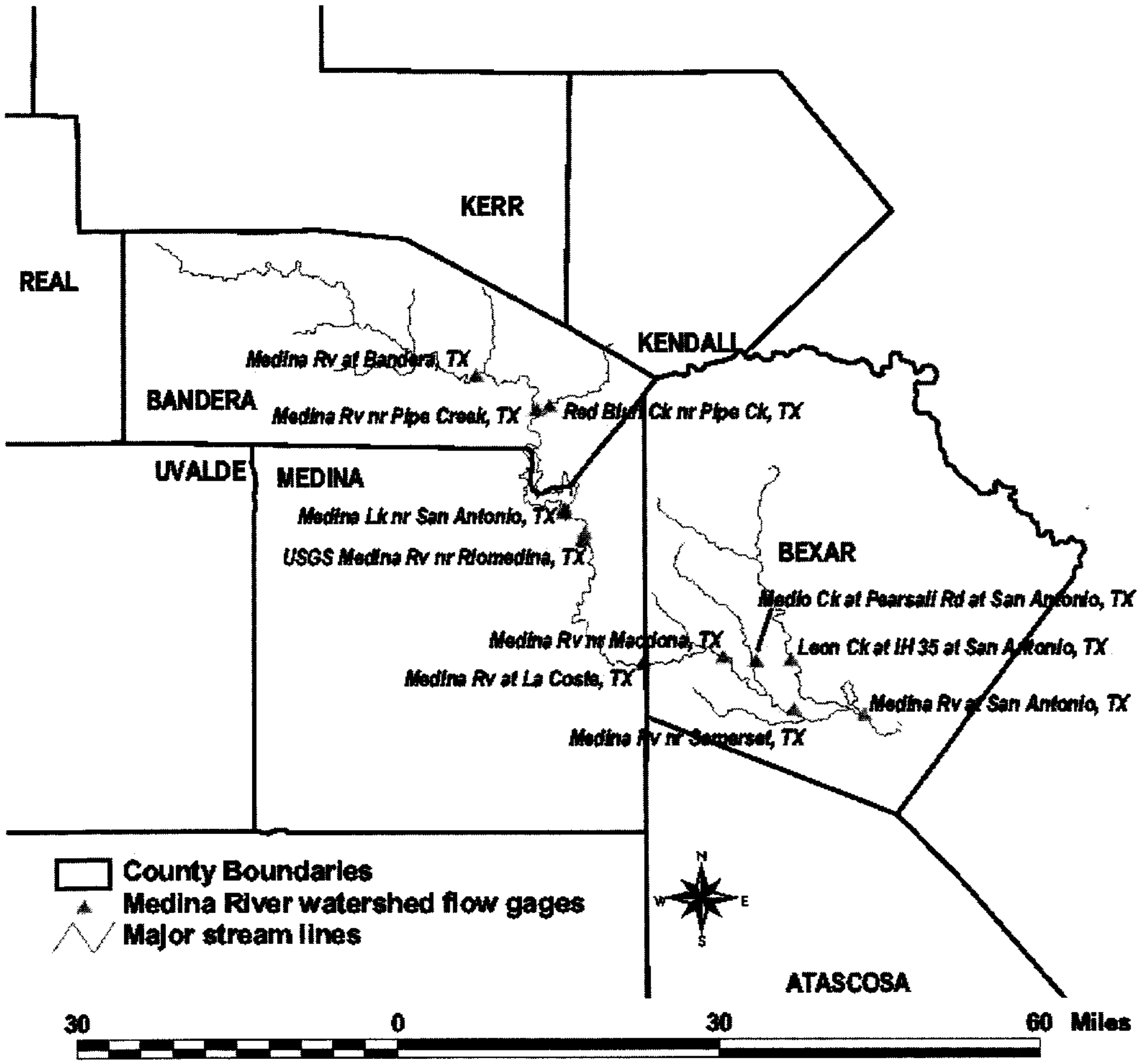


Figure 4-5. Medina River Flow Gages

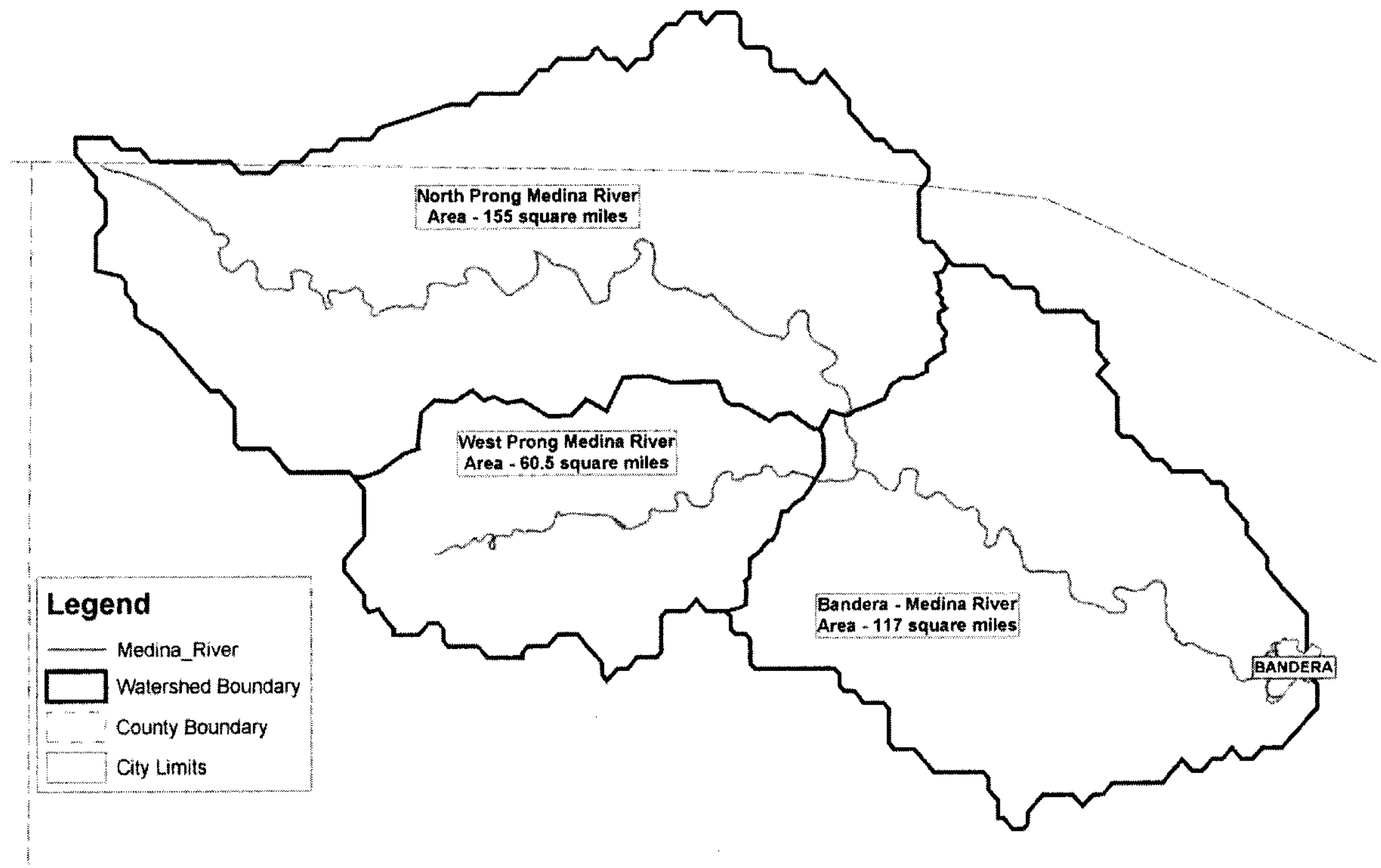


Figure 4-6. Upper Medina River Watershed Above the City of Bandera

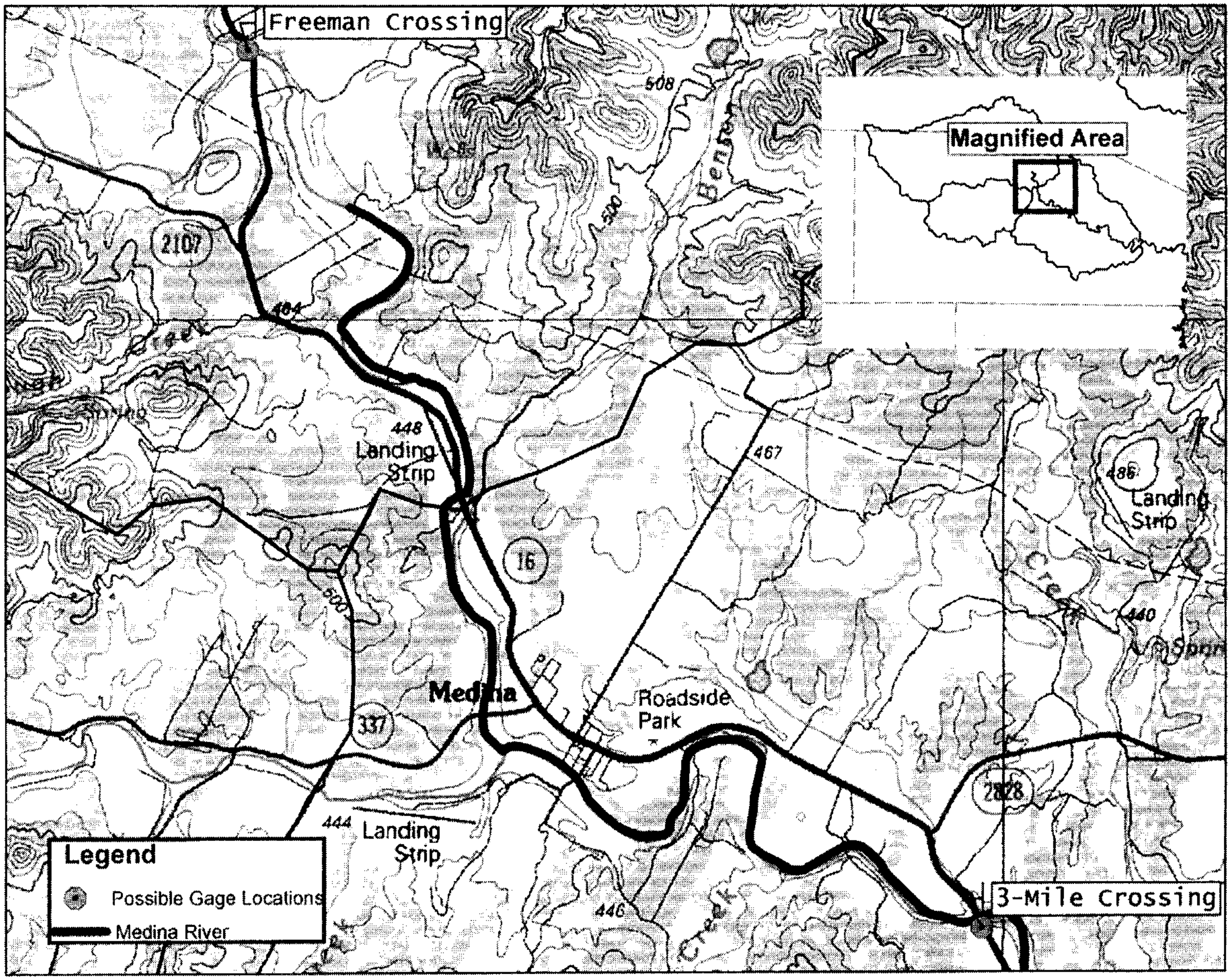


Figure 4-7. Possible Locations of New Streamflow Gages in the Upper Medina River Watershed

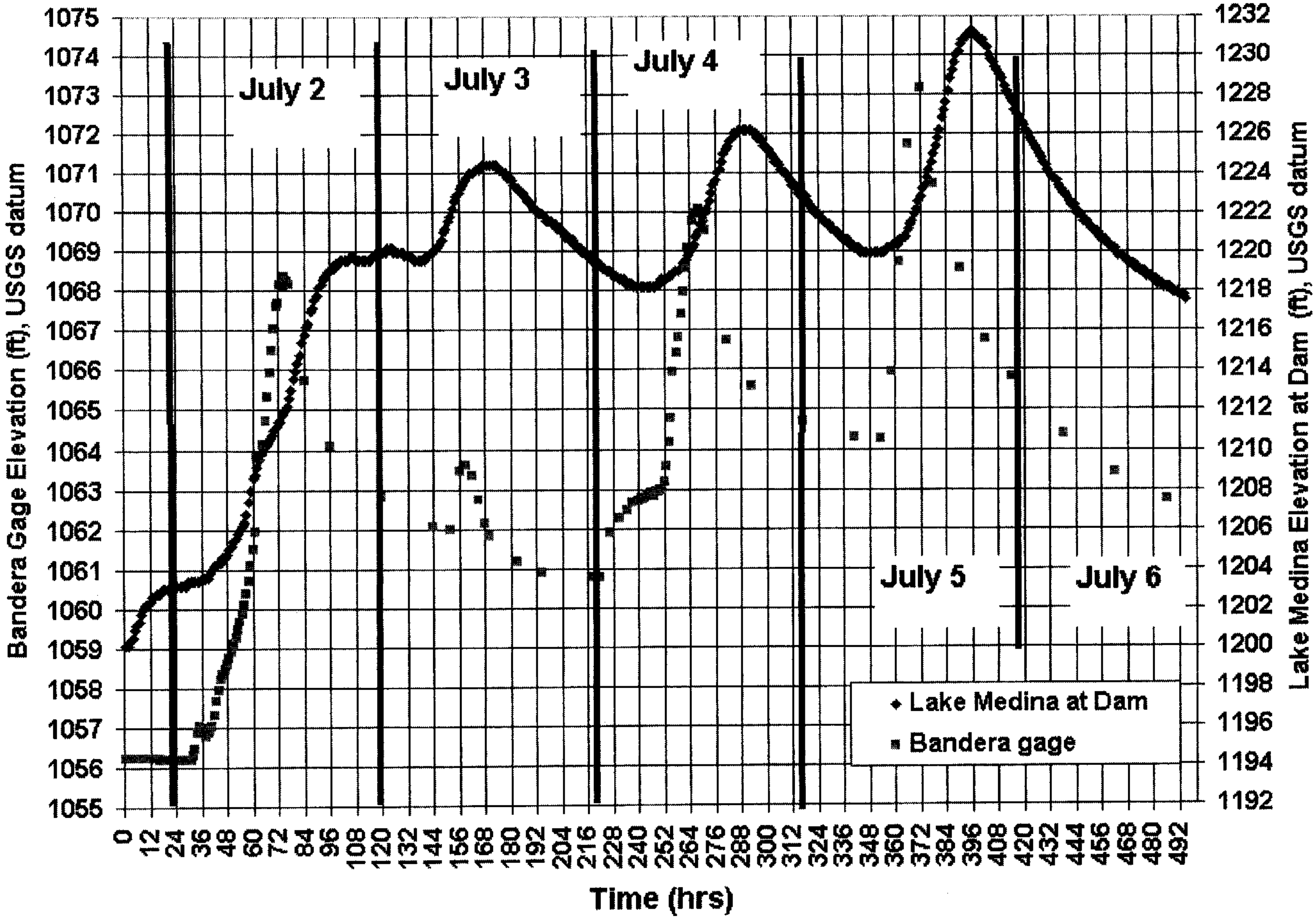


Figure 4-8. Stage Data, July 2002 Flood

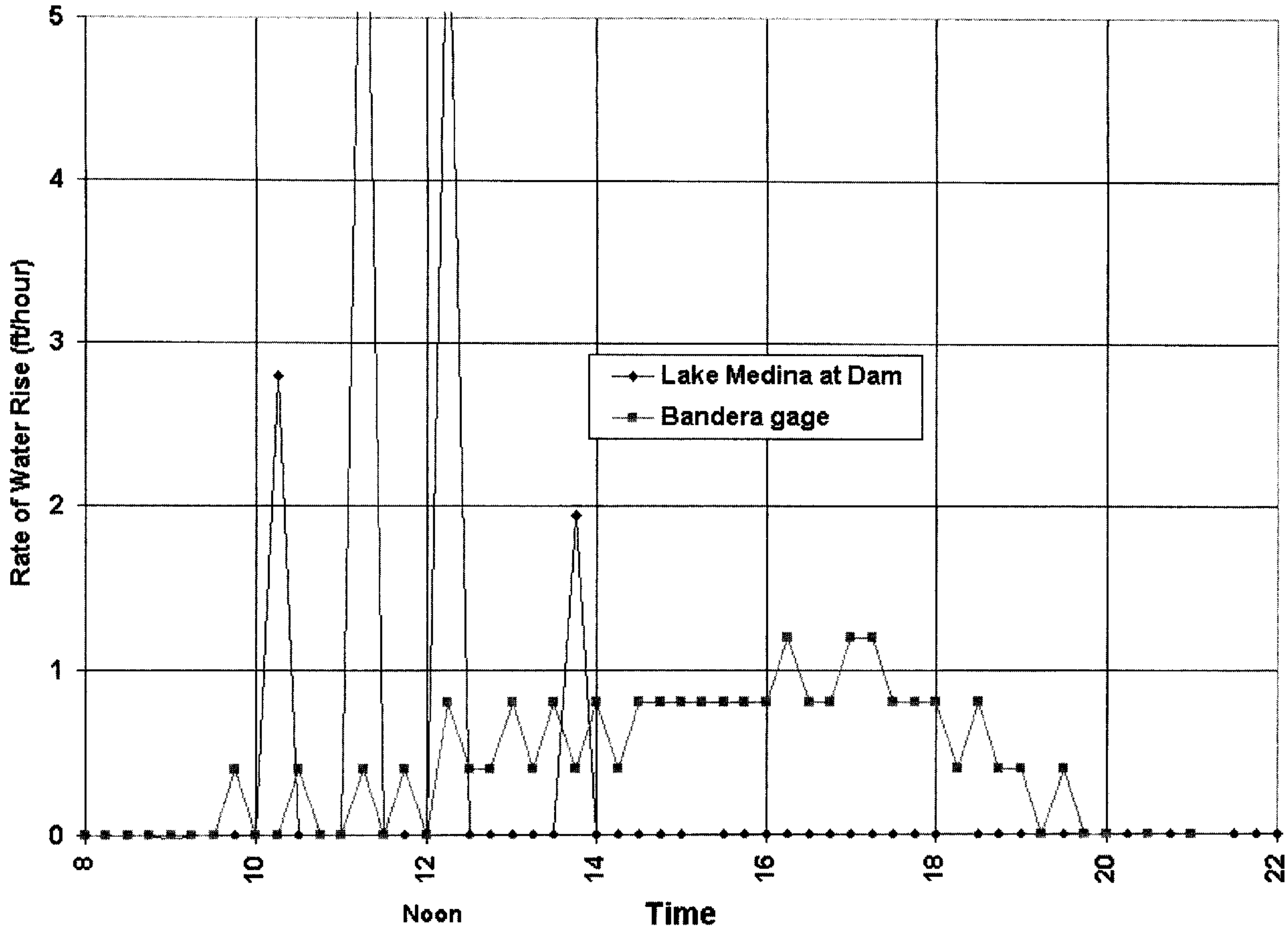
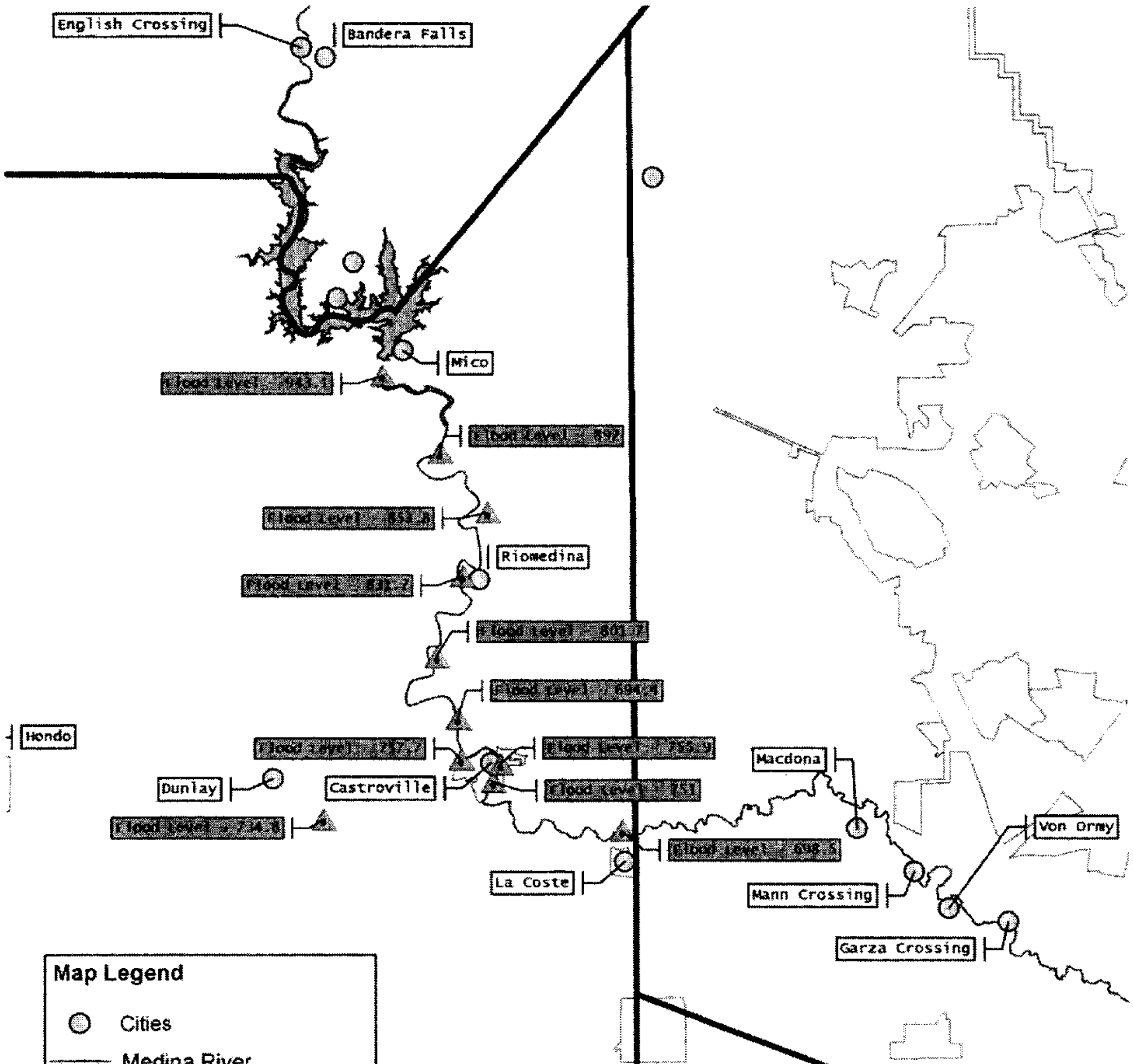


Figure 4-9. Rate of Rise, July 5, 2002



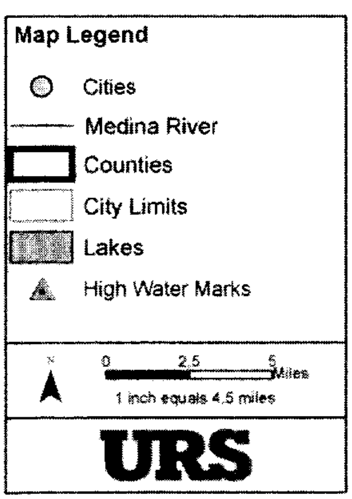


Figure 4-10. High Water Marks Listed for Medina County in "July 2002 Flood High Water Mark Survey Report"

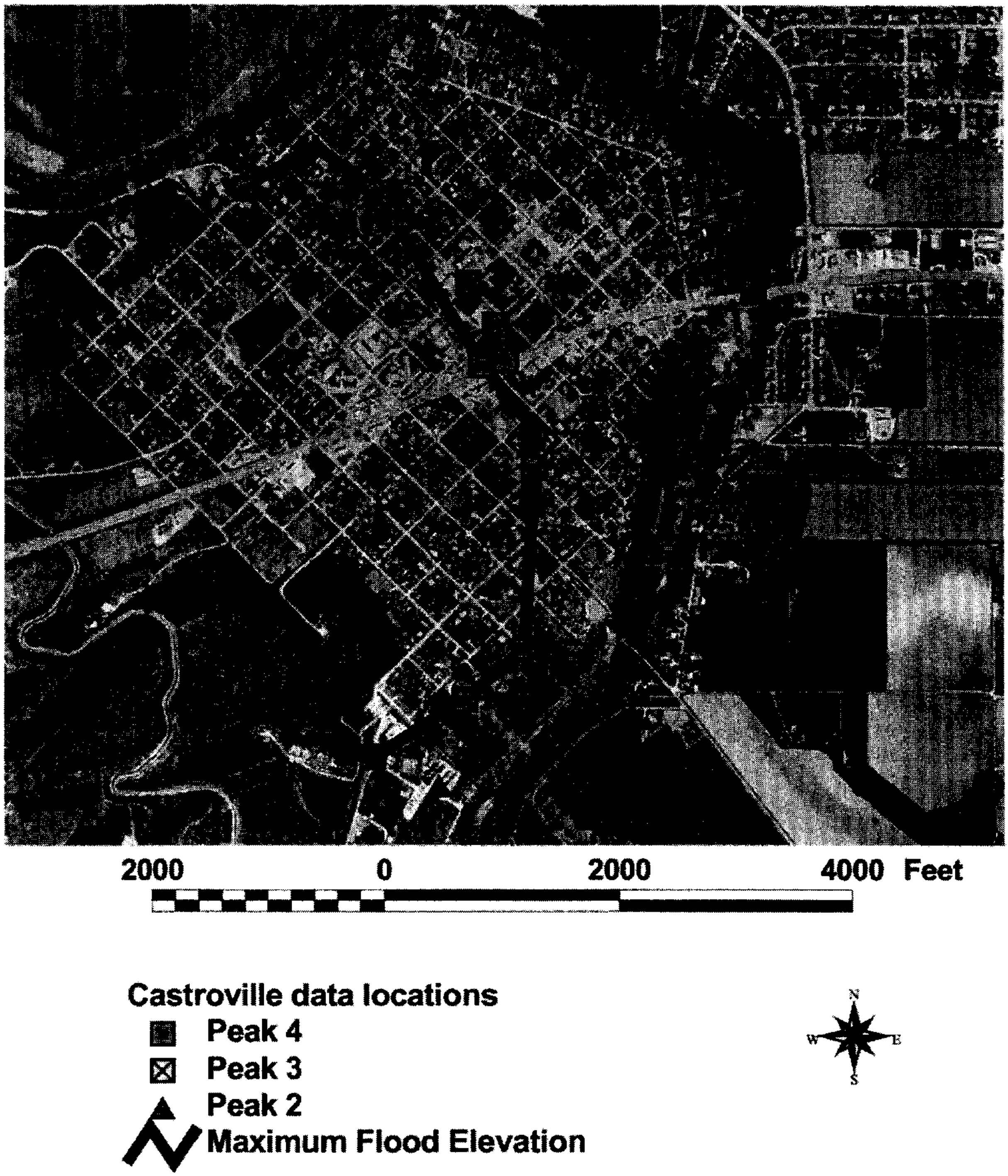


Figure 4-11
Peak Flood Elevation
Castroville, 2002 Flood

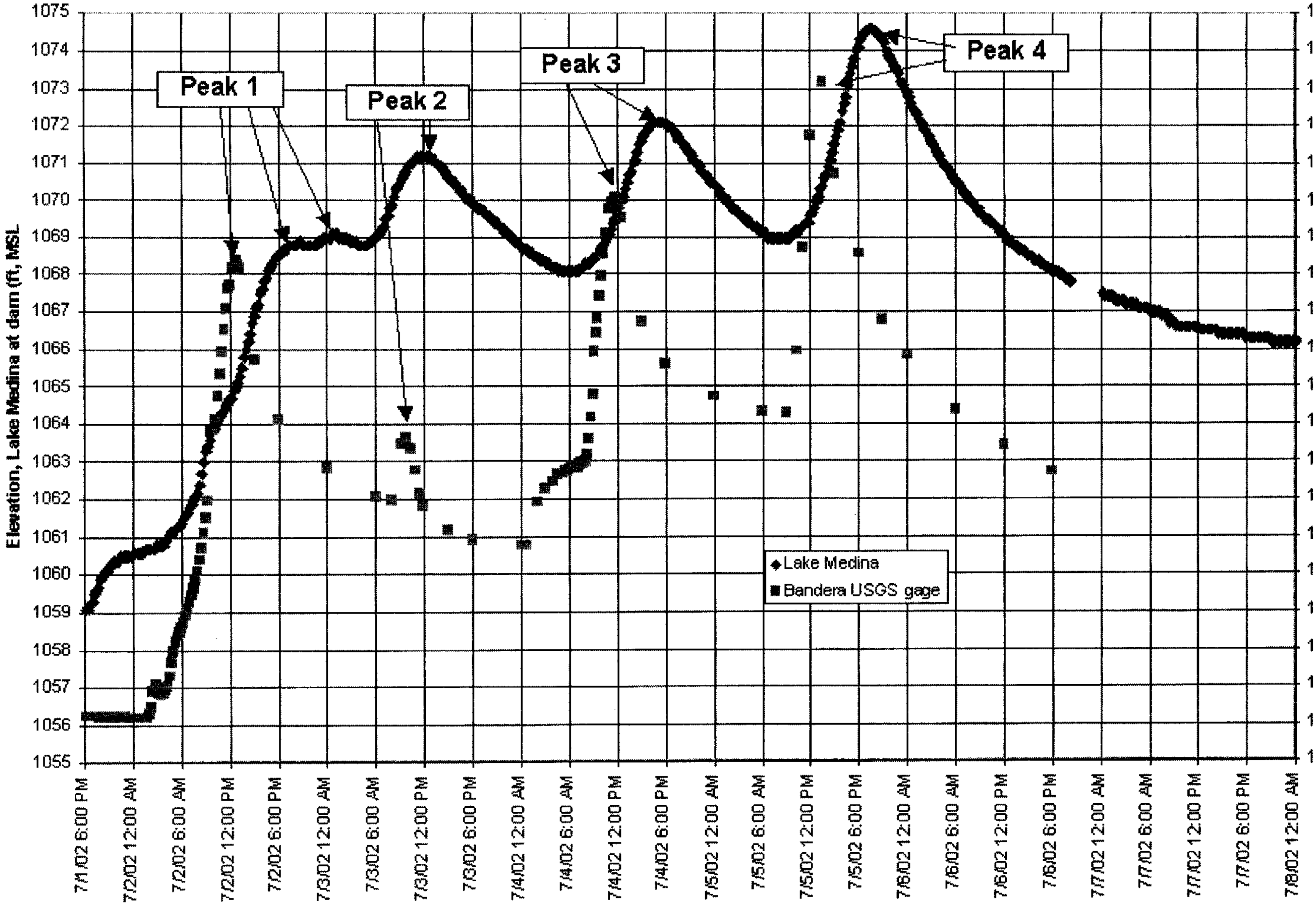


Figure 4-12. Stage Data, July 2002 Flood

5.0 REFERENCES

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Appendix 2A

West Gulf River Forecast Center, Medina River Basin Water Balance

INTRODUCTION

To properly understand the water volume issues surrounding the Medina River Basin above the La Coste, TX gage, a water balance of the region was completed. This consists of several sub-basins each of which is listed in Table 1. The water balance is valuable in understanding the amount of water within the system, potential sources and sinks for that water and potential data collection or recording errors that complicate the modeling of the basin. This calculation file documents the steps to complete a water balance, where sufficient data was available for the Medina River Basin.

DATA

Several sources of data were used as part of the Water Balance. These sources include:

- Stream flow data from the Bandera and La Coste gages located on the Medina River and recorded by the USGS.
- 1-hour resolution XMRG precipitation files for estimation of rainfall within the Medina River Basin.
- Estimated values of potential evaporation (PET) derived and discussed as part of the "Medina River Basin NWSRFS Calibration, PET Development" calculation file.

Due to lack of data for several of the sub-basins delineated within the Medina River Basin only the Bandera sub-basin and the La Coste sub-basin were identified as possible locations to perform a water balance. Further, the La Coste sub-basin was eliminated for the water balance analysis because of diversions and dams within its boundaries that do not have adequately gaged outlets. Therefore this analysis is concerned only with the Bandera sub-basin (BDAT2) and the two upstream sub-basins, the West Medina River Prong (WMPT2) and the North Medina River Prong (NMPT2).

Water Balance

The water balance was completed by determining the following parameters:

- Period of Record;
- Mean Areal Precipitation;
- Runoff Coefficient; and
- Actual Evapotranspiration.

Each of these is discussed in the following sections.

Period of Record

The period of record for each of the data sets was compared to select a time period where sufficient data is available to complete the water balance. Table 2A-1 shows the period of record associated with each dataset. The time period selected for completing the analysis was January 1995 to December 2002. This time period consisted of the overlap between the available stream flow, evaporation and XMRG precipitation data for BDAT2 sub-basin.

Table 2A-1. Period of Record for Each Dataset Used in Water Balance Analysis

Dataset	Start Date	End Date
XMRG Precipitation	January 1995	December 2003
USGS Streamflow	October 1991	September 2003
PET Evaporation	June 1988	December 2002

Mean Areal Precipitation

The BDAT2 sub-basin is located at the headwaters of the Medina River Basin. The primary source of water for this type of basin is precipitation. Other sources of streamflow such as springflow originating from locations outside the sub-basin were considered negligible for this study. The volume of water for entering the sub-basin based on mean areal precipitation (MAP) was estimated from XMRG precipitation data and using the 'mapx' subroutine of NWSRFS. An XMRG data set consists of many discrete values of precipitation that cover an entire region. These data sets are stored in a grid format on an hourly basis. The 'mapx' subroutine of NWSRFS extracts the values of precipitation from the XMRG data set that correspond to the boundaries of a given sub-basin and produce a MAP value for the entire sub-basin. Multiplying the MAP value by the area of the sub-basin gives the volume of water that entered the balance equation for a given hour. This process is completed for each hourly time interval to create an estimate of the volume of water entering the system through precipitation.

MAP values were determined for each of the sub-basins above the Bandera gage. Water volumes for each sub-basin were calculated separately and then summed on a monthly interval to obtain a water volume not biased by basin size. Figure 1 shows a plot of total monthly volumes entering the sub-basins above the Bandera gage due to precipitation over the period of record.

Runoff Coefficient

Runoff is the amount of water that exits the water balance through gaged streamflow at the basin outlet. In our case the water leaving the sub-basin at the Bandera gage is considered runoff. The volume of runoff is determined by integrating the recorded flowrate data to produce volumes for a given time. Given the length of the period of record we chose to integrate the flowrate on a monthly timestep. Values of monthly volume can be found in Table 1 in Appendix A.

The runoff coefficient (ROC) is a measurement of how much of the water entering the system through water sources leaves the system in runoff. In our case the primary source of water is precipitation. Equation 1 shows the equation used to calculate ROC. Determining the ROC helps evaluate the hydrologic characteristics of the sub-basin and their similarity to other sub-basins. Also, it can provide insight into whether there are problems with the data collected for the project. Because we are only completing a water balance on one sub-basin the latter reason for calculating the coefficients will be the primary importance.

Bandera Monthly Volume Comparison 2002

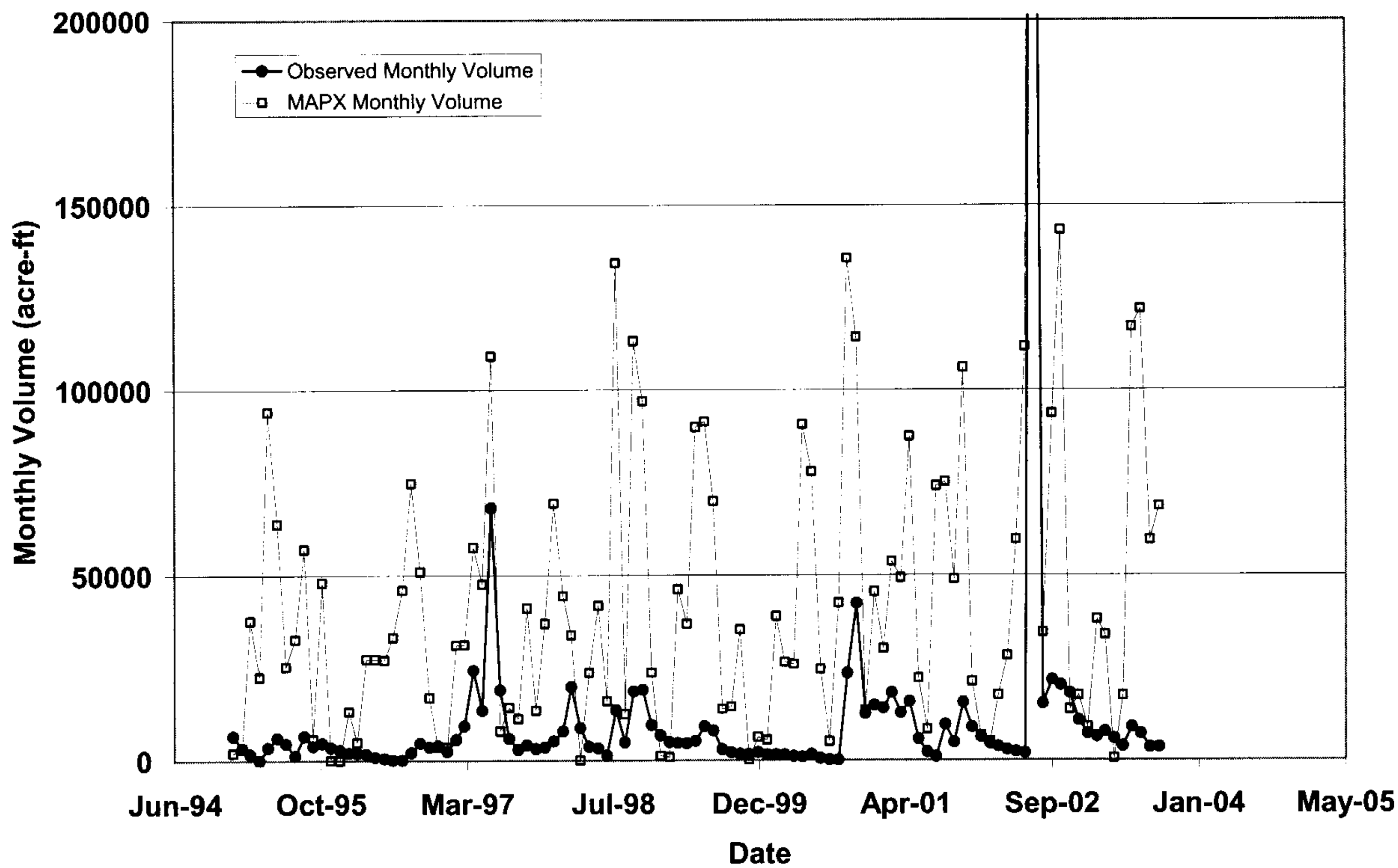


Figure 2A-1. Monthly totals of MAPX precipitaiton volume and streamflow volumes over time.

$$ROC = \frac{RO}{MAP} \qquad \text{Eq. 1}$$

Table 1 in Attachment 1 shows the monthly values of ROC. Values in bold occur when the value for ROC is greater than 1. A value greater than 1 for ROC indicates that more water left the water system through RO then entered the water system through precipitation. Because the values are calculated over a monthly time period, it is possible that valid data could cause values slightly greater than 1. However, extreme values can signify problems with the data. In our case, there are nine months where the ROC indicates there may be problems with the input data. The quality of the data for these months will affect the ability to calibrate the NWSRFS model.

Actual Evapotranspiration

Actual Evapotranspiration (AET) was estimated by subtracting the RO value from the MAP value on a yearly time interval. Table 2A-2 contains these values. Values of AET ranged from 13.62 in. to 28.75 in. compared to the estimated value of 71.7 inches estimated from the PET Development calculation file. The AET/PET ratios shown in Table 2 show AET is much lower on average than PET. This is a similar trend as discussed in the PET development calculation file. This may justify the use of the lower PET curve found in the existing 6-hour interval NWSRFS model of the Medina River Basin.

Table 2A-2. Yearly Values Estimated for AET and AET/PET

Year	AET (inches)	AET/PET
1995	19.39	0.27
1996	16.84	0.23
1997	13.62	0.19
1998	27.65	0.39
1999	19.76	0.28
2000	28.75	0.40
2001	27.91	0.39
2002	23.93	0.33
Average	22.23	0.31

Calibration Strategies Based on the Water Balance Analysis

Evaluating the water balance for the Medina River above the Bandera gage was helpful in determining locations within the period of record that are possibly affected by poor data quality. It also provided verification as to whether the PET values determined as part of the PET Development calculation file are reasonable to use for calibration. Based on these results it is recommended that PET developed with the calculation are suitable for use in the calibration of the NWSRFS model. Also, it is recommended that the months of December 1995, April 1998, November 1999 and April 2000 be removed from the calibration process because the available data for these time periods are suspect.

Attachment 1

Table 1 – ROC Values Calculated for Each Month Over the Period of Record

Month-Year	ROC	Month-Year	ROC	Month-Year	ROC	Month-Year	ROC
Jan-1995	3.31	Apr-1997	0.42	Jun-1999	0.10	Aug-2001	0.01
Feb-1995	1.02	May-1997	0.28	Jul-1999	0.11	Sep-2001	0.13
Mar-1995	0.05	Jun-1997	0.62	Aug-1999	0.21	Oct-2001	0.10
Apr-1995	0.00	**Jul-1997**	**2.38**	Sep-1999	0.15	Nov-2001	0.15
May-1995	0.04	Aug-1997	0.41	Oct-1999	0.05	Dec-2001	0.42
Jun-1995	0.10	Sep-1997	0.26	**Nov-1999**	**8.59**	Jan-2002	0.93
Jul-1995	0.18	Oct-1997	0.10	Dec-1999	0.34	Feb-2002	0.88
Aug-1995	0.04	Nov-1997	0.23	Jan-2000	0.27	Mar-2002	0.21
Sep-1995	0.12	Dec-1997	0.10	Feb-2000	0.04	Apr-2002	0.10
Oct-1995	0.67	Jan-1998	0.07	Mar-2000	0.06	May-2002	0.04
Nov-1995	0.10	Feb-1998	0.18	Apr-2000	0.04	Jun-2002	0.02
Dec-1995	**56.85**	Mar-1998	0.59	May-2000	0.01	Jul-2002	0.99
Jan-1996	0.00	**Apr-1998**	**135.24**	Jun-2000	0.02	Aug-2002	0.44
Feb-1996	0.16	May-1998	0.16	Jul-2000	0.02	Sep-2002	0.23
Mar-1996	0.41	Jun-1998	0.08	Aug-2000	0.03	Oct-2002	0.14
Apr-1996	0.06	Jul-1998	0.08	Sep-2000	0.00	**Nov-2002**	**1.33**
May-1996	0.03	Aug-1998	0.10	Oct-2000	0.17	Dec-2002	0.61
Jun-1996	0.02	Sep-1998	0.39	Nov-2000	0.37	Jan-2003	0.79
Jul-1996	0.00	Oct-1998	0.16	Dec-2000	0.93	Feb-2003	0.17
Aug-1996	0.00	Nov-1998	0.20	Jan-2001	0.33	Mar-2003	0.23
Sep-1996	0.03	Dec-1998	0.40	Feb-2001	0.47	**Apr-2003**	**11.20**
Oct-1996	0.09	**Jan-1999**	**5.27**	Mar-2001	0.34	May-2003	0.21
Nov-1996	0.21	**Feb-1999**	**5.59**	Apr-2001	0.26	Jun-2003	0.08
Dec-1996	**1.12**	Mar-1999	0.10	May-2001	0.18	Jul-2003	0.06
Jan-1997	0.70	Apr-1999	0.12	Jun-2001	0.26	Aug-2003	0.06
Feb-1997	0.18	May-1999	0.06	Jul-2001	0.26	Sep-2003	0.05
Mar-1997	0.30						

Appendix 2B

West Gulf River Forecast Center, Medina River Basin PET Development

INTRODUCTION

The purpose of this calculation file is to develop estimates of both potential evaporation and potential evapotranspiration for use in calibration of the Sacramento Soil Moisture Accounting Model within the National Weather Service River Forecast System (NWSRFS). The Sacramento model requires estimates of potential evapotranspiration in units of mm per day.

DATA

The following data was used in the development of this calculation:

- Maps of annual free surface (FWS) evaporation (in inches) and pan evaporation coefficients for the contiguous 48 United States, as found in the NOAA Technical Report 34, "Evaporation Atlas for the Contiguous 48 United States."
- Mean monthly, seasonal, and annual class A pan evaporation (in inches) for stations in the area of the Medina River Basin, as found in the NOAA Technical Report NWS 34, "Mean Monthly, Seasonal and Annual Pan Evaporation for the United States."
- Measured pan evaporation data collected at San Antonio International Airport (IAP) from the NCDC database for the year 2002.
- Historical regional monthly surface evaporation data from Texas Water Development Board (TWDB) for Bandera and Medina counties.

FREE WATER SURFACE EVAPORATION CALCULATION

Four datasets were compiled that represent the PET for the Medina River Basin above Bexar County. These methods include:

- NWS Technical Report Estimation;
- Monthly Average at San Antonio IAP;
- TWDB Historical Record; and
- Existing NWSRFS PET.

These are discussed below.

NWS Technical Report Estimation

The first method (the NWS approach) was used to derive pan evaporation patterns from the data given an estimated annual evaporation quantity. NOAA Technical Report NWS 34 describes the following approach to estimate monthly pan evaporation data for locations with no observed data:

1. Determine annual (or seasonal) values for FWS evaporation from the maps in the NOAA Technical Report NWS 33.
2. Locate stations with climate characteristics similar to those of the desired location that have data tabulated in the NOAA Technical Report NWS 34.

3. Determine monthly fractions of annual (or seasonal) evaporation for the stations from the table.
4. Multiply these monthly fractions by the annual (or seasonal) FWS evaporation value determined in step 1 to get the annual (or seasonal) distribution of evaporation for the desired location.

In this case, the annual FWS evaporation determined from the evaporation map for the Medina River Basin area is approximately 58-62 inches/year. The station used to derive the missing fractions for the winter months was a combination of the San Antonio IAP and McCook stations reported in NWS TR34. From these data, a monthly distribution of FWS evaporation for each sub-basin was determined. The resulting evaporation curve is shown in Figure 2B-1. Attachment 1 contains the spreadsheet calculations used to determine the potential evaporation curve.

Monthly Average at San Antonio International Airport

The second method utilized existing data at the San Antonio IAP station to provide more accurate local pan evaporation data for the Medina River Basin (recorded from 1995 to 2002). Measured values of pan evaporation were combined to estimate monthly total evaporation for each month over the period of record. Figure 2B-1 shows contains a plot of the average monthly pan evaporation values recorded at the San Antonio IAP over the period of record for calibration.

TWDB Historical Record

The TWDB has a database of historical surface evaporation data for the entire state of Texas (TWDB, 2002). The dataset consist of monthly values of surface evaporation from 1960 thru 2002. Figure 2B-1 includes a plot of the monthly average from 1995 to 2002 or the period of record selected for the calibration. These data also match the two previously compiled datasets. Also, because this data set includes historical records it would include periods of excessive and minimal evapotranspiration. For this reason URS decided the TWDB PET estimation would be best suited as the period of record estimation of PET.

EXISTING PET CURVE

The current 6-hour NWSRFS model contains existing values for PET. The monthly average values for PET were extracted from the existing model for comparison to the values estimated in this calculation file. Figure 2B-1 shows the existing values plotted along with the newly estimated values. The monthly averages from this data show reasonable agreement with the three other datasets compiled for PET.

CONCLUSIONS

The monthly distributions and annual totals for evaporation for the Medina River Basin were estimated. There were four sets of PET data compiled for this calculation file. The results of the four datasets show reasonable agreement. The data set compiled by the TWDB was selected as the historical PET data set to use for NWSRFS calibration.

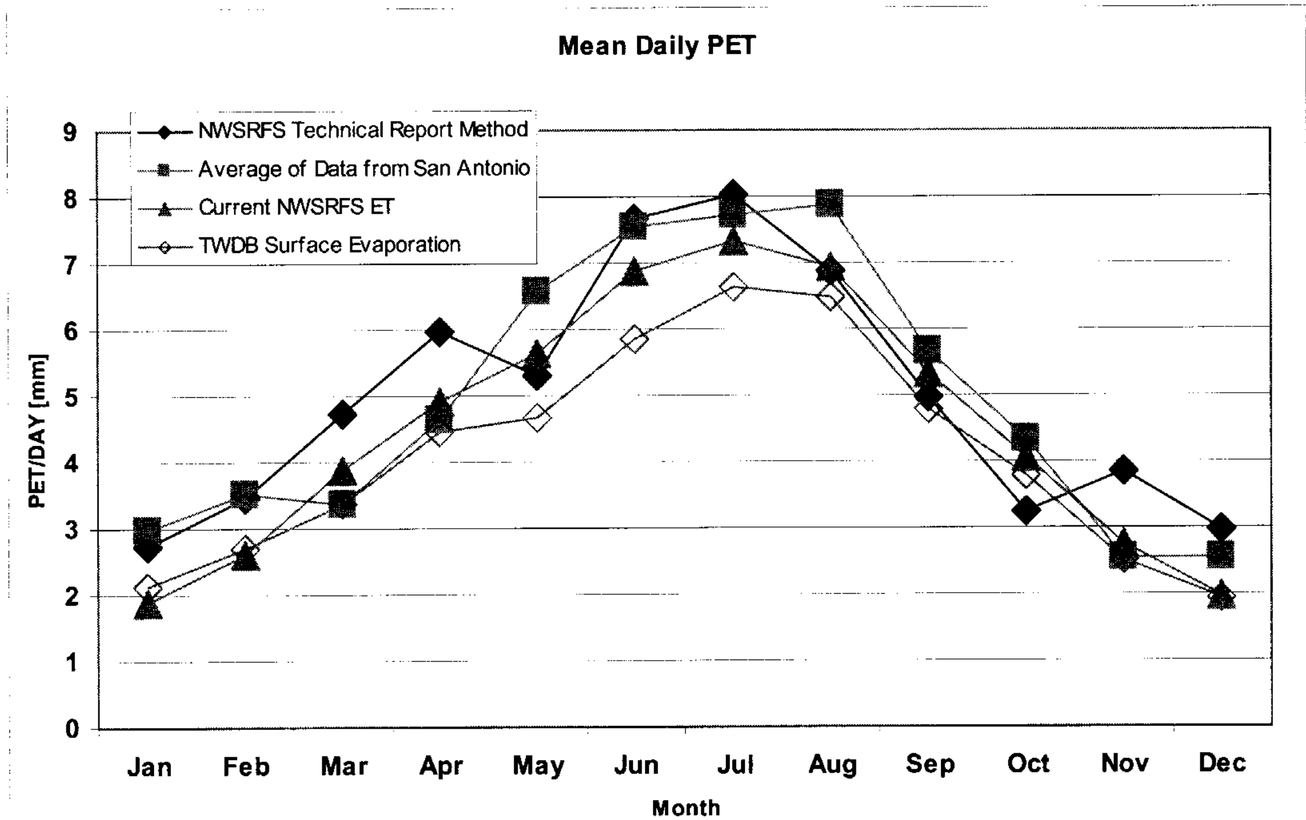


Figure 2B-1. Mean Daily PET values determined from NWS approach, monthly average at San Antonio IAP, Monthly average compiled by TWDB and current NWSRFS PET.

Attachment 1

Pan Coefficient	0.69
Annual FWS Evap	60
May to Oct FWS Evap	56

Compate Pan A Evaporation in Inches of Stations in the Vicinity (from NOAA Technical Report NWS 34 Table I)

Station	Lat Lon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
McCook	29 20, 98 23	4.18	5.07	8.01	8.86	9.18	10.43	11.97	11.69	8.94	7.37	5.7	4.53	95.93
Ratio to Annual		0.04	0.05	0.08	0.09	0.10	0.11	0.12	0.12	0.09	0.08	0.06	0.05	

Measured Pan A Evaporation in Inches of Stations in the Vicitnity (from NOAA Technical Report NWS 34 Tabel II)

Station	Lat Lon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	May to Oct
San Antonio WSO	29 31, 98 28	2.96	3.55	5.55	6.29	7.8	9.72	10.94	10.16	7.38	5.44	3.74	2.98	76.51	51.44
Ratio to Seasonal						0.15	0.19	0.21	0.20	0.14	0.11				

Average computed and estimated annual and seasonal values in Inches

Station	An.Pan A	An.FWS*	Se.Pan A	Se.FWS
McCook	95.93	66.19		
San Antonio			51.44	35.49
Difference to Values from 1)		6.19		20.51

*FWS = Pan A * Pan Coefficient

Ratio to seasonal ratios to the annual FWS Value

Seasonal FWS	35.49
Annual FWS	66.19
Ratio	0.54

6) Scaling of seasonal ratios to annual FWS values

Ratios	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Nov to Apr
Seasonal Ratios					0.15	0.19	0.21	0.20	0.14	0.11			1.00	
Seasonal Scale*					0.08	0.10	0.11	0.11	0.08	0.06			0.54	0.46
Annual Ratios	0.04	0.05	0.08	0.09	0.10	0.11	0.12	0.12	0.09	0.08	0.06	0.05		0.46
Ratio of winter ratios**	0.09	0.11	0.18	0.20							0.13	0.10		
Adjusted winter ratios***	0.05	0.06	0.10	0.11	0.08	0.10	0.11	0.11	0.08	0.06	0.07	0.05		
Final ratios														

* Seasonal saled = Monthly fraction / Sum of Seasonal fractions * Ratio from 5)
** Ratio of winter ratios = Monthly ratio value / annual raio values Nov to Apr
*** Adjusted winter ratios = Ratio of winter ratios * Seasonal ratios remainder Nov to Apr

7) Monthly FWS values in Inches

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Monthly FWS*	3.334755	4.044787	6.390284	7.068404	5.382	6.7068	7.5486	7.0104	5.0922	3.7536	4.547393	3.613981	64.4932

*Average Monthly FWS = Annjual FWS from 5) * Final Ratios from 6)

8) Vegetation Factors from NWSRFS Calibration Notes for Southern Mixed Forest

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Vegetation Factor	1	0.95	0.9	1	1.2	1.35	1.3	1.2	1.15	1.05	1	1	

9) Potential Evapotranspiration per Month

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
PET (inches)*	3.334755	3.842547	5.751256	7.068404	6.4584	9.05418	9.81318	8.41248	5.85603	3.94128	4.547393	3.613981	71.69389

*PET = FWS * Vegetation Factor

10) Potential Evapotranspiration per Day

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	31	28.25	31	30	31	30	31	31	30	31	30	31
PET (inches) *	0.107573	0.136019	0.185524	0.235613	0.2083355	0.301806	0.3165542	0.2713703	0.195201	0.1271381	0.15158	0.11658
PET (mm) **	2.732348	3.454892	4.712319	5.984582	5.2917213	7.6658724	8.0404765	6.8928062	4.9581054	3.2293068	3.850126	2.961133

* PET_DAY = PET_MONTH/Days in Month
**PET[mm] = PET [inches] * 25.4

11) Average Measured Pan Evapotranspiration at San Antonio Airport (1995 - 2002)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
inches	0.12	0.14	0.13	0.18	0.26	0.30	0.30	0.31	0.22	0.17	0.10	0.10
mm	2.96	3.51	3.37	4.62	6.57	7.56	7.71	7.88	5.67	4.32	2.56	2.55

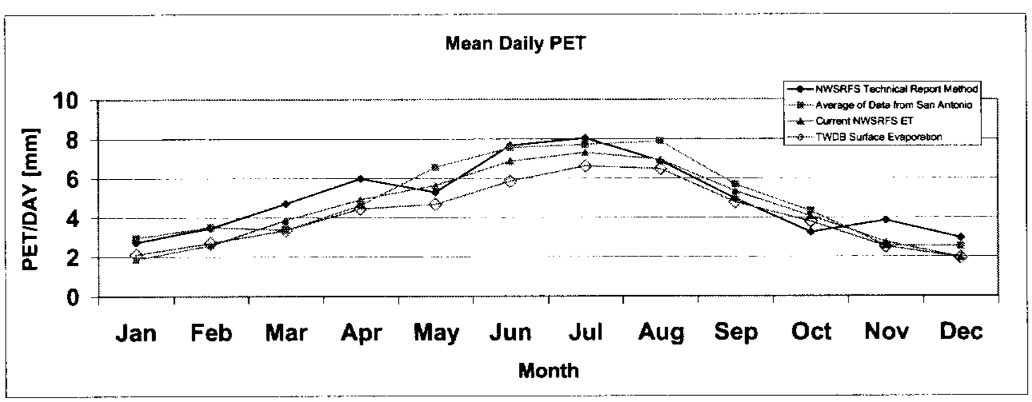
12) Average ET based on TWDB Surface Evaporation Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
inches	0.08	0.11	0.13	0.18	0.18	0.23	0.26	0.26	0.19	0.15	0.10	0.08
mm	2.12	2.69	3.35	4.46	4.67	5.86	6.63	6.49	4.78	3.78	2.53	1.95

13) Average ET taken from current calibration of NWSRFS for Medina River Basin

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
inches	0.07415771	0.10201587	0.15238559	0.19352593	0.222315412	0.270585185	0.288265233	0.273641577	0.209985185	0.159956989	0.10817778	0.07760573
mm	1.88360573	2.59120317	3.87008602	4.91555852	5.64681147	6.872863704	7.321936918	6.950496057	5.333623704	4.062907527	2.74771556	1.97118566
	0.63549105	0.7382309	1.14992899	1.06284261	0.858922297	0.909275335	0.949399439	0.882026399	0.940407622	0.940477319	1.07372484	0.77387303

13) Plot



Appendix 2C

West Gulf River Forecast Center, Medina River Basin Unit Hydrographs

INTRODUCTION

Unit Hydrographs are used in the NWSRFS model to distribute runoff estimated by rainfall-runoff models over time. They are required for each sub-basin defined in the Medina River Basin. URS used the SCS Unit Hydrograph method to calculate 1-hour interval unit hydrographs for each sub-basin. The purpose of this calculation file is to discuss the generation of these hydrographs.

DATA

Data used for generating unit hydrographs include:

- USGS Quadrangle maps for the entire Medina River Basin
- Existing Watershed boundaries from current 6-hour interval NWSRFS model of the area
- Locations of outlet points for each sub-basin

Basin Delineation

The first step to creating unit hydrographs is to determine the area of each sub-basin. To complete this task the boundaries of the sub-basins were determined. USGS Quadrangle maps were geo-referenced and combined with existing sub-basin boundaries and locations of new and existing sub-basin outlet points using ArcGIS. Where boundaries for sub-basins did not exist they were created by perpendicular intersection of elevation equipotential lines starting at the outlet until an existing boundary is reached. Figure 1 shows the delineated boundaries for each sub-basin. Corresponding basin areas were calculated using ArcGIS and are shown in Table 1.

Lag Time

The SCS unit hydrograph method requires basin area and lag time to produce a unit hydrograph lag time for each sub-basin. Estimating these values were accomplished by: 1) deriving a lag time for the sub-basin above the Bandera gage by hydrograph inspection and 2) using this value to extrapolate lag time measurements for other basins depending on basin characteristics.

Lag time values for the current NWSRFS BDAT2 sub-basin were derived based on graphical inspection of rainfall and runoff hydrographs. Figure 2 shows an example hydrograph that was used for determining lag time for the BDAT2 sub-basin. The difference in times at the peak for each of the two curves is defined as the lag time. These hydrographs show a time difference of 12 hours. This data along with the sub-basin characteristics were then used to estimate lag time values for the other basins.

$$Lag = C_1 C_t (L L_c)^{0.3}$$ Equation C.1

C_t = an empirical coefficient derived from gauged nearby watersheds
C_1 = conversion coefficient (0.75 SI, 1.0 English)
L = the distance of the mainstream from the basin outlet to the upstream divide (in km or miles)
L_c = the distance from the outlet to a point on the stream nearest the centroid of the watershed area (along the main stream)

The Snyder Method for creation of unit hydrograph relates sub-basin lag time to basin properties by Equation C.1. Using the derived lag time for the Bandera gage the value for C_t for the region was estimated. The derived C_t, X.X, was then applied to the other sub-basins for estimating a lag time for each. Table C.1 contains a summary of the input parameters and lag time results for each of the sub-basins. These lag times were used to create synthetic unit hydrographs for each basin using the SCS method.

Unit Hydrograph Generation

Based on the basin areas and time of concentration estimates for each sub-basin, unit hydrographs were generated using the SCS unit hydrograph method. Figure 3 shows the intiail unit hydrographs created for use with the updated NWSRFS model. It is anticipated that changes will be made to these hydrographs during the calibration process, especially in the sub-basins where no observed hydrographs are available.

Table 2C-1. Basin Area and Lag Time for Medina River Basin Sub-basins

Basin	Area (square miles)	L (m)	L_c (m)	C_1	C_t	Lag Time (hrs)
Current						
BDAT2	335	92613	36718	0.75	1.395	12
Updated						
WMPT2	60	28838	14419	0.75	1.395	6
NMPT2	157	55895	27947	0.75	1.395	10
BDAT2	117	38935	36718	0.75	1.395	9
LACT2	299	13844	10690	0.75	1.395	5
CSRT2	109	76780	44297	0.75	1.395	12
MDLT2	22	67969	46301	0.75	1.395	12

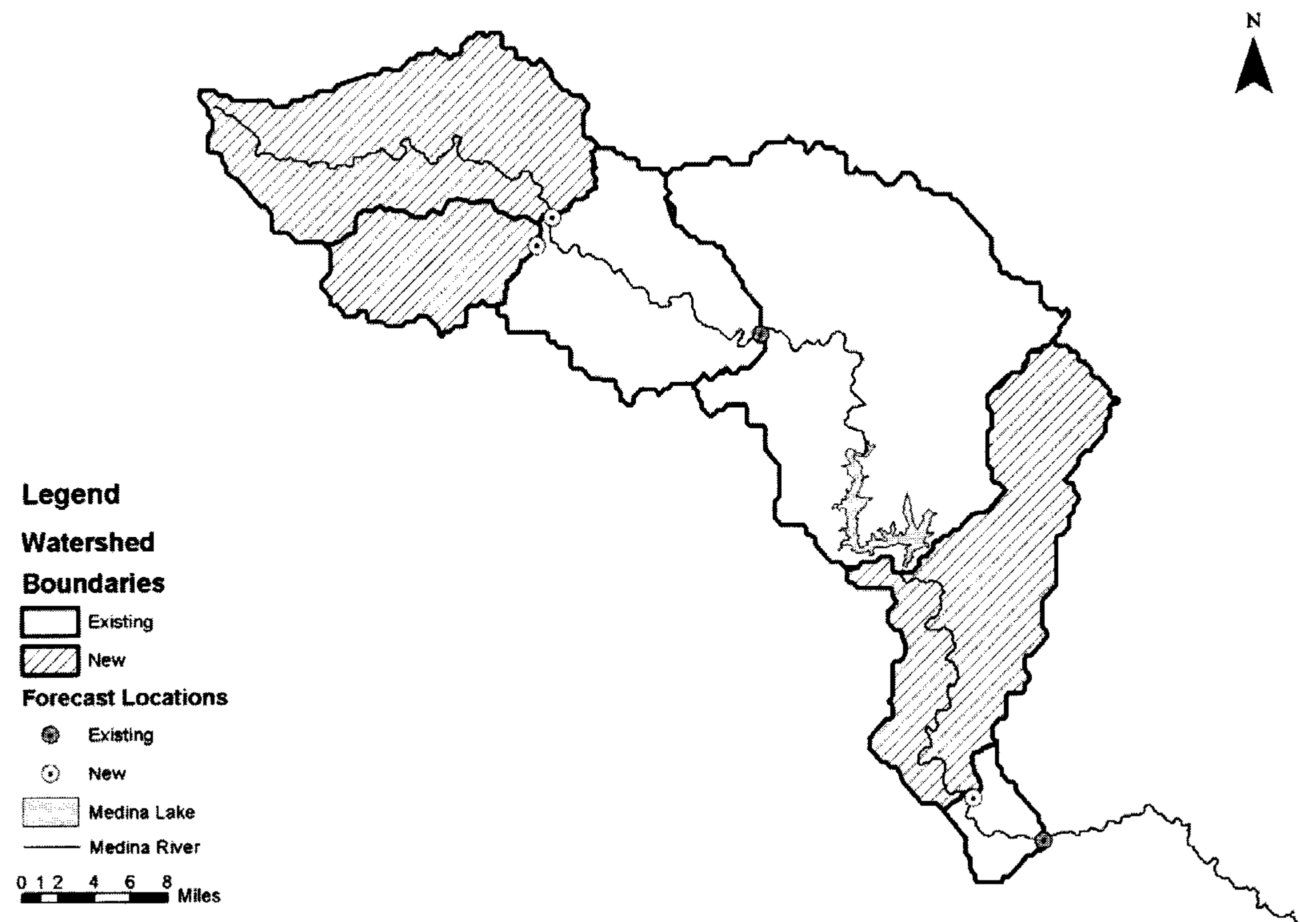


Figure 2C-1. Basin boundaries for sub-basins included in the 1-hour interval NWSRFS model of the Medina River Basin.

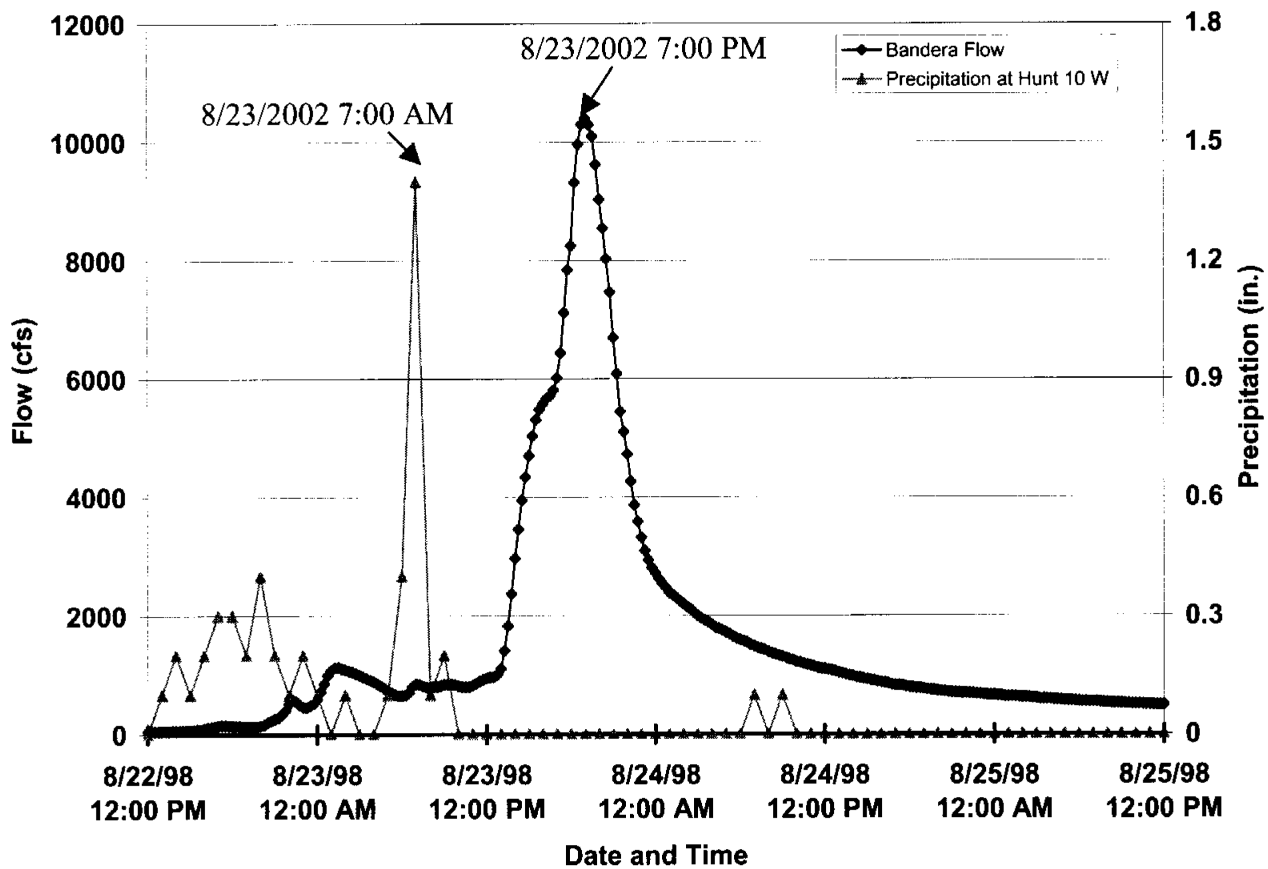


Figure C2-2. Flow and rainfall hydrographs used to graphically determine lag time for the Bandera sub-basin of the Medina River Basin.

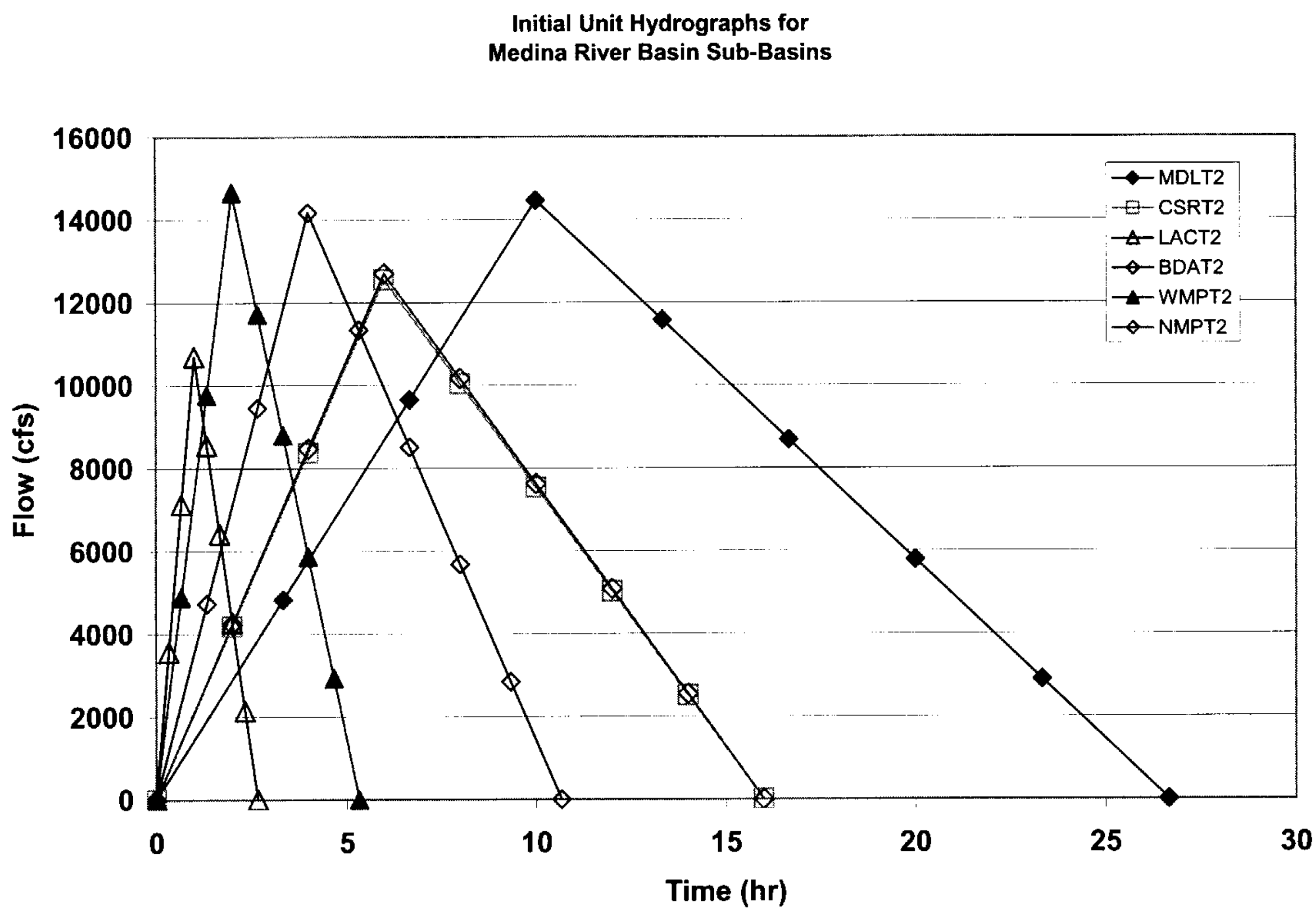


Figure 2C-3. Initial Unit Hydrographs calculated for use with NWSRFS 1-hour interval model of Medina River Basin.

Appendix 2D

West Gulf River Forecast Center, Medina River Basin Routing

INTRODUCTION

Routing streamflow through a sub-basin is necessary to simulate the time delay caused by the distance traveled in the stream and the attenuation of peak flows due to storage affects and hydraulic head losses in the stream channel. There are several methods for estimating the routing of stream flow. For the Medina River Basin the Muskingum method was selected. The purpose of this calculation file is to present the methods used to determine Muskingum routing parameters for the sub-basins of the Medina River Basin.

DATA

The following data were used for the routing parameter development for the Medina River Basin:

- River length from each basin outlet to the next downstream basin outlet from 24K resolution hydrography layer developed by the USGS;
- Lag/K parameters extracted from the existing NWSRFS model for the Medina River Basin.
- USGS discrete velocity measurements at the Bandera and La Coste gages.

PARAMETER ESTIMATES

The Muskingum method of routing relies on two values to adjust flows through a stream or river channel. They are K and x. K, the proportionality coefficient, represents the travel time of the flood wave through a channel. The "x" parameter, or the weighting factor, adjusts the type of storage represented based on the channel shape and type. Two methods for estimating these parameters were investigated. They are below.

Hydrograph Analysis

One method for deriving the Muskingum routing parameters is based on analysis of observed runoff hydrographs of upstream and downstream outlet points. Unfortunately, the lack of a sufficient number of gaged locations on the Medina River Basin do not allow for the use of this method. Within the BDAT2 sub-basin no upstream gages exist. For determining routing through the LACT2, the Medina Lake Dam and Diversion Lake Dam add significant routing effects that limit the effectiveness of graphical estimation of Muskingum routing. According to Linsley et al. (1982) when storage is not a function of flow Muskingum routing will not work well. Because changes in flow between LACT2 and BDAT2 are dependent on available storage in the dams and the amount of diversion flow, using the analysis of observed hydrographs was not completed. An alternative method was sought for initial estimates of these parameters

Sub-Basin Average Velocities

Because the hydrograph analysis was not feasible, an estimate was needed to determine the K and x parameters. Another method for making initial estimates of Muskingum routing parameters is to assume a stream velocity and the 'x' weighting factor and calculate the K based on an assumed velocity. Average velocities over the period of record at several USGS gages along the Medina River were found to range from 0.3 m/s to 1.1 m/s. An initial estimate of 1 m/s for the stream velocity is within this range. Using this velocity the values for K in Table 2D-1 were produced.

The 'x' parameter can vary between 0.1 and 0.3 for stream channels. The midpoint of this range will be used as an initial estimate. It is anticipated that these values will change during the calibration process to better match the observed data.

Table 2D-1. Summary of Stream Length, K and x for Sub-basins Along the Medina River

		Muskingum	
Basin	Stream Length (m)	K (hrs)	x
BDAT2	32861	9	0.2
MDLT2	46384	13	0.2
CSRT2	37335	10	0.2
LACT2	11092	3	0.2

Existing Values

Existing Values for "K" were extracted from the current NWSRFS model of the Medina River Basin for sub-basins that had values defined. Because the boundaries of the sub-basins have changed the values can not be directly compared to new estimates. These values are presented only to give perspective of what values have been used in the past.

Table 2D-2. Summary of K and x Parameter Values Used in the existing NWSRFS Model

Sub-basin	K
BDAT2	N/A
MDLT2	6
CSRT2	N/A
LACT2	6

Appendix 2E

Input Decks Used for Calibration

```
    ******************************BDAT2*******************************
BNDERA-MEDINA RIVER (BDAT2)  (335 MI2)
 01 1995   12 2002  ENG
DEF-TS
WPMT2     MAP     1          INPUT
sana/bdat2/WMPT2_697.mapx01
NPMT2     MAP     1          INPUT
sana/bdat2/NPMT2_697.mapx01
BDAT2     MAP     1          INPUT
sana/bdat2/BDAT2_697.mapx01
WPMT2     MAPE   24          INPUT
sana/Medina.mape
NPMT2     MAPE   24          INPUT
sana/Medina.mape
BDAT2     MAPE   24          INPUT
sana/Medina.mape
BDAT2     QIN     1          INPUT
sana/bdat2/BDAT2_QIN_Shift.qin
BDAT2     QME    24          INPUT
sana/bdat2/Bdat.qme
WPMT2     INFW    1
WPMT2     ROCL    1
WPMT2     SMZC    1
LOCALW     SQIN   1
WPMT2R    SQIN    1
NPMT2     INFW    1
NPMT2     ROCL    1
NPMT2     SMZC    1
LOCALN    SQIN    1
NPMT2R    SQIN    1
BDAT2     INFW    1
BDAT2     ROCL    1
BDAT2     SMZC    1
LOCALB    SQIN    1
BDAT2     SQME   24
BDAT2     SQIN   1          OUTPUT
sana/bdat2/bdat2.sqin01
END
SAC-SMA    WPMT2
BANDERA-MEDINA RIVER        1  WPMT2    MAP       WPMT2    INFW
             WPMT2    WPMT2   SUMS        1   1
            1.000 .595 35.0 64.00.1500.0000.0500.011    0 .000
             13.0 1.01 71.0 50.0 325.0.1210.0070.400 .3000.000
 WPMT2    MAPE       .77 .77 .78 .80 .831.907.074.582.171.771.631.02
              3.   4.  12.   0.  43.   1.
CLEAR-TS
```

```
 LOCALW   SQIN   1
UNIT-HG    WPMT2
MEDINAPRON-MED RIVER        60.5     7         ENGL     .000
 WPMT2    INFW    1  LOCALW   SQIN    1
 3256.117  6512.934  9769.415  7815.532   5861.65   3907.76   1953.88
LAG/K      WPMT2
LOCALW    SQIN  1 WPMT2R   SQIN  1     3     0 ENGL
   3.0      0.      3.0   8000.      3.0 999999.
   0.0
0
SAC-SMA    NPMT2
BANDERA-MEDINA RIVER        1  NPMT2    MAP      NPMT2    INFW
             NPMT2     NPMT2    SUMS        1    1
            1.000 .595 35.0 64.00.1500.0000.0500.011    0 .000
            13.0 1.01 71.0 50.0 325.0.1210.0070.400 .3000.000
 NPMT2    MAPE     .77 .77 .78 .80 .832.715.964.762.171.771.631.02
              3.   4.   12.   0.   43.   1.
CLEAR-TS
 LOCALN   SQIN    1
UNIT-HG    NPMT2
BANDERA-MEDINA RIVER        157.0    7         ENGL     .000
 NPMT2    INFW    1  LOCALN    SQIN    1
  8468.16 16936.330 25404.500  20323.60  15242.70  10161.80   5080.90
LAG/K      NPMT2
LOCALN    SQIN  1 NPMT2R   SQIN  1     3     0 ENGL
   3.0      0.      3.0   8000.      3.0 999999.
   0.0
0
SAC-SMA    BDAT2
BANDERA-MEDINA RIVER        1  BDAT2    MAP      BDAT2    INFW
             BDAT2     BDAT2    SUMS        1    1
            1.000 .595 35.0 64.00.1500.0000.0500.011    0 .000
            13.0 1.01 71.0 50.0 325.0.1210.0070.400 .3000.000
 BDAT2    MAPE     .77 .77 .78 .80 .832.085.733.792.171.771.631.02
              3.   4.   12.   0.   43.   1.
CLEAR-TS
 LOCALB   SQIN    1
UNIT-HG    BDAT2
BANDERA-MEDINA RIVER        117.2    7         ENGL     0.00
 BDAT2    INFW    1  LOCALB    SQIN    1
  6300.79 12601.60  18902.39   15121.91  11341.44   7560.95   3780.49
ADD/SUB    WPMT2R
 BDAT2    SQIN    1  WPMT2R   SQIN    1
ADD/SUB    NPMT2R
 BDAT2    SQIN    1  NPMT2R   SQIN    1
ADD/SUB    LOCALB
```

```
 BDAT2   SQIN   1 LOCALB  SQIN   1
MEAN-Q    BDAT2
 BDAT2   SQIN   1 BDAT2   SQME  24
PLOT-TS    BDAT2
   BANDERA-MEDINA RIVER   3   1   2   0
 ARIT 120      0.0     5700   2
 BDAT2   SQIN   1     SIMULATED     *
 BDAT2   QIN    1     OBSERVED      0
WY-PLOT    BDAT2
BANDERA-MEDINA RIVER   2       896.  700.  NO
 BDAT2   QME       OBSERVED      0
 BDAT2   SQME      SIMULATED     *
STAT-QME   BDAT2
BANDERA-MEDINA RIVER    1106.  BDAT2   SQME  24  BDAT2   QME   24
STOP
END
*******************************LACT2*********************************
LA COSTE-MEDINA RIVER
  01 1995   08 2000  ENG
DEF-TS
BDAT2     SQIN   1        INPUT
sana/bdat2/bdat2.sqin01
BDAT2R    SQIN   1
CSRT2     MAPE  24        INPUT
sana/Medina.mape
CSRT2     INFW   1
CSRT2     ROCL   1
CSRT2     SMZC   1
CSRT2     SQME  24
CSRT2     SQIN   1
CSRT2R    SQIN   1
LACT2     INFW   1
LACT2     ROCL   1
LACT2     SMZC   1
MDLT2     MAPE  24        INPUT
sana/Medina.mape
LACT2     MAPE  24        INPUT
sana/Medina.mape
LACT2R    SQME  24
LACT2L    SQME  24
LACT2     SQIN   1
LACT2L    SQIN   1
LACT2     SQME  24
LACT2     QME   24        INPUT
sana/lact2/LaCoste.qme
LACT2     QIN    1        INPUT
```

```
sana/lact2/LaCoste.qin01
MDLT2    INFW   1
MDLT2    ROCL   1
MDLT2    SMZC   1
MDLT2    SQME   1
MDLT2    SPEL   1
MDLT2    RQIE   1
MDLT2    PELE   1
MDLT2    RSTE   1
MDLT2L   SQIN   1
MDLT2R   SQIN   1
MDLT2R   SQME  24
INFLOW   SQIN   1
INFLOW   SQME   1
MDLT2    MAP    1        INPUT
sana/lact2/MDLT2.mapx01
LACT2    MAP    1        INPUT
sana/lact2/LACT2.mapx01
CSRT2    MAP    1        INPUT
sana/lact2/CSRT2.mapx01
END
LAG/K    BDAT2
BDAT2   SQIN  1 BDAT2R   SQIN  1     3     2 ENGL
   7.0     0.     7.0   8000.     14.0 999999.
   7.0     0.     7.0 999999.
0
SAC-SMA    MDLT2
MEDINA LAKE              1  MDLT2    MAP       MDLT2    INFW
             MDLT2    MDLT2    SUMS        1   1
             1.0 1.00 25.0 61.00.1000.0000.0050.008    0 .000
            13.0 1.01 55.0 50.0 325.0.1210.0030.400 .0200.200
 MDLT2    MAPE     .99 .87 .87 .87 .871.001.961.971.801.701.651.40
              1.  0.0   1.  0.8   2.   1.
CLEAR-TS
 MDLT2L  SQIN   1
UNIT-HG    MDLT2
MEDINA LAKE              299.0   10         ENGL
 MDLT2    INFW    1  MDLT2L    SQIN    1
  9044.00  18089.00  27134.00  36179.00  30752.00  25325.00  19898.00
 14471.00   9044.00   3617.00
SAC-SMA    CSRT2
CASTROVL-MEDINA           1  CSRT2    MAP       CSRT2    INFW
             CSRT2    CSRT2    SUMS        1   1
             1.0 1.00 25.0 61.00.1000.0000.0050.008    0 .000
             13.0 1.01 55.0 50.0 325.0.1210.0030.400 .0000.200
 CSRT2    MAPE     .99 .87 .87 .87 .871.001.961.971.801.701.651.40
```

```
            1. 0.0  1. 0.8  2.  1.
CLEAR-TS
 CSRT2  SQIN  1
UNIT-HG   CSRT2
CASTROVL-MEDINA          109.0  10       ENGL
 CSRT2   INFW   1 CSRT2   SQIN   1
  3297.  6594.   9891.  13189.  11210.  9232.0  7254.0
  5725.  3297.   1318.
LAG/K    CSRT2
CSRT2   SQIN  1 CSRT2R  SQIN  1    3    2 ENGL
  1.0     0.     1.0   8000.     1.0 999999.
  1.0     0.     1.0 999999.
0
SAC-SMA   LACT2
LA COSTE-MEDINA          1  LACT2   MAP      LACT2   INFW
            LACT2   LACT2   SUMS       1   1
            1.0 1.00 25.0 61.00.1000.0000.0050.008   0 .000
            13.0 1.01 55.0 50.0 325.0.1210.0030.400 .0000.200
 LACT2   MAPE    .99 .87 .87 .87 .871.001.961.971.801.701.651.40
            1.  0.0  1.  0.8  2.  1.
CLEAR-TS
 LACT2L  SQIN  1
UNIT-HG   LACT2
LA COSTE-MEDINA          22.1   5       ENGL    .000
 LACT2   INFW   1 LACT2L  SQIN   1
  2673.   5346.   3742.   2138.    534.
ADD/SUB   MDLT2L
 INFLOW  SQIN   1 MDLT2L  SQIN   1
ADD/SUB   BDAT2R
 INFLOW  SQIN   1 BDAT2R  SQIN   1
MEAN-Q    INFLOW
 INFLOW  SQIN   1 INFLOW  SQME   1
RES-SNGL  MDLT2
GENERAL
TITLE 'MEDINA LAKE'
UNITS ENGLISH ACFT
PARMS
ELVSSTOR      920.00   940.00   960.00   980.00   1000.00  &
         1015.00  1030.00  1050.00  1057.00  1060.00  &
         1070.00  1072.00  1075.00  1079.00  1090.00  &
           .00   600.00  3000.00  12000.00  30200.00  &
        52500.00  82500.00 150000.00 179400.00 192000.00  &
       217200.00 254000.00 271400.00 295000.00 370000.00
INTERP LINEAR
ENDP
TIME-SERIES
```

```
INSTQIN INFLOW   SQIN 1
MEANQIN INFLOW   SQME 1
MEANQOUT MDLT2   SQME 1
POOL    MDLT2   SPEL 1
ENDTS
CARRYOVER
INFLOW     625.37
Q-MEAN     500.00
Q-INST     500.00
POOL0     1072.00
POOL1     1073.00
STORAGE  254000.00
ENDCO
ENDGENL
SPECIFIC
RAINEVAP(1)
PARMS
EVAP    .070    .100    .150    .190    .220    .270  &
        .290    .270    .210    .160    .110    .080
DIST     .05     .05     .05     .05     .05     .05  &
         .06     .06     .07     .07     .07     .07  &
         .03     .03     .03     .03     .03     .03  &
         .02     .02     .02     .02     .02     .02
ENDP
TIME-SERIES
PCPN MDLT2   MAP 1
ENDTS
ENDRAIN
SPILLWAY(1)
PARMS
TYPE UNC
CREST 1072.00
ELVSQ 1072.00   1072.50   1073.00   1074.00  &
    1076.00   1078.00   1080.00   1082.00  &
    1084.00   1085.50  &
    0.00      500.00    3000.00   7200.00  &
    15500.0  24500.0   35500.0   48200.0  &
    66000.0   100000.
INTERP LINEAR
QSLUICE  27.0
QGEN    00.0
ENDP
CARRYOVER
OLDQ      27.00
ENDCO
ENDSPWY
```

```
ADJUST(1)
TIME-SERIES
OBSH    MDLT2   SPEL  1
ADJQO   MDLT2   RQIE  1
ADJH    MDLT2   PELE  1
ADJS    MDLT2   RSTE  1
ENDTS
ENDADJ
ENDSPEC
RCL
DO SPILLWAY
ENDRCL
END
LAG/K     MDLT2R
MDLT2   RQIE  1 MDLT2R   SQIN 1    0    2 ENGL  .00      .0
       .000
      4.000        .000        4.000    999999.000
      0
ADD/SUB   LACT2R
 LACT2   SQIN   1 MDLT2R  SQIN   1
ADD/SUB   CSRT2L
 LACT2   SQIN   1 CSRT2R  SQIN   1
ADD/SUB   LACT2L
 LACT2   SQIN   1 LACT2L  SQIN   1
MEAN-Q    LACT2
 LACT2   SQIN   1 LACT2   SQME  24
MEAN-Q    MDLT2R
 MDLT2R  SQIN   1 MDLT2R  SQME  24
PLOT-TS   LACT2
   LACOSTE-MEDINA RIVER   3   1   6   0
 ARIT  120      0.0      5700   6
 LACT2   QIN    1      OBSERVED      0
 LACT2   SQIN   1      SIMULATED     *
 CSRT2   SQIN   1      SIMULATED     &
 CSRT2R  SQIN   1      SIMULATED     @
 LACT2L  SQIN   1      SIMULATED     %
 MDLT2L  SQIN   1      SIMULATED     %
WY-PLOT   LACT2
LA COSTE-MEDINA RIV    2        272. 790.  NO
 LACT2   QME      OBSERVED     O
 LACT2   SQME     SIMULATED    *
STAT-QME   LACT2
LA COSTE-MEDINA RIV     272.  LACT2   SQME  24  LACT2    QME    24
STOP
END
```

Appendix 4A

Questionnaires from February 2004 Meetings

QUESTIONAIRE
MEDINA RIVER FLOOD PROTECTION PLANNING STUDY

Name: Scott Lampright
Organization: Bexar County Emerg Mgmt
Address: 203 W. Nueva, Ste 302
San Antonio, TX 78207

E-mail: slampright@co.bexar.tx.us
Phone: (210) 335-0300

A. FLOOD PREDICTION

We are working with SARA, City of San Antonio and others to prepare a GIS Mapping System for Bexar County. This will allow us to predict flood inundation at various levels.

Do you plan to generate your own information as to predicted flood stage and timing? If so, how? Bandera & La Coste – only gauges in 2002 (Use 6 hour Time Step) – want to go to 1 hr

Adding Prediction Pts at Lake, and at Castroville

Bandera EMC – Install additional meter well above Bandera to give 6-8 hrs additional time. a 59% of water at Dam from Bandera County.

– San Geronimo Creek needs an additional meter

What needs exist in terms of flood prediction?

Recommendations:

— Medina Co. Establish an EOC hire an EMC (contact AACOG for Assistance)
-- Have one source of information – From the EOC.
— Relocate BMA Board President to Medina Co. EOC
-- Make calls from there to Contacts.
— Need Gauge(s) upriver near Bandera to cover non-Dam break Conditions
— Need Flood (Watershed) Conditions
— Need accurate inundation maps for both Flood and Dam Failure (At Maximum Flood Stage) – i.e. at 2002 Flood Levels and Lake Full
— BMA Fund GIS Flood Inundation Mapping System for Medina and Bandera Counties (Software).

1-1

B. ORGANIZATION ACTIONS DURING WATCHES AND WARNINGS

What are the ~~current~~ Projected responsibilities of your organization during:

NWS Flood Watch
- Consider evacuation procedures (Pre-plan) and Needs, Define areas to be evacuation
- Notify EOC Staff, VFDs, and Bexar County Municipalities
- Consult with NWS, Medina Co.

NWS Flood Warning (predicted stage crest and time)
- Evacuate as needed, Shelter as needed
- Prepare for Search + Rescue
- Activate EOC

BMA Lake Medina Dam Watch Condition

UNDEFINED BY BMA/URS
- Prepare for evacuation, sheltering
- Notify EOC Staff, VFDs and Bexar County Municipalities, BC Sheriff Office
- Consult with Medina Co., NWS, BMA, etc

BMA Lake Medina Dam Possible Dam Failure Condition

Consider Evacuation
Prepare for S+R
Activate EOC
Continue consultation
Define Areas to Be evacuation

BMA Lake Medina Dam Imminent Dam Failure Condition

Evacuate, Shelter, Mass Care
Call for State (DDC) Assistance
Prepare for S+R

BMA Lake Medina Dam Failure Condition
- Evacuate, Shelter, Mass Care
- S+R
- Call for State Assistance (Air Resources, ARNG etc)

What are your thoughts on changes to your responsibilities of your organization during:

NWS Flood Watch

Add GIS Mapping Capabilities.

NWS Flood Warning (predicted stage crest and time)

Improve Communications to better address changing conditions.

BMA Lake Medina Dam Watch Condition

Define Condition

BMA Lake Medina Dam Possible Dam Failure Condition

Needs to include overtop crest >6 hrs out

Define Condition

BMA Lake Medina Dam Imminent Dam Failure Condition

Define Condition

BMA Lake Medina Dam Failure Condition

Add Watershed Flood Conditions to cover non-Dam break condition

1-2

ORGANIZATION ACTIONS DURING WATCHES AND WARNINGS (continued)

What other recommendations do you have? Communications are the key to success in this situation. Improve communications. Medina County needs Emerg Mgmt Coordinator, EOC, and Emergency Mgmt Plan. Links with ~~[illegible]~~ Medina and Bandera counties.

C. ORGANIZATION ACTIONS WITH RESPECT TO EVACUATIONS

Does your organization have responsibility for issuing evacuation orders? If so:

Area (physical/ political boundaries) of responsibility: Bexar County (Unincorporated)

How is decision made as to evacuation, given warnings/ watches? Specifically:

Is there written guidance? ~~[illegible]~~ Yes. Evacuation Annex to EM Plan.

How is time-of-day considered? Yes. Nightime evacuation / Severe wx create additional complications.

Discussion (current procedures, needs)

Does your organization have any responsibility for communicating an evacuation order?

Area (physical/ political boundaries) of responsibility: Bexar County (Unincorporated)

Means of communication:

Type of Communication	Used?	Comment (# of equip, # of staff, on order/request?)
Reverse 911	Yes	Through Bexar Metro 911
Tone Alert Radios	Yes	Including NWS Wx Radios
Sirens	No	
TV/ radio messaging	Yes	
Mobile announcement systems	Yes	Fire, Police, Sheriff
Wireless announcement systems	~~Yes~~ No	
Broadcast e-mail	Yes	To all Cities in Bexar Counties
Door-to-door canvassing	Yes	Fire, Police, Sheriff, Public Works
Surveillance Systems	Yes	TxDot Systems on Major Roads

C. ORGANIZATION ACTIONS WITH RESPECT TO EVACUATIONS (Continued)

Does your organization have any responsibility for evacuating people with special needs (bedridden, etc.)? If so, describe

Area (physical/ political boundaries) of responsibility: Bexar County (Unincorporated)

Needs/ideas to facilitate/ improve current system (are there sufficient resources?).
Will make use of all available evacuation Means. Few Day care, Adult care resources in Flood plain area

Does your organization have any responsibility for post-evacuation security? If so, describe:

Area (physical/ political boundaries) of responsibility: See Above

Needs/ideas to facilitate/ improve current system(are there sufficient resources?).
Sheriff, Constables, municipal Police, DPS, National Guard (if avail) in conjunction with Public Works currently used for Security.

Does your organization have any responsibility for housing evacuees? If so, describe:
Bexar County Housing & Human Services — Working with Amer. Red Cross

Area (physical/ political boundaries) of responsibility: See Above

Needs/ideas to facilitate/ improve current system (are there sufficient resources?).
Sufficient Shelter Capabilities exist (We are tasked to shelter 20,000 – 30,000 from Corpus Christi during a hurricane).

1-4

D. PUBLIC EDUCATION

Does your organization have any ongoing public education programs related to emergency procedures during floods? If so, please describe:

Yes. We give talks to community organizations, Media Releases, and public information programs (Fliers, Posters etc).

Ideas/ recommendations as pertain to public education?

Critical To success. Public meetings will improve BMA's image as well as inform. Fliers, Brochures, Maps, inserts to Telephone books, insert in utility bills.

Spanish & English

1-5

E. INFRASTRUCTURE PLANNING

Does your organization have responsibility for the following infrastructure during/ following a flood:

Infrastructure Element	Area (physical/ political boundary)	Is there an existing written Emer Plan for this element?	Comment (current resources, needs)
Roads	Unincorporated Bexar Co	Yes EM Plan	
Power	Yes – But public utilities have primary Responsibility	Utilities Annex to Em Plan	
Water	"	"	
Sewer	"	"	
Housing	Yes Housing and Human Services	Shelter and Mass Care Annex	

If your responsibility, how are people addressed who are not in the floodplain/ dam break inundation area, but who are cut off from the transportation system, water and/or power?
Advise them to shelter in place – usually short duration. Search and Rescue as needed. Keep isolated individuals informed by all means (radio, tv, website etc)

Comments/ Ideas/ Needs

F. CRITICAL ISSUES

What in your opinion are the critical issues associated with emergency management of a future flood in the Medina River Valley? What are your ideas for improvement?

- Communications.
- EM Plans For Medina County } Work with DEM, AACOG, BMA (Funding) To assist.
- EOC For Medina County
  - -- Single point of coordination, command, and control
- Bexar County will further engage with Medina County on these issues.

G. DO YOU WANT THIS FORM INCLUDED IN AN APPENDIX OF THE STUDY REPORT? Yes No

NOT WITHOUT OUR ABILITY TO EDIT/CORRECT.

1-7

4 feet over spillway

QUESTIONAIRE
MEDINA RIVER FLOOD PROTECTION PLANNING STUDY

Name: JOHN A. "JACK" WILLIAMSON, M.D.
Organization: MEDINA RANCH - DIVERSION LAKE
Address: 303 PARK HILL DR., SAN ANTONIO, 78212

E-mail: jmbwmson@swbell.net
Phone: (210) 805-8059 mobile = 210-213-0465 lake = (830) 751-2465

A. FLOOD PREDICTION

Do you plan to generate your own information as to predicted flood stage and timing? If so, how? Medina Ranch has 25 shareholders. Of those only 3 live on the lake; the other 22 use homes on week-ends. All of us will be watching TV, radio, etc. and will evacuate early in threatening situation.

What needs exist in terms of flood prediction?

Simply a notification phone call

Recommendations:

Set up EOC in Castroville with good communications.

B. ORGANIZATION ACTIONS DURING WATCHES AND WARNINGS

What are the current responsibilities of your organization during:

NWS Flood Watch

NWS Flood Warning (predicted stage crest and time)

BMA Lake Medina Dam Watch Condition

BMA Lake Medina Dam Possible Dam Failure Condition

BMA Lake Medina Dam Imminent Dam Failure Condition

BMA Lake Medina Dam Failure Condition

To be certain all 25 shareholders are notified of flood risk and assist with evacuation as indicated.

What are your thoughts on changes to your responsibilities of your organization during:

NWS Flood Watch

NWS Flood Warning (predicted stage crest and time)

BMA Lake Medina Dam Watch Condition

BMA Lake Medina Dam Possible Dam Failure Condition

BMA Lake Medina Dam Imminent Dam Failure Condition

BMA Lake Medina Dam Failure Condition

Making certain that all parties on the lake have been contacted.

ORGANIZATION ACTIONS DURING WATCHES AND WARNINGS (continued)

What other recommendations do you have?

None

C. ORGANIZATION ACTIONS WITH RESPECT TO EVACUATIONS

Does your organization have responsibility for issuing evacuation orders? If so:

Area (physical/ political boundaries) of responsibility: Diversion Lake

How is decision made as to evacuation, given warnings/ watches? Specifically:

Is there written guidance?

How is time-of-day considered?

Early action through phone or personal contact.

Discussion (current procedures, needs)

Does your organization have any responsibility for communicating an evacuation order? No

Area (physical/ political boundaries) of responsibility:

Means of communication:

Type of Communication	Used?	Comment (# of equip, # of staff, on order/request?)
Reverse 911		
Tone Alert Radios		
Sirens		
TV/ radio messaging		
Mobile announcement systems		
Wireless announcement systems		
Broadcast e-mail		
Door-to-door canvassing		
Surveillance Systems		

C. ORGANIZATION ACTIONS WITH RESPECT TO EVACUATIONS (Continued)

Does your organization have any responsibility for evacuating people with special needs (bedridden, etc.)? If so, describe No.

Area (physical/ political boundaries) of responsibility:

Needs/ideas to facilitate/ improve current system (are there sufficient resources?).

Does your organization have any responsibility for post-evacuation security? If so, describe:

Area (physical/ political boundaries) of responsibility: Medina Ranch surrounds Diversion Lake – access gates are locked.

Needs/ideas to facilitate/ improve current system(are there sufficient resources?).

Does your organization have any responsibility for housing evacuees? If so, describe:

25 lake homes are weekend homes.

Area (physical/ political boundaries) of responsibility:

Needs/ideas to facilitate/ improve current system (are there sufficient resources?).

D. PUBLIC EDUCATION

Does your organization have any ongoing public education programs related to emergency procedures during floods? If so, please describe:

Thru newsletters and periodic meetings.

Ideas/ recommendations as pertain to public education?

E. INFRASTRUCTURE PLANNING

Does your organization have responsibility for the following infrastructure during/ following a flood:

Infrastructure Element	**Area (physical/ political boundary)**	**Is there an existing written Emer Plan for this element?**	Comment (current resources, needs)
Roads	On ranch	No	Some homes isolated in case of flood, so early evacuation = important.
Power			
Water			
Sewer			
Housing			

If your responsibility, how are people addressed who are not in the floodplain/ dam break inundation area, but who are cut off from the transportation system, water and/or power?

Comments/ Ideas/ Needs

F. CRITICAL ISSUES

What in your opinion are the critical issues associated with emergency management of a future flood in the Medina River Valley? What are your ideas for improvement?

G. DO YOU WANT THIS FORM INCLUDED IN AN APPENDIX OF THE STUDY REPORT? Yes No

QUESTIONAIRE
MEDINA RIVER FLOOD PROTECTION PLANNING STUDY

Name: RAlph C. DRESSER
Organization: Bandera County Emergency Mgt Coordinator & Fire Marshal
Address: 685 Lookout Drive Lakehills, TX 78063

E-mail: rdresser@texas.net
Phone: 830-612-3335 — Cell 830-688-1093 — Pgr 210-746-4152

A. FLOOD PREDICTION

Do you plan to generate your own information as to predicted flood stage and timing? If so, how?

Yes ① Sheriffs observer's on scene at community of Medina at point where Medina River West Prong joins Medina River North Prong — This gives about 6 Hrs warning to Bandera City " " " 12 " " " Medina Lake Dam
② Improved Prediction By NWS
③ Transmitting Flow Gages Installed from this Study

What needs exist in terms of flood prediction?

① How much Rain falling where over what period of time NWS
② Flow gages that transmits to several Agencies and EOC's in Bandera, Medina and Bexar Counties
③ Current Soil Saturation levels to influence Runoff Flow — Lake level to estimate Fill Rate — Time

Recommendations:

Have only one source of receiving data and determining essential — critical — Emergency Actions necessary. The County 24 Hr alerting point for Rural Counties is the Sheriffs Dispatch — 24/7 365/yr. They alert the Sheriff — County Judge who activates the County EOC. (Normally not manned until Activated) The EOC staff headed by the County Judge or Emerg Mgt Coord Receives and Evaluates all available data and Directs All Actions in their County as well as seeking Assistance from other Counties, State and Federal Agencies

3-1

G

B. ORGANIZATION ACTIONS DURING WATCHES AND WARNINGS

What are the current responsibilities of your organization during:

NWS Flood Watch Activate EOC — If Directed by County Judge — Sheriff
— If I determine the need and
Judge - Sheriff not available

NWS Flood Warning (predicted stage crest and time)
Alert All First Responders & Local Agencies
Sheriffs Deputies, Constables, DPS, Game Wardens, Vol Fire Dept
EMS

BMA Lake Medina Dam Watch Condition
A Dam Failure affects Bandera Citizens by rapidly
loosing water only — Not water Build ups or walls of water

BMA Lake Medina Dam Possible Dam Failure Condition
See Above

BMA Lake Medina Dam Imminent Dam Failure Condition
Try to give Medina County, Bexar County EOC & DPS
As much warning As possible

BMA Lake Medina Dam Failure Condition
See Above

What are your thoughts on changes to your responsibilities of your organization during:

NWS Flood Watch We need all the technological help we can get
to give Above notices

NWS Flood Warning (predicted stage crest and time)
See Above

BMA Lake Medina Dam Watch Condition encourage it from our Advisory Position
only

BMA Lake Medina Dam Possible Dam Failure Condition Advisorys to EOC only.
Not Activators of
Emergency Actions

BMA Lake Medina Dam Imminent Dam Failure Condition
See Above

BMA Lake Medina Dam Failure Condition
See Above

3-2

2

ORGANIZATION ACTIONS DURING WATCHES AND WARNINGS (continued)

What other recommendations do you have?

Keep All informed of any plan - equipment changes

C. ORGANIZATION ACTIONS WITH RESPECT TO EVACUATIONS

Does your organization have responsibility for issuing (Recommended) evacuation orders? If so:

Area (physical/ political boundaries) of responsibility: Sheriff has entire county; chief of Police/Mayor has Bandera City; 8 Vol Fire Dept have specific areas of Responsibility & Action

How is decision made as to evacuation, given warnings/ watches? Specifically:

Is there written guidance? County Judge EOC checklist

How is time-of-day considered? - Work Days vs Weekend - Time of year to consider campers, Hunters Etc

Discussion (current procedures, needs) Better Comm Capability of All Agencies

Does your organization have any responsibility for communicating an evacuation order? yes thru Sheriff
There is no Radio or TV stations in Bandera County
Area (physical/ political boundaries) of responsibility: All of County Scanners used

Means of communication: Sheriff Primary & Secondary Freq - used by All Law Enforcement Vol Fire - EMC — Many Citizens Monitor Freq on Scanners

Type of Communication	Used?	Comment (# of equip, # of staff, on order/request?)
Reverse 911		
Tone Alert Radios	✓	
Sirens		Bandera City only
TV/ radio messaging		
Mobile announcement systems	✓	Deputies & VFD's into Community with CAR Bull Horns
Wireless announcement systems		
Broadcast e-mail		Not Reliable
Door-to-door canvassing	✓	used Around Lake in 02 Flood
Surveillance Systems		

3-3

3

C. ORGANIZATION ACTIONS WITH RESPECT TO EVACUATIONS (Continued)

Does your organization have any responsibility for evacuating people with special needs Yes
(bedridden, etc.)? If so, describe I keep a current list of All Special Needs in EOC - use First Responders or Deputies to Respond

Area (physical/ political boundaries) of responsibility: All County

Needs/ideas to facilitate/ improve current system (are there sufficient resources?).
Better input from clinics - Senior Citizens groups - individuals

Does your organization have any responsibility for post-evacuation security? If so, describe: Sheriff Law Enforcement only

Area (physical/ political boundaries) of responsibility: All County

Needs/ideas to facilitate/ improve current system(are there sufficient resources?).
Need a map of Flood Prone Areas - will get it to appropriate citizens

Does your organization have any responsibility for housing evacuees? If so, describe: Advise only. city & civic groups set up & run shelters - aided by First Responders & other Volunteer groups

Area (physical/ political boundaries) of responsibility: All County

Needs/ideas to facilitate/ improve current system (are there sufficient resources?).

Better means of reliable communication to All County citizens.

3-4

4

D. PUBLIC EDUCATION

Does your organization have any ongoing public education programs related to emergency procedures during floods? If so, please describe: Yes –

– Sheriff's TRIAD Group for Senior Citizens – goes in and County community 1/yr.

– 2 newspaper (weekly only) on WED –

– Meeting with interested Community Groups – POA's – Clubs – Lodges etc

Ideas/ recommendations as pertain to public education?

E. INFRASTRUCTURE PLANNING

Does your organization have responsibility for the following infrastructure during/ following a flood:

Infrastructure Element	Area (physical/ political boundary)	Is there an existing written Emer Plan for this element?	Comment (current resources, needs)
Roads			TX DOT has STATE ROADS County Roads & Bridges for County
Power			Bandera Electric Coop
Water			only About 10 Communities + Bandera City have water systems others have private wells
Sewer			only Bandera City ~~has~~ & Flying L Ranch has central Sewer System others use septic systems
Housing			Little or no ordinance authority for County governments.

If your responsibility, how are people addressed who are not in the floodplain/ dam break inundation area, but who are cut off from the transportation system, water and/or power?

if High Dry – shelter in place
if not go to nearest shelter –

Comments/ Ideas/ Needs

F. CRITICAL ISSUES

What in your opinion are the critical issues associated with emergency management of a future flood in the Medina River Valley? What are your ideas for improvement?

Single Point of Control & Info at County Level than EOC

G. DO YOU WANT THIS FORM INCLUDED IN AN APPENDIX OF THE STUDY REPORT? Yes No

EOC/FM
Bandera County

3-7

9

QUESTIONAIRE
MEDINA RIVER FLOOD PROTECTION PLANNING STUDY

Name: Carl Friesenhahn
Organization: Tx DOT
Address: 2304 Avenue E
Hondo, Tx 78861

E-mail:
Phone:

A. FLOOD PREDICTION

Do you plan to generate your own information as to predicted flood stage and timing? If so, how? No

What needs exist in terms of flood prediction?

we monitor weather radar (NOAA) and supplement this with inspectors that drive the roads to monitor water elevations of various creeks & streams and low water crossings

Recommendations:

B. ORGANIZATION ACTIONS DURING WATCHES AND WARNINGS

What are the current responsibilities of your organization during:

NWS Flood Watch
Monitor flooding conditions on State Roads & Bridges

NWS Flood Warning (predicted stage crest and time)
Monitor flooding conditions and close roads/bridges as deemed necessary based on water level, ~~[illegible]~~

BMA Lake Medina Dam Watch Condition
Represent TxDOT @ Command Center (Sheriff's Office)
close roads as necessary due to Flooding

BMA Lake Medina Dam Possible Dam Failure Condition
Same as for watch conditions

BMA Lake Medina Dam Imminent Dam Failure Condition

BMA Lake Medina Dam Failure Condition

What are your thoughts on changes to your responsibilities of your organization during:

NWS Flood Watch

NWS Flood Warning (predicted stage crest and time)

BMA Lake Medina Dam Watch Condition

BMA Lake Medina Dam Possible Dam Failure Condition

BMA Lake Medina Dam Imminent Dam Failure Condition

BMA Lake Medina Dam Failure Condition

ORGANIZATION ACTIONS DURING WATCHES AND WARNINGS (continued)

What other recommendations do you have?

C. ORGANIZATION ACTIONS WITH RESPECT TO EVACUATIONS

Does your organization have responsibility for issuing evacuation orders? If so:

No

Area (physical/ political boundaries) of responsibility:

How is decision made as to evacuation, given warnings/ watches? Specifically:

Is there written guidance?

How is time-of-day considered?

Discussion (current procedures, needs)

Does your organization have any responsibility for communicating an evacuation order?

Area (physical/ political boundaries) of responsibility:

Means of communication:

Type of Communication	**Used?**	Comment (# of equip, # of staff, on order/request?)
Reverse 911		
Tone Alert Radios	yes	Weather radio @ main office
Sirens		
TV/ radio messaging		
Mobile announcement systems		
Wireless announcement systems		
Broadcast e-mail		
Door-to-door canvassing		
Surveillance Systems		
	Yes	two-way radios (low band)

C. ORGANIZATION ACTIONS WITH RESPECT TO EVACUATIONS (Continued)

Does your organization have any responsibility for evacuating people with special needs (bedridden, etc.)? If so, describe No

Area (physical/ political boundaries) of responsibility:

Needs/ideas to facilitate/ improve current system (are there sufficient resources?).

Does your organization have any responsibility for post-evacuation security? If so, describe: No

Area (physical/ political boundaries) of responsibility:

Needs/ideas to facilitate/ improve current system(are there sufficient resources?).

Does your organization have any responsibility for housing evacuees? If so, describe: No

Area (physical/ political boundaries) of responsibility:

Needs/ideas to facilitate/ improve current system (are there sufficient resources?).

D. PUBLIC EDUCATION

Does your organization have any ongoing public education programs related to emergency procedures during floods? If so, please describe: No

Ideas/ recommendations as pertain to public education?

E. INFRASTRUCTURE PLANNING

Does your organization have responsibility for the following infrastructure during/ following a flood:

Infrastructure Element	**Area (physical/ political boundary)**	**Is there an existing written Emer Plan for this element?**	Comment (current resources, needs)
Roads (S/2te)	Hondo Area Office covers Medina, Uvalde, Frio & Atascosa Co.	No specific plan. Have policies and procedures for closing roads	We have equipment for clearing debris off of roadways, bridges in order to open to traffic
Power			
Water			
Sewer			
Housing			

If your responsibility, how are people addressed who are not in the floodplain/ dam break inundation area, but who are cut off from the transportation system, water and/or power?

Comments/ Ideas/ Needs

F. CRITICAL ISSUES

What in your opinion are the critical issues associated with emergency management of a future flood in the Medina River Valley? What are your ideas for improvement?

Notification
communication
information/education web site
coordination
plan implementation (training)

G. DO YOU WANT THIS FORM INCLUDED IN AN APPENDIX OF THE STUDY REPORT? Yes No

Appendix 4B

Debris Management Plan Outline Example

APPENDIX B
DEBRIS MANAGEMENT PLAN OUTLINE EXAMPLE

The following outline can be used to develop a Debris Management Plan.

DEBRIS MANAGEMENT PLAN

PURPOSE

- To provide policies and guidance to _______________ for the removal and disposition of debris caused by a major disaster.
- To facilitate and coordinate the management of debris following a disaster in order to mitigate against any potential threat to the lives, health, safety, and welfare of the impacted citizens, expedite recovery efforts in the impacted area, and address any threat of significant damage to improved public or private property.

SITUATION AND ASSUMPTIONS

SITUATION

- Natural and manmade disasters precipitate a variety of debris that include, but are not limited to, such things as trees, sand, gravel, building construction material, vehicles, personal property, and hazardous materials.
- The quantity and type of debris generated from any particular disaster will be a function of the location and kind of event experienced, as well as its magnitude, duration, and intensity.
- The quantity and type of debris generated, its location, and the size of the area over which it is dispersed will have a direct impact on the type of collection and disposal methods utilized to address the debris problem, associated costs incurred, and how quickly the problem can be addressed.
- In a major or catastrophic disaster, many state agencies and local governments will have difficulty in locating staff, equipment, and funds to devote to debris removal, in the short-term as well as long-term.

ASSUMPTIONS

- A natural disaster that requires the removal of debris from public or private lands and waters could occur at any time.
- The amount of debris resulting from an event or disaster could exceed the local government's ability to dispose of it.
- If the natural disaster requires, the Governor would declare a state of emergency that authorizes the use of State resources to assist in the removal and disposal of debris. In the event Federal resources are required, the Governor would request through FEMA a Presidential Disaster Declaration.
- Private contractors will play a significant role in the debris removal, collection, reduction and disposal process.
- The debris management program implemented by the local government will be based on the waste management approach of reduction, reuse, reclamation, resource recovery, incineration and landfilling.

APPENDIX B
DEBRIS MANAGEMENT PLAN OUTLINE EXAMPLE

CONCEPT OF OPERATIONS

Emergency Operations Center Activation

- Define how the County Emergency Management Agency will activate the Emergency Operations Center (EOC).
- Define who will make up the Debris Management Task Force (DMTF) and their specific duties and responsibilities.
- The EOC Director or his designated representative in conjunction with the DMTF will determine the extent of damage and resulting debris and issue appropriate directives to implement this annex.
- Create an appendix that contains a listing of key points of contact.

Estimating the Type and Amount of Debris

- Designate public works department personnel to determine the estimated amount of debris generated as soon as possible.
- Define the estimating methods to be used. One method to estimate debris is to conduct a drive-through "windshield" damage assessment and estimate the amount of debris visually. Another method is an aerial assessment by flying over the area using State Police and/or National Guard helicopters and Civil Air Patrol reconnaissance flights. The damaged area can be assessed either visually or using aerial photography. Once the area has been assessed actions can be taken to implement Phase I debris clearing procedures and institute requests for additional State or Federal assistance.

Site Selection Priorities

- Determine the number of Temporary Debris Storage and Reduction (TDSR) sites and location of these sites for the collection and processing of debris.
- Prioritize which sites will be opened based on the amount of debris estimated.

First Priority: Pre-determined TDSR sites
Second Priority: Public property within the damaged area
Last Priority: Private property

Pre-Designated TDSR sites

- Pre-identified TDSR sites should be identified on county maps.
- Either Solid Waste Authority or Public Works should maintain detailed information pertaining to each of these sites. Designate which agency has responsibility.
- Detailed information should include exact location, size, available ingress and egress routes and results of an environmental assessment and initial data samples.
- Baseline data should include videotapes, photographs, documentation of physical and biological features, and soil and water samplings.
- The list of TDSR sites should be reviewed annually and updated as necessary as part of the normal maintenance plan.

TDSR Site Preparation.

- Identify the preparatory actions that need to be accomplished after a pre-designated TDSR site has been selected.
- Develop a Memorandum of Understanding or a Memorandum of Agreement if required.
- Identify who would be responsible for updating the initial base line data and develop an operation layout to include ingress and egress routes.

Existing Landfills.

- Identify location of county and private landfills.
- Identify any restrictions, limitations or tipping fees.

DEBRIS REMOVAL

General

- Hurricanes and other natural disasters can generate unprecedented amounts of debris in a few hours or a few minutes. The debris may be equally heavy in both urban and rural areas depending on the magnitude of the tree blow-down and associated structural damage such as homes, businesses, utilities and signs. This section provides guidelines on debris removal issues, including emergency roadway clearance, public rights-of-way removal, mobile home park removal, private property removal, navigation hazard removal, and Household Hazardous Waste (HHW) removal.
- Debris removal, regardless of source, becomes a high priority following a disaster. Debris management strategy for a large-scale debris removal operation divides the operation into two phases.
- Phase I consists of the clearance of the debris that hinders immediate life saving actions being taken within the disaster area and the clearance of that debris which poses an immediate threat to public health and safety.
- Phase II operations consist of the removal and disposal of that debris which is determined necessary to ensure the orderly recovery of the community and to eliminate less immediate threats to public health and safety.

APPENDIX B
DEBRIS MANAGEMENT PLAN OUTLINE EXAMPLE

Emergency Roadway Debris Removal (Phase I)

- Identify critical routes that are essential to emergency operations.
- Define how efforts will be prioritized between local agencies.
- Identifying areas that State and Federal assistance can target.
- Define what actions take place during Phase I.
- Example: Roadway debris removal involves the opening of arterial roads and collector streets by moving debris to the shoulders of the road. There is no attempt to physically remove or dispose of the debris, only to clear key access routes to expedite the:
  - Movement of emergency vehicles,
  - Law enforcement,
  - Resumption of critical services and,
  - Assessment of damage to key public facilities and utilities such as schools, hospitals, government buildings, and municipal owned utilities.
- Define the type of debris that may be encountered such as tree blow-down and broken limbs; yard trash such as outdoor furniture, trash cans, utility poles, power, telephone and cable TV lines, transformers and other electrical devices; building debris such as roofs, sheds and signs; and personal property such as clothing, appliances, boats, cars, trucks and trailers.
- Define the priority to open access to other critical community facilities, such as municipal buildings, water treatment plants, wastewater treatment plants, power generation units, and airports.
- The requirement for government services will be increased drastically following a major natural disaster. Develop procedures to determine the damage done to utility systems. Activities involving these facilities should be closely coordinated with their owners and/or operators.

Local, Tribal, State and Federal Assistance

- Identify local, tribal, State and Federal government assets that may be available such as:
  Municipal workers and equipment
  Local and State Department of Transportation (DOT) workers and equipment
  National Guard
  Local contractors
  U.S. Department of Agriculture (USDA) Forest Service chain saw crews
  Local U.S. Army Corps of Engineers (USACE) workers and equipment

Supervision and Special Considerations

- Immediate debris clearing (Phase I) actions should be supervised by local public works or DOT personnel using all available resources. Requests for additional assistance and resources should be made to the State Emergency Operations Center (EOC). Requests for Federal assistance will be requested through the State Coordinating Officer (SCO) to the FEMA Federal Coordinating Officer (FCO).
- Special crews equipped with chain saws may be required to cut up downed trees. This activity is hazardous, and common sense safety considerations are necessary to reduce the chance of injury and possible loss of life. When live electric lines are involved, work crews should coordinate with local utility companies to have power lines deenergized for safety reasons.

- Front-end loaders and dozers should be equipped with protective cabs. Driveway cutouts, fire hydrants, valves, and stormwater inlets should be left unobstructed. All personnel should wear protective gear, such as hard hats, gloves, goggles, and safety shoes.
- The USDA Forest Service and other State and Federal land management agencies are equipped for fast responses to tornadoes, and hurricanes. Assistance would be requested through the State SCO to the FCO according to standard procedures.

Public Rights-of-Way Debris Removal and Disposal (Phase II)

- Debris is simply pushed to the shoulders of the roadway during the emergency opening (Phase I) of key routes. There is little time or concern for sorting debris at that time. The objective is to provide for the safe movement of emergency and support vehicles into and out of the disaster area. As removal operations progress, the initial roadside piles of debris become the dumping location for additional yard waste and other storm-generated debris, such as construction material, personal property, trash, white metals such as refrigerators, washers, dryers and hot water heaters, roofing and even household, commercial, and agricultural chemicals.
- Define how the DMTF will coordinate debris removal operations.
- Define how local and State government force account employees will transition from Phase I to Phase II operations.
- Determine if Mutual Aid agreements exist.
- Determine if local contractors will be needed to assist in Phase II operations.
- Determine if additional State and/or Federal assistance will be required.
- Develop local field inspection teams. The teams become the "eyes and ears" for the DMTF.
- Coordinate through local agencies to establish a contracted work force capable of expeditious removal of the debris.
- Develop an independent team using the local and State personnel to monitor the removal activities. This team becomes the debris manager's "eyes and ears" in the field.
- Conduct daily update briefings with key debris managers. Ensure that all major debris removal and disposal actions are reviewed and approved by the local debris manager.
- Ensure that a representative of the DMTF attends all briefings to resolve any coordination problems between State and Federal debris removal efforts and local debris removal and disposal efforts.
- Coordinate with local, tribal and State DOT and law enforcement authorities to ensure that traffic control measures expedite debris removal activities.
- Establish a proactive information management plan. Emphasis should be placed on actions that the public can perform to expedite the cleanup process, such as separating burnable and nonburnable debris; segregating HHW; placing debris at the curbside; keeping debris piles away from fire hydrants and valves, reporting locations of illegal dump sites or incidents of illegal dumping; and segregating recyclable materials.

- The public should be kept informed of debris pick-up schedules, disposal methods and ongoing actions to comply with State and Federal Environmental Protection Agency (EPA) regulations, disposal procedures for self-help and independent contractors, and restrictions and penalties for creating illegal dumps. The Public Information Officer (PIO) should be prepared to respond to questions pertaining to debris removal from the press and local residents. The following questions are likely to be asked:
  - *What is the pick-up system?*
  - *When will the contractor be in my area?*
  - *Who are the contractors and how can I contact them?*
  - *Should I separate the different debris materials and how?*
  - *How do I handle Household Hazardous Waste?*
  - *What if I am elderly?*

Private Property Debris Removal

- Dangerous structures should be the responsibility of the owner or local government to demolish to protect the health and safety of adjacent residents. However, experience has shown that unsafe structures will remain because of the lack of insurance, absentee landlords, or under-staffed and under-equipped local governments. Consequently, demolition of these structures may become the responsibility of DMTF.
- Develop procedures to ensure complete cooperation with numerous local and State government officials to include the following: real estate offices, local law and/or code enforcement agencies, State historic preservation office, qualified contractors to remove HHW, asbestos, lead-based paint, and field teams to photograph the sites before and after demolition.
- Include a copy of Demolition of Private Property checklist
- Include copies of sample ordinances that can be activated when a "state of emergency" is implemented, eliminating any unnecessary waiting period.
- The most significant building demolition problem will be that local governments do not have proper ordinances in effect to handle emergency condemnation procedures. Moreover, structures will be misidentified or have people or belongings in them when the demolition crews arrive necessitating removal by local law enforcement. Close coordination is essential, and it is recommended that at least one FEMA staff person be on site to work directly with the local government staff to ensure that all required legal actions are taken.

Household Hazardous Wastes Removal

- HHW may be generated as a result of a major natural disaster. HHW may consist of common household chemicals, propane tanks, oxygen bottles, batteries, and industrial and agricultural chemicals. These items will be mixed into the debris stream and will require close attention throughout the debris removal and disposal process.
- Consider HHW response teams be assigned and respond ahead of any removal efforts. Consider preparing draft emergency contracts with generic scopes of work. Coordinate with regulatory agencies concerning possible regulatory waivers and other emergency response requirements.
- Arrange for salvageable hazardous materials to be collected and segregated based on their intended use. Properly trained personnel or emergency response HHW contractors should accomplish removal of hazardous waste. Coordinate with regulatory agencies to ensure cleanup actions meet local, tribal, State, and Federal regulations.

- Complete HHW identification and segregation before building demolition begins. Qualified contractors should remove HHW debris. Regular demolition contractors can remove uncontaminated debris.
- A separate staging area for HHW materials, contaminated soils, and contaminated debris should be established at each TDSR site. The staging area should be lined with an impermeable material and bermed to prevent contamination of the groundwater and surrounding area. Materials should be removed and disposed of using qualified HHW personnel/contractors in accordance with local, tribal, State and Federal regulations.

TEMPORARY DEBRIS STORAGE AND REDUCTION SITES

- Once the debris is removed from the damaged area, it will be taken to temporary debris storage and reduction sites.
- Removal and disposal actions should be handled at the lowest level possible based on the magnitude of the event. It follows the normal chain of responsibility, i.e., local level, county level, State level, and when resources are exceeded at each level of responsibility, Federal assistance may be requested according to established procedures. Because of the limited debris removal and reduction resources, the establishment and operation of TDSR sites are generally accomplished by contracts.
- Emphasis is placed on local government responsibilities for developing debris disposal contracts. Local, tribal, county and/or State governments may be responsible for developing and implementing these contracts for debris removal and disposal under most disaster conditions.
- The DMTF should review all debris disposal contracts. There should be a formal means to monitor contractor performance to ensure that funds are being used wisely.
- **Site Preparation.** The topography and soil conditions should be evaluated to determine best site layout. Consider ways to make remediation and restoration easier when planning site preparation.
- **Site Operations.** Site preparation and operation are usually left up to the contractor, but guidance can help avoid problems with the ultimate closeout.
- Establish lined temporary storage areas for ash, HHW, fuels, and other materials that can contaminate soils, groundwater and surface water. Set up plastic liners, when possible, under stationary equipment such as generators and mobile lighting plants. Include this as a requirement of the contract scope of work.
- If the site is also an equipment staging area, monitor fueling and equipment repair to prevent and mitigate spills such as petroleum products and hydraulic fluids. Include clauses in contract scope of work to require immediate cleanup by the contractor.
- Be aware of and mitigate things that will irritate the neighbors such as:
  smoke - proper construction and operation of incineration pits. Don't overload air curtains.
  dust - employ water trucks.
  noise - construct perimeter berms.
  traffic - proper layout of ingress and egress procedures to help traffic flow.

DEBRIS REDUCTION METHODS

Volume Reduction by Incineration

- There are several incineration methods available including **uncontrolled open incineration, controlled open incineration, air curtain pit incineration, and refractor lined pit incineration.** The DMTF should consider each incineration method before selection and implementation as part of the overall volume reduction strategy.
- **Uncontrolled Open Incineration:** Uncontrolled open incineration is the least desirable method of volume reduction because it lacks environmental control. However, in the haste to make progress, the Department of Natural Resources may issue waivers to allow this method of reduction early in a disaster.
- **Controlled Open Incineration:** Controlled open incineration is a cost-effective method for reducing clean woody debris in rural areas. This option must be terminated if mixed debris such as treated lumber, poles, nails, bolts, tin and aluminum sheeting enters the waste flow. Clean woody tree debris presents little environmental damage and the resulting ash can be used as a soil additive by the local agricultural community. Department of Agriculture and county agricultural extension personnel should be consulted to determine if and how the resulting ash can be recycled as a soil additive. Responsible agencies and telephone numbers should be provided.
- **Air Curtain Pit Incineration:** Air curtain pit incineration offers an effective means to expedite the volume reduction process by substantially reducing the environmental concerns caused by open incineration. Specifications and statements of work should be developed to expedite the proper use of the systems, because experience has shown that many contractors and subcontractors are not fully knowledgeable of the system operating parameters.
- **Refractor Lined Pit Incineration:** Pre-manufactured refractory lined pit burners are an alternative to air curtain open pit incineration. The units can be erected on site in a minimal amount of time. Some are portable and others must be built in-place. The units are especially suited for locations with high water tables, sandy soil, or where materials are not available to build above ground pits. The engineered features designed into the units allow for a reduction rate of approximately 95 % with a minimum of air pollution. The air curtain traps smoke and small particles and recirculates them to enhance combustion that reaches over 2,500 degrees Fahrenheit. Manufacturers claim that combustion rates of about 25 tons per hour are achievable while still meeting emission standards.
- Local officials, environmental groups, and local citizens should be thoroughly briefed on the type of incineration method being used, how the systems work, environmental standards, health issues, and the risk associated with each type of incineration. PIOs should take the initiative to keep the public informed. A proactive public information strategy to include press releases and media broadcasts should be included in any operation that envisions incineration as a primary means of volume reduction.

Environmental Controls

Environmental controls are essential for all incineration methods, and the following should be considered:

- A setback of at least 1,000 feet should be maintained between the debris piles and the incineration area. Keep at least 1,000 feet between the incineration area and the nearest building. Contractors should use fencing and warning signs to keep the public away from the incineration area.
- The fire should be extinguished approximately two hours before anticipated removal of the ash mound. The ash mound should be removed when it reaches 2 feet below the lip of the incineration pit.
- The incineration area should be placed in an above ground or below ground pit that is no wider than 8 feet and between 9 and 14 feet deep.
- The incineration pits should be constructed with limestone and reinforced with earth anchors or wire mesh to support the weight of the loaders. There should be a 1-foot impervious layer of clay or limestone on the bottom of the pit to seal the ash from the aquifer.
- The ends of the pits should be sealed with dirt or ash to a height of 4 feet.
- A 12-inch dirt seal should be placed on the lip of the incineration pit area to seal the blower nozzle. The nozzle should be 3 to 6 inches from the end of the pit.
- There should be 1-foot high, unburnable warning stops along the edge of the pit's length to prevent the loader from damaging the lip of the incineration pit.
- Hazardous or contaminated ignitable material should not be placed in the pit. This is to prevent contained explosions.
- The airflow should hit the wall of the pit about 2 feet below the top edge of the pit, and the debris should not break the path of the airflow except during dumping.
- The pit should be no longer than the length of the blower system, and the pit should be loaded uniformly along the length.

Volume Reduction by Grinding and Chipping

- Hurricanes and tornadoes may present the opportunity to employ large-scale grinding and chipping operations as part of the overall debris volume reduction strategy. Hurricanes can blow away scarce topsoil in the agricultural areas and cause extensive tree damage and blow-down. This two-fold loss, combined with local climatic conditions, may present an excellent opportunity to reduce clean woody debris into suitable mulch that can be used to replenish the topsoil and retain soil moisture.
- Grinding and chipping woody debris is a viable reduction method. Although more expensive than incineration, grinding and chipping is more environmentally friendly, and the resulting product, mulch, can be recycled. In some locations the mulch will be a desirable product because of shallow topsoil conditions. In other locations it may become a landfill product.
- Grinding and chipping woody debris reduces the large amounts of tree blow-down. Chipping operations are suitable in urban areas where streets are narrow or in groves of trees where it is cheaper to reduce the woody vegetation to mulch than to move it to a central grinding site and then returning it to the affected area. This reduces the costs associated with double handling.

- The DMTF should work closely with local environmental and agricultural groups to determine if there is a market for mulch. Another source for disposal of ground woody debris may be as an alternative fuel for industrial heating or for use in a cogeneration plant.
- There are numerous makes and models of grinders and chippers on the market. When contracting, the most important item to specify is the size of the mulch. If the grinding operation is strictly for volume reduction, size is not important. However, mulch to be used for agricultural purposes must be of a certain size and be virtually free of paper, plastic and dirt.
- The average size of wood chips produced should not exceed 4 inches in length and ½ inch in diameter. Production output should average 100 to 150 cubic yards per hour when debris is moderately contaminated, which slows feeding operations, and 200 to 250 cubic yards per hour for relatively clean debris. Note that this is not machine capability; this is contractor output or performance capability.
- Contaminants are all materials other than wood products and should be held to 10% or less for the mulch to be acceptable. Plastics are a big problem and should be eliminated completely. To help eliminate contaminants, root rake loaders should be used to feed or crowd materials to the grapplers. Bucket-loaders tend to scoop up earth, which is a contaminant and causes excessive wear on the grinder or chipper. Hand laborers should remove contaminants prior to feeding the grinders. Shaker screens should be used when processing stumps with root balls or when large amounts of soil are present in the woody debris.
- Chippers are ideal for use in residential areas, orchards, or groves. The number of damaged and uprooted trees presents significant problems if they are pushed to the rights-of-way for eventual pick-up and transport to staging and reduction sites. The costs associated with chipping are reasonable because the material does not need to be transported twice.
- Grinders are ideal for use at debris staging and reduction sites because of their high volume reduction capacity. Locating the grinders is critical from a noise and safety point-of-view. Moreover, there is a need for a large area to hold the woody debris and an area to hold the resulting mulch. Ingress and egress to the site is also an important consideration.

Volume Reduction by Recycling

- Recycling reduces mixed debris volume before it is hauled to a landfill. Recycling is attractive and strongly supported by _________ because there may be an economic value to the recovered material if it can be sorted and sold. A portable Materials Recovery Facility could be set up at the site. Metals, wood, and soils are prime candidates for recycling. The major drawback is the potential environmental impact of the recycling operation. In areas where there is a large usage of chemical agricultural fertilizer, the recovered soil may be too contaminated for use on residential or existing agricultural land.
- Hurricanes may present opportunities to contract out large-scale recycling operations and to achieve an economic return from some of the prime contractors who exercise their initiative to segregate and recycle debris as it arrives at the staging and reduction sites. Recycling has significant drawbacks if contracts are not properly written and closely monitored.

- Specialized contractors should be available to bid on disposal of debris by recycling, if it is well sorted. Contracts and monitoring procedures should be developed to ensure that the recyclers comply with local, tribal, State and Federal environmental regulations.
- Recycling should be considered early in the debris removal and disposal operation because it may present an opportunity to reduce the overall cost of the operation. The following materials are suitable for recycling.
- **Metals.** Hurricanes and tornadoes may cause extensive damage to mobile homes, sun porches, and green houses. Most of the metals are non-ferrous and suitable for recycling. Trailer frames and other ferrous metals are also suitable for recycling. Metals can be separated using an electromagnet. Metals that have been processed for recycling can be sold to metal recycling firms.
- **Soil.** Cleanup operations using large pieces of equipment pick up large amounts of soil. The soil is transported to the staging and reduction sites where it is combined with other organic materials that will decompose over time. Large amounts of soil can be recovered if the material is put through some type of screen or shaker system. This procedure can produce significant amounts of soil that can either be sold or recycled back into the agricultural community. This soil could also be used at local landfills for cover. It is more expensive to transport and pay tipping fees at local landfills than to sort out the heavy dirt before moving the material. Monitoring and testing of the soil may be necessary to ensure that it is not contaminated with chemicals.
- **Wood.** Woody debris can be either ground or chipped into mulch.
- **Construction Material.** Concrete block and other building materials can be ground and used for other purposes if there is a ready market. Construction materials and wood can also be shred to reduce volume. This construction material could also be used at local landfills for cover.
- **Residue Material.** Residue material that cannot be recycled, such as cloth, rugs, and trash, can be sent to a landfill for final disposal.

TDSR SITE CLOSE-OUT PROCEDURES

- Each TDSR site will eventually be emptied of all material and be restored to its previous condition and use. The contractor should be required to remove and dispose of all mixed debris, construction and demolition (C&D) debris, and debris residue to approved landfills. Quality assurance inspectors should monitor all closeout and disposal activities to ensure that contractors complied with contract specifications. Additional measures will be necessary to meet local, tribal, State and Federal environmental requirements because of the nature of the staging and reduction operation.
- The contractor must assure the DMTF that all sites are properly remediated. There will be significant costs associated with this operation as well as close scrutiny by the local press and environmental groups. Site remediation will go smoothly if baseline data collection and site operation procedures are followed.
- The basic close-out steps are to remove all debris from the site; conduct an environmental audit or assessment; develop a remediation or restoration plan approved by the appropriate environmental agency; execute the plan; get acceptance from the landowner; and terminate lease payments, if applicable. The key to timely closeout of the mission is the efficient scheduling of the above activities for multiple sites. Therefore, critical path scheduling of all the activities as far in advance as possible will minimize down time between steps.
- **Environmental Restoration.** Stockpiled debris will be a mix of woody vegetation, construction material, household items, and yard waste. HHW and medical wastes should be segregated and removed prior to stockpiling. Activities at the debris disposal sites will include anyone or a combination of the following activities: stockpiling, sorting, recycling, incineration, grinding, and

chipping. Incineration is done in air curtain pits and generally only woody debris is incinerated; however, the efficiency of the incineration and the quality of incineration material is highly variable. Contamination may occur from petroleum spills at staging and reduction sites or runoff from the debris piles, incineration sites, and ash piles.

- **Site Remediation.** During the debris removal process and after the material has been removed from each of the debris sites, environmental monitoring will be needed to close each of the sites. This is to ensure that no long-term environmental contamination is left on the site. The monitoring should be done on three different media: ash, soil, and groundwater.
- The monitoring of the ash should consist of chemical testing to determine the suitability of the material for landfilling.
- Monitoring of the soils should be by portable methods to determine if any of the soils are contaminated by volatile hydrocarbons. The contractors may do this if it is determined that hazardous material, such as oil or diesel fuel was spilled on the site. This phase of the monitoring should be done after the stockpiles are removed from the site.
- The monitoring of the groundwater should be done on selected sites to determine the probable effects of rainfall leaching through either the ash areas or the stockpile areas.
- Consider the following requirements to closeout a temporary staging and reduction site(s).
  - Coordinate with local and State officials responsible for construction, real estate, contracting, project management, and legal counsel regarding requirements and support for implementation of a site remediation plan.
  - Establish a testing and monitoring program. The contractor should be responsible for environmental restoration of both public and leased sites. Contractors will also be required to remove all debris from sites for final disposal at landfills prior to closure.
  - Reference appropriate and applicable environmental regulations.
  - Prioritize site closures.
  - Schedule closeout activities.
  - Determine separate protocols for air, water and soil testing.
  - Develop cost estimates.
  - Develop decision criteria for certifying satisfactory closure based on limited baseline information.
  - Develop administrative procedures and contractual arrangements for closure phase.
  - Inform local, tribal and State environmental agencies regarding acceptability of program and established requirements.
  - Designate approving authority to review and evaluate contractor closure activities and progress.
  - Retain staff during closure phase to develop site-specific remediation for sites, as needed, based on information obtained from the closure checklist.

ORGANIZATION AND RESPONSIBILITIES

Local Government Agencies and Departments

- Identify each government agency or department that has debris clearing, removal or disposal actions.
- Define their responsibilities in detail.

Supporting Agencies

- Identify each government agency or department that has debris clearing, removal or disposal actions.
- Define their responsibilities in detail.

APPENDIX B
DEBRIS MANAGEMENT PLAN OUTLINE EXAMPLE

ADMINISTRATION AND LOGISTICS

- All agencies will document personnel and material resources used to comply with this annex. Documentation will be used to support any Federal assistance that may be requested or required.
- Requests for support and/or assistance will be upchanneled from the local level to the county level EOC and then to the State EOC. Requests for Federal assistance will be made by the State EOC through established procedures, as outlined in the Federal Response Plan.
- All agencies will ensure 24-hour staffing capability during implementation of this annex, if the emergency or disaster requires.
- Define who will be responsible to initiate an annual update of this annex. It will be the responsibility of each tasked agency to update its respective portion of the annex and ensure any limitations and shortfalls are identified and documented, and work-around procedures developed, if necessary.

AUTHORITIES AND REFERENCES

- Develop a listing of authorities and references identified in this annex.

APPENDICES

- Develop a listing of appropriate appendices that support this annex.

Appendix 4C

Excerpts from Lake Medina Dam Emergency Action Plan

EMERGENCY NOTIFICATION FLOWCHART FOR MEDINA LAKE DAM

Emergency Condition

↓

Observer

↓

BMA Field Foreman
Brian Sullivan
Shop office 830-985-3271
Mobile 210-825-9869

↓

BMA Board President
Tommy Fey
Office 830-709-4733
Mobile 210-508-9957

-1-

1. PRIMARY CONTACT - (Will coordinate all local agencies listed in this section below)

Medina County Sheriff Department		
Emergency Dispatch	24 hr	830-741-6153
Sheriff Gilbert Rodriquez		830-741-6150
ALTERNATE CONTACTS – in order (If unable to contact Sheriff)		
Medina County		
EMC, Brian Dopp		830-741-6021
Judge James E. Barden		830-741-6020
Medina County Sheriff/ EMC to contact:		
Texas Dept of Public Safety		
DPS Dispatch Center	24 hr	210-531-2280
Bandera County		
Sheriff James MacMillan	24 hr	830-796-3771
Judge Richard Evans		830-796-3781
Bexar County		
EMC, Carl Mixon		210-335-0300
Sheriff Ralph Lopez	24 hr	210-335-6000
Judge Nelson Wolf		210-335-2626
San Antonio Dispatch	24 hr	210-207-7744
City of Castroville		
EMC, Tim Fousse		830-931-0234
Police Dept		830-931-2222
Mayor Robert Hancock		830-931-4070
ESD #1, Medina County		
Polly Edlund		830-931-3358

-2-

BMA OFFICE

1. BMA Business Manager		830-665-2132
Ed Berger		
2. BMA Dam Caretaker	home:	830-612-2294
J.R. Gulley	mobile:	210-287-0933

2. NATIONAL WEATHER SERVICE
San Antonio/Austin Office

24 Hours	830-606-3600, Press 3
8-4 pm	830-606-3617 x206

Primary Contact – contact periodically for updated river information:
Hydrologist, Mark Lenz x228

River Forecasting Center 817-831-3289

3. URS ENGINEERING

Project Manager, Jeff Irvin	Office	512-419-6523
Austin Office	Cell	512-658-0856

4. TEXAS COMMISSION ON ENVIRNMENTAL QUALITY
Emergency Response Hotline- Austin, Texas 1-800-832-8224
Dam Safety Team

Coordinator, Warren Samuelson	Office	512-239-5195
	Home	512-238-6660

5. TEXAS DEPT OF TRANSPORTATION
Hondo Area Office 8-5pm, 830-426-2522 (Mtce.) or 830-741-8024 (Main)

Primary Contact		
Area Engineer, Carl Friesenhahn	Mobile	830-426-1923
	Home	830-538-2713
Secondary Contact		
Asst. Area Engr, Greg Biediger	Home	830-612-2464
	Mobile	830-426-1924

-3-

DOWNSTREAM RESIDENTS
From Medina Lake Dam to Diversion Dam

1. Medina Ranch, Inc.
   Primary contact will call 22 vacation residents
   Ranch Foreman,
   Tony Sammis mobile 210-213-5729
   President,
   Dr. John Williamson mobile 210-213-0465
2. David Zinsmeister 830-612-3704
3. James Calvert (phone # N/A)
4. Nancy & Bob Wallace 830-612-2536, 210-764-0797
5. Irene Kocurek 830-612-2842
6. Residents below Diversion Dam will be contacted by Sheriff's department.

Last Updated: July 29, 2004

4.2 Emergency Conditions

Once an emergency has been identified, it must be classified according to its urgency. The following five classifications shall be used.

Situation		Examples of Condition
Watch Condition	A problem has been detected which requires constant monitoring or immediate action to repair or correct, or a potentially hazardous situation is developing.	Medina River Flood Warning Issued by National Weather Service (NWS) for Bandera or Medina County watersheds upstream of Medina Lake.
		Flow at elevation 1068 ft Mean Sea Level (not BMA datum) overtopping Emergency Spillway by 4 ft with water rising or additional major short term rainfall predicted.
		Significant changes noted in dam, foundation, or abutment seepage rates, without evidence of erosion or rock spalling.
Possible Dam Crest Over-topping	A Watch Condition providing warning of potential dam crest overtopping	USGS Gage 08178880 at Bandera with stage exceeding 38 ft (elevation 1228 ft Mean Sea Level), while Medina Lake level exceeds 1069 ft Mean Sea Level (not BMA datum).
		If Medina Lake level exceeds 1071 ft Mean Sea Level (not BMA datum) (seven feet over the spillway crest), use rate of rise (calculated every 15 minutes) to estimate time to rise to elevation 1076 feet. A possible dam crest overtopping condition exists if flood reaches this elevation within six hours.
		If the NWS predicts overtopping of the Dam Crest to occur.
Dam Crest Over-topping	A Watch Condition providing notice that dam crest has been overtopped	Water is going over the dam crest at any location.
Possible Dam Failure	A Watch Condition that is getting progressively worse	Use rate of rise (calculated every 15 minutes) to estimate time to rise to elevation 1079.3 feet. A possible dam failure condition exists if flood reaches this elevation within six hours.
		Further increases in dam, foundation, or abutment seepage rates, without evidence of erosion or rock spalling.
Imminent Dam Failure	The Field Foreman has determined that conditions at the dam will progress to a failure of the dam and an uncontrollable release of the reservoir.	Overtopping of Dam Crest by 3.3 ft (1079.3 ft msl).
		Movement of Dam (crest or abutment)
		Rock spalling, plucking, or erosion in foundation or abutment from impact of overtopping.
		Abutment or foundation seepage with rock erosion, spalling, or plucking.
Dam Failure	A failure has occurred and a flood wave is now heading downstream.	A failure has occurred and a flood wave is now heading downstream.

4.3 Emergency Actions

Once the emergency has been classified, the following actions are recommended.

Situation	Recommended Action	Responsible Person
Watch Condition	1. Issue Watch Condition Warning Message (p.4-7) per Notification Plan	Board President
	2. Instigate continuous monitoring of structure	Field Foreman
	3. Obtain assistance from expert consultants, as needed	Board President
	4. Initiate calculation of lake level Rate of Rise (Eqn #1) every 15 minutes after lake level reaches 1072 ft mean Sea Level (not BMA Datum)	Field Foreman
	5. Issue cancellation of Watch Condition when condition no longer exists	Board President
Possible Dam Crest Over-topping	1. Issue Possible Dam Crest Overtopping Warning Message (p.4-7) per Notification Plan	Board President
	2. Obtain assistance from expert consultants, as needed	Board President
	3. Issue cancellation of Possible Dam Crest Overtopping Warning when condition no longer exists	Board President
Dam Crest Over-topping	1. Issue Possible Dam Crest Overtopping Warning Message (p.4-7) per Notification Plan	Board President
	2. Issue cancellation of Dam Crest Overtopping Warning when condition no longer exists	Board President
Possible Dam Failure	1. Issue Possible Dam Failure Warning Message (p.4-7) per Notification Plan	Board President
	2. Issue cancellation of Possible Dam Failure Warning when condition no longer exists	Board President
Imminent Dam Failure	1. Issue Imminent Dam Failure Warning Message (p.4-7) per Notification Plan	Board President
	2. Issue cancellation of Imminent Dam Failure Warning when condition no longer exists	Board President
Dam Failure	1. Issue Dam Failure Warning Message (p.4-7) per Notification Plan	Board President

4.4 Emergency Conditions Based on Water Levels

Note: All other conditions of the Dam (structural, foundation, etc.) should also be monitored and evaluated with the water levels during an emergency situation. This table is consistent with the Table on page 4-2 and is intended as a further clarification of that table.

Water Level (ft MSL)	Description	Resulting Action
1064	Water begins to overtop Spillway	No emergency condition, continue to periodically monitor.
1068	Water is overtopping Spillway by 4 ft	Go to ***Watch Condition***
1069	Call National Weather Service for water level at Bandera USGS Gage, which is 6 hours upstream of Medina Lake Dam.	If Bandera USGS Gage is below 1228 ft MSL, remain at ***Watch Condition.***
		If Bandera USGS Gage is at or above 1228 ft MSL, go to ***Possible Dam Crest Overtopping.***
1072	Calculate Estimated Time to Overtop Dam Crest (Eqn #2) using Rate of Rise (Eqn #1), every 15 min.	If water is predicted to overtop elevation 1076 in more than 6 hours, remain at ***Watch Condition***
		If water is predicted to overtop elevation 1076 in less than 6 hours, go to ***Possible Dam Crest Overtopping Condition.***
1076	Water begins to overtop Dam Crest Continue to Calculate Estimated Time to reach elevation 1079.3 (Eqn #3) using Rate of Rise (Eqn #1), every 15 min.	Go to ***Dam Crest Overtopping Condition***
		If water is predicted to overtop elevation 1079.3 in more than 6 hours, remain at ***Dam Crest Overtopping Condition***
		If water is predicted to overtop elevation 1076 in less than 6 hours, go to ***Possible Dam Failure Condition.***
1079.3 or higher	Water is more than three feet over dam crest.	Go to ***Imminent Dam Failure.***

4.5 Water Level Rate of Rise Calculations

The Water Level Calculation Sheet shown in Figure 4-1 can be used as a reference to calculate water levels and predicted water levels. In order to calculate the Rate of Rise of the water level use Equation #1. To calculate the Estimated Time to Overtop Crest use Equation #2. To calculate the Estimated Time to Overtop Elevation 1079.3 use Equation #3.

4.6 Water Level Monitoring Log

The Water Level Monitoring Log in Figure 4-2 can be used during an emergency to periodically record important information about the water levels, emergency condition status, rate of rise of the water level, estimated time to overtop crest, structural condition, and any other important comments.

Figure 4-1. Water Level Calculation Sheet

Equation # 1 - Rate of Rise

Starting Water Level [ ] ft MSL Ending Water Level [ ] ft MSL

Start Time [ ] End Time [ ]

$$\text{Rate of Rise (ft/hr)} = \frac{\text{Ending Water Level - Starting Water Level (ft)}}{\text{End Time - Start Time (hrs)}}$$

= [ ] ft/hr

Equation #2 - Estimated Time to Overtop Crest

Current Water Level [ ] ft MSL

Current Time [ ]

Step 1

Distance to Crest (ft) = 1076 ft MSL - Current Water Level (ft MSL)

= [ ] ft

Step 2

$$\text{Hours to Reach Crest (hrs)} = \frac{\text{Distance to Crest (ft)}}{\text{Rate of Rise (ft/hr)}}$$

= [ ] hrs

Equation #3 - Estimated Time to Elevation 1079.3 ft Mean Sea level

Current Water Level [ ] ft MSL

Current Time [ ]

Step 1

Distance to Crest (ft) = 1079.3 ft MSL - Current Water Level (ft MSL)

= [ ] ft

Step 2

$$\text{Hours to Reach 1079.3 (hrs)} = \frac{\text{Distance to 1079.3 (ft)}}{\text{Rate of Rise (ft/hr)}}$$

= [ ] hrs

Figure 4-2. Water Level Monitoring Log

Date	Time	Emergency Condition Level	Water Level (ft MSL)	Rate of Rise	Est. Time to Overtop Crest	Structural Condition	Comments

4.7 Sample Notification Messages

WATCH CONDITION MESSAGE. THIS IS A DAM EMERGENCY MESSAGE. BEXAR-MEDINA-ATASCOSA COUNTIES WID #1 AT MEDINA LAKE DAM HAS DECLARED A WATCH CONDITION. *(Briefly describe the problem/reason per Table 1).* THERE IS NO IMMEDIATE DANGER OF THE DAM FAILING; HOWEVER, THE POTENTIAL DOES EXIST. REQUEST YOU INITIATE APPROPRIATE EMERGENCY MANAGEMENT PROCEDURES. FOR VERIFICATION, CALL THE PHONE NUMBERS LISTED ON PAGE 1-1 OF THE MEDINA LAKE DAM EMERGENCY ACTION PLAN. ADDITIONAL INFORMATION WILL BE PROVIDED AS IT BECOMES AVAILABLE.

POSSIBLE DAM FAILURE WARNING MESSAGE. THIS IS A DAM EMERGENCY MESSAGE. THE BEXAR-MEDINA-ATASCOSA COUNTIES WID #1 AT LAKE MEDINA LAKE DAM, HAS DELCARED A POSSIBLE DAM FAILURE WARNING CONDITION. *(Briefly describe the problem/reason per Table 1).* THERE IS A POSSIBILITY THAT THE DAM COULD FAIL **PER INTERIM SAFETY GUIDELINES ESTABLISHED IN THE JULY 2002 FLOOD**. REQUEST YOU INITIATE EMERGENCY MANAGEMENT PROCEDURES AND PREPARE FOR EVACUATION OF THREATENED AREAS. IF MEDINA LAKE DAM FAILS, FLOODING WILL OCCUR ALONG THE MEDINA RIVER. FOR VERIFICATION, CALL THE PHONE NUMBERS LISTED ON PAGE 1-1 OF THE LAKE MEDINA LAKE DAM EMERGENCY ACTION PLAN. ADDITIONAL INFORMATION WILL BE PROVIDED AS IT BECOMES AVAILABLE.

IMMINENT DAM FAILURE WARNING MESSAGE. URGENT!! THIS IS A DAM EMERGENCY MESSAGE. THE BEXAR-MEDINA-ATASCOSA COUNTIES WID #1 AT LAKE MEDINA DAM HAS DETERMINED THAT THE DAM IS IN IMMINENT DANGER OF FAILING **PER INTERIM SAFETY GUIDELINES ESTABLISHED IN THE JULY 2002 FLOOD**.. REQUEST YOU IMMEDIATELY INITIATE EMERGENCY MANAGEMENT PROCEDURES AND BEGIN EVACUATION OF THREATENED AREAS IMMEDIATELY DOWNSTREAM PER THE MEDINA LAKE DAM EMERGENCY ACTION PLAN. (If warning is issued based SOLELY upon potential for flow over crest, add: THIS WARNING IS BASED UPON THE POTENTIAL FOR THIS FLOOD OVERTOPPING THE DAM CREST AND NOT UPON IDENTIFICATION OF FAILURE CONDITIONS, AND THEREFORE EVACUATION IS ONLY PLANNED AT THIS TIME FOR AREAS IMMEDIATELY DOWNSTREAM OF THE RESERVOIR PER THE MEDINA LAKE DAM EMERGENCY ACTION PLAN.). IF MEDINA LAKE DAM FAILS, A FLOOD WAVE WILL MOVE DOWN THE MEDINA RIVER THROUGH CASTROVILLE AND LA COSTE, AND ON DOWN THE RIVER. FOR VERIFICATION, CALL THE PHONE NUMBERS LISTED ON PAGE 1-1 OF THE MEDINA LAKE DAM EMERGENCY ACTION PLAN.

DAM FAILURE MESSAGE. EMERGENCY! THIS IS A DAM FAILURE EMERGENCY MESSAGE. THIS IS THE BEXAR-MEDINA-ATASCOSA COUNTIES WID #1, MEDINA LAKE DAM HAS FAILED. A FLOOD WAVE IS NOW MOVING DOWN THE MEDINA RIVER AND THE PEAK WILL REACH *(list prominent points and the time to reach them, per travel times in Emergency Action Plan).* EVACUATE THREATENED AREAS IMMEDIATELY. FOR VERIFICATION, CALL THE PHONE NUMBERS LISTED ON PAGE 1-1 OF THE MEDINA LAKE DAM EMERGENCY ACTION PLAN.

Appendix 4D

FEMA Siren Guidance

CPG 1–17
MARCH 1, 1980

OUTDOOR WARNING SYSTEMS GUIDE

federal emergency
management agency

CPG 1-17

OUTDOOR
WARNING SYSTEMS
GUIDE

FEDERAL EMERGENCY MANAGEMENT AGENCY
Washington, D.C. 20472

March 1980

NOTE TO USERS OF THE FEMA CPG 1-17

This publication supersedes the following portions of the Federal Civil Defense Guide

Part E, Chapter 1, Appendix 3

Part E, Chapter 1, Appendix 4, Annex 1

Also superseded are any other publications of FEMA and FEMA Regional Offices which are inconsistent with CPG 1-17

OUTDOOR WARNING SYSTEMS GUIDE

Abstract

This practical guide has been developed to aid public officials in determining the requirements for outdoor warning systems.

- The guide covers, in a simplified form, the principles of sound, outdoor warning systems and devices, propagation and detection of sound out of doors, avoiding hazardous noise exposures, and warning system planning, testing, and use.

- The guide is adapted from Report No. 4100, Bolt Beranek and Newman Incorporated, produced under Contract No. DCPA-01-78-C-0329, Work Unit No. 2234E. Report No. 4100 is based upon a survey of the current literature on the subject, and upon discussions with Civil Preparedness personnel and vendors. No experimental work has been performed.

- The guide is a replacement for Federal Guide, Part E. Chapter 1, Appendix 3, "Principles of Sound and Their Application to Outdoor Warning Systems," and Part E, Chapter 1, Appendix 4, Annex 1, "General Instructions for Determining Warning Coverage," both published in December 1966.

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OUTDOOR WARNING SYSTEMS GUIDE

I. PURPOSE

The purpose of this guide is to set forth the basic principles of sound that are applicable to audible outdoor warning devices and to describe a method for planning and laying out an effective outdoor warning system. This guide concentrates on the selection, siting, and operation of audible outdoor warning devices.

II. INTRODUCTION

Audible outdoor warning systems (sirens, air horns, etc.) are an essential component of the Civil Defense Warning System (CDWS) established by the Federal Government to advise government agencies and the public of impending enemy attack or other disaster. Following the detection of an attack or other hazard, information is disseminated over the Federal Emergency Management Agency (FEMA) dedicated communication network -- The National Warning System (NAWAS) -- to more than 2,000 locations throughout the United States. From these locations, the public can be informed of a potential hazard through the Emergency Broadcast System (EBS), TV stations, the news media, and other means.

Outdoor warning systems can advise people that a hazard exists and that they should determine the nature of the hazard by listening to the radio, etc. For more information on other aspects of the CDWS, see CPG 1-14, "Civil Preparedness, Principles of Warning," June 30, 1977.

III. PRINCIPLES OF SOUND

A. Terminology - Since outdoor warning devices use sound to alert listeners to danger, this section starts with a brief introduction to the vocabulary and principles of sound.

- Sound is a form of mechanical energy that moves from a source (a voice, a musical instrument, a siren) to a listener as tiny oscillations of pressure just above and below atmospheric pressure. When people hear sounds, they can distinguish their loudness, their tone or pitch, and variations of loudness and pitch with time. The loudness and pitch variations of some sounds are recognized as having certain meanings, such as with speech sounds.

- Instruments used to measure sounds give the magnitudes of sounds in decibels (abbreviated here as dB(C)). This magnitude is closely related to what we hear as loudness. Thus, an audible warning device that produces 110 dB(C) at 100 ft. (30 m) away sounds louder than one that produces only 100 dB(C) at the same distance. All audible outdoor warning devices are rated in terms of their sound output at 100 ft. in dB(C).

- Instruments can also measure the frequency components of a sound in Hertz (Hz). They are closely related to what we hear as pitch. As discussed below, the frequency components of the sound from an audible outdoor warning device are important in determining how far that sound will carry through the air and how well it will be heard. Most audible outdoor warning devices produce sound within the frequency range from about 300 Hz to about 1,000 Hz.

B. Attenuation - It is well known that sound decreases in magnitude (in loudness and in dB(C)) at greater distances from its source. This decrease is called attenuation with distance, and it is caused by a number of factors described in Section V-A. The amount of sound available to warn a listener can be calculated simply with the following equation:

$$\begin{bmatrix}\text{Amount of Sound}\\\text{Available to Warn,}\\\text{in dB(C)}\end{bmatrix} = \begin{bmatrix}\text{Sound Output of}\\\text{Audible Warning}\\\text{device, in dB(C)}\end{bmatrix} \text{ minus } \begin{bmatrix}\text{Attenuation}\\\text{with Distance,}\\\text{in dB(C)}\end{bmatrix}$$

Thus, if it is known that an audible outdoor warning device produces 110 dB(C) at 100 ft. (30 m), and that the attenuation with distance is 25 dB(C), then the amount of sound left over to warn people is 110 - 25 dB(C), or 85 dB(C).

C. Hearing - Whether the amount of sound available to warn people will indeed be sufficient to do the job depends upon several factors. First, the warning sound must be audible above the ambient, or background, noises. These ambient noises change constantly in loudness and pitch, depending upon noise-producing activities in the vicinity of the listener. Second, the warning sound must get the attention of the listener away from what he is doing. Normally, people "close out" of their minds distracting sounds that are not pertinent to what they are doing. A warning sound must penetrate this mental barrier. Tests have shown that to attract a listener's attention away from what he is doing, a warning sound must be about 9 dB(C) greater than would be sufficient to make it audible to someone who was concentrating on listening for it, and not doing anything else.

All of these factors suggest that a warning sound must be loud: loud enough to overcome attenuation with distance, to exceed the background noise, and to attract attention. Yet it cannot be too loud, or there is risk of injuring the hearing of some people who listen to it. This risk, which is discussed in greater detail in Section V-B, can occur when people are exposed to audible warning sounds exceeding 123 dB(C).

IV. OUTDOOR WARNING SYSTEMS AND DEVICES*

When a civil preparedness official buys an audible outdoor warning system for his community, he will be purchasing:

- The sound-making devices.
- The controls and equipment that operate the devices.

In this manual, the controls and equipment are not discussed. These vary with the manufacturer and are completely described in vendors' literature. The civil preparedness official should be aware, however, that the costs of the system will include both kinds of components, as well as installation costs.

The sound-making devices themselves can be of three different types:

- Sirens.
- Electronic (loudspeaker) devices.
- Horns and whistles.

A. Sirens - Sirens are by far the most widely used sound-making devices for outdoor warning systems. Sirens are capable of producing very intense sounds by chopping the flow of compressed gas (usually air). The fundamental frequency (pitch) of a siren sound is determined by the rate at which the flow is chopped, in cycles per second.** Sirens are powered by electric motors, gasoline engines, compressed air, or steam. Electric-motor-driven sirens are the most common for civil preparedness purposes.

Some sirens are nondirectional -- that is, they continuously produce the same sound in all directions horizontally from the source. The most powerful sirens, however, use a horn that radiates a beam of sound in a single direction. The horn is then rotated several times a minute, so that the beam sweeps through the entire area around the siren. For a stationary listener, the sound from such a siren goes up and down in loudness as the horn sweeps around.

B. Electronic Loudspeaker (or Voice/Sound) Sources - Loudspeaker sound sources have the advantage that they can broadcast voices as well as siren-like sounds. Therefore, they can be used to issue messages as well as warning sounds to the public. However, their sound-output capability is less than that available from siren sources, so that more sources may be required to cover the same area.

*While in the past there were Federal matching funds for this purpose, the current FEMA budget contains no such funds and future budgets may not include such funds.

**Some sirens, known as two-tone sirens, generate two frequencies simultaneously by using two airflow chopping rates.

Furthermore, sound reflections from large surfaces or simultaneous messages from several loudspeaker sources at different distances may "garble" the signal so badly that some listeners will not be able to understand voice messages.

C. Horns and Whistles - Air horns have the advantage that the sounds they produce cannot be confused with those of emergency vehicles or fire department sirens. When a suitable air supply is already available, the cost of a horn installation is very low. In addition, the air horn requires a minimum of maintenance and, because it weighs very little, is easily installed.

In the absence of an air supply or commercial storage cylinders, a compressor, storage tanks, and related appurtenances are necessary. These increase costs substantially, for horns require more power than many outdoor warning devices of the same decibel (dB(C)) rating.

In general, the comments on air horns apply to steam whistles as well. However, steam supplies are even more expensive than air supplies. It is generally not practical to install steam whistles unless an adequate steam supply is already available.

D. Ratings and Specifications - The sound outputs of acoustic outdoor warning devices are given in terms of their maximum decibels (dB(C)) measured at 100 ft. (30 m) from the device. The siting guidelines in this manual are based upon this figure.

The fundamental sound frequencies of almost all outdoor warning devices are in the range from 300 to 1,000 Hz. (Some devices "warble" up and down in pitch within this frequency range. See Subsection E.) Below 300 Hz, reduced human hearing sensitivity and higher background noise levels combine to restrict warning ranges. Above 1,000 Hz, sounds are more rapidly attenuated in the atmosphere, so the warning range is again restricted.

The sounds from audible outdoor warning devices are generally focused into the horizontal plane surrounding the device. Sound radiated upward would be wasted, and sound radiated downward close to the device is unnecessary and may be hazardous. (See Section VI-B.) As indicated above, some sirens may radiate a "beam" of sound in one direction horizontally, and have a mechanical means for rotating this beam around a vertical axis.

E. Warning Signals - Different cities and towns use their outdoor warning systems in different ways. Most local governments, however, follow the Federal Emergency Management Agency (FEMA) guidance and use a certain signal to warn people of an enemy attack, and a different signal to notify them of a peacetime disaster. These warning signals are:

• Attack Warning - This is a 3- to 5-minute wavering (warbling in pitch) tone on sirens, or a series of short blasts on horns or other devices. The Attack Warning signal shall mean that an actual attack against the country has been detected and that protective action should be taken immediately. The Attack Warning signal shall be repeated as often as warnings are disseminated over the National Warning System or as deemed necessary by local government authorities to obtain the required response by the population, including taking protective action related to the arrival of fallout. The meaning of the signal "protective action should be taken immediately" is appropriate for the initial attack warning and any subsequent attacks. This signal will also be used for accidental missile launch warnings.

• Attention or Alert Warning - This is a 3- to 5-minute steady signal from sirens, horns, or other devices. This signal may be used as authorized by local government officials to alert the public to peacetime emergencies. In addition to any other meaning or requirement for action as determined by local government officials, the Attention or Alert signal shall mean to all persons in the United States, "Turn on radio or TV. Listen for essential emergency information."

• A third distinctive signal may be used for other purposes, such as a local fire signal.

V. BASIC FACTS ABOUT SOUND OUT OF DOORS

A. Attenuation with Distance - As sound moves away from an outdoor warning device toward potential listeners, it can be greatly altered by the atmosphere. For example, everyone knows that the loudness of a sound decreases as the listener gets further from the source. Also, beyond a few hundred feet from a steady sound source, the loudness varies with time, being unnoticeable at some times and quite pronounced at others. Such effects, which are characteristic of the propagation of sound out-of-doors, are caused by the factors described below.

1. Divergence - As sound radiates away from a source, its intensity decreases with distance because its energy is spread over a larger and larger area. From a point-source, this decrease is called "spherical divergence" or "inverse square loss," because the sound intensity decreases inversely with the square of the distance from the source to the receiver (sound level decreases 6 dB for each doubling of source-receiver distance).

2. Attenuation Caused By Ground Effects - The ground produces a number of effects on the propagation of sound over its surface. Perhaps the simplest of these is the interferometer effect, which occurs when sound is propagated over a hard, flat surface. For any

given source and receiver height, there are two sound-wave paths between the source and the receiver: one direct, and the other - somewhat longer - reflected off the ground surface. Under some conditions, the sound waves arriving at a listener along these two paths interfere with each other, and cancel out. The opposite effect can also occur: the two sound waves can add, and a "gain" (negative attenuation) is observed. When the ground is soft and absorbs some sound, this effect becomes even more complicated.

3. Barriers - A barrier is any large solid object that breaks the line of sight between the sound source and the listener. In general, a barrier can introduce up to 20 dB of attenuation. The sound available behind the barrier comes from diffraction around the barrier, or from sound energy scattered into the region behind the barrier from other wave paths.

4. Effects of Vertical Temperature and Wind Gradients: Atmospheric Refraction - The speed of sound in air increases with temperature. Furthermore, when the wind is blowing, the speed of sound is the vector sum of the sound speed in still air and the wind speed. The temperature and the wind in the atmosphere near the ground are frequently nonuniform. This atmospheric nonuniformity produces refraction (bending) of sound wave paths. Near the ground, this refraction can have an effect on the attenuation of sound propagated through the atmosphere.

During the daytime in fair weather, temperature normally decreases with height (lapse), so that sound waves from a source near the ground are bent upward. In the absence of wind, an "acoustic shadow," into which no direct sound waves can penetrate, forms around the source. Large attenuations are observed at receiving points well into the shadow zone - just as if a solid barrier had been built around the source. On clear nights, a temperature increase with height is common near the ground (inversion) and the "barrier" disappears.

Wind speed almost always increases with height near the ground. Because the speed of sound is the vector sum of its speed in still air and the wind vector, a shadow zone can form upwind of a sound source, but is suppressed downwind.

The combined effects of wind and temperature are usually such as to create acoustic shadows upwind of a source, but not downwind. Only under rare circumstances will a temperature lapse be sufficient to overpower wind effects and create a shadow completely surrounding a source. It is less rare, but still uncommon, for a surface inversion to be sufficiently strong to overcome an upwind shadow entirely.

5. Foliage - Large amounts of dense foliage (100 ft. (30 m) or more) can attenuate sound somewhat, although small amounts of foliage have no effect.

6. Absorption of Sound in the Atmosphere - Sound is absorbed in the atmosphere in a way that depends upon the humidity. In general, this loss is most pronounced at high frequencies and is of lesser importance at the sound frequencies produced by outdoor warning devices.

7. Summary - The combination of all the factors that cause sound to be attenuated in the atmosphere is both complicated and unpredictable. If one were to observe the sound from a warning device 1,000 ft. (300 m) or farther away, he would find that it varies with time as much as 20 to 30 dB, depending upon the conditions of the atmosphere and the ground. This manual provides (Section V-C) a simple and conservative method for estimating warning ranges. It is important to realize, though, that this is an estimate which -- like the weather -- cannot be guaranteed.

B. Hearing - The most important factors determining the ability of a warning sound to alert a potential listener are the barriers to sound in the listener's immediate vicinity, and the background or masking noise at his location.

1. Local Barriers - A potential listener indoors or inside a motor vehicle is much less likely to be alerted by a warning sound of a given loudness than someone out of doors. This is, of course, because of the attenuation of the sound as it comes through the walls of the structure surrounding him. In general, an outdoor warning device cannot be counted on to alert people in vehicles or buildings unless they are very close to the device.

It is interesting to note that the current activity toward improving the energy-conservation properties of buildings will have the concomitant effect of increasing their sound-attenuating properties. Thus, it is even less likely in the future that people indoors will be alerted by outdoor audible warning devices.

2. Background Noise and Detectability - The most important factor that determines the detectability of a sound is the signal-to-noise ratio measured over a range of frequencies around the signal frequency. The "noise" portion of this ratio is the background noise at the listener's location. Thus, for a given level of warning signal, the background noise is critical to determining warning signal effectiveness.

Recent studies have shown that the outdoor background noise in a community is strongly correlated with local population density. This correlation presumably results from the fact that outdoor noise levels are almost always caused by motor vehicle traffic, which correlates well with population density. Thus, population density is a better metric of background noise than zoning or land-use patterns like "residential," "business," and "heavy industrial."

Recent studies have also shown that the level of sound from a warning device must be about 9 dB higher than the level detectable under laboratory conditions in order to attract the attention of otherwise preoccupied observers.

3. Deleterious Effects of Warning Sounds - When audible warning devices are used "in earnest" to alert a population of impending disaster, it seems surprising that anyone would be concerned about any deleterious effects of the sounds themselves. Indeed, many local noise ordinances specifically exempt warning sounds from noise-level restrictions. Nevertheless, in some communities sirens are operated so frequently (such as to provide tornado warnings in midwestern towns) that complaints about their noise level have been reported. Furthermore, the warning devices must be tested from time to time, and the resulting high noise levels could be viewed as disturbing and/or damaging under these circumstances.

4. Hearing Damage - For test purposes, audible warning devices should be so located and operated that no person is likely to be subject to a sound level great enough to cause hearing damage. A suitable limit for this purpose, based upon recommendations of the Committee on Hearing, Bioacoustics and Biomechanics (CHABA) of the National Academy of Sciences, is 123 dB(C).

Loud sounds, even if not potentially damaging, can be viewed as a disturbance by some residents of a community. Operators of audible outdoor warning systems should realize this fact, and should:

- Minimize the frequency and duration of tests of outdoor warning devices. Alternatively, "growl tests" can be conducted (see Section VII) when the source is a siren.

- Refrain from conducting tests at night when people are relaxing and sleeping.

- Avoid locating warning devices too close to noise-sensitive activities.

5. Summary - The detectability of an auditory warning signal is a function of the level of the signal at the potential listener's ears relative to the background noise at his location.

Because of local barriers, it is probable that a much smaller proportion of the potential listeners indoors or in vehicles can be alerted by an audible warning system, relative to the proportion that could be alerted out of doors.

No person should be exposed to the sound of an outdoor warning device if it exceeds 123 dB(C).

C. Estimating Range of Coverage - All of the factors in the previous two subsections -- on propagation losses and on signal detection -- have been combined to obtain the warning effectiveness ranges illustrated in Figure 1. The range, or radius, of coverage of any audible outdoor warning device can be determined from Figure 1 on the basis of the rated output of the warning device at 100 ft. Figure 1 indicates, for example, that a warning device rated 120 dB(C) will have a range of about 3,700 ft. (1.1 km) in suburban and rural areas, when mounted above the rooftops. In an urban area, when the device is mounted below the rooftops, its effective range will be about 1,200 ft. (0.35 km).

The upper curve in Figure 1, applicable to suburban and rural areas, is very close to 10 dB per doubling of distance for a 70-dB warning signal level. The lower curve of Figure 1, that applicable to urban high-rise areas, takes into consideration the greater attenuation caused by shielding and the higher background noise levels existing in downtown areas.

Two important features of Figure 1 should be emphasized. The first is the "NOTE" in the caption, which makes clear the uncertainties associated with the range prediction process. The second important point is embodied in the parenthetical remarks "over rooftops" and "below rooftops" in the labels of the curves. It is strongly recommended that warning devices be mounted above the prevailing rooftop height in areas where buildings are less than 3 to 4 stories high. In urban high-rise areas, of course, the opposite may be advisable.

VI. PLANNING AN OUTDOOR WARNING SYSTEM

A. Determining Warning Coverage - The basic tools for planning an outdoor warning system are a good topographic map of the community, a drafting compass, knowledge of the sound output ratings of the warning devices to be used, and Figure 1 from this manual.

Planning itself can be broken down into the following steps:

1. The civil preparedness official should locate, on the map:

- Downtown areas that contain tall buildings .
- Hills or any other barriers that would obstruct the flow of sound .
- Residential (suburban) or rural areas with low buildings over which sound can move freely .

2. The official should locate the public or business buildings that would be good sites for a warning device. (The community civil preparedness officer will, of course, have to double-check the usefulness of the site and obtain permission from the owner to install the device.)

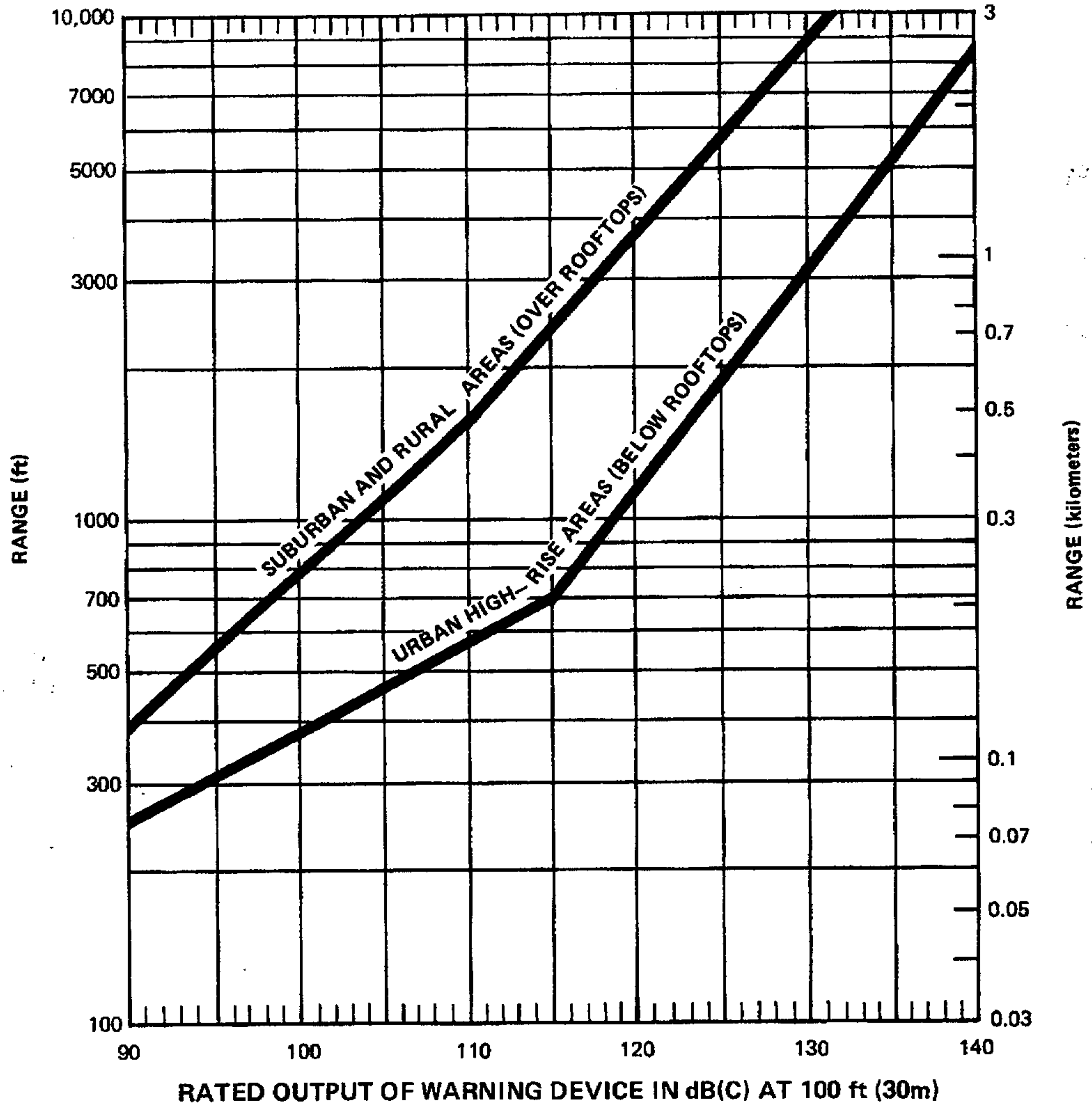


Figure 1
Effective Ranges of Outdoor Warning Devices As a Function of Their Rated Sound Output in dB(C) at 100 ft (30m)
Note: Differences less than ±2dB(C) in rated output, and differences less than ±15% in range, are not generally significant

3. The official should circle, on the map, the area in which each device will be effective, using ranges read from Figure 1.

It is a good idea to start the layout with the obvious warning device locations, such as:

- Noisy places (freeway interchanges, rail yards, etc.).

- Locations with good line-of-sight coverage (hill-tops, centers of radial street patterns).

- Locations where permission to install the devices can be readily obtained (public buildings, parks).

Noise-sensitive locations (hospitals, schools, residential buildings) should be avoided.

Many layouts are possible for most communities, and several trials may be necessary to obtain a layout with the minimum number of devices.

The product of this planning effort should look like Figure 2, a map covered with interlocking circles, each centered on a single warning device. (Note that the circles do not overlap to any major degree.) This layout attempts to make maximum use of warning devices rated 120 (dB(C)), so that the minimum number of different types of devices will be required.

The finished planning map can help answer a major question: What will the entire outdoor warning system cost? The number of circles indicates the number of devices needed and is a clue to the costs of installation and maintenance, as well as to the costs of control circuits for the system.

If the total cost, as estimated during planning, is too high, civil preparedness officials may want to redesign the system, perhaps decreasing the total number of devices by increasing the sound level rating of each device to be used.

B. <u>Siting to Avoid Hazardous Exposure</u> - Detailed siting of each device should take into consideration the factors desirable to maximize coverage, described in Section VI-A. Installations should also be sited to avoid exposing anyone to sound levels exceeding 123 dB(C). In general, this second requirement can be achieved by mounting the device high enough above ground level so that the sound is directed mostly over the heads of people standing on the ground near the device. The minimum height needed to meet this requirement, as calculated for one type of siren with a well-designed horn, is illustrated in Figure 3. This figure indicates, for example, that a device rated at 120 dB(C) should be mounted at least 32 ft. (10 m)

FIGURE 2. MAP WITH CIRCLES CENTERED ON SINGLE WARNING DEVICES

LEGEND

SOURCE	
A	125 dB(C) mounted in suburban area at fire station: Range 5900 ft. (1.8 km)
A-1	125 dB(C) mounted in suburban area at fire station: Range 5900 ft. (1.8 km)
B	120 dB(C) mounted at major road intersection: Range 3700 ft. (1.1 km)
C	120 dB(C) mounted in industrial area: Range 3700 ft. (1.1 km)
D	120 dB(C) mounted on hilltop: Range 3700 ft. (1.1 km)
E	120 dB(C) mounted at turnpike interchange: Range 3700 ft. (1.1 km)
E-1	120 dB(C) mounted at turnpike interchange: Range 3700 ft. (1.1 km)
F	120 dB(C) mounted in park: Range 3700 ft. (1.1 km)
G	120 dB(C) mounted in high-rise area at city hall: Range 1200 ft. (0.36 km)
H	120 dB(C) mounted in high-rise area at highway interchange: Range 1200 ft. (0.36 km)
I	120 dB(C) mounted in high-rise area on highway bridge: Range 1200 ft. (0.36 km)

(Map With Circles Centered on Single Warning Devices) above the ground. Of course, a higher mounting may be desirable to place the source above the prevailing rooftop height.

Note that Figure 3 has been established for just one type of source. It may not be applicable to other products. The public official should ask the vendor about the proper mounting height to limit the exposure of people standing on the ground to 123 dB(C) or less.

In those cases where it is impossible to mount the device high enough to achieve a safe sound level on the ground, large signs should be prominently displayed on the device, reading:

> CIVIL PREPAREDNESS WARNING ____________ (horn, siren, etc.)
>
> CAUTION!
>
> THIS ____________ (siren, horn, etc.) OPERATES AUTOMATICALLY. ITS SOUND CAN BE DANGEROUS TO YOUR HEARING. WHEN IT STARTS TO OPERATE, COVER YOUR EARS AND MOVE AT LEAST 200 FEET AWAY.

In some urban areas, it may be necessary to mount warning devices in such a way that the main sound beam is directed at adjacent buildings. When this occurs, the devices should be mounted no closer than indicated in Figure 4. A much greater separation than indicated by Figure 4 would be desirable for the comfort of building occupants.

VII. SYSTEM TESTING AND USE

Once an outdoor warning system is installed, civil preparedness officials must ensure that the system does indeed alert residents of the community. A system is successful only if:

- Residents of the community know how the signal sounds and why it is being sounded
- Residents can differentiate between system testing and a true alert
- Each device is operating as it should

A. Knowledge of Warnings - Americans are almost two generations removed from the days of World War II, when the voice of the air raid siren, the information it carried, and the proper reaction to it were familiar to everyone in the community. Though the potential of

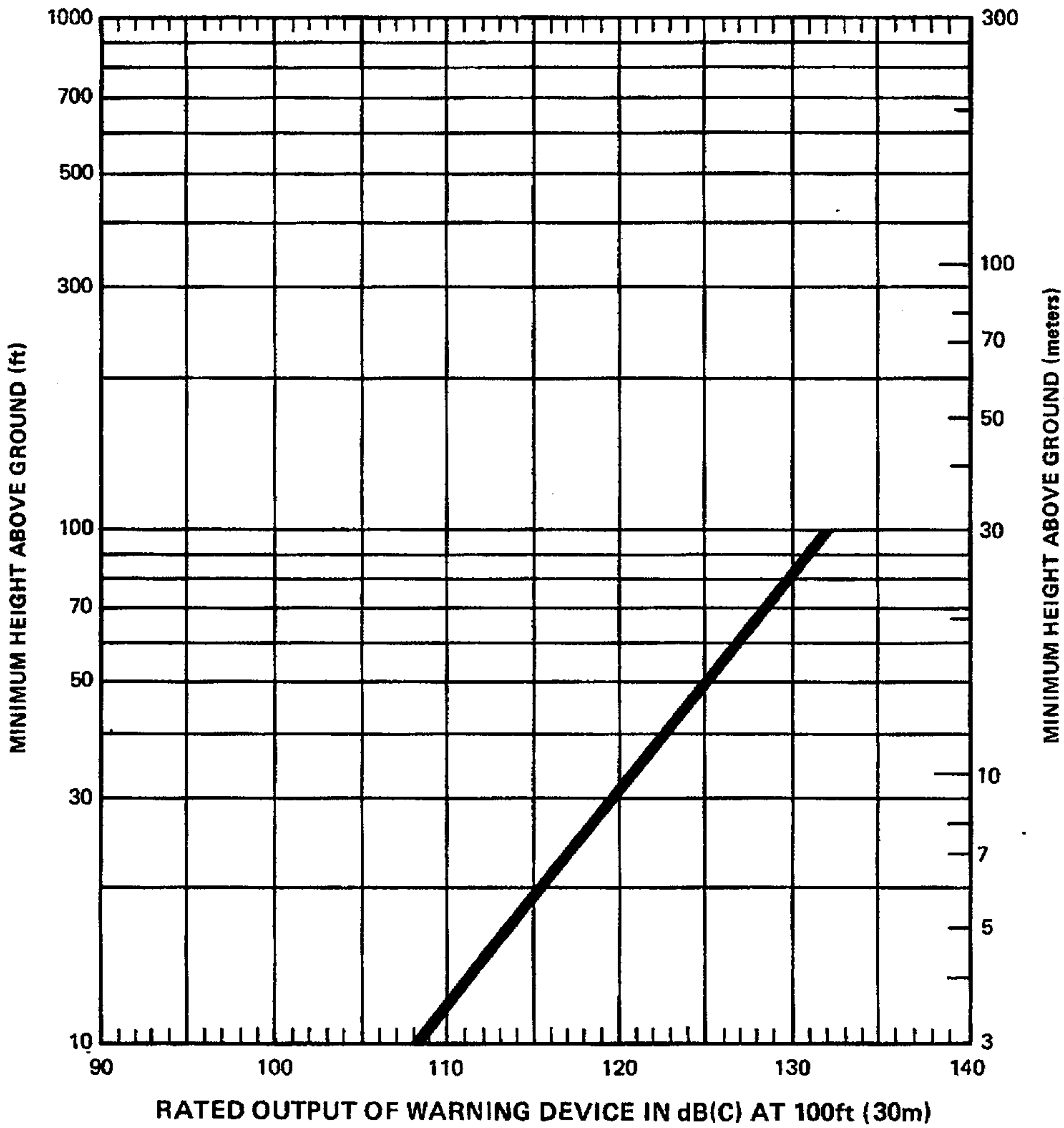


Figure 3

Minimum Mounting Height of a Typical Warning Device to Avoid Risk of Hearing Damage to Pedestrians (for horizontal beam)

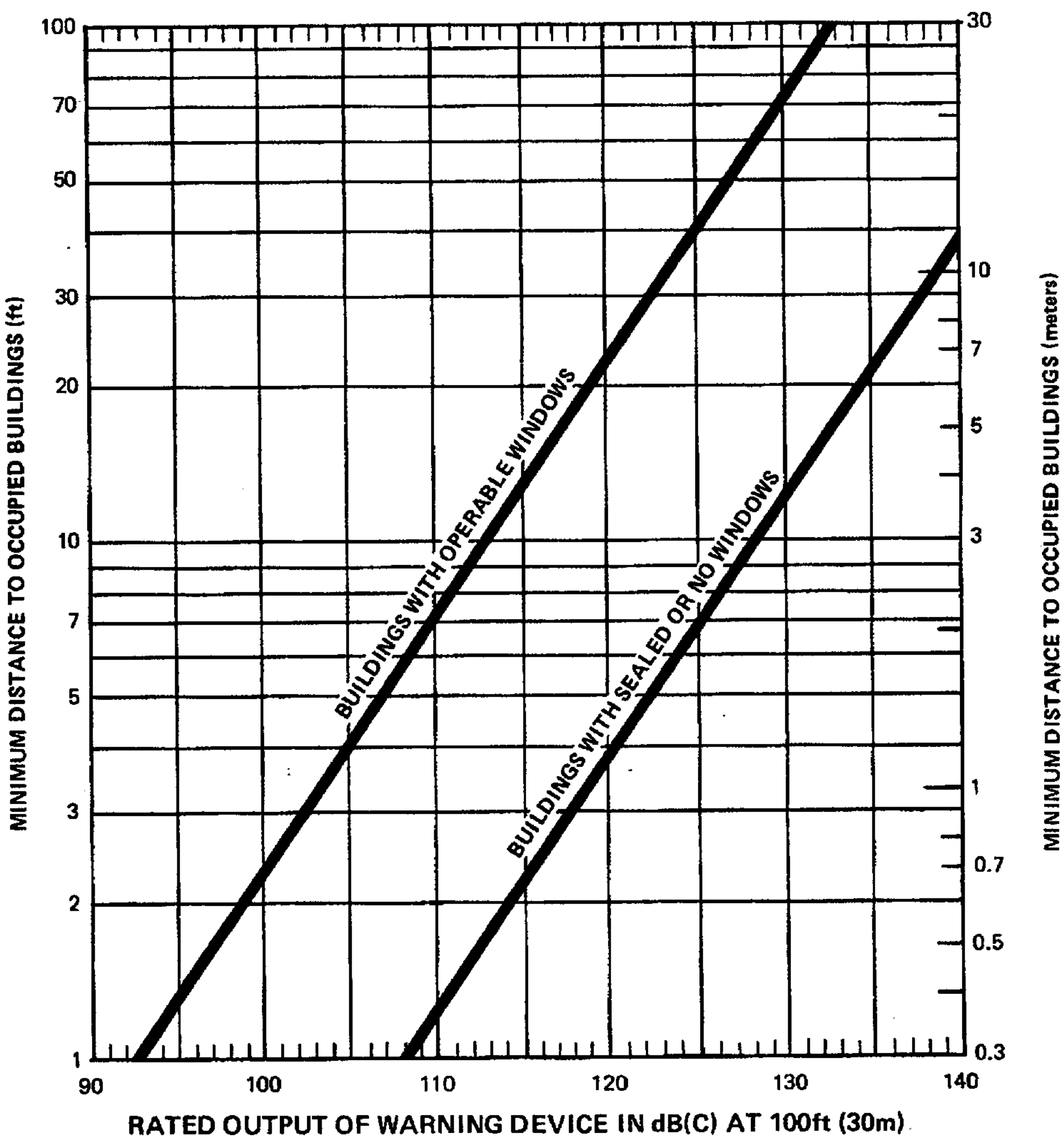


Figure 4
Minimum Distance to Avoid Risk of Hearing Damage to Occupants of Adjacent Buildings Located in Sound Beam of Warning Device

enemy attack remains, the usefulness of outdoor warning systems may have dwindled. If so, civil preparedness officials can turn the situation around, primarily through a controlled program of testing and a well-planned public information campaign.

B. Testing/Alert - Detailed information on the testing of outdoor warning systems is given in CPG 1-14 which includes recommendations that local officials:

- Test the outdoor warning system approximately once a month .
- Publicize the testing day and time each month.
- Test by sounding the "Attention" or "Alert" signal (the steady sound) for no more than 1 minute.
- Follow with 1 minute of silence.
- Finish by sounding the "Attack Warning" (rising/falling signal or series of short blasts) for no more than 1 minute.
- Emphasize, in all public announcements, that testing signals are sounded for less than 1 minute only, while in an actual emergency, all warnings would be sounded for 3 to 5 minutes and would probably be repeated .

When sirens are used, and must be tested more frequently than once a month, a "growl test" is acceptable. In a growl test, the siren is sounded for so short a time that it never produces significant sound output, yet long enough so that officials can determine that it is working.

C. Public Information Campaign - The civil preparedness official who must create a public information campaign has two advantages as he starts. First, the information he must communicate is neither lengthy nor hard to understand and, second, he is talking to people about their own safety. He should involve all community media, such as newspapers and radio/television stations, in his campaign; he should not overlook such useful forms of communication as posters in public buildings, newsletters sent out by community organizations, flyers enclosed in utility bills, and opportunities to address school assemblies.

The message must be straightforward, and the best campaign will repeat the same announcement, in the same words, again and again. Suggestions for conducting a public information campaign are contained in "Ideas for Conducting Awareness Campaigns," MP-83.

Appendix 4E

Sample Siren Vendor Information

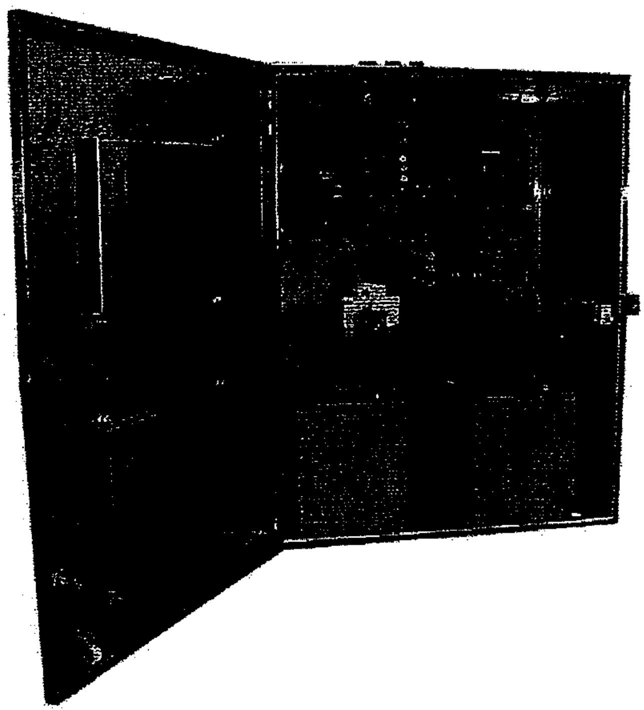
ATI

Acoustic Technology, Inc.

SoundBlaster SERIES
Outdoor High Powered Speaker Station
Tone & Voice System

Model #HPSS

This system can be configured for operation up to 3200 Watts of continuous audio output power. Provides reliable alarm tone notification and emergency voice instructions for emergency warning and notification.



Standard Equipment

Includes a NEMA4 Stainless Steel Siren control enclosure with an attached isolated and ventilated battery compartment, enclosure mounting bracket and mounting hardware. The siren enclosure contains a Class D Amplifier integrated with a high performance RTU section, a conventional VHF or UHF radio and mounting hardware, an intrusion switch, a temperature compensated battery charger and a power ON/OFF circuit breaker.

- Antenna equipment sold seperately per site requirements.

- Batteries not included.**
  (Refer to the last page for recommended battery types.)

Features

- Produces eight standard alarm tones and live PA broadcast.
- Custom alarm tones and digital messages.
- Automatic gain control for consistent output volume on live voice announcements.
- Local and remote activation, testing and status reporting. One compact Class D Amplifier integrated with a high performance controller capable of producing 1600 watts RMS of continuous output audio power.
- A second (non-integrated) Class D Amplifier is required for 3200 watt operation.
- Our Patented Class D Amplifier is a robust and highly efficient amplifier design that maintains an efficiency of over 90% independent of the input waveform shapes or amplitude.
- ATI's Class D Amplifier uses a unique drive method that reduces stress, improves efficiency and reduces failures of the output audio speakers.
- Very low amplifier popping during turn on and turn off further reduces premature and preventable sound driver failures.
- All Print Circuit Boards are conformal coated permitting the operation of ATI's siren in harsh environments.
- Very low system component count thus high MTBF (Mean Time Between Failures) and low MTTR (Mean Time To Repair). One board contains a complete high performance controller section with a universal Radio interface and onboard Modem. This is integrated with ATI's patented high efficiency 1600 watts RMS switch mode Class D Amplifier. By integrating these two sections, ATI offers a very compact and robust siren system.
- In the standard configured system, a radio is used to receive and transmit FSK data signals. (Other Communication Media available.)
- All Communication Transmissions use a revolving security coding method to prevent unauthorized system activations.
- NEMA4X Stainless Steel Enclosure

Acoustic Technology, Inc. 30 Jeffries Street East Boston, MA 02128 tel (617) 567-4969 fax (617) 569-2964
www.atisystem.com EMAIL: sales@atisystem.com

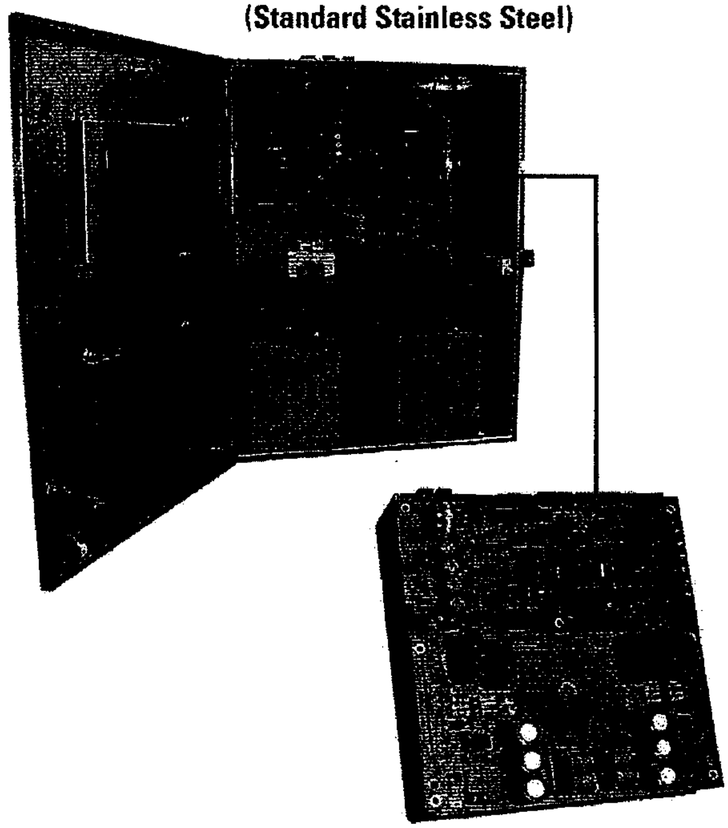
Model # HPSS16

Omni Directional Sound Pattern

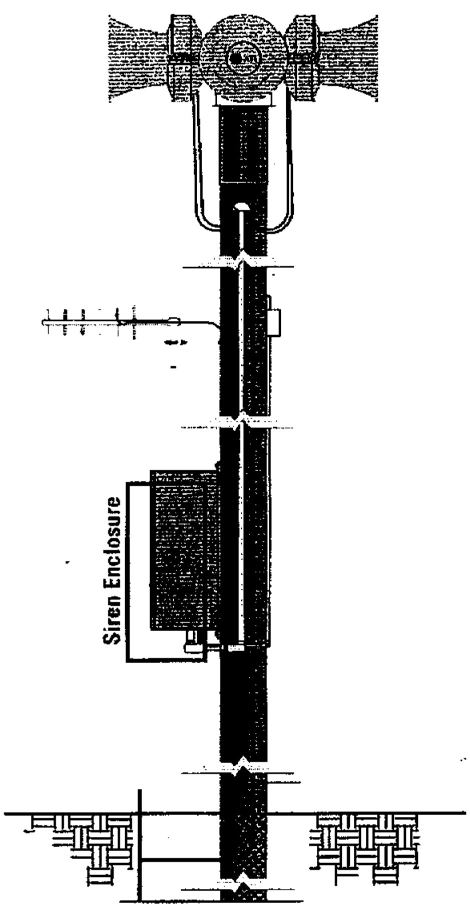
1600 Watts Output Power (121 dBC at 100')

- Includes four 400 Watt speaker assemblies with mounting bracket, 50 feet of speaker cable and a speaker pole mounting kit.
- Speaker assemblies can be configured to be directional.

Siren Enclosure (Standard Stainless Steel)

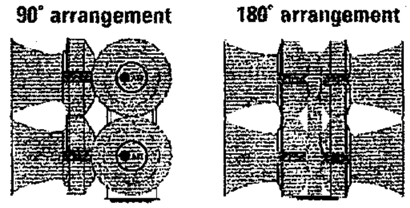


1600 Watt Amplifier



1600 Watts
Omni Directional Sound Pattern

90° arrangement **180° arrangement**



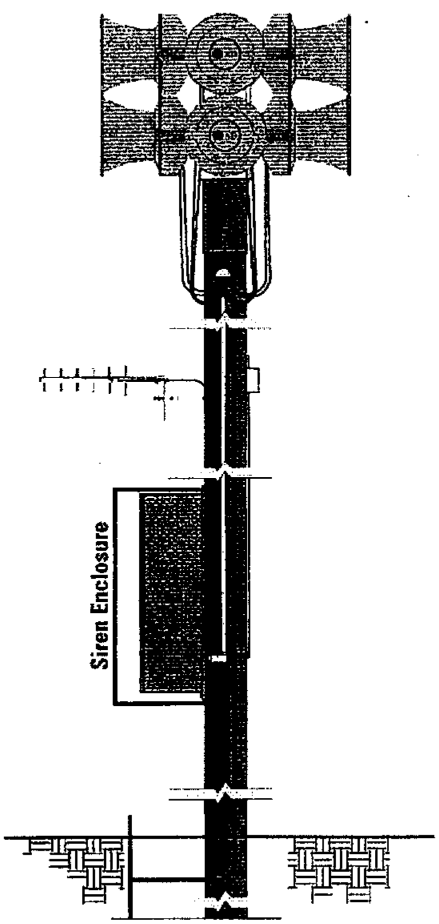
1600 Watts
Directional Sound Pattern

Model # HPSS32

Omni Directional Sound Pattern

3200 Watts Output Power (127 dBC at 100')

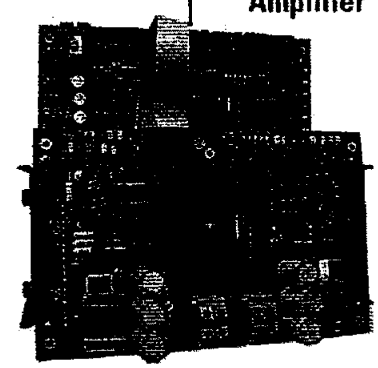
- Includes eight 400 Watt speaker assemblies with mounting brackets, 50 feet of speaker cable and a speaker pole mounting kit.
- One auxiliary Class D Amplifier with an interconnecting cable and mounting screws.
- An additional ventilated Stainless Steel battery enclosure.



3200 Watts
Omni Directional Sound Pattern

Additional Battery Enclosure
(Standard Stainless Steel)

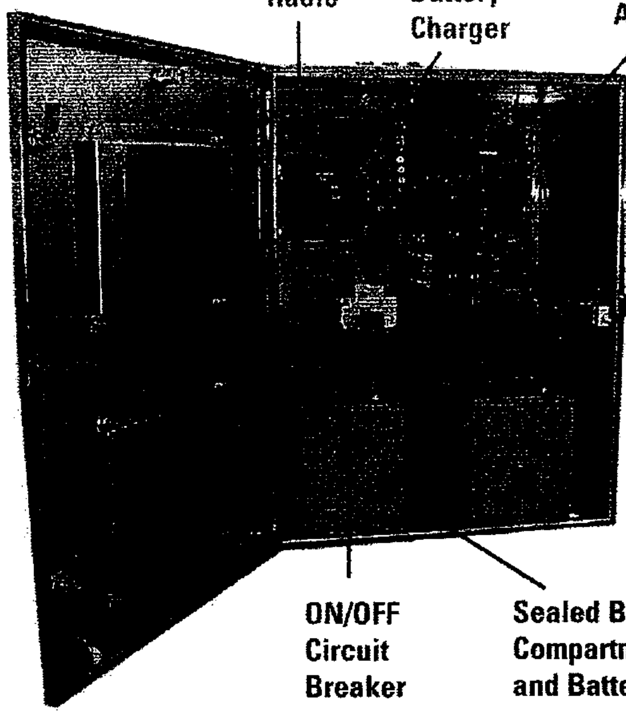
1600 Watt
Amplifier



1600 Watt
Auxiliary Amplifier

SIDE VIEW of the
Siren Enclosure
(Standard Stainless Steel)

Siren Enclosure



Optional Features & Upgrades

1. **Pre-Recorded Voice Message Option (-DM)**
   This option includes a pre-recorded Digital Message Board and storage PROMs. The pre-recorded messages are professionally recorded and then digitized and stored. Available in blocks of 20, 40, or 80 individual messages. If additional messages are required, consult (up to 255 messages are possible).

2. **Solar Power Options (-SP)**
   Includes solar panels sized for your location, a regulator, 30 feet of power cable and solar panel mounting bracket(s). Available in 55W, 75W, or 100W solar panels.

3. **Trunked Radio Upgrade** (-T)
   Replaces the standard conventional radio with an 800 or 900 MHz Trunked radio to interface with your trunking radio system.

4. **Antenna Surge Protector Option (-ASP)**
   Used in high lightning areas. Rated for 50,000 amps IEC.

5. **Strobe Output Option (-STR)**
   Controls a string of Strobe Lights of up to 10 amps of total current draw. Refer to the Strobe Selection Chart to order the Strobes separately.

Specifications for the Model #HPSS

General	
Operating Temperature	-20°C to +85°C (-40°C with battery heater)
Humidity	0 to 95% Non-Condensing
Standby without AC	8 days (2 batteries with 100 AHr capacity)
Maximum Alarm Duration	30 minutes
Enclosure Weight	80 lbs (without batteries)
Controller Size (in inches)	28" H x 22" W x 14" D
400W Speaker Weight	70 lbs
Electrical	
AC Input Voltage	120 VAC or 240 VAC 50/60 Hz
Maximum Operating Current	[illegible]
Communications	
Modem Modulation	FSK (preferred) or DTMF
Radio Output Power	[illegible] Watts
Amplifier Section	
Audio Output Power	1600 Watts RMS Continuous per Amplifier
THD	Less than [illegible]
Power Bandwidth	250 Hz - 5 Hz
Class of Operation	True Class D
Efficiency	>90%
Operating Temperature	[illegible] to +85°C
Output Regulation	1 dB or better, no load to full load
Operating Voltage Range	[illegible]
Protection	Protected against primary over current, output over current or shorts & output voltage spikes.
Controller Section	
Program Storage	256K Flash Memory/100 yrs data retention
Addressing	DIP switches for easy address selection
Local Activation	Six pushbuttons for local testing and activation
Radio Interface	[illegible]
Expansion Ports	RS485, RS232 and a second 1600 Watt amplifier
Other Ports	[illegible]
Other Features	Build in AGC circuit, tone generator, and digital adjustable audio gain.
Active Power without radio	< 100 milliamperes
Standby Power	< 5 milliamperes
Batteries (not included)	
**Recommended battery types	Everstart #27DC-6 (www.everstart-batteries.com) or Interstate #SRM-29 (www.interstatebattery.com)

2001 Siren

- Ideal for outdoor warning
- New & Improved Stator Increases efficiency and Sound Output.
- 128 dBC output
- Directional, rotating siren for maximum coverage
- Three distinct warning signals
- Full battery operation or battery backup
- Patented stator/horn design allows highly efficient, high output operation
- Maintenance free sealed bearing motors
- Weather resistant coating
- 5 year limited warranty

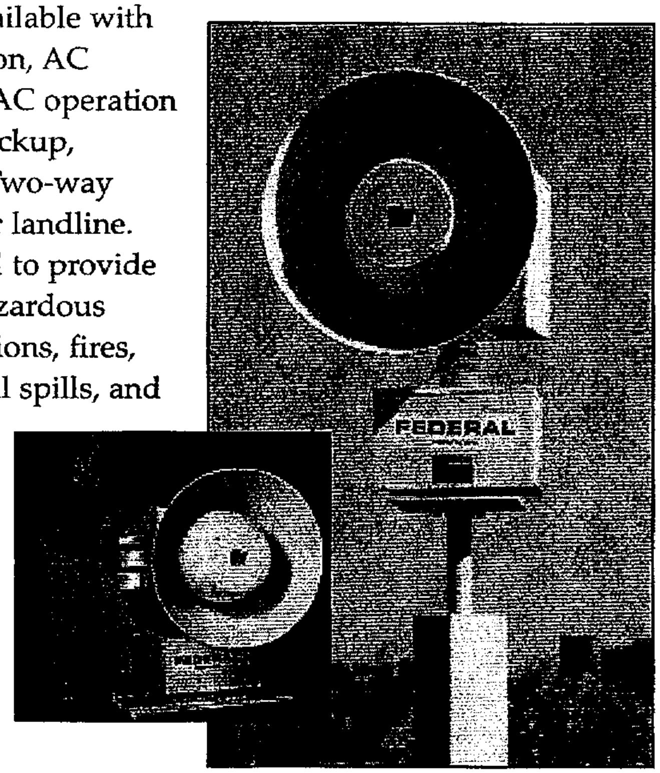
"Warning the World"

The 2001 Siren is a high power, rotating, uni-directional siren that offers an anechoic certified signal strength of 128 dBC at 100 feet. The high decibel output provides maximum coverage with minimum installation cost. Radio activation can further minimize installation costs by eliminating the need for leased dedicated control lines.

The siren's projector produces a 60 degree projection of sound which rotates at 2 RPM and can produce three signals for various applications. The three signal options are Steady, Wail, and Fast Wail.

The 2001 Siren will supply a minimum of 15 minutes of full power output from its batteries after AC power loss. The siren controls are available with battery operation, AC operation and AC operation with battery backup, One-way and Two-way radio control or landline.

Ideally suited to provide warning for hazardous weather conditions, fires, floods, chemical spills, and other types of emergencies, the 2001 siren is a perfect choice to protect any community.



FEDERAL SIGNAL CORPORATION
Federal Warning Systems

2001 SIREN SPECIFICATIONS

POWER REQUIREMENTS*

Siren Motor: 48V (DC or full wave rectified AC)
100 amps. (nom.)
Rotator Motor: 48V (DC or full wave rectified AC)
3 amps. (nom.)

WIRING

Siren Motor: 2 AWG
Rotator Motor: 12 AWG

MOTOR TYPE

Siren: Series Wound DC 6 Hp
Rotator: Permanent Magnet DC 1/3 Hp

SIGNAL INFORMATION

Signal	Frequency Range	Sweep Rate
STEADY	750 Hz	N.A.
WAIL	470-705 Hz	10 sec.
FAST WAIL	600-705 Hz	3.5 sec.

Signal Duration: 3min. (programmable)
Signal Output (SPL): 128 dBC (on axis) at 100' (30.5 m)
Effective Range at 70dBC: 5600ft
Rotation: 2-8 RPM (Adjustable)

DIMENSIONS

Height x Width x Depth: 55" x 37" x 41"
140cm x 94cm x 10cm

WEIGHT

Shipping Weight: 410 lbs. (186.4 kg)

OPERATING TEMPERATURE

-30°C to +60°C**

* Power requirements refer to the power supplied by the batteries or optional AC operation with battery backup.

** The siren can operate throughout this temperature range provided that battery temperature is maintained at -18°C or higher.

ORDER INFORMATION*

2001SRN	Rotating Electro-mechanical Siren 128 dBC, 48 VDC, Pole Mount Included
2001AC[1]	AC operated controller, 208 or 220/240 VAC (specify voltage) NEMA 3R control cabinet, two 48 VDC contactors and transformer/rectifier, 182 lbs. 53 kg
2001DC[1,2]	120 VAC controller, NEMA4 control cabinet, four chargers, two 48 VDC contactors and NEMA 3R battery cabinet. 224 lbs. 102 kg

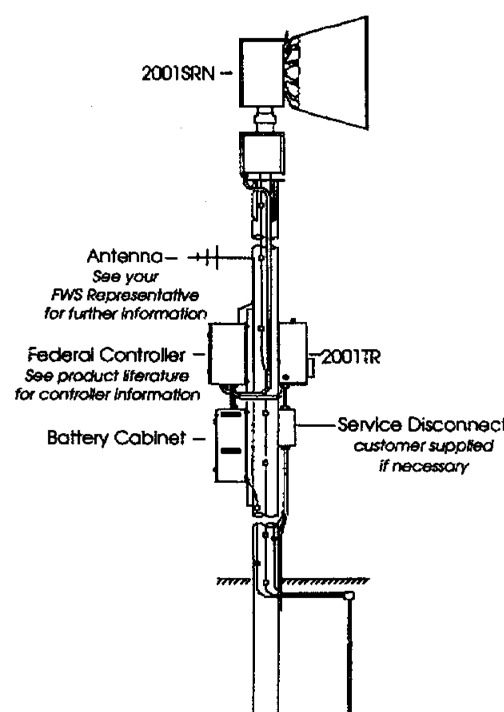
*2001 Siren requires a Federal Controller.
(See Controller Product Literature)

[1] For use with Electro-mechanical sirens.
Antenna and cable are not included with any radio activation control and must be purchased separately. (See your FWS Representative).

[2] Batteries not included. Four Delco Voyager Model M24MF required.

Landline Option

2001HR	Rotator Holding Relay for use with external timer.



FEDERAL SIGNAL CORPORATION
Federal Warning Systems
2645 Federal Signal Drive, University Park, IL 60466-3195
Sales: 800/548-7229 • Fax: 708/534-4855
Visit us at www.federalwarningsystems.com

Modulator Siren Series

Federal Signal's Modulator Siren Series is capable of producing intense warning signals over a large area. An efficient design enables the siren to produce a high sound level while making moderate demands on the battery power source.

- Produces high intensity warning signals
- Warning signals, voice communication and continued emergency operation regardless of primary power outages
- Excellent frequency response for clear voice reproduction
- 360° coverage with no sound variation in the horizontal plane
- Increased power during voice reproduction
- Easy servicing through convenient access panels
- Aerodynamic design reduces wind loading concerns
- Fully tested in Federal Signal's certified anechoic chamber

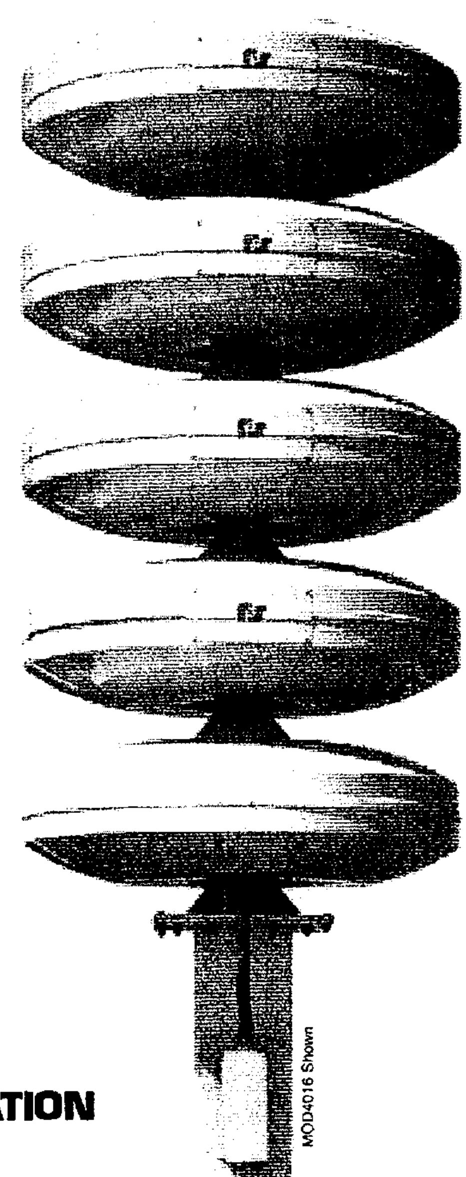
"Warning the World"

The innovative omni-directional electronic Modulator Speaker Array consists of modules that each utilize four 100 watt drivers*. The Modulator Siren is available in various models (see reverse side.)

The Modulator Speaker Array provides a flat frequency response from 200 to 2000Hz for excellent voice reproduction and offers warning signals such as: Wail (Attack); Pulsed Steady; Steady (Alert); Fast Wail; Pulsed Wail and Westminster Chime which are produced by the Modulator Siren Control Unit. Custom tones can be purchased upon request.

The Digital Voice option produces four (4) or eight (8) minutes of highly intelligible audio messaging.

An excellent alert and notification device, the Modulator Siren is ideal for locations where people congregate outdoors, or in industrial settings where immediate instruction is necessary.



MOD4016 Shown

*MOD6048 utilizes eight drivers per module.

FEDERAL SIGNAL CORPORATION
Federal Warning Systems

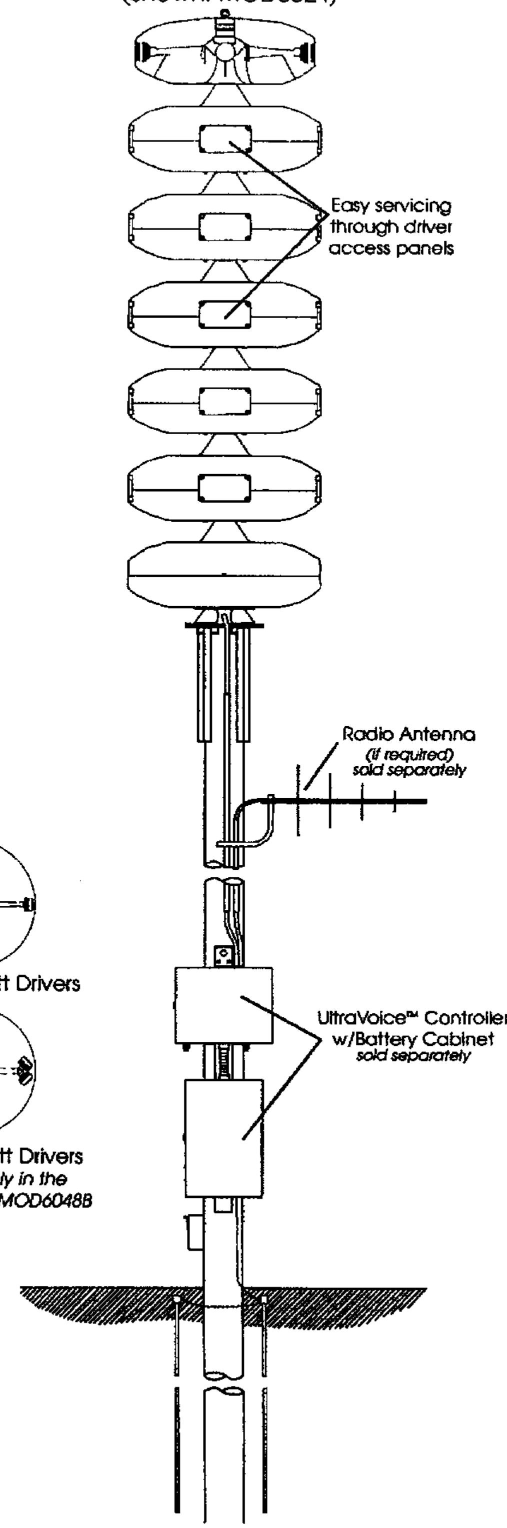
MODULATOR SIREN SERIES SPECIFICATIONS

Color: Off White
Paint Type: TGIC-Polyester Powder Coat
Modulator Horn Type: Hyperbolic Flare
Frequency Response: 200-2000Hz
Horizontal Coverage: 360° +/- 1dB
Diameter: 44-1/2"

Model Number	Active Modules*	Watts	dBc @ 100'**	Effective Range @ 70 dBC	Height in Inches	Shipping Weight Lbs.	Net Weight Lbs.
MOD1004	1	400	106	1200'	43.17	350	181
MOD2008	2	800	112	1800'	63.70	400	296
MOD3012	3	1200	115	2200'	84.30	600	411
MOD4016	4	1600	118	2800'	105.0	750	526
MOD5020	5	2000	120	3100'	125.5	1000	641
MOD6024	6	2400	121	3400'	146.08	1270	760
MOD6048	6	4800	125	4500'	146.08	1438	928

*The bottom module contains no active devices and is used simply as a reflective surface.
**Based on far field measurements.

Pole Mounted
(Shown: MOD6024)

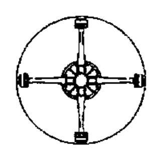


ORDER INFORMATION*
Electronic Speaker Arrays

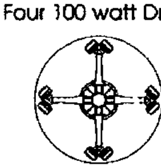
ALUMINUM SERIES A - *Includes 40' cable*

MOD1004 One module, Four Drivers per Module
MOD2008 Two modules, Four Drivers per Module
MOD3012 Three modules, Four Drivers per Module
MOD4016 Four modules, Four Drivers per Module
MOD5020 Five modules, Four Drivers per Module
MOD6024 Six modules, Four Drivers per Module
MOD6048 Six modules, Eight Drivers per Module

**See UltraVoice™ Controller product literature for specifications.*



Four 100 watt Drivers



Eight 100 watt Drivers
available only in the MOD6048 and MOD6048B

FEDERAL SIGNAL CORPORATION
Federal Warning Systems
2645 Federal Signal Drive, University Park, IL 60466-3195
Sales: 800/548-7229 • Fax: 708/534-4855
Visit us at www.federalwarningsystems.com

ISO 9001

9/02

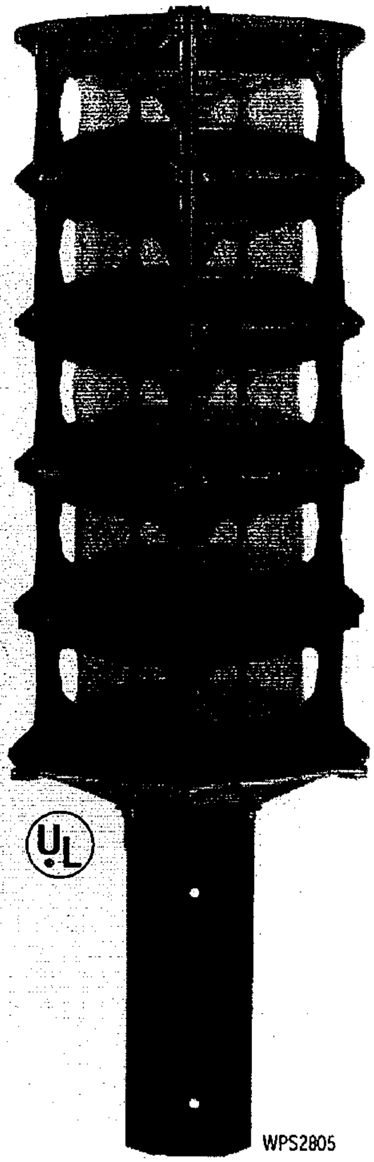
WPS2800 Series

WHELEN®

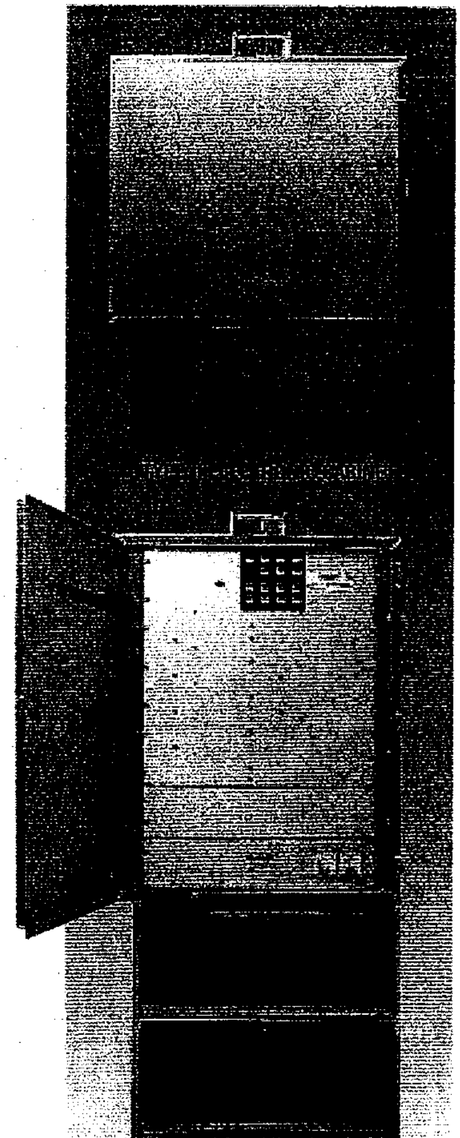
Mass Notification Warning Systems

Alert and Inform

The most effective way to warn the public is to issue a siren warning and follow it with a clear, deliberate and powerful voice message. This two-step approach, alert and inform, will eliminate confusion, restore order and most importantly, save lives. Our WPS2800 Series accomplishes this in two ways. One is to alert, the other is to inform through omni-directional voice and siren warning. The WPS2800 Series delivers siren warning and broadcasting of unequalled clarity at uniform power levels (+/- 1dB) throughout 360°.

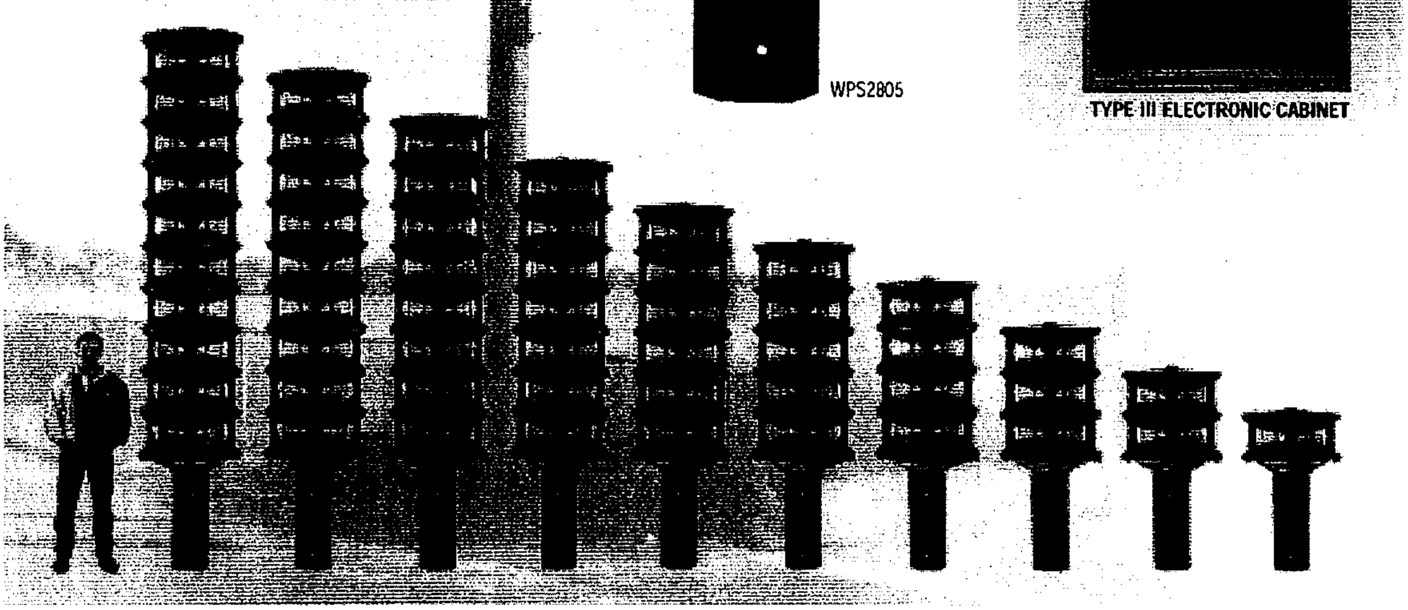


WPS2805



TYPE III ELECTRONIC CABINET

Ten models serve a wide variety of applications as shown here in ratio to a person's size.



WPS2800 Series

High-Power Voice and Siren Systems...

SYSTEM FEATURES

- Choice of 1 to 10 Omni-Directional Speaker Cells Assembled in a Vertical Column
- Ten Models, 108dBc to 126dBc @ 100'
- 50' Cable Included
- Pole Top Mounting Bracket Included
- Two or Three Compartment (Type II or III)* Natural Finish Aluminum Cabinet
- Public Address Capability
- Battery Powered, Minimum of 30 Minutes of Full Power Output with Batteries of Our Recommendation
- AC Temperature Compensated 10 Amp Battery Charger
- Local Controls or Remote Controls
- Power Amplifiers
- Electronic Siren Controller
- Tone Generator
- Timer
- Local Control Push Buttons
- Battery Switch
- Low Battery Alarm
- SI TEST®
- Battery Tray
- Lightning Arrestor
- Six Standard Public Warning Tones - Wail, Whoop, Attack, Hi-Lo, Alert, Airhorn

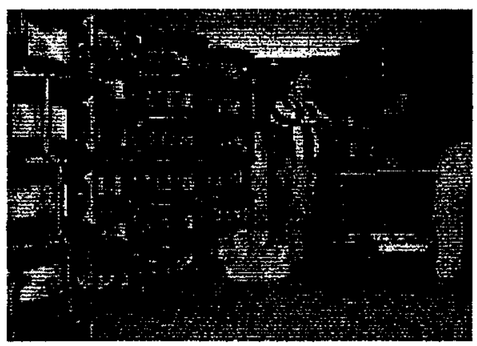
SYSTEM OPTIONS

- **SBC240, SBC260** - Solar Power[1]
- **WPSBATT** - Delco S2000 or Interstate Workaholic 31-MHD Batteries
- **WPSNCMIC** - Noise Cancelling Microphone
- Alternate Tone Set
- **RDVM** - Digital Voice Message Capability[2]

NOTES:

(1) Solar power option.
2 - 40 watt panels or 2 - 60 watt panels, mounting bracket and regulator.

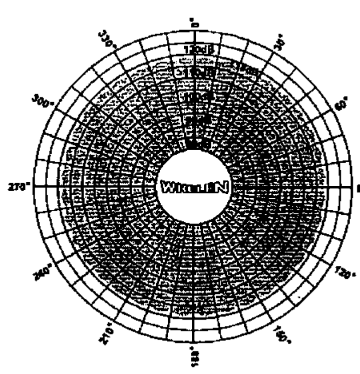
(2) RDVM - 1-16 message capability with 240 or 480 seconds available for recording.



All of our WPS-2800 Series speaker arrays are custom made to fulfull your specific requirements.

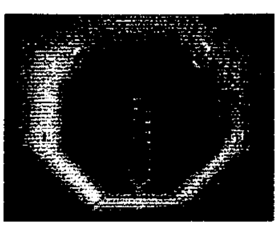
COVERAGE CHART

UNIFORM COVERAGE +/- 10dB 360°



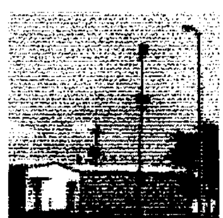
SYSTEM OPTIONS

Whelen's Super-Power 400 watt speaker driver and a standard 100 watt speaker driver. The Whelen driver is used in the WPS4000 and WPS2800 Series High-Power Voice and Siren Systems.

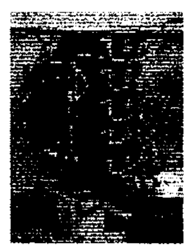


Whelen WPS2800 Series siren systems are wind-tunnel tested to insure performance and reliability in the most trying conditions.

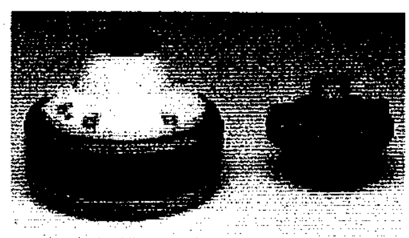
Our electronics assembly area is staffed with the most dedicated professionals in the industry.



Whelen siren with Solar Regulator in the field.



Type II Electronics Assembly detail.



Whelen Siren 400 Watt Speaker Driver shown with Standard 100 Watt Speaker Driver..

SIX STANDARD WARNING TONES

TONE	TONE SYMBOL	FREQUENCY	SWEEP RATE
WAIL		410 - 675	4 sec/1 sec
ALERT		465	Steady
HI/LO		465/650	.8 sec/.8 sec
ATTACK		410 - 490	1 sec/1 sec
AIR HORN		465 - 650	Modulated/1.6 sec
WHOOP		300 - 465	3

WPS2800 Series Performance Chart

MODELS	PERFORMANCE SPL* @ 100'	RANGE
WPS2801	108	
WPS2802	114	
WPS2803	115	
WPS2804	118	
WPS2805	119	
WPS2806	121	
WPS2807	123	
WPS2808	124	
WPS2809	125	
WPS2810	126	

0 50

Performance chart footnotes: *All 100' performance levels listed represent repeatable results with +/- 2dB to stated levels under free field conditions when warning systems are maintained to factory specification and tested according to published guidelines.
Estimated 70dB and 60dB perimeters are based on the Federal Emergency Management Agency's -10dB per distance doubled path model, discussed in FEMA publication CPG 1-17, "Guide to Outdoor Warning Systems."

WHELEN

Public and Industrial Warning for Every Application

SIREN ACTIVATION CONTROLS

Our VHF High and UHF siren activation control packages include the following:

- Radio and Radio Interface
- Tone Squelch
- 2-3dB Gain Omni-Directional Antenna with Bracket
- 35' of RG58 Antenna Cable
- Polyphaser
- SI TEST

Other features are dependant upon one or two-way controls. Whelen equipment can be interfaced with many different types of two-way radio communications products and systems including 800Mhz trunking, Motorola's MOSCAD, FSK, Narrow-Band and VHF Low Band. The following is available:

ONE-WAY CONTROLS

- **AUXIN** - Auxiliary Board for Contact Closure Activation
- **D2020LL** - 10 Digit DTMF Landline Activation
- **D2020H** - 10 Digit DTMF VHF High Band / 150-170 Mhz
- **D2020U** - 10 Digit DTMF UHF / 450-470 Mhz
- **WPSTT** - Two Tone Sequential Option

TWO-WAY CONTROLS

- **AUXCS** - Two-Way Contact Closure Activation and Status Board
- **C2020LL** - 10 Digit DTMF Two-Way Landline Activation
- **C2020H** - 10 Digit DTMF VHF High Band / 150-170 Mhz
- **C2020U** - 10 Digit DTMF UHF / 450-470 Mhz

Options:

- **FSKXMOD** - Converts the Above Siren Activation Controls to FSK Format
- **STATUS** - Cabinet Window LED Status Indicator (Monitors Siren Conditions)
- **PGINT** - Paging Interface to Interface Whelen Audio, Voice and Tones with Existing Paging Systems
- **INTRU** - Intrusion Alarm (Available with Two-Way only)

RADIO CONTROL

Whelen offers both one-way radio controls, D2020 Series, and two-way radio control/status monitoring systems, COMM/STAT™, for the WPS2800 Series.

REMOTE STATION DIGITAL VOICE

Up to sixteen pre-recorded, digital voice messages may be stored at the remote station using Whelen's Remote Station Digital Voice Module. Messages are factory set for optimum power and clarity. A brief radio command (less than one second) may be used to activate the variable length messages.

SI TEST®

Only Whelen's Diagnostic Silent Test, SI TEST®, fully exercises the siren system without disturbing the public. Diagnostic SI TEST®. Information includes:

- AC Power On/Off.
- DC Power At Operational Levels.
- Partial Speaker Driver/Power Amplifier Operation.
- Full Speaker Driver/Power Amplifier Operation.

Whelen Products are Pre-Assembled, Pre-Wired and Tested at our Facility to Ensure Product Quality and Reliability!

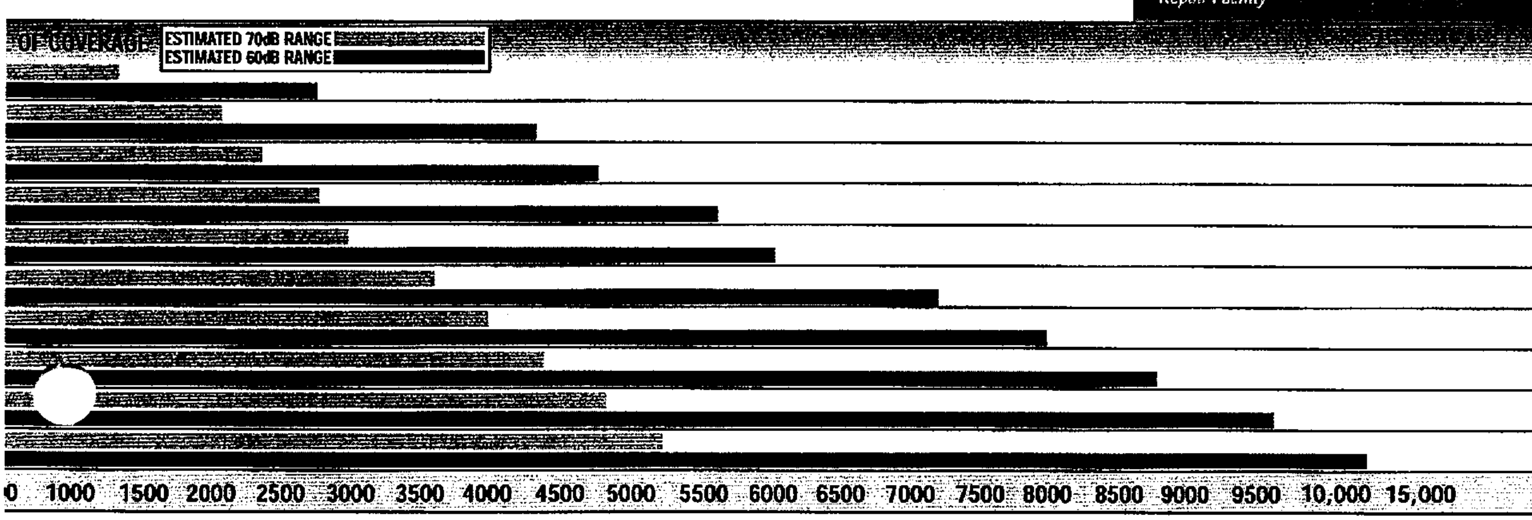
Testing Station

2800 Series Speakers Assembly

Type II Cabinet Assembly

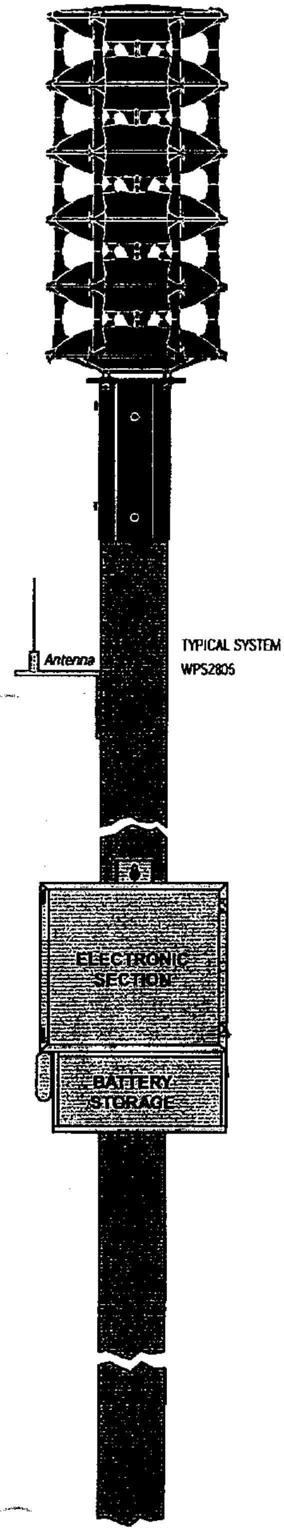
Type III Cabinet Assembly

Repair Facility

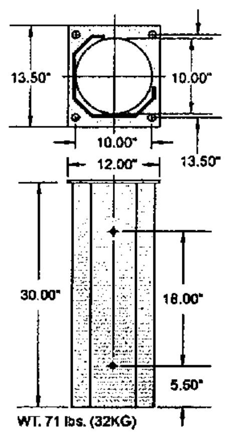


WPS2800 Series

Specification Data



TYPICAL SYSTEM
WPS2805



POLE TOP BRACKET

The pole top bracket for the WPS2800 Series is furnished in a natural finish, core-ten steel. The pole top bracket will accept a utility pole having a 10" top diameter.

Product Support

At Whelen Engineering, we not only design and manufacture the best warning systems available, we stand behind every product we make. For a copy of our warranty, write to us at our main office in Chester, Connecticut.

If you're interested in the most reliable, the most up-to-date warning systems - and the service that comes with them - give us a call. Find out why Whelen Engineering is the first name in public warning.

A product specification sheet with installation details is available for each WPS2800 Series High-Power Voice and Siren Systems.

WHELEN®
ENGINEERING COMPANY, INC.
PUBLIC WARNING PRODUCTS
Route 145, Winthrop Road
Chester, Connecticut 06412-0684
(860) 526-9504
1-800-637-4736
Fax: (860) 526-4784
Internet: www.whelen.com
e-mail: iowsales@whelen.com

112202-WPS2800-10537C

WPS2800 Series Specifications

MODEL	SPL @ 100'	SYSTEM WATTAGE SIREN AUDIO	SYSTEM WATTAGE VOICE AUDIO	HEIGHT Inches (CM)	WIDTH Inches (CM)	DEPTH Inches (CM)	SPEAKER ASSEMBLY WEIGHT lbs. (kg.)	ELECTRONIC CABINET WEIGHT lbs. (kg.)
WPS2801	108dBc	400	500	18.7 (47.5)	32.5 (82.5)	_	116 (52.6)	233 (105.9)
WPS2802	114dBc	800	1000	31.1 (79)	32.5 (82.5)	_	162 (73.5)	240 (109.1)
WPS2803	115dBc	1200	1500	43.5 (110.5)	32.5 (82.5)	_	208 (94.4)	247 (112.3)
WPS2804	118dBc	1600	2000	56.0 (142)	32.5 (82.5)	_	254 (115)	254 (115.4)
WPS2805	119dBc	2000	2500	68.4 (173.7)	32.5 (82.5)	_	300 (136)	261 (118.6)
WPS2806	121dBc	2400	3000	80.8 (205)	32.5 (82.5)	_	370 (168)	424 (192.7)
WPS2807	123dBc	2800	3500	93.2 (237)	32.5 (82.5)	_	416 (188.7)	431 (195.9)
WPS2808	124dBc	3200	4000	105.6 (268)	32.5 (82.5)	_	462 (209.5)	438 (199.1)
WPS2809	125dBc	3600	4500	118.1 (300)	32.5 (82.5)	_	508 (230.4)	445 (202.3)
WPS2810	126dBc	4000	5000	130.5 (331.4)	32.5 (82.5)	_	560 (254)	452 (205.5)
Electronics Cabinet[1] (WPS2801 to 5)	_	_	_	40.7 (103)	30.0 (76)	10.0 (25.4)	_	_
Electronics Cabinet[1] (WPS2806 to 10)	_	_	_	64.4 (164)	30.0 (76)	10.0 (25.4)	_	_
Pole Top Bracket	_	_	_	30.5 (76)	12.0 (30.5)	10.0 (25.4)	71 (32)	_

EQUIPMENT IS CONFIGURED FOR 120 VAC INPUT POWER, OTHER INPUT VOLTAGES SUPPLIED UPON REQUEST.
[1] A 6.00" WIDE MOUNTING CHANNEL ADDS 3.50" IN HEIGHT AND 2.00" IN DEPTH.

Appendix 4F

Sample Video Surveillance Vendor Information

3950 Series The Integrated Solution for Camera, Positioner and Control

COHU

Day/Night DSP Color Camera for natural color images by day, monochrome light sensitivity by night

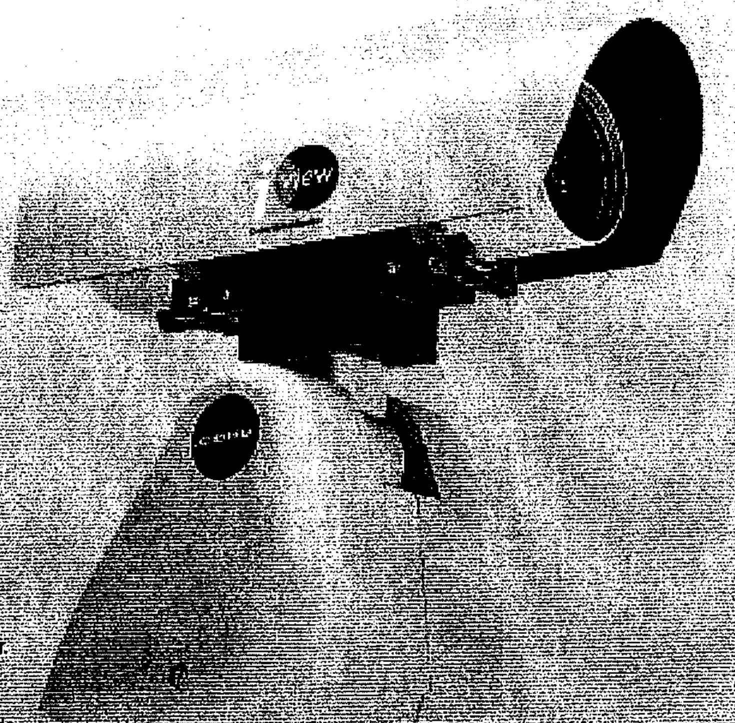
470 HTVL resolution color camera

23x optical zoom range

Sealed and pressurized enclosure for clean, reliable operation

Accurate, fast positioning with programmable presets, sectors, tours, more

Multi-protocol for easy integration



The 3950 Series "i-view" system combines a high performance camera, a sealed and pressurized enclosure with sunshield, and a precision positioner. The small, unobtrusive package is designed for outdoor surveillance. Easy installation and integration is assured with a choice of three mounting configurations and a wide range of communication protocols.

Extended Zoom Range

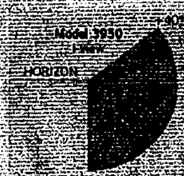
The i-view camera features a 23x optical zoom range (3.6 mm to 82.8 mm), with selectable automatic or manual focus. With its high resolution (470 HTVL) the i-view camera is ready to produce clear images of just about anything within its field of view.

Day/Night Camera Technology

Automatic Day/Night switching technology assures vivid color images during daylight, and high sensitivity monochrome images after dark. This greatly extends the nighttime or low-light capability of the camera. Day/Night operation, coupled with the camera's progressive scan sensor and internal scan converter, makes the 3950 Series ideal for traffic management, surveillance, and access control installations.

Fast Positioning

A high-speed positioner with up to 0.25° accuracy provides 360° continuous rotation and up to 64 user-defined preset positions, each with a two-line, 24-character title.



Touring, Sector IDs and Privacy Zones

Up to eight tours, each with up to 32 preset positions and dwell time, can be stored in and recalled from memory. Set up to sixteen sectors in a horizontal plane, each with its own identification title. In addition, eight programmable zones can be set to prevent the viewing of selected scenes.

Built for the Not-So-Great Outdoors

Cohu knows how to build for bad weather and environmental conditions. The 3950 Series operates in temperatures ranging from -40° to +131°F, and with operational wind loading to 90 MPH. It lasts longer, too. The sealed and pressurized enclosure protects the camera against salt, grime, dirt, and moisture, promoting operational reliability and reduced maintenance.

Multi-protocol Control for Complete Flexibility

All camera and positioner functions are controlled by the integrated receiver/driver, operable via RS-422 serial communications with digital position feedback. The included camera control software, WinMPC, sets up camera and positioner functions. i-view cameras are multi-protocol, so they can be easily and inexpensively integrated into systems from different manufacturers.

In case of power failure, all 64 preset camera/positioner positions are stored in nonvolatile memory. Stored system configurations, such as privacy zones or titles, or firmware upgrades can be uploaded into the i-view remotely.

SYSTEM SPECIFICATIONS

Pan/Tilt Drive
Angular Travel: 360° continuous pan range, -90° to +40° tilt range
P/T speed (preset): 100°/sec
Preset Accuracy: >0.25°
Pan Speed (manual): 40°/sec
Tilt Speed (manual): 20°/sec

Electrical
115VAC, 50/60Hz; Combined camera and positioner uses 50 W max.

Weight
Combined camera and positioner, 28 lbs (16 kg)

Environmental
–40° to 55°C (–40° to 131°F) for sustained system operation

Presets
64 preset positions

Title Generation
2 lines of 24 characters each for camera ID; plus preset ID, sector ID, privacy zone, and low pressure alarm

Tours
8, each consisting of 32 presets with dwell time per preset per tour.

Sectors
16 in the horizontal plane

Privacy Zones
8 programmable zones can be set for video blanking.

Cloning
Positioner settings (presets, title, etc.) can be stored to file for easy duplication

Humidity
100% relative humidity

Vibration (less lens)
Sine vibration from 5 to 30 Hz, 1/2 g, 3 axis, one hour

Shock (less lens)
Up to 10 g, 11 ms, in any axis under nonoperating conditions

Air Contaminants
Withstands exposure to sand, dust, fungus, and salt atmosphere, per MIL-E-5400T, paragraph 3.2.24.7, 3.2.24.8, and 3.2.24.9

Acoustic Noise
Can withstand environments >150 dB continuously for 30 minutes

EMI
FCC rules, Part 15, Subpart J, for Class A devices

CAMERA

Imager
1/4" color, progressive scan, interline transfer CCD

Resolution
NTSC or PAL: 470 horizontal TV lines

Lens
Integral 23X optical, 3.6 to 82.8 mm with 10X digital, auto/manual focus

Sync
Phase adjust line lock for system-wide sync

Day/Night Switchover
Day (color) / night (mono), manual or auto

Sensitivity (scene)
3.0 lux @ 1/60 sec. (color day)
0.2 lux @ 1/4 sec. (color day)
0.3 lux @ 1/60 sec. (mono night)
0.02 lux @ 1/4 sec. (mono night)

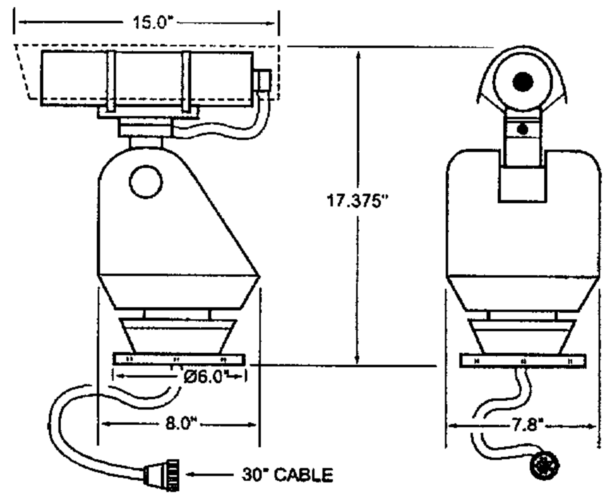
Housing Pressurization
Sealed and pressurized to 5 psi with dry nitrogen; Rated IP67, NEMA 4X

COMMUNICATIONS

Communications
RS-422 serial with digital position feedback;
RS-485 optional

Protocol
Non-proprietary Cohu standard; others available: American Dynamics, Pelco, Ultrak, Vicon, Javelin, Kalatel, Phillips, NTCIP

Firmware
Stored in flash memory; upload via serial port

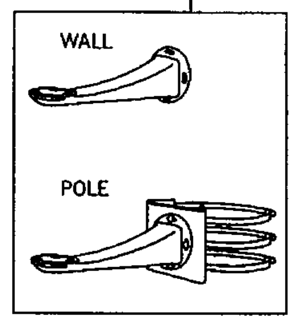


ORDERING INFORMATION

395X-XX - XXXX

- **WALL** - Wall mount
- **POLE**- Pole mount
- **PEDD** - Pendant mount

PROTOCOL
1 - Cohu
2 - American Dynamics
3 - Pelco D
4 - Ultrak
5 - Vicon
6 - Javelin
7 - Kalatel
8 - Phillips
9 - NTCIP

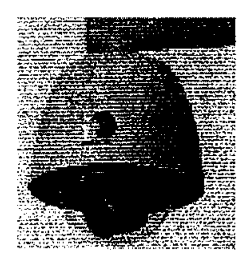


VIDEO
3 - NTSC Phase Adjust
7 - PAL Phase Adjust

POWER
5 - 115 VAC

High performance DSP camera in 3.5" sealed and pressurized housing, high speed positioner, sunshield.

Same great features are available in the 3920 Series i-dome



COHU
Cohu, Inc. / Electronics Division
ISO 9001 Certified

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P.O. Box 85623
San Diego, CA 92186-5623
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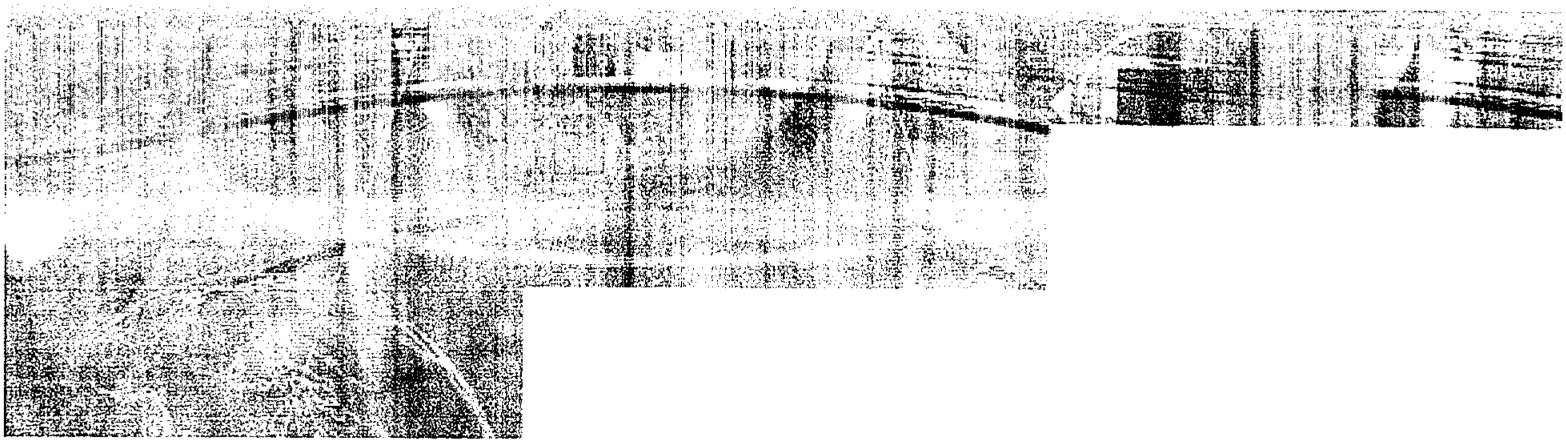
FAX: (858) 277-0221
www.cohu-cameras.com
info@cohu.com

3950 12-02
Printed in USA



AXIS 2400+/2401+
Video Servers

Follow-ups to the world's most sold video servers

The AXIS 2400+ / 2401+ Video Servers are high performance video servers designed for professional surveillance applications, giving increased memory and performance compared to their predecessors.

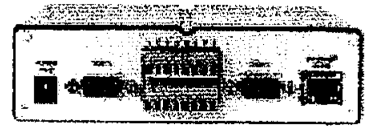
Connecting directly to an Ethernet network or modem, the AXIS 2400+ can accommodate up to four analog video streams, whereas the AXIS 2401+ accommodates a single video input stream and a video output for the connection of an analog monitor. Transforming traditional analog video into high-quality digital images, these Axis video servers provide a comprehensive single box solution for video transmission over intranet networks, or the Internet.

Easy to install and use, a professional surveillance application can be up and running in minutes. The system is as open or as closed as you like.

- Live video and remote monitoring - with standard TCP/IP networks
- Increased memory and performance
- High quality motion-JPEG images at up to 30 frames / second
- Support for Pan, Tilt, Zoom units
- Built-in Web Server

AXIS®
COMMUNICATIONS

Technical Specification - AXIS 2400+/2401+ Video Servers



General

- Use as a standalone system or added on to existing CCTV systems
- Remote configuration and status using Web based tools
- PPP/Modem support
- Event handling including mail, TCP, HTTP and FTP notification and video upload
- Audio functionality available in combination with the AXIS 2191 Audio Module

System Requirements

Compatible with:

- Operating systems such as Windows 2000, Windows XP, Windows NT, Windows ME and Linux
- Web browsers such as Internet Explorer 4.x, 5.x, 6.x or Netscape Navigator 4.x

Hardware and System

- CPU: ETRAX 100LX, 32 bit RISC, 100 MIPS
- Compression chip: ARTPEC-1
- 4 MB Flash memory
- 32 MB SDRAM
- 100baseTX Fast Ethernet or 10baseT Ethernet
- Network protocols: TCP/IP, HTTP, FTP, SMTP, NTP, ARP, DHCP, BOOTP and more
- Based on Linux version 2.4 operating system

Connections

Network

- RJ45 connection to 10/100 Mbit Ethernet networks

Video inputs

- The AXIS 2400+ has four BNC composite video inputs with 75/Hi Z termination
- The AXIS 2401+ has a single BNC composite video input with 75/Hi Z termination and one BNC video loop-through port
- Auto sensing for NTSC and PAL

I/O

- A single Terminal Block connector providing four opto-isolated alarm inputs and a single output relay

Serial connectors

- 9 pin D-SUB RS-232 max 115 Kbit/s
- 9 pin D-SUB RS-232 or RS-485/422 half duplex, max 115 Kbit/s

Power

3 alternative power sources:

- External power supply 12V AC, 9.6 VA (PS-D, included)
- 9-20V AC, min 10VA
- 6-30V DC, min 7W

Video

Frame rate

- Image frame rate: up to 25 (PAL)/30 (NTSC) frames/second
- Bandwidth control prevents data saturation on the network

Compression

- Motion-JPEG video, as well as JPEG still images

Resolution	Compression level		
	Low	Medium	High
NTSC 352x240	10 KB	7 KB	3 KB
NTSC 704x480	43 KB	28 KB	13 KB
PAL 352x288	12 KB	8 KB	4 KB
PAL 704x576	52 KB	34 KB	20 KB

- 5 levels of compression are available. The file size of a JPEG compressed image depends on the actual content of the image. Images containing a lot of detail will generate larger files. Image quality is controlled through the level of compression. High compression yields smaller files at the expense of image quality, while low compression results in larger files, but maintains image quality. The table above shows average file sizes, derived from real life tests

Resolution

- QCIF: 176 x 112 (NTSC), 176 x 144 (PAL)
- CIF: 352 x 240 (NTSC), 352 x 288 (PAL)
- 4CIF: 704 x 480 (NTSC), 704 x 576 (PAL)

Video features

- Date and time stamp and text overlay. Color control (B/W or color)

Security

- User level password protection for restricted camera access

Pre/Post alarm buffer

- Up to 12 MB memory available for pre/post alarm image storage, i.e. approx. 16 minutes of video at one frame/second, CIF resolution, normal compression

Pan/Tilt/Zoom

- PTZ support for remote camera control. Currently supported units and protocols include: EVI-G20/21, EVI-D30/31, EVI-D100/100P, Canon VC-C4/VC-C4R, Videmech 682/555rx, Ernitech ICU-PTZ S, Pelco DD5-C, Ultrak KD6/Smartscan III, Kalatel KTD-312, Surveyor TransitRCM, Daiwa DMP15-h1, Videor Tech. VPT42RS, Videotronic KON 485/HDI-5DE/SN-15AH, VCL 8" Microsphere, Lilin PIH717, IVC Pan/Tilt, Panasonic WV-CS850/854, Panasonic CS850A/854A, Molynx D05RX/L, Sensormatic SpeedDome Ultra III, Philips CSI Autodome G3A
- Future support for other PTZ units will be added – check Axis web site for the latest update

Firmware updates

- Flash memory allows firmware updates over the network, using FTP over TCP/IP. Firmware upgrades available from Axis' web site at: www.axis.com

Customer Applications

- Compliance with the AXIS HTTP API for applications and systems integration
- Support for shell scripting to allow user defined applications
- Up to 0.5 MB available for storage of customer Web pages and scripts

Operating Conditions

- Temp: 40-125°F (5-50°C)
- Humidity: 20-80% RHG

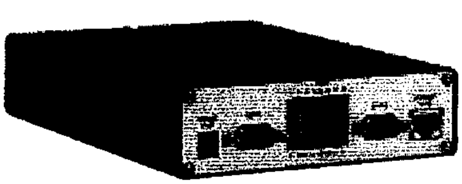
Dimensions and Weight

- Height: 1.7" (4.2 cm)
- Width: 5.7" (14.5 cm)
- Length: 8.7" (22.0 cm)
- Weight: 1.7 lb. (0.8 kg), excluding power supply

Approvals

- EMC: FCC Class A, EN55022/1994, EN55024/1998
- Safety: EN60950, UL, CSA

20407/EN/R1/0304



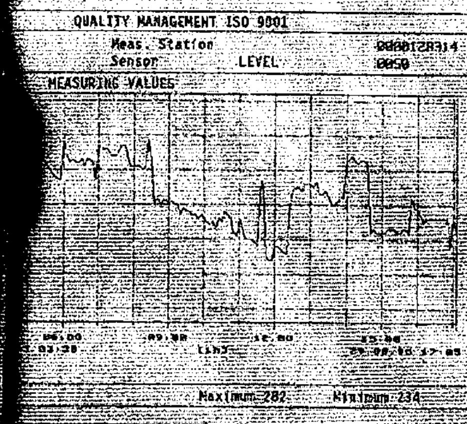
For more information visit our website: www.axis.com

AXIS COMMUNICATIONS

Appendix 4G

Sample Vendor Material for Ultrasonic Surface Water Elevation Measurement Gages

OTT
HYDROMETRIE



Radarsensor for the touchless measurement of surfacewater level

Kalesto


River with debris


Mountain stream

Kalesto

The Kalesto radarsensor represents a new type of level measurement for surfacewater which offers many advantages in hydrological field applications.
Kalesto is the first level sensor from OTT which does not come in direct contact with the water. Thanks to its compact design and the non-contact measuring principle, the sensor can be installed easily and inconspicuously, at no great cost in terms of time or money.
With the Kalesto, problems like disruption of measuring operation caused by high-water, silt accumulation, debris, plant growth etc. as well as time-consuming maintenance are eliminated.
Cumbersome stilling wells are replaced by an integrated software filter for averaging wave motion. The measuring signals are transferred to a data logger by means of a RS 485 interface, over distances of up to 1,000 m. A power supply of 12 V (rechargeable battery, solar energy) and low power consumption enable the device to operate independently in the most remote areas. Kalesto is particularly suitable for areas where conventional measuring systems cannot be used or where a station needs to be set up quickly and inexpensively.

Examples of use

In addition to the conventional applications, the Kalesto is also suitable for use in:

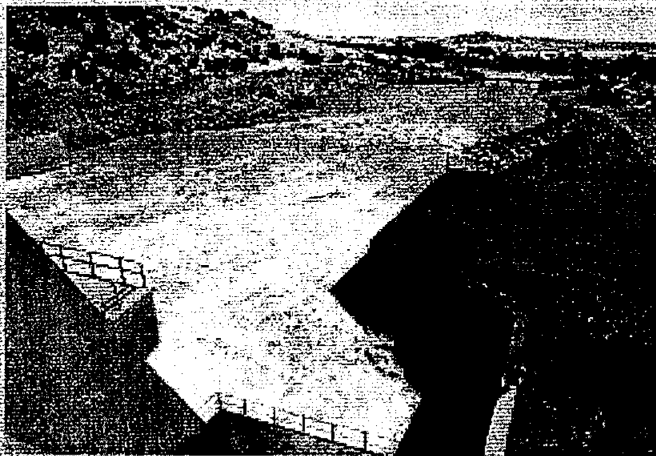
Brackish water, drains, rivers where great fluctuations are present
– no contact with the measuring medium

Irrigation canals, grachts, falajs
– simple installation e.g. on an extension arm

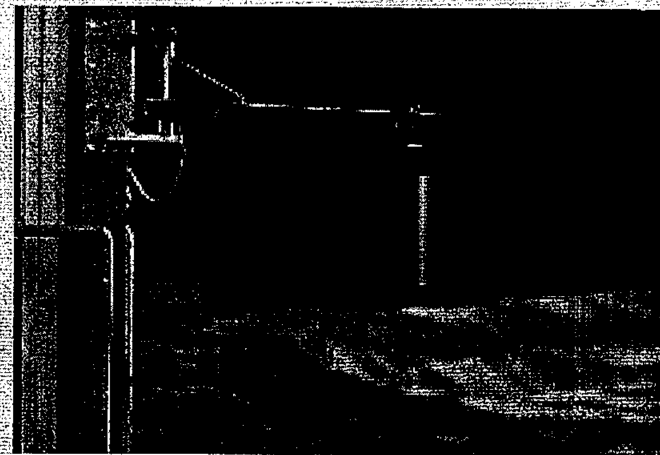
Water containing large amounts of suspended matter e.g.: mountain streams, wadis, etc.
– no silt accummulation
– sensor is easily moved e.g. when changes in water cross-section (low flow) occur; compared to stations with a gauging shelter and stilling well or inlet pipe

Short-term measurements, portable operation
Easy to handle - the same sensor can be used for a variety of projects without any need for alterations. The usual inconvenience associated with fixed lengths of measuring tubes, pressure sensor cables or float cable is thus avoided.

Weirs, harbour basins, dam walls, recharge dams
Not installed in water ⇒ the hydraulic system is not damaged, unaffected by construction and maintenance work.



Sediment loaded rivers



Installation at a "extension arm"

Features

- Non contact measuring principle, no damage caused by silt accumulation or debris
- Simple, inexpensive installation - no difficult fitting procedure necessary
- 12 V DC power supply; low power consumption enables operation with rechargeable batteries or solar
- Cost reduction due to low maintenance requirements
- RS 485 interface (data line up to 1.000 m), optional SDI 12 signal (RS 485 ⇔ SDI 12 converter)
- Integrated lightning protection fitted as standard
- Minimal risk of vandalism due to robust, weatherproof housing (IP 68)

Installation / Function

The Kalesto can be fitted easily and quickly, on a bridge, measuring frame, pipeline or "extension arm", for example.

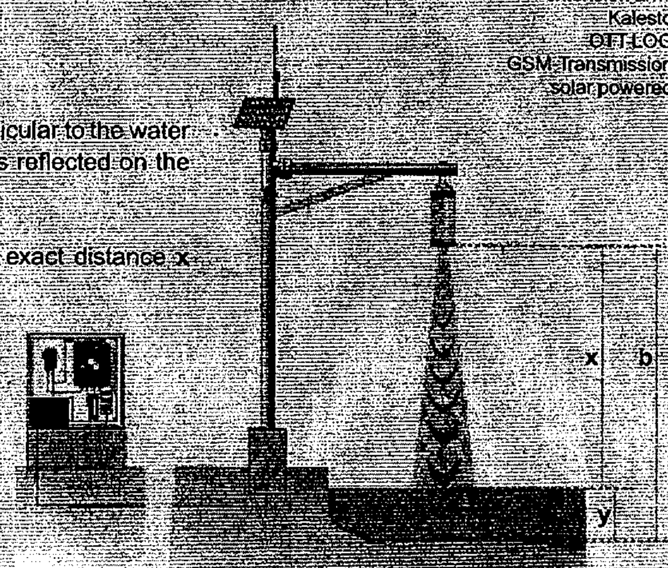
The water level is measured contactless from the air
⇒ absolute measuring principle.
The Kalesto sends radar waves (microwaves) perpendicular to the water surface. These waves are then mixed with the signals reflected on the surface.

An intelligent signal processor (DSP) calculates the exact distance **x** between the sensor and the surface of the water.

Digital measured values, status values and any error messages present are scanned by means of an external data logger via the RS 485 interface.

The data logger calculates the water level **y** out of the system length **b** and the distance **x** and makes the stored values available for further processing.

Example for installation:
"extension arm"
Kalesto
OTT LOG
GSM Transmission
solar powered



Extensions

OTT-LOG
Multi-channel
data logger

Kalesto / OTT LOG - an ideal combination

Circular memory, buffered for up to 400,000 measured values (1 MB)
– preselectable sample- / storage intervals
– event-driven recording

RS 232 interface for directly connecting the Kalesto HYDROSENS combination to various remote data transmission systems (serial modem / GSM, satellite, radio, etc.)

Three additional slots for connecting other sensors (e.g. for conductivity, temperature, precipitation, etc.)

CAN-bus for connection to other HYDROSENS modules, such as an OTT-COM communication module
– Alarm management when levels either exceed or fall below limit values and connection to an OTT-S measured value announcer

HYDROSENS
«MIDI»

Wall-mounted cabinet, IP 64 (190 x 250 x 140 mm W/H/D) for housing the OTT-LOG data logger

Optical interface (infra-red technology)
Reading of OTT-LOG stored values on site with a notebook or VOTA multifunctional unit.

LCD for clear display of system and sensor parameters (level recorder function)

Operating terminal
A clearly laid-out operating matrix allows parameters for the data logger and the relevant sensors to be set quickly and directly on site using the integrated touch sensitive keyboard.

Technical Data

Dimensions:

Dia:
160 mm

Length:
560 mm incl.
mounting threat
M 16 x 60 mm

Weight:
8 kg

Material:
Aluminium body, UV resistant plastic (POM) cover, protection IP 68

Measuring range: 1.5 ... 30 m (5 ... 90 ft)

Resolution: 1 mm (0.01 ft optional)

Accuracy:
± 1 cm (± 0.03 ft) over the complete measuring range

Temperature range: -40 °C ... +80 °C

Sensor technology:
Touchless measurement of water level using the FMCW principle (Frequency Modulated Continuous Waves)

microwaves:	24.125 GHz, 5 mW
beam width:	± 5°
dead range:	1.5 m (5 ft)
installation distance:	min. 1 m (3 ft), e.g. from a wall
measuring interval:	17 sec. (40 values, creating mean values)

Power supply:
Nominal 12 V DC 9 ... 15 V DC (accu, solar- or mains supply)
500 mA active
< 1 µA stand by

Integrated lightning protection (standard) to reduce the possibility of damage caused by over voltage (lightning).

RS 485 interface:
– digital data transmission up to 1.000 m (3,000 ft) distance
– Transmission rate 9,600 bps

Signal line:
Connection Radarsensor ↔ data logger.
Standard length 3 m (10 ft) (max. 1.000 m / 3,000 ft)
– Outer dia = 6 mm incl. connecting clamps

Sign of registration:

I C T DB10 117L

Small design details may be changed without notice.

Delivery program, e.g.:

Raingauges
Shaft Encoders
Data Loggers
Remote Data Transmission
Waterlevel Recorders
Current Meters

OTT HYDROMETRIE
OTT MESSTECHNIK GmbH & Co. KG
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Ludwigstraße 16 · D-87437 Kempten
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Fax ++49 (0)831 / 56 17-209
eMail: info@ott-hydrometry.de
http://www.ott-hydrometry.de

63.100.000.P.E D-H/1.109909 KKW

Installation

The Compact-Station can be installed in a wide range of locations. The pre-formed stand with base plate can be mounted on a concrete base, a natural hard surface (such as bedrock) or a bridge. The special design shape of the stand and base plate also allows for it to be attached to either a groundwater or surface water stilling well of up to 120 mm. If the base plate is removed, the station can be attached to walls. Thanks to the sub-frame, which is preassembled in the factory, the Compact Station takes only a few hours to be assembled. The first measured and logged data will be available the very same day.

Secure stand to concrete foundation

Insert pole with solar panel and GSM antennae into the stand

Attach sub-frame, connect sensors and close protective housing.

Technical data

Mechanical specifications
- Stand: U profile with base plate; 100 DIN1026-StZn; 1.7 m
- Aluminium pole, anodised; pole dia. 70 mm x 5 mm; bracket on end of pole for antenna and solar panel
- Protective housing: GFK plastic; 275 x 300 x 540 mm; 1.4301 stainless steel sub-frame; safe from flooding
- Total height: 4.2 m

Power supply
- 12 V / 30 W solar panel; 450 x 530 mm (x 2 if required)
- Solar charge regulator and exhaustive discharge protection (Power Control Unit 12)
- Maintenance-free back-up battery 12 V / 24 Ah

OTT – Your partner for:
- Water level measurement in ground and surface water
- Discharge measurement
- Precipitation
- Water quality measurement
- Data management and communications
- HydroService: consulting, training, installation and maintenance

OTT MESSTECHNIK GmbH & Co. KG
P.O. Box 2140 · D-87411 Kempten
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E-mail: info@ott-hydrometry.com
Internet: http://www.ott-hydrometry.com

We reserve the right to make technical changes. 56.560.000.P.E · As at: 02/2001

OTT HYDROMETRIE

Autonomous, cost-effective measurement station for collection of hydrological data

Compact-Station

CompactStation

Increasingly, the ability to forecast environmental data precisely and accurately to specific criteria is becoming more important. To do this a measurement network is required which can gather up-to-date environmental data reliably and in a cost effective manner. At OTT we have come up with an interesting solution to meet these requirements: the new CompactStation. This fully equipped measurement station can operate as a stand-alone unit thanks to its solar power supply and GSM communications option. It does not require any external utility supplies and can be mounted quickly and cheaply in a single day and as a rule permission to erect the sites are not required.

Design

The CompactStation is supplied with all components required to operate a measurement station: sensor, data-logger, communication equipment as well as a power supply. These components are mounted on a sub-frame at the factory to the customers specification. The sub-frame can then be inserted into the station during installation.
The housing is constructed using the diving bell principle, this means that an air pocket prevents the unit from flooding even if it is inundated by flood water and prevents the instruments from being harmed.
The design and construction material of the unit also deter unauthorised access to the instruments as well as protection against the elements. In its standard design, the CompactStation has an integral stand with a base plate to secure it to a concrete foundation. Alternatively, it can be mounted to a bridge or convenient wall with other fixing options. The extension pole can have one, or if required, two solar panels as well as the communication antennae. The pole can also be used to mount meteorological sensors giving the unit even more flexibility. The customer can specify, GSM, radio or satellite options to communicate the data collected. The design of the CompactStation gives the customer a fully autonomous monitoring station that can be erected quickly and cost-effectively giving them an effective alternative to conventional monitoring stations.

CompactStation basic package

- Sub-frame with protective housing
- 12 V / 30 watt solar panel
- Solar charge regulator and exhaustive discharge protection
- 12 V / 24 Ah battery pack
- Stand (U profile; 1.7 m)
- Aluminium pole (dia. 70 mm; 3 m)
- Assembly set

Equipment options

Data-logger
- HYDROSENS (MIDI housing)
- LogoSens •

Water level
- Kalesto radar sensor
- NIMBUS bubble principle sensor
- Thalimedes shaft encoder

Water quality
Conductivity, pH value, temperature, ORP, dissolved oxygen, turbidity:
- MINISONDE 4a / DATASONDE 4a
- Quanta / Quanta-G

Communications
- GSM modem
- Radio
- Satellite

Discharge measurement
- Ultrasonic system Sonicflow
- Kalesto radar sensor

Meteorology
- Wind speed and direction
- Air temperature, humidity and pressure
- Global solar radiation

OTT HydroService

OTT's comprehensive HydroService can, if required, look after the stations from design to data evaluation. In this way, we truly offer a one-stop-shop as we coordinate and carry out the planning and construction required to mount the station. This involves installing and connecting sensors, mounting the station and commissioning it and providing documentation.

Maintenance

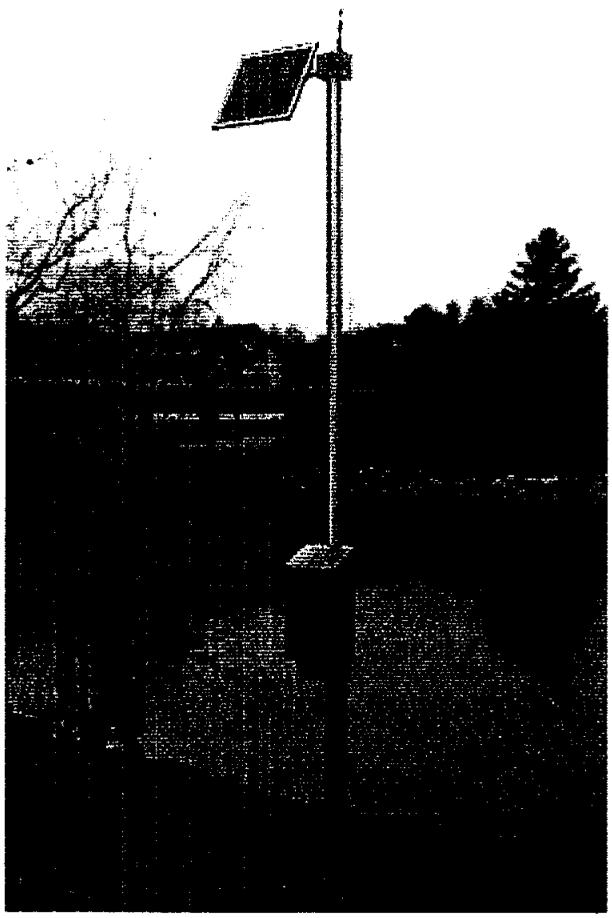
OTT offers a maintenance package specially designed to meet your needs. For example, we will check the performance of all important components at specified intervals.
Furthermore, we can offer a full replacement service in the event of station vandalism or storm damage.
Also, at strategically important sites a level of redundancy can be built into the station ensuring the highest possible security for essential data collection and retrieval.

Data management

As a further service, we offer you a complete data management system. This allows the data to be read out, verified and automatically forwarded to the customer. To achieve this we use our own bespoke application software HYDRAS 3 with the capability to: archive, edit, display and report on all data collected from the stations.

CompactStation

Autonomous, cost-effective measurement station for collection of hydrological data



[Details:]

The new CompactStation is a fully equipped measurement station that can operate as a stand-alone unit thanks to its solar power supply and GSM communications option. It does not require any external utility supplies and can be mounted quickly and cheaply in a single day.

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CompactStation Equipment options

Data-logger	• HYDROSENS (MIDI housing) • LogoSens ®
Communications	• GSM-Modem • Radio • Satellite
Water level	• Kalesto radar sensor • NIMBUS bubble principle sensor • Thalimedes shaft encoder
Water quality Conductivity, pH value, temperature, ORP, dissolved oxygen, turbidity:	• Minisonde 4a • Datasonde 4a • Quanta / Quanta-G
Discharge measurement:	• Ultrasonic system Sonicflow • Kalesto radar sensor
Meteorology	• Wind speed and direction • Air temperature, humidity and pressure • Global solar radiation

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