# SALT AND GILA RIVERS
# TRES RIOS NORTH LEVEE

# SUMMARY REPORT
# CONTRACT FCD 2010C027
# WORK ASSIGNMENT #2

## Maricopa County

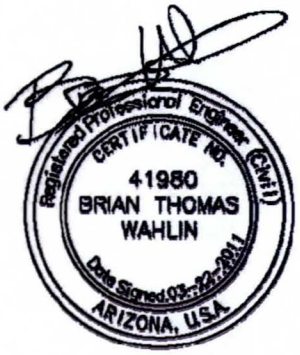
Prepared for:

**Flood Control District of Maricopa County**
2801 W. Durango Street
Phoenix, Arizona 85009

Prepared by:

**WEST Consultants, Inc.**
8950 South 52nd Street, Suite 210
Tempe, Arizona 85284

March 22, 2011

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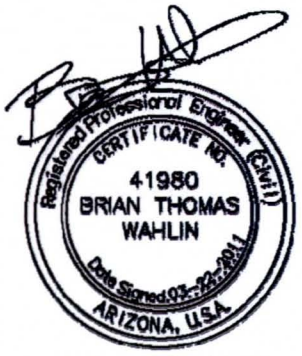


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# 1. Introduction and Coordination

WEST Consultants Inc. (WEST) was retained by the Flood Control District of Maricopa County (District) to aid the District and the U.S. Army Corps of Engineers, Los Angeles District (LACOE) in preparing a Letter of Map Revision (LOMR) package in support of the constructed Tres Rios North Levee. Dr. Brian Wahlin, Ph.D., P.E., D.WRE served as project manager and Chuck Davis, CFM served as project engineer.

This Summary Report has been developed according to the Technical Data Notebook (TDN) standards as specified in the Arizona Department of Water Resources State Standard SS1-97, but this version of the report is only an intermediate version as of March 11, 2011. Several additional tasks still need to be completed before finalizing the Summary Report and LOMR package.

- The remaining tasks to complete the LOMR package have been outlined in the body of this report and highlighted for clarification.

- Two highlighting colors have been used in the body of the report herein to identify different intermediate text that will need to be updated based on remaining task items before submitting the LOMR package. The action items that still need to be completed are highlighted in yellow, and estimates of the amount of effort required to complete these remaining items are highlighted in blue.

The LOMR study focuses on Phases 1A, 1B, and 1C of the Tres Rios North Levee along the Salt and Gila Rivers. The Salt River flows from east to west in the upper portion of the project reach; it is then joined by the Gila River, and the lower portion of the project reach maintains the name of the Gila River. This segment of the Gila River is also known as the Lower Gila River with respect to the overall watercourse alignment. Phases 1A and 1B consist of a new Tres Rios North Levee along the north bank of the Salt-Lower Gila River system that begins at approximately the 105$^{th}$ Avenue alignment and extends to 123$^{rd}$ Avenue (El Mirage Road). Phase 1C consists of a flood wall constructed along the west side of El Mirage Road from the Salt River to Southern Road. The entire project area consists of the north bank between 91$^{st}$ Avenue and approximately 123$^{rd}$ Avenue, with the area between 91$^{st}$ Avenue and the 105$^{th}$ Avenue alignment being comprised of constructed wetlands for environmental restoration. The hydraulic study limits are approximately 83$^{rd}$ Avenue along the Salt River upstream extending downstream to just below the Bullard Avenue Bridge downstream of the Agua Fria-Gila confluence along the Gila River. The project is within the Salt and Gila Rivers 100-year regulatory floodplain with over 65 percent of the constructed levee encroaching into the FEMA defined floodway as shown on the FIRM panels published 9/30/2005. A vicinity map showing the route of the levee embankment, the location of the existing bridge in the study reach, and the location of the primary constructed wetlands feature (that has been graded as of November, 2010) is shown in Figure 1-1.

The vertical datum of the existing Flood Insurance Study (FIS) HEC-RAS model (Michael Baker, 1999) is NGVD 1929 according to the published flood insurance profiles for the Salt and Gila Rivers (FEMA, 2005). This topography was developed as 4-foot contour interval mapping using photogrammetric methods based on aerial photography collected by Michael Baker, Jr.,

Inc., in 1991 and 1992. The horizontal datum of this mapping was NAD83, International Feet, projected in Arizona State Plane Central Zone coordinates.

Newer 1-foot topography in the main channel area of the Salt River was collected by Towill, Inc., on behalf of the LACOE in 2001. The new topography and all other elevations were also in the same vertical datum as the older 4-foot topography (NGVD 1929). This topography was developed as 1-foot contour interval mapping using photogrammetric methods based on aerial photography collected by Towill, Inc., on October 23, 2001. The horizontal datum of this mapping was NAD83, U.S. Survey Foot, also projected in Arizona State Plane Central Zone coordinates. For hydraulic modeling of the study reach, the newer 1-foot topography was used in the main channel and the older 4-foot topography was used in the overbank areas of the Salt and Gila Rivers by merging the two sets of topographic data. A Triangulated Irregular Network (TIN) was generated from the merged datasets in ArcView GIS v3.2a (ESRI, 2000). The TIN was used to cut channel cross-sections for the hydraulic model using the HEC-GeoRAS extension (2000) of ArcView GIS.

The hydrologic data (100-year event discharge) for this project were obtained from the FEMA Maricopa County Flood Insurance Study (FIS), FEMA, dated September 30, 2005. Water surface elevations in the upstream and downstream model limits were tied-in to those in the HEC-RAS model developed by Michael Baker (1999). The Baker model is currently the basis for the existing FIS data for the Salt/Gila River system in the vicinity of the Tres Rios Levee. This report will provide data to support revisions to those data with regards to the recently constructed Levee System features.

The purpose of the study is to re-delineate the 100-year floodplain and floodway of the Salt and Gila Rivers with the constructed Tres Rios North Levee and related features in place through a LOMR request package. The work meets the requirements of the Arizona Department of Water Resources State Standard Attachment SSA1-97 (ADWR, 1997).

Based on the National Flood Insurance Program (NFIP) requirements for LOMR studies, a certain amount of public notification is required to complete the LOMR. This public notification includes (1) a legal advertisement run in a widely circulated newspaper two times with approximately one week between runs; (2) notification letters and personalized small-area maps mailed to affected property owners in the vicinity of the study area informing them of changes to the flood hazards affecting their property and of right-of-entry for survey access; (3) one open-house public meeting at the District office or near the study area to inform the public about floodplain terminology and to obtain public input concerning observed flooding events; and (4) development of graphics, full-size study plots with indices mounted on poster boards, and Google Earth visualization tools (pending internet availability) for the open-house public meeting. These will all be completed prior to the submission of the LOMR submittal to FEMA. The District will provide all the reproduction and mailing materials for the mailers, and WEST will provide technical assistance in developing these mailers. Also, at least two (2) representatives from WEST will attend the open-house public meeting.

WEST expects that coordination efforts including the development of draft notification letters, personalized small area maps, graphics development for the open-house meeting, and attending an open-house meeting will require approximately 6 hours of labor by the project manager, 16

hours by a staff engineer, and 4 hours by a drafter. Additionally, Google Earth visualization could be provided to be able to show residents very detailed views of their parcels with the effective and updated mapping products at the open-house meeting. This would require 4 hours of labor by a staff engineer, and this task item could only be provided pending internet availability at the open-house meeting location.

## 2. Data Collection and Form Completion

### 2.1 Data Collection

WEST expects that remaining data collection tasks will include verifying roughness parameter estimations and ascertaining the number of culverts in the low-flow roadway crossings in the reach by conducting an additional one-day field visit to the site for two WEST personnel for a total of 16 hours.

### 2.2 Study Documentation Abstracts for FEMA Submittals

Information related to Sections 2.1.1 through 2.1.10 of the Arizona State Standard Attachment SSA1-97, dated November 1997, is included following page X.

WEST expects that completing the ADWR abstract forms will require approximately 1 hour of labor by a staff engineer.

### 2.3 FEMA Forms

Forms required by FEMA are included in the text of this LOMR following the ADWR forms. Note that the interior drainage section of the levee/floodwall portion of the riverine structures form will be addressed by the Design Documentation Report (DDR) developed in-house by the U.S. Army Corps of Engineer, Los Angeles District (USACE 2011).

WEST expects that completing the FEMA MT-2 forms will require approximately 16 hours of labor by a staff engineer and 2 hours of review by the project manager.

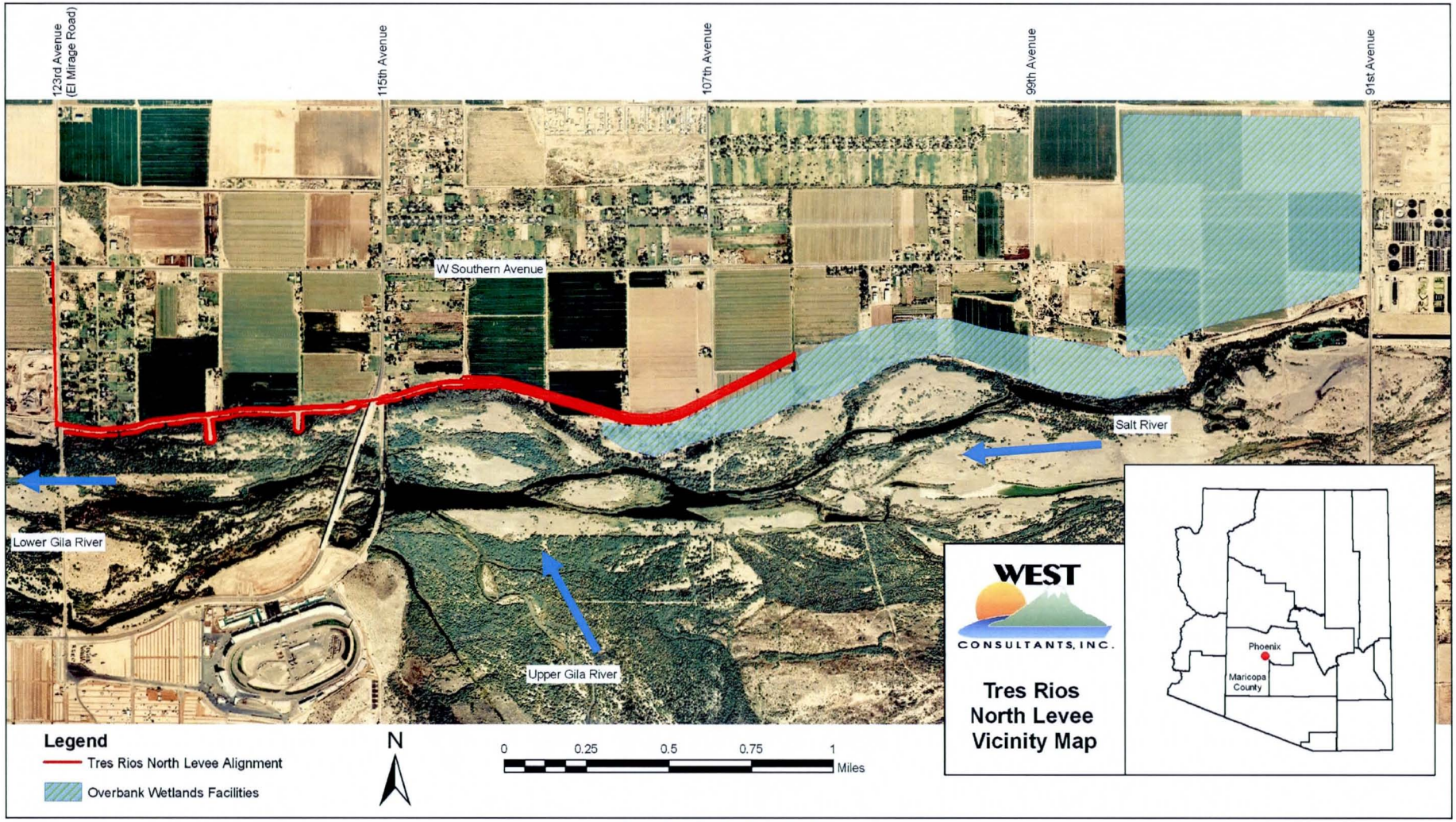


**Figure 1-1. Project Location Map**

## 3. Surveying and Mapping Information

### 3.1 Field Survey Information

Primary data regarding the field survey information has been delivered by the LACOE. Supporting documentation for the survey data can be found in Appendix C. These data include As-built plans for the Levee System features and survey information for cross-sections collected in 2011 to check the 2001 topography. Based on this survey information, the RMSE of the 2001 topography is +/-X.XX' in the vertical and +/-X.XX' in the horizontal. The locations of these surveyed cross-sections coincided with cross-section alignments in the post-project HEC-RAS model provided by the LACOE.

Independently verifying the 1-foot contour interval topographic dataset by field survey, if completed, will fall to the District. WEST expects that at least 3 to 5 cross-sections will need to be verified independently for this task item. Locations of these cross-sections should coincide with cross-section alignments in the post-project conditions model, and these cross-section locations will be determined upon further investigation and review of the post-project conditions model. WEST will recommend locations of likely similitude between the current topographic conditions and 2001 topographic conditions based on a comparison of recent and pre-project aerial photographs. WEST expects that this task will require approximately 4 hours of labor by the project manager and 4 hours of labor by a staff engineer. It is assumed the actual survey will be performed by the District.

### 3.2 Mapping

Data regarding the mapping information have been delivered by the U.S. Army Corps of Engineers, Los Angeles District. Two sets of topographical mapping have been merged into a single product: 4-foot contour interval and 1-foot contour interval mapping. The 4-foot mapping covers mostly the river overbank areas, while the 1-foot mapping covers the main channel areas. The merged topographic mapping product is included on a disk in Appendix C. The extents of the 4-foot topography provided by the District and the 1-foot topography provided by the LACOE are shown in Figure 3-1. Additionally, a certification statement for the 1-foot topography provided by the LACOE has been provided in Appendix C.

Independently verifying the 1-foot contour interval topographic dataset by field survey, if completed, will fall to the District. WEST expects that at least 3 to 5 cross-sections will need to be verified independently for this task item. Locations of these cross-sections should coincide with cross-section alignments in the post-project conditions model, and these cross-section locations will be determined upon further investigation and review of the post-project conditions model. WEST will recommend locations of likely similitude between the current topographic conditions and 2001 topographic conditions based on a comparison of recent and pre-project aerial photographs. WEST expects that this task will require approximately 4 hours of labor by the project manager and 4 hours of labor by a staff engineer. It is assumed the actual survey will be performed by the District.

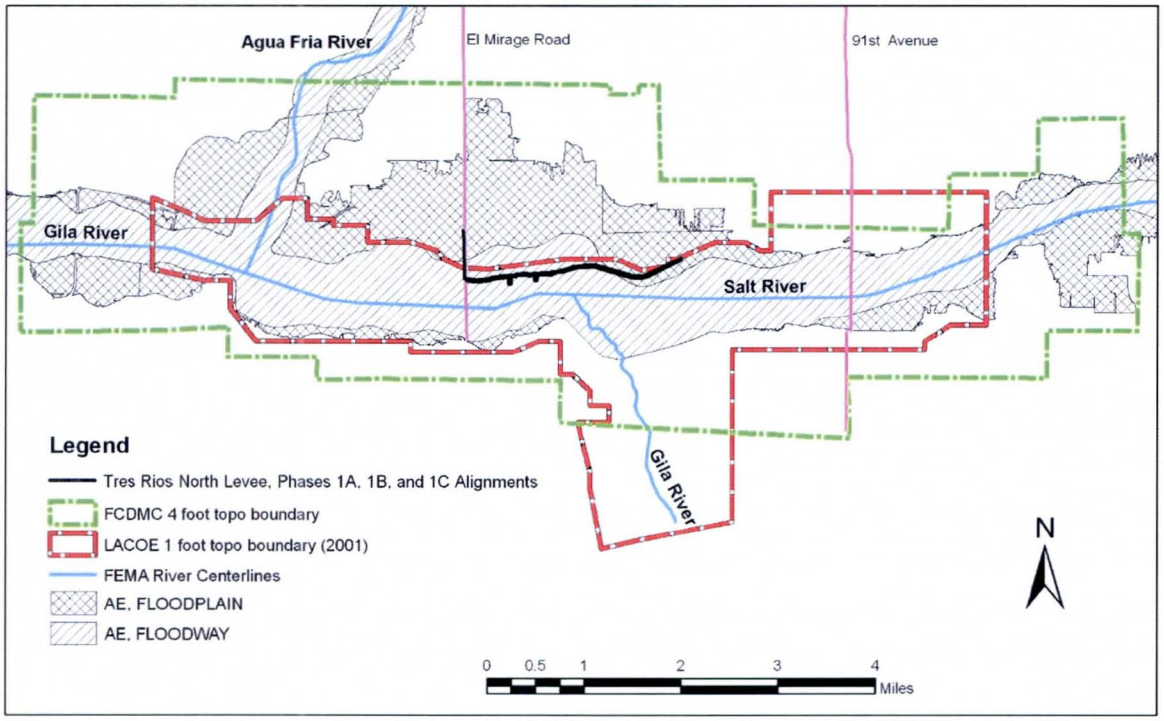


**Figure 3-1. Extents of the Topographic Datasets Used for the Study**

## 4. Hydrology

The current FEMA regulatory 100-year discharge for the Salt River study reach is 164,000 cfs, with a drainage area of 13,700 square miles (FEMA, September 30, 2005). The current FEMA regulatory 100-year discharge for the Gila River study reach below the Salt River confluence is 227,000 cfs, with a drainage area of 42,900 square miles immediately below the confluence of the Gila and Salt Rivers – the Gila River upstream of the Salt River confluence drains approximately 29,200 square miles. Of this 42,900 square miles, approximately 60% of the drainage area (25,400 square miles) has regulated and controlled runoff, primarily due to the operation of Roosevelt Dam on the Salt River and Coolidge Dam on the Gila River (USACE, 2011).

The current Flood Insurance Study hydrology is based on Michael Baker's 1999 analysis of the 100-year flood for the Salt and Gila Rivers, which was largely based on a report completed by the LACOE in 1996 titled *Section 7 Study for Modified Roosevelt Dam, Arizona (Theodore Roosevelt Dam): Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam* (USACE, 1996).

Table 4-1 lists the discharges at flow change locations for the pre-project conditions and the post-project conditions HEC-RAS models. As can be seen from this table, the flows are equivalent for both the pre-project conditions and post-project conditions hydraulic models.

**Table 4-1. Discharges Used in the Main Channel of the Hydraulic Model**

| Flow Change Location (HEC-RAS Cross-Section ID Number) | Pre-project Conditions Discharge (cfs) | Post-project Conditions Discharge (cfs) |
|---|---|---|
| 203.48 (River: Salt, Reach: Salt) | 162,000 | 162,000 |
| 199.47 (River: Gila, Reach: Lower Gila) | 227,000 | 227,000 |
| 1.67 (River: Gila, Reach: Upper Gila) | 65,000 | 65,000 |

As expected, the post-project conditions HEC-RAS model delivered by the LACOE used the hydrology originally delivered to the LACOE as part of the PED model deliverable, which are slightly different that the FIS flows. Therefore, the current flows in the HEC-RAS model are 162,000 cfs in the Salt River, 65,000 cfs in the Upper Gila, and 227,000 cfs in the Lower Gila. These flows can be changed in the final hydraulics model to reflect the FIS flows (164,000 cfs in the Salt River, 227,000 cfs in the Lower Gila River, and 63,000 cfs in the Upper Gila River); however, the calculated freeboard might be slightly less with a flow of 164,000 cfs in the Salt River. On the other hand, using the original flow value of 162,000 cfs as per the PED model could cause consternation with FEMA during the review process.

# 5. Hydraulics

## 5.1 Method Description

Several hydraulic models for the Tres Rios North Levee project area are mentioned in this report. The first model is the effective Flood Insurance Study (FIS) HEC-RAS model (Michael Baker, 1999); the other models were developed by LACOE using HEC-RAS version 4.1. Following is a brief description of the hydraulic models mentioned in this report:

1. Effective Model. The existing Michael Baker FIS HEC-RAS, version 2.1, model generated through District contract FCD 92-01.

2. Duplicate Effective Model. The effective HEC-RAS model run in HEC-RAS version 4.1 with modifications made to duplicate the hydraulics and water surface elevations of the original FIS HEC-RAS, version 2.1, model. An encroached version of this model was also created. The task of developing these models will fall to LACOE, and WEST can complete these models if requested.

3. Corrected Effective Model. The duplicate effective model with corrections made to roughness parameters, structure data, ineffective flow areas, and other parameters which appeared to be outdated or otherwise incorrect in the effective model. An encroached version of this model was created. The task of developing these models will fall to LACOE, and WEST can complete these models if requested. (*NOTE: This model may or may not be necessary for the final LOMR depending on the differences between the duplicate effective model and the pre-project conditions model.*)

4. Pre-project Conditions Model. A hydraulic model using the 1-foot and 4-foot merged topography obtained from photogrammetric methods. This model was based on the 2001 topography and does not include any of the constructed Tres Rios North Levee project features. The task of developing this model will fall to LACOE, and WEST can complete this model if requested.

5. Post-project Conditions Model. A hydraulic model with the constructed Tres Rios North Levee project features. This model has been developed using the most recent topography plus the As-Built plans of the levee and other project features such as the overbank wetlands (OBW) near 91st Avenue. This model will created by the LACOE. An additional post-project conditions model showing a "without OBW embankment" scenario will be required for the LOMR submittal as well. This model is discussed in more detail below.

A comparison of the water surface elevations obtained using all of the hydraulic models can be seen in Table 5-2. The effective, duplicate effective, and corrected effective (if necessary) models were created to comply with FEMA requirements for this LOMR request. The pre-project conditions model was used to establish the hydraulics at the time that the 2001 topography was flown; this model is considered the "existing conditions" model from the Preconstruction Engineering and Design (PED) Hydraulic Design of the Tres Rios North Levee study completed previously by WEST for the LACOE (WEST, 2003). The post-project conditions model establishes the current hydraulics with the levee and attendant features in place. The most relevant comparisons were between the pre-project conditions and the post-project conditions models, since the differences show the impacts of the levee project features. Comparison of surcharges between the pre-project and the post-project conditions encroached models has been conducted for floodway analysis. This was done to verify the effect of the constructed levee features on water surface elevation surcharge.

The vertical datum of the 4-foot contour interval topography used in the effective FIS model (Michael Baker, 1999) was NGVD 1929 according to the published flood insurance profiles for the Salt and Gila Rivers (FEMA, 2005). The 2001 topography and all other elevations are also in the same vertical datum.

Effective Model

The effective flood insurance model of the Salt and Gila Rivers was based on four HEC-RAS models, each consisting of a reach of the river either with or without "levees" included. These "levees" reflect non-certifiable roadway embankments in the reach that act as levees, and the models analyze hydraulic conditions in the reach either with those embankments in place or assuming the embankment washes out during a flood. The original HEC-RAS files have the names Reach2, Reach3, R2wlevee, and R3wlevee. The most upstream reach with the 91st Avenue crossing was found in the second model, Reach3. All four of the effective models can be found on a disk located in Appendix E. The 100-year water surface elevations obtained from the effective model in the vicinity of the levee system can be seen in Table 5-2.

Duplicate Effective Model

Data regarding the duplicate effective models are being delivered by the LACOE. The task of developing these models will fall to LACOE, and WEST can complete these models if requested.

WEST expects that completing a duplicate effective model will require approximately 2 hours of labor by the project manager and 16 hours of labor by a staff engineer.

Corrected Effective Model

Data regarding the corrected effective models are being delivered by the LACOE. The task of developing these models will fall to LACOE, and WEST can complete these models if requested.

WEST expects that completing a corrected effective model could require approximately ½ of an hour of labor by a company principal, 2 hours of labor by the project manager, and 40 hours of labor by a staff engineer. This estimate of the required effort to complete this task could change depending on how well the final pre-project conditions model matches the output from the duplicate effective model.

Pre-project Conditions Models

Data regarding the pre-project conditions model are being delivered by the LACOE. The difference in water surface elevations between the pre-project conditions model and the effective model are shown in Table 5-1. The differences in water surface elevations between the two models can be explained in part by the more detailed and more up-to-date topography used in the pre-project conditions model within the main channel and in the overbanks, the much more closely spaced cross-sections in the pre-project conditions model, the corrections to natural changes in the channel made to the effective model (as explained in the Corrected Effective Model section, page X), and the addition of man-made structures along the reach following the development of the effective model but prior to the construction of the Tres Rios North Levee that were reflected in the pre-project conditions model.

The pre-project conditions model needs to be updated to match the roughness values that the LACOE has provided in the post-project conditions model. The only difference between the pre-project and post-project conditions models is supposed to be the representation of the as-built levee features in the topography; all of the hydraulic parameters (roughness coefficients, expansion/contraction coefficients, etc.) should be identical so the differences in water surface profiles between the two models can be attributed directly to the levee features alone. J.E. Fuller completed the Phase III pre-project conditions model for LACOE, which is the model that will be termed in the LOMR as the post-project conditions model because it represents post-project conditions for the Phase II features. This model varied from the original PED model in two primary ways: (1) the Phase I and Phase II Tres Rios North Levee were added to the topography and (2) several hydraulic parameters (primarily roughness coefficients) were significantly changed throughout the model. Therefore, the pre-project conditions model based on the 2001 topography will have to be updated to reflect all of the changes to the hydraulic parameters made by J.E. Fuller. As mentioned above, the LACOE is to provide this model.

WEST expects that completing a pre-project conditions model could require a significant effort (approximately 2 hours of labor by the LACOE project manager and 40 hours of labor by a staff

engineer). Additionally, WEST can provide technical support and review for the LACOE if requested.

**Table 5-1. Increase in Water Surface Elevations between Pre-project Conditions Model and Effective Model**

| Pre-project Conditions Cross-Section | Equivalent FIS Cross-Section* | Pre-project Conditions Water Surface Elevations (ft) | Effective FIS Water Surface Elevations (ft) | Pre-project Conditions Minus Effective (ft) |
|---|---|---|---|---|
| | | | | |
| | | | | |

*Note: The horizontal alignment of the pre-project cross-sections and the equivalent FIS cross-sections may differ by as much as XXX feet

Post-project Conditions Models

Data regarding the post-project conditions model are being delivered by the LACOE.

J.E. Fuller completed the Phase III pre-project conditions model for LACOE, which is the model that will be termed in the LOMR as the post-project conditions model because it represents post-project conditions for the Phase II features. Required updates to the post-project conditions model are currently being addressed by the LACOE, including the removal of the "levee" option in HEC-RAS in areas of the model not representing the Tres Rios North Levee, consistency in model roughness values, adding an additional guide dike into the model at 97$^{th}$ Avenue, and others.

Additionally, FEMA may require that the embankment for the overbank wetlands be removed from the model, creating a second post-project conditions model to submit to FEMA. This may be required because this embankment removes a portion of the floodplain from the mapped inundation area, but the OBW embankment is not being certified as a levee. Typically, any embankments not certified as a levee will be required to be removed from the topography for hydraulic analysis to determine the extent of inundation effects by removal of the non-certified embankment, especially when that embankment ties in with the constructed levee, as is the case with the OBW embankment.

Based on this requirement from FEMA, it is likely that two (2) post-project condition models will have to be created, a "with OBW embankment" model and a "without OBW embankment" model. The current HNTB model can be considered the "with OBW embankment" model, but Ineffective Flow Areas (IFAs) should be used at the crest of the embankment instead of the "levee" feature in HEC-RAS. To create the "without OBW embankment" model, the IFAs at the crest of the embankment should be removed from the model, and the water surface elevations and corresponding inundation area behind the embankment should be mapped as part of the floodplain. (It should be noted that the cross-sections upstream of the Tres Rios North Levee alignment—i.e., XS 200.6 and higher—do not have to have the OBW embankment physically removed from the geometry. The "without OBW embankment" analysis refers only to the

mapping of the floodplain assuming the embankment is not in place.) Also, this will show that the backwater effects from the levee features would not cause flow to go around the east end of the levee's Phase 1A alignment on the landward side if the OBW embankment were to fail. As mentioned above, the LACOE is to provide this model.

WEST expects that completing a post-project conditions model could require a significant effort (approximately ½ of an hour of labor by the LACOE senior engineer, 2 hours of labor by the LACOE project manager, and 40 hours of labor by a staff engineer). Additionally, WEST can provide technical support and review for the LACOE if requested.

Table 5-2 shows the 100-year water surface profiles for five different models. The last column in Table 5-2 shows the increase in floodplain water surface elevation between the "with OBW embankment" post-project conditions model and the pre-project conditions model in context with the allowable rise for encroachment per the current FIS data. As mentioned earlier, the main differences between the post-project and the pre-project conditions model is the addition of the levee and all related features along the north bank of the river. Plots of the annotated flood profiles showing the post-project conditions water surface elevations are shown in the Exhibit Maps Appendix (Appendix G).

**Table 5-2. Salt River and Gila River 100-Year Water Surface Profiles (NGVD 1929)**

| Cross-Section | Equivalent FIS Section | Effective Model (ft) | Corrected Effective Model (ft) | Pre-project Conditions Model (ft) | Post-project Conditions Model (ft) | Post-project Minus Pre-project (ft) |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |

Upon completion of the modeling tasks, WEST expects that completion of Tables 5-1 and 5-2 above can be completed with the labor estimates provided in Section 7 of this report.

5.2 Work Study Maps

Work study maps are being delivered by the LACOE. These may be altered to meet the District's standards for work study maps by WEST.

If work maps are required to be completed from scratch, WEST expects that this would require significant effort. However, the LACOE indicated in recent conversations that they will be providing the work map products, although the District will not request that the LACOE provide work maps that conform to District standards. Based on a mapping scale of 1" = 200' and plotting paper of 24" x 36", approximately 30 panels will be required to cover area of the entire hydraulic model as it has currently been developed (from the 83rd Avenue alignment to the Bullard Avenue Bridge) and an assumed extension of the model for tie-in with the effective model water surface elevation. Based on this number of work map study panels, WEST estimates that ½ of an hour of labor by a company principal, 4 hours of labor by the project manager, 16 hours of labor by a staff engineer, and 60 hours of labor by a drafter would be required for this task. However, if the model has to be extended further upstream and

downstream of the current estimation of the required hydraulic modeling reach in order to properly tie in to the effective model water surface elevations due to updated topography or other reasons, the number of panels would increase, thereby increasing the labor estimate for this task.

## 5.3 Parameter Estimation

### 5.3.1 Roughness Coefficients (Pre-project and Post-project Conditions)

Data regarding the estimation of roughness coefficients for the models are being delivered by the LACOE.

In the Technical Memorandum from HNTB to Van Crisostomo dated December 15, 2010, and titled "Revised Draft Tres Rios Phase 3 Pre-Project Hydraulic Analysis Review," HNTB states that the LACOE provided HNTB with an HEC-RAS model developed by J.E. Fuller and completed in May 2010 as the post-project conditions model. WEST expected that the LACOE was working with the HEC-RAS model developed by WEST as part of the PED study. The new HEC-RAS model developed by Fuller was delivered to HNTB with the title "Tres Rios Phase 3 Environmental Restoration Project Design Documentation Report - Hydraulic Analysis Appendix." The HNTB technical memorandum states that "Roughness values were increased and reassigned to have vertical variation as a function to discharge" and "Horizontal roughness variation was revised based on updated land cover information" compared to the PED model developed by WEST for the LACOE. Based on this information, WEST obtained the 2010 Fuller report Phase 3 post-project conditions model to determine if the description of roughness coefficients from that report matched the roughness coefficient values provided in the final updated HNTB model. These did not match. Therefore, a more thorough, detailed description of roughness coefficient values used by HNTB will be required to complete this section of the report. It is estimated that completion of this task will require 16 hours of labor by a staff engineer.

### 5.3.2 Expansion and Contraction Coefficients

Data regarding the estimation of expansion and contraction coefficients for the models are being delivered by the LACOE.

The Phase 3 post-project conditions HEC-RAS model developed by J.E. Fuller changed the expansion and contraction coefficients initially set in the PED model. Based on this information, WEST obtained the 2010 Fuller report for the model updates in order to determine the reasons to change expansion and contraction coefficients in the model. WEST estimates that updating these descriptions will require 2 hours of labor by a staff engineer.

## 5.4 Cross-Section Descriptions

Data regarding the descriptions of cross-sections in the model are being delivered by the LACOE. Figure 5-1 shows the cross-section alignments in the hydraulic models adjacent to the levee.

Since the cross-sections in the final model delivered by LACOE seem to be the same as the PED cross-sections, the description of the cross-sections from the PED report should be applicable in

most of the modeled reach. Some of the cross-section descriptions may be required to be changed in the vicinity of the levee features. WEST estimates that 2 hours of labor by a staff engineer would be required to complete this task.

ADD FIGURE HERE

**Figure 5-1. Post-project Conditions Cross-Sections and Tres Rios North Levee Alignment**

## 5.5 Modeling Considerations

### 5.5.1 Hydraulic Jump and Drop Analysis

None identified.

### 5.5.2 Bridges and Culverts

Two bridge crossings are present in the current post-project conditions model: the 115th Avenue Bridge downstream of the confluence of the Salt and Gila Rivers, and the Bullard Avenue Bridge downstream of the confluence of the Agua Fria River. In addition, several paved low-flow crossings with roadway profiles that are nearly at grade lie within the study reach. Considering their low profiles with respect to the relatively large FIS discharges, they are considered insignificant to the hydraulic analysis results and were therefore not included in the hydraulic model. However, they are still labeled on the work maps.

Information on the two bridges is provided in Table 5-3. Table 5-4 shows the freeboard for the proposed 100-year water surface profile at the two bridges under the post-project conditions model.

No culverts or low-water crossing culvert embankments were modeled in HEC-RAS due to their relatively small size in comparison to the 100-year flow depths in the main channel. However, there are XX culverts along the low-profile road crossings for the 91st Avenue crossing, the El Mirage Road crossing, and the crossing immediately upstream of the 115th Avenue Bridge.

**Table 5-3. Bridge Data: Salt and Gila Rivers**

| Bridge ID | Highway | Mile Post | Structure No. | Bridge Type | Agency |
|---|---|---|---|---|---|
| 115th Avenue Bridge | 115th Avenue (Avondale Blvd) | XXX | 10163 | Steel Girder | MCDOT |
| Bullard Avenue Bridge | Bullard Avenue | XXX | XXX | ??? | ??? |

**Table 5-4. Freeboard at Bridges for 100-Year Profile (Post-project Conditions)**

| Cross-Section | Description | Water Surface Elevation | Low Chord Bridge Elevation | Freeboard (ft) |
|---|---|---|---|---|
| XXX | 115th Avenue bridge, upstream face | XXX.XX | XXX.XX (lowest low chord elevation) | X.XX |
| | | | XXX.XX (highest low chord elevation) | X.XX |
| XXX | Bullard Avenue bridge, upstream face | XXX.XX | XXX.XX (lowest low chord elevation) | X.XX |
| | | | XXX.XX (highest low chord elevation) | X.XX |

WEST will need to contact MCDOT to receive the final plans for the 115th Avenue bridge structure (WEST already has the as-built plans for the Bullard Ave bridge on file). At that time, the Tables 5-3 and 5-4 above can be completed. This task should require approximately 4 hours of labor by a staff engineer at WEST.

### 5.5.3 Levees and Dikes

The primary feature of the Tres Rios North Levee project is the levee embankment along the north bank. On the north bank, freeboard design to the top of the coarse aggregate base cap (or other top of levee protection in the transition regions near the bridge) was set between 3.0 feet and 3.25 feet. U.S. Army Corps of Engineers' Flood Damage Reduction Analysis software, HEC-FDA, was used to obtain necessary freeboard for the proposed levee at a minimum 95% reliability level (i.e., a non-exceedance probability of 0.95) for levee overtopping. Stage uncertainty was computed using the methodology described in "Risk-based Analysis for Flood Damage Reduction Studies," EM 1110-2-1619 (USACE,

1996). More detailed information for the freeboard uncertainty calculations is given in the PED report (WEST, 2003), which is attached as an appendix to the DDR (USACE, 2011). The final freeboard values are shown in Table 5-5 below.

For all of the bank protection along the levee, the toe-down elevations of the bank protection were designed to withstand scour from the 100-year event. These toe-down depths varied from 2.50 to 4.28 feet throughout the length of the levee alignment.

An embankment stability analysis was performed by the LACOE. Their analysis indicates that the proposed embankment slopes are globally stable. Other analyses included for the levee structure included a seepage analysis and a settlement analysis. A copy of the geotechnical report including all of these analyses is provided as an appendix to the DDR (USACE, 2011). The DDR can be found in Appendix H of this report.

An interior drainage study was performed from the landward side of the levee, and the interior drainage analysis can be found as an appendix to the DDR (USACE, 2011). The results of this analysis identified possible flooding conditions on the landward side of the levee due to local runoff that would otherwise pass directly to the Salt/Gila River but would be prevented from so doing by the construction of the levee. This analysis provided the information required to design several interior drainage features to prevent these flooding conditions due to the construction of the levee. These features are summarized in the following list:

- 4 catch basins to store the local runoff volume of the interior drainage areas, varying in capacity from 5.5 to 26 acre-feet;
- 5 collector channels, 4 of which direct water into the catch basins and one which is located on the west side of the overbank wetlands area upstream of the levee embankment and directs flows south directly into the Salt River; and
- 4 outlet culverts (one per catch basin) sized to pass the design peak discharge from the catch basin's associated drainage area and fitted with a flap gate to prevent additional flooding on the landward side of the levee from water in the Salt-Lower Gila River system during high stage.

More detailed information regarding the location, sizing, and final design of the interior drainage features can be found in Appendix B of the DDR (USACE, 2011). A copy of the DDR can be found in Appendix H of this report.

**Table 5-5. Freeboard along the Levee Embankment for 100-Year Profile (Post-Project Conditions)**

| Cross-Section | Levee Station | Levee Elevation | Water Surface Elevation | Freeboard to Top of Levee | Comments |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

5.5.4 Islands and Split Flows

None identified.

5.5.5 Ineffective Flow Areas

Data regarding the ineffective flow area (IFA) locations in the model are being delivered by the LACOE.

The IFAs in the current version of the post-project conditions model delivered by the LACOE are not the same as the IFAs in the PED model. Since the IFAs will have to be changed to reflect the removal of the "levee" features of the HEC-RAS geometric data editor that are currently in the geometry but not representing the Tres Rios North Levee alignment, the description of the IFAs from the J.E. Fuller report will not be sufficient for this section. However, updates to these descriptions should not require significant additional effort (2 hours of labor by a staff engineer).

5.5.6 Supercritical Flow

Subcritical flow regime was modeled in HEC-RAS. No supercritical condition was considered with regards to FEMA modeling standards.

5.6 Floodway Modeling

The original floodway boundary was laid out by Michael Baker, Jr. (1999) so that the encroached water surface elevations would not be more than one foot higher than the un-encroached elevations, per FEMA regulations.

Data regarding the floodway modeling are being delivered by the LACOE (please see Appendix E for modeling output).

In order to verify that the placement of the proposed levee embankment will not cause excessive surcharge, a comparison of the encroached post-project conditions water surface elevations with those for the pre-project conditions will be conducted. The increase in the encroached post-project conditions water surface elevations compared to the pre-project conditions was less than or equal to one foot everywhere in the project reach. A summary of the floodway water surface profiles for the various models will be provided in Table 5-6.

Affected landowners will be notified regarding the proposed floodway changes per FEMA requirements. Copy of any public notice(s) required will be provided in appendix B.6.

WEST expects that completing the floodway encroachment analysis for the final model delivered by LACOE will require approximately ½ of an hour of labor by a company principal, 2 hours of labor by the project manager, and 20 hours of labor by a staff engineer.

**Table 5-6. Summary of Floodway (Encroached) Water Surface Profiles**

| Cross-Section | Existing Conditions Model (ft) | Proposed Conditions Model (ft) | Effective (FIS) Encroached Profile (ft) | Encroached Existing Conditions (with existing floodway) (ft) | Encroached Existing Conditions (with proposed floodway) (ft) | Encroached Proposed Conditions (with proposed floodway) (ft) | Encroached Proposed Minus Base Flood Proposed (ft) | Allowable Encroached rise (ft) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

## 5.7 Problems Encountered During the Study

### 5.7.1 Special Problems and Solutions

None were identified.

### 5.7.2 Modeling Warning and Error Messages

Data regarding the modeling warning and error messages are being delivered by the LACOE.

WEST expects that completing a write-up to address the modeling warning and error messages for the final model delivered by LACOE will require approximately 1 hour of labor by the project manager and 6 hours of labor by a staff engineer.

## 5.8 Calibration

Data regarding the calibration of the hydraulic models are being delivered by the LACOE.

WEST will need to further review the Tres Rios Phase 3 pre-project conditions HEC-RAS model report to ensure that J.E. Fuller did not perform any additional calibration, but it is assumed that they did not calibrate the hydraulic model beyond the level of calibration completed in the PED report. If this is the case, the description of the hydraulic model calibration from the PED report should be sufficient for this section.

## 5.9 Final Results

### 5.9.1 Hydraulic Analysis Results

A summary table of the post-project condition (without floodway encroachment) hydraulic modeling results for the 100-year event is presented in Table 5-7. The table summarizes the following variables by cross-section: peak discharge, water surface elevation, critical water surface elevation, average channel velocity, top width, hydraulic depth, Froude number, and stations for left and right edges of water surface. For comparative purposes, the floodplain and floodway elevations of the effective models and those calculated for this analysis are presented in graphical form in Figure 5-2.

Data regarding the hydraulic analysis results are being delivered by the LACOE.

WEST expects that generating plots (Figure 5-2) and tables (Table 5-7) of the results for the final model delivered by LACOE can be completed with the labor estimates provided in Section 7 of this report.

### 5.9.2 Verification of Results

Data regarding the verification of hydraulic analysis results are being delivered by the LACOE.

WEST expects that no verification will be possible.

### 5.9.3 Special Problems and Solutions

Data regarding the verification of hydraulic analysis results are being delivered by the U.S. Army Corps of Engineers, Los Angeles District.

WEST expects that the special problems section can be completed by WEST in the labor estimate provided in Section 5.7.2 above. Therefore, this task should not require any additional effort on the part of WEST, the District, or LACOE.

ADD FIGURE HERE

**Figure 5-2. Water Surface Elevation Comparison along the Salt-Lower Gila River System**

**Table 5-7. HEC-RAS Floodplain Summary Output (Post-Project Conditions)**

| River | River Sta | Q Total (cfs) | W.S. Elev (ft) | Crit W.S. (ft) | Vel Chnl (ft/s) | Top Width (ft) | Hydr Depth (ft) | Froude # Chl | Sta W.S. Lft (ft) | Sta W.S. Rgt (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| | | | | | | | | | | |

WEST expects that generating plots (Figure 5-2) and tables (Table 5-7) of the results for the final model delivered by LACOE can be completed with the labor estimates provided in Section 7 of this report.

# 6. Erosion and Sediment Transport

The main function of the Salt-Gila River System Sediment Transport model was to develop models to estimate baseline sediment conditions (pre-project conditions) and sediment conditions in the future (post-project conditions) to identify the impacts of the Tres Rios North Levee project features on the long-term sediment processes of the system. This model is included in Appendix F.

## 6.1 Method Description

A base conditions sediment transport model using HEC-6T (Thomas, 2002) was developed and adjusted to insure hydraulic similarity between the sediment transport model and the HEC-RAS model. A discussion of the modifications necessary to the modeling parameters to provide hydraulic similarity between the HEC-6T model and the HEC-RAS model results are provided in the following sections. HEC-6T parameter adjustment was necessary to reproduce water surface elevations from the HEC-RAS model for each pre-project and post-project condition modeled.

The computer program HEC-6T: "Sedimentation in Stream Networks", version 5.13 (2002), was used to conduct the numerical sediment transport modeling. Copeland's solution of the Exner equation (EXNER 7 HEC-6T option) is used in the sediment transport simulations to enable armoring to occur.

### 6.1.1 Hydrology

WEST developed a 105-year (1889-1993) series of hydrographs at the Salt-Gila confluence based on historical flows collected from various sources, including the USGS and the LACOE. Due to gaps in the hydrologic datasets used to create the 105-year record and uncertainty in flow routing procedures, sensitivity analyses were performed on the hydrologic record to determine the impact of hydrology on the final sediment conditions in the reach. It was found that the uncertainty due to missing data and routing parameters was not significant. More detailed information regarding the development of the hydrologic datasets for the sediment transport analysis can be found in the final PED report (WEST, 2003), which is attached as an appendix to the DDR (USACE, 2011). The DDR can be found in Appendix H of this document.

### 6.1.2 HEC-RAS Model Conversion

The geometry of the HEC-RAS hydraulic model was converted into a text file with the format required by the HEC-6T program. Conveyance limits defined in HEC-RAS using 5-year-discharge ineffective flow boundaries were coded in HEC-6T using XL records. The advantage of using XL record is that it allows deposition to occur in the ineffective flow areas. X3 records were used to set the encroachment limits or prevent flow into areas protected by natural or man-made levees. The upstream and downstream bridge cross-sections from the HEC-RAS model were retained. More detailed information regarding the conversion of the HEC-RAS into the HEC-6T format for the sediment transport analysis can be found in the final PED report (WEST, 2003), which is attached as an appendix to the DDR (USACE, 2011).

## 6.2 Parameter Estimation

### 6.2.1 Boundary conditions

Using normal flow considerations, an elevation-discharge rating curve was developed at the downstream boundary of the Lower Gila River (cross-section 195.16) for starting water surface elevations. The rating curve at this point was generated for discharges ranging from 0 cfs to 225,000 cfs at 7,500 cfs increments for a bed slope of 0.002 ft/ft. More detailed information regarding the boundary conditions for the sediment transport analysis can be found in the final PED report (WEST, 2003), which is attached as an appendix to the DDR (USACE, 2011).

### 6.2.2 Roughness Coefficients (Manning's *n* values)

Roughness coefficients (Manning's *n* values) were varied with depth at each cross-section in the HEC-6T model. After running the 5-, 20- and 100-year flood events in HEC-RAS, the profile output tables were used to extract conveyance weighted Manning's *n* values for the channel, the left overbank, and the right overbank for the different discharges. The modified data was then entered into the HEC-6T input file using NV records. A default value of 0.04 was used to fill blanks when the conveyance in an overbank area was zero. The result was a configuration of roughness coefficients changing vertically by discharge as well as horizontally by distance. More detailed information regarding the roughness coefficients for the sediment transport analysis can be found in the final PED report (WEST, 2003), which is attached as an appendix to the DDR (USACE, 2011).

## 6.3 Modeling Considerations

The decisive factor in selecting the proper sediment transport function was based on available bed gradation and maximum grain size. Initial data received from the LACOE supported a maximum grain size diameter of 76 mm. The bed material in the study reach is composed primarily of sand and gravel. Sand is the main transport size, but there is also a high percentage of gravel in the bed. Based on the analysis of the material, the Toffaleti-Meyer-Peter Muller (TMPM) combination transport method was used in the sediment transport simulations. This method accounts for sand and gravel transport and is well suited for river systems such as the Salt-Lower Gila. Also, by accounting for both sand and gravel, the TMPM method gives a higher, more realistic estimate of total sediment concentration (and thus total sediment load) compared with Yang's method for the study area. Based on field observations, to facilitate modeling and to represent larger diameter gravels and cobbles noted in the bed, a maximum grain size of 300 mm was used in the final sediment transport runs in HEC-6T.

### 6.3.1 Bed Sediment Characteristics

The particle size distribution of the bed sediment is typically the driving force of a sediment transport model. Due to the importance of this data in a sediment transport analysis, the LACOE and WEST personnel collected 22 surface samples along the Salt and Lower Gila reaches of the project area for the PED study. The data from these samples were then utilized within the HEC-6T model at various cross-sections. At locations with high spatial variability of sediment characteristics in the horizontal direction (i.e., across the channel), WEST and LACOE personnel collected more than one sample along a cross-section to represent the different types of bed material. In these cases, the resulting

gradation from the samples was combined into a single averaged gradation curve for use in the HEC-6T model. Information for these samples (including sampling locations and gradations) can be found in the final PED report (WEST, 2003), which is attached as an appendix to the DDR (USACE, 2011).

### 6.3.2 Inflowing Sediment Load

The HEC-6T model requires input of the bed material load at the upstream limit of the project reach for the entire range of discharges. For this model, inflowing sediment load had to be specified in the Salt River and Upper Gila River reaches (the two upstream boundaries of the model). The PED study investigated several alternative methodologies for estimating the inflowing sediment load for these two reaches. The final inflowing sediment load estimate used for the upstream end of the Salt River was obtained from the outflowing sediment load from the Rio Salado Oeste HEC-6T Modeling Study (WEST, 2002). The Rio Salado Oeste reach of the Salt River is immediately upstream from Tres Rios study reach. The final inflowing sediment load estimate used for the upstream end of the Upper Gila River was obtained from an equilibrium sediment load analysis based on representative cross-sections near the upstream end of the Upper Gila model limits within the PED study. This method is designed to estimate a sediment inflowing load and gradation that will provide stability in bed elevations throughout the model for an indefinite period of time (i.e., that the inflowing sediment load is equivalent to the transport capacity of the reach and the outflowing sediment load). The sediment loads were estimated for a range of discharges up to 200,000 cfs for the Salt and 100,000 cfs for the Upper Gila. More detailed information regarding the estimation of inflowing sediment loads for the sediment transport analysis can be found in the final PED report (WEST, 2003), which is attached as an appendix to the DDR (USACE, 2011).

### 6.3.3 Movable Bed and Erosion Limits

In general, sediment dynamics tend to be more significant within the active channel, where the bed can either degrade or aggrade in response to erosion or deposition, respectively. The overbank areas tend to be more stable and are normally free of erosion, but these areas can experience deposition. HD records were used to specify a bed sediment depth of 25 feet for all cross-sections in the HEC-6T model. Movable bed limits were identified at the boundary of the main channel in HD records. The movable bed limits extend beyond the 5-year low flow channel (regime channel) and the defined bank stations (which were defined based on a regime equation proposed by Blench (1970) and were based on the 5-year low flow channel as well). During high flows, significant deposition and scour were expected to occur within the movable bed limits, but only deposition was expected to extend to the overbank areas. More detailed information regarding the estimation of movable bed and erosion limits for the sediment transport analysis can be found in the final PED report (WEST, 2003), which is attached as an appendix to the DDR (USACE, 2011).

## 6.4 Problems encountered during the study

The only special consideration encountered during this sediment transport study was the requirement of toe-down depth calculations for the Tres Rios North Levee.

### 6.4.1 Special problems and solutions

An estimate of local scour along the levee was needed so that levee protection can be placed sufficiently low in the streambed to prevent undermining damage from potential degradation, a depth referred to as toe-down depth. Several regime equations were tested and results from the various methods were compared. The hydraulic calculations were performed for the post-project conditions model (referred to as the proposed conditions model in the PED study). The average depths of scour obtained from each of the equations were added to the magnitude of predicted degradation to arrive at total required toe-depth, and the most conservative method was chosen for the design. A 30% safety factor was added in the final toe-depth. Based on information available in the hydraulics and hydrology appendix of the DDR (specifically Plate 9), it was determined that levee toe-down depth should be between 2.5 and 3.47 feet for phase 1A and between 3.47 and 4.28 feet for phase 1B. More detailed information regarding the estimation of toe-down depth for the sediment transport analysis can be found in the final PED report (WEST, 2003), which is attached as an appendix to the DDR (USACE, 2011).

### 6.4.2 Modeling warning and error messages

None identified.

## 6.5 Calibration

The sediment transport model cannot be directly calibrated to historical conditions because detailed historical bed elevation data are not readily available, and the bed elevation changes have been influenced by man-made changes to the Salt River. However, calibration of the HEC-6T model for hydraulic similarity compared to the HEC-RAS model is important, and significant effort was made to ensure this calibration.

Initially, the HEC-6T model was calibrated with a fixed bed using the 5-, 20- and 100-year flows, and the resulting water surface profiles were compared to the pre-project HEC-RAS results (titled the Existing Conditions or Condition 1 hydraulic models in the PED study). For the purpose of Tres Rios Levee design, an effort was made to keep the difference in water surface elevations within 0.1 ft. This was accomplished by increasing the Manning's $n$ values in the overbank areas for the 5-year and 20-year flows (i.e., ineffective flow areas for low flows) and calculating the corresponding effective depth across the channels. Adjustments of Manning's $n$ were performed for calibration purposes for all cross-sections beginning with the downstream section in the Lower Gila reach. These adjustments were performed to reach agreement between the HEC-RAS and HEC-6T water surface elevations and channel velocities. More detailed information for the hydraulic calibration from this analysis is given in Appendix G of the PED report (WEST, 2003), which is attached as an appendix to the DDR (USACE, 2011).

## 6.6 Final Results

The HEC-6T model simulations were performed to predict the long-term aggradation or degradation of the system. Simulations were performed for the following scenarios: a) pre-project conditions (referred to as the "existing conditions" model in the PED report), and b) post-project conditions (referred to as the "levee only conditions" model in the PED report).

### 6.6.1 Erosion and sediment transport analysis results

#### 6.6.1.1 Pre-project Conditions Model Results

The HEC-6T model simulation was performed for a period of 105 years with two major events of 1891 and 1993. The results show an overall lowering of the average bed elevations indicating potential for erosion in most parts. The model responded to the 1891 event with deposition along the study reach during the first part of the flood hydrograph followed by erosion during the latter part. However, no significant change was noted at the 1993 major event, indicating the stability of the reach in response to recent floods. The Salt-Lower Gila reaches did not show significant deviation from the expected results presented in the PED report, given the nature of the reaches, existing ponding conditions, and braiding. Since the Upper Gila River is heavily vegetated, the long-term average bed elevation did not show significant variation.

#### 6.6.1.2 Post-project Conditions Model Results

The analysis reported in the PED Report (WEST, 2003) indicates that changes in bed elevations due to changes in flow conditions as the result of the levee are minimal. The only differences noted in the PED study (which were only at two locations in the model) were attributed to numerical modeling anomalies rather than differences between the conditions modeled in the PED report.

### 6.6.2 Verification of results

The sediment transport model cannot be directly calibrated to historical conditions or verified because detailed historical bed elevation data are not readily available, and the bed elevation changes have been influenced by significant man-made changes to the Salt River. However, sensitivity analyses were performed for parameters in the sediment transport analysis that include a certain amount of uncertainty due to the nature of the parameter estimation techniques; these parameters included inflowing hydrographs, inflowing sediment loads, and roughness coefficients. The model proved to not be significantly sensitive to any of these parameters in the vicinity of the levee. This provides increased confidence in the model results. More detailed information regarding the sensitivity analyses is given in the PED report (WEST, 2003), which is attached as an appendix to the DDR (USACE, 2011).

# 7. Draft FIS Report Data

## 7.1 Summary of Discharges

Table 7-1 summarizes the discharges used for the pre-project and post-project conditions models.

**Table 7-1. Summary of Discharges**

| Flow Change Location, HEC-RAS Cross-Section ID Number, River, and Reach | FIS Flooding Source and Location | Pre-project Conditions Discharge (cfs) | Post-project Conditions Discharge (cfs) |
|---|---|---|---|
| XS: 203.48, River: Salt, Reach: Salt | Salt River at 67th Avenue | 162,000 | 162,000 |
| XS: 199.47, River: Gila, Reach: Lower Gila | Gila River below confluence with Salt River | 227,000 | 227,000 |
| XS 1.67, River: Gila, Reach: Upper Gila | N/A | 65,000 | 65,000 |

As originally expected, the post-project conditions HEC-RAS model delivered by the LACOE used the hydrology originally delivered to the LACOE as part of the PED model deliverable. Therefore, the current flows in the HEC-RAS model are 162,000 cfs in the Salt River, 65,000 cfs in the Upper Gila, and 227,000 cfs in the Lower Gila. These flows can be changed to reflect the FIS flows (164,000 cfs in the Salt River, 227,000 cfs in the Lower Gila River, and 63,000 in the Upper Gila); however, the calculated freeboard might be slightly less with a flow of 164,000 cfs in the Salt River. On the other hand, using the original flow value of 162,000 cfs as per the PED model could cause consternation with FEMA during the review process.

## 7.2 Floodway Data

Data regarding the floodway are being delivered by the LACOE.

The draft floodway data is listed in Table 7-2. The table summarizes the following variables for the floodway by cross-section: width, section area, and mean velocity. The table also lists by cross-section the base flood water surface elevations for floodway and floodplain, and the corresponding water surface elevation increases. Also, the final floodway data table in FIS format will be generated similarly to Table 7-2 below.

If floodway data are required to be completed from scratch, WEST expects that this would require approximately 12 hours of labor by a staff engineer to complete, including the generation of the floodway data table in Table 7-2 below and the final FIS floodway data table.

**Table 7-2. Floodway Data Table**

| Flooding Source | | Floodway | | | 1-Percent-Annual-Chance Flood Water Surface | | | |
|---|---|---|---|---|---|---|---|---|
| Cross-Section | Distance[1] (mi) | Width (ft) | Section Area (sq ft) | Mean Velocity (ft/s) | Regulatory (ft NAVD) | Without Floodway (ft NAVD) | With Floodway (ft NAVD) | Increase (ft) |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

[1]Miles above confluence with Gila River for the Salt River Flooding Source and Feet above confluence with Gillespie Dam for the Gila River

7.3 Annotated Flood Insurance Rate Maps

Data regarding the annotated Flood Insurance Rate Maps are being delivered by the LACOE. These may be altered to meet the District's standards by WEST. Annotated Flood Insurance Rate Maps show the revised 1% annual chance floodplains and floodway boundaries. As can be seen from these drawing, the revised boundaries tie into the effective boundaries. These annotated FIRMs are designed to inform FEMA how the requester anticipates the FIRMs will be revised. Copies of draft annotated Flood Insurance Rate Maps will be included in the Exhibit Maps Appendix (Appendix G).

If annotated FIRMs are required to be completed from scratch, WEST expects that this would require approximately 2 hours of labor by the project manager, 8 hours by a staff engineer, and 24 hours by a drafter to complete.

7.4 Flood Profiles

Data regarding the flood profiles are being delivered by the LACOE. These may be completed by WEST if requested. Draft flood profiles and draft annotated flood profiles are included in the Exhibit Maps Appendix (Appendix G).

If flood profiles are required to be completed from scratch, WEST expects that this would require approximately 1 hour of labor by the project manager, 8 hours by a staff engineer, and 24 hours by a drafter to complete.

## 8. Response to FEMA Review Comments

After the initial submittal of most LOMRs, FEMA will provide review comments for some or all of the deliverables that have to be addressed before FEMA will approve the LOMR. It is assumed that this will occur for the Tres Rios North Levee LOMR package as well. Responses to those comments will be delivered by the LACOE, and WEST can complete these comment responses if requested.

WEST expects that completing responses to FEMA comments could require approximately 8 hours of labor by a project manager and 80 hours of labor by a staff engineer. Additionally,

WEST can provide technical support and review of documentation from the LACOE and assist in its finalization if requested.

## 9. HIS Data Deliverables

Although the LACOE will be providing GIS data, it is not expected to be delivered as per the District's HIS standards. GIS deliverables from the LACOE will include the topography used for the mapping, floodplains, floodways, cross-sections, etc. WEST will be responsible for updating these GIS files to the District's HIS standards.

WEST expects that generating the HIS data deliverables of the results for the final model delivered by LACOE will require approximately 8 hours of labor by the project manager, 12 hours by a staff engineer, and 32 hours by a drafter (52 total hours). The output of this task will include GIS data available for input to the FCDMC HIS Database. These data will be provided in a format that will meet the District's HIS standards.

## 10. Summary Table for Scope of Work Development

A summary of the hours estimated to complete the tasks and subtasks described in the preceding sections is provided in Table 10-1 below.

## Table 10-1. Summary of Estimated Hours Required to Complete Remaining LOMR Tasks

| Task or Subtask | Hours | | | | TOTAL HOURS |
|---|---|---|---|---|---|
| | *Principal* | *Project Manager* | *Staff Engineer* | *Drafter* | |
| 1. Coordination | | | | | |
| 1.1. Develop project schedule | | 2 | 2 | | 4 |
| 1.2. Coordination meetings (every 4 weeks) | | 48 | 48 | | 96 |
| 1.3. Attend one public meeting and preparation | | 6 | 16 | 4 | 26 |
| 1.4. Google Earth visualization development | | | 4 | | 4 |
| 2. Data Collection and Form Completion | | | | | |
| 2.1. Data Collection | | 8 | 8 | | 16 |
| 2.2. ADWR Forms | | | 1 | | 1 |
| 2.3. FEMA (MT-2) Forms | | 2 | 16 | | 18 |
| 3. Surveying and Mapping Information | | 4 | 4 | | 8 |
| 4. Hydrology | | | | | |
| 5. Hydraulics | | | | | |
| 5.1 Hydraulic Models | | | | | |
| 5.1.1. Effective Model | | | | | |
| 5.1.2. Duplicate Effective Model | | 2 | 16 | | 18 |
| 5.1.3. Corrected Effective Model *(see Note 1)* | 0.5 | 2 | 40* | | 42.5* |
| 5.1.4. Pre-project Conditions Model *(see Note 1)* | | 2 | 40* | | 42* |
| 5.1.5. Post-project Conditions Models *(see Note 1)* | 0.5 | 2 | 40* | | 42.5* |
| 5.2 Work Study Maps *(see Note 2)* | 0.5 | 4 | 16** | 60** | 80.5** |
| 5.3 Parameter Estimation | | | | | |
| 5.3.1. Roughness Coefficients *(see Note 3)* | | | 16*** | | 16*** |
| 5.3.2. Expansion/Contraction Coefficients *(see Note 3)* | | | 2*** | | 2*** |
| 5.4 Cross-Section Descriptions | | | 2 | | 2 |
| 5.5 Modeling Considerations | | | | | |
| 5.5.1. Hydraulic Jump and Drop Analysis | | | | | |
| 5.5.2. Bridges and Culverts | | | 4 | | 4 |
| 5.5.3. Levees and Dikes | | | | | |
| 5.5.4. Islands and Split Flows | | | | | |
| 5.5.5. Ineffective Flow Areas | | | 2 | | 2 |
| 5.6 Floodway Modeling | 0.5 | 2 | 20 | | 22.5 |
| 5.7 Problems Encountered During the Study | | | | | |
| 5.7.1. Special Problems and Solutions | | | | | |
| 5.7.2. Modeling Warning and Error Messages | | 1 | 6 | | 7 |
| 5.8 Calibration | | | | | |
| 5.9 Final Results | | | | | |
| 6. Erosion and Sediment Transport | | | | | |
| 7. Draft FIS Report Data | | | | | |
| 7.1 Summary of Discharges | | | | | |
| 7.2 Floodway Data | | | 12 | | 12 |
| 7.3 Annotated Flood Insurance Rate Maps | | 2 | 8 | 24 | 34 |
| 7.4 Flood Profiles | | 1 | 8 | 24 | 33 |
| 8. Response to FEMA Review Comments | | 16 | 120 | | 136 |
| 9. HIS data deliverables | | 8 | 12 | 32 | 52 |
| 10. Complete TDN (writing, figure development, etc.) | 2 | 10 | 20 | | 32 |
| TOTALS | 4 | 122 | 483 | 144 | 753 |

*Note 1: Exact scope of modeling tasks depends on final deliverables provided by the LACOE
**Note 2: Task assumes work maps developed by the LACOE will not be to District standards
***Note 3: Effort depends on HNTB final reporting of HEC-RAS deliverable

# Appendix A: References

## A.1 Data Collection Summary

# Data Received and Data Needed List

**Data Received as of 02/18/2011**

Topographic data – LACOE has provided a signed letter by Harvey Beverly, former LACOE survey section chief, certifying the topography.

Hydraulic models – LACOE has provided a draft version of the post-project conditions model.

As-built drawings – LACOE has currently provided Phase 1A, Phase 1B, and OBW as-built drawings.

Operations and Maintenance Plans – LACOE has provided the operations and maintenance plans for Phase 1A.

**Data Needed as of 02/18/2011**

Hydraulic models – Several items are still needed for the LOMR submittal including (a) the duplicate effective HEC-RAS model, (b) the corrected effective HEC-RAS model (if this model is determined to be needed), (c) the updated existing or pre-project conditions HEC-RAS model, (d) the two final post-project condition HEC-RAS models ("with OBW embankment" and "without OBW embankment" models), and (e) the encroachment (i.e., floodway) analysis model for the final post-project conditions HEC-RAS model.

As-built drawings – LACOE is to provide the final Phase 1C as-built drawings upon completion of construction of Phase 1C.

Levee certification documentation – LACOE is to provide the final NLSER and DDR documentation. The NLSER will meet the levee certification requirement of the MT-2 forms, and the DDR will include portions that will meet the geotechnical analysis, freeboard analysis, interior drainage analysis, and sediment transport analysis requirements of the MT-2 forms.

Hydraulic analysis output – Several items are still needed for the LOMR submittal including (a) the floodway data table, (b) flood profiles, (c) work maps, (d) annotated FIRM panels, and (e) error analysis from CHECKRAS with written responses to any errors not addressed in the final HEC-RAS model identified in the CHECKRAS output.

Operations and Maintenance Plan – LACOE is to provide the final Operations and Maintenance Plan for the Phase 1B, Phase 1C (when completed), and OBW features of the Tres Rios North Levee (O&M plan for Phase 1A has already been received).

Datum and projection verification – A document certifying that all modeling output has been provided with (a) elevations referencing the NGVD 29 vertical datum, (b) the factor required for conversion between NAVD 88 and NGVD 29 in the study reach, and (c) horizontal coordinates in the Arizona State Plane Coordinate System, Central Zone, NAD83.

# LOMR Data Collection List

1. Which FEMA panels are affected? [MT-2 Form 1 (Page 1 of 2), Section B, Line 1]

   *Current status of deliverable: COMPLETED. 5 affected FIRM panels have been identified.*

2. Who is (are) the community representative(s)? [MT-2 Form 1 (Page 2 of 2), Section D]

   *Current status on deliverable: NOT COMPLETED.*

3. Who will certify elevation information? [MT-2 Form 1 (Page 2 of 2), Section D]

   *Current status on deliverable: COMPLETED. LACOE has provided a signed letter by Harvey Beverly, former LACOE survey section chief, certifying the topography.*

4. Hydrology, one of two options [MT-2 Form 2 (Page 1 of 2), Section A, Line 1],

   a. New flows based on additional hydrologic analysis or

   b. FIS flows (which have already been approved by FEMA)

   *Current status on deliverable: COMPLETED. The FIS flows will be used for this modeling effort.*

5. Hydraulics [MT-2 Form 2 (Pages 1 to 2 of 2), Section B, Line 4]

   a. Effective model

      *Current status on deliverable: COMPLETED. This model has been obtained from the District.*

   b. Duplicate effective model

      *Current status on deliverable: NOT COMPLETED.*

   c. Corrected effective model

      *Current status on deliverable: NOT COMPLETED.*

   d. Existing or pre-project conditions model

      *Current status on deliverable: NOT COMPLETED.*

   e. Proposed or post-project conditions model (two proposed conditions models may be required)

*Current status on deliverable: NOT COMPLETED.*

f. Encroachment analyses for those models that require an encroachment analysis

*Current status on deliverable: NOT COMPLETED.*

6. Is there any placement of fill? [MT-2 Form 2 (Page 2 of 2), Section D, Line 2]

    a. If there is, NFIP regulations for fill placement must be met.

*Current status on deliverable: NOT COMPLETED.*

7. Is there any modification of the floodway? [MT-2 Form 2 (Page 2 of 2), Section D, Line 3]

    a. If there is, public notification will be required.

*Current status on deliverable: NOT COMPLETED.*

8. Do the models show any BFE increases? [MT-2 Form 2 (Page 2 of 2), Section D, Line 1]

    a. If there is an increase in any BFE, public notification will be required.

    b. If there is an increase in any BFE, public acceptance will also be required.

*Current status on deliverable: NOT COMPLETED.*

9. Hydraulic structures, including channelization, bridges/culverts, dams/basins, and levees/floodwalls [MT-2 Form 3 (Page 1 of 10), Section A, Line 1]

*Current status on deliverable: NOT COMPLETED.*

10. Levees [MT-2 Form 3 (Pages 4 to 10 of 10), Section E]

    a. As-built drawings [Information regarding the types of plans required are in MT-2 Form 3 (Page 4 of 10), Section E, Subsection 1, Line e; the plans themselves must be attached to the final LOMR packet]

    *Current status on deliverable: NOT COMPLETED. Waiting on Phase 1C and OBW as-built information from LACOE.*

    b. O&M plan [Information regarding the types of operations and maintenance information required are in MT-2 Form 3 (Page 10 of 10), Section E, Subsections 10, 11, 12; the O&M plans themselves must be attached to the final LOMR packet]

    *Current status on deliverable: NOT COMPLETED.*

c. Geotechnical report including seepage [MT-2 Form 3 (Pages 5 to 8 of 10), Section E, Subsections 4, 5, 6, 7]

*Current status on deliverable: NOT COMPLETED. LACOE is still finalizing the Geotechnical DDR appendix.*

d. Minimum freeboard, either a deterministic determination or a stochastic, risk-based assessment of freeboard, which method is LACOE planning to do for the LER? [MT-2 Form 3 (Page 4 of 10), Section E, Subsection 2]

*Current status on deliverable: COMPLETED. This is based on the WEST Consultants PED Report (WEST, 2003).*

e. Certification [MT-2 Form 3 (Page 4 of 10), Section E, Subsection 1, Line d]

*Current status on deliverable: NOT COMPLETED. LACOE is still finalizing the DDR and NLSER.*

f. Interior drainage [MT-2 Form 3 (Page 9 of 10), Section E, Subsection 8]

i. Pumping

ii. Flap gates

*Current status on deliverable: COMPLETED. LACOE has provided the interior drainage report in the draft DDR.*

11. Sediment transport [MT-2 Form 3 (Page 10 of 10), Section F]

a. Sediment loading, scour and deposition, debris flow

b. This can typically be accounted for in the calculations for levee toe-down design completed by the USACE. WEST completed a toe-down analysis and a sediment transport modeling study for the original PED study in 2002.

*Current status on deliverable: COMPLETED. This is based on the WEST PED report (WEST, 2003).*

12. Verify datums and projections [MT-2 Form 2 (Page 2 of 2), Section C]

*Current status on deliverable: NOT COMPLETED. Still need to convert all modeling output from the NGVD 29 to the NAVD 88 vertical datum.*

13. Output [Information regarding the hydraulics required for the LOMR packet can be found in MT-2 Form 2 (Pages 1 to 2 of 2), Section B, Line 4 and information regarding the annotated FIRMs can be found in MT-2 Form 2 (Page 2 of 2), Section C; however, the information listed below must be attached as appendices to the

a. Floodway data table

*Current status on deliverable: NOT COMPLETED.*

b. Flood profiles

*Current status on deliverable: NOT COMPLETED.*

c. Work maps

*Current status on deliverable: NOT COMPLETED.*

d. Annotated FIRMs

*Current status on deliverable: NOT COMPLETED.*

e. CHECKRAS

*Current status on deliverable: NOT COMPLETED.*

# Appendix A: References

## A.2 Referenced Documents

# References


1. ADWR (1997). Instructions for Organizing and Submitting Technical Documentation for Flood Studies. Arizona Department of Water Resources State Standard Attachment SSA 1-97.

2. ArcView GIS, v. 3.2a (2000). Environmental Systems Research Institute, Inc.

3. Blench, T., 1970, Regime Theory Design of Canals and Sand Beds, Journal of the Irrigation and Drainage Division, ASCE, 96(IR2), Proc. Paper 7381, 205-213.

4. FEMA (1988, revised 2005). Flood Insurance Study. Maricopa County, Arizona, and Incorporated Areas.

5. HEC-RAS, River Analysis System, version 2.1 (1997). "Hydraulic Reference Manual." Hydrologic Engineering Center, Davis, CA.

6. HEC-RAS, River Analysis System, version 4.1 (2010). "Hydraulic Reference Manual." Hydrologic Engineering Center, Davis, CA.

7. Michael Baker, Jr., Inc. (1999). Salt-Gila River Floodplain Delineation Restudy, submitted to the Flood Control District of Maricopa County.

8. Thomas, W.A. (2002) HEC-6T v.5.13, "Sedimentation in Stream Networks," Mobile Boundary Hydraulics (MBH), Clinton, MS.

9. U.S. Army Corps of Engineers (1996). Risk-based Analysis for Flood Damage Reduction Studies, EM 1110-2-1619, Washington, DC.

10. U.S. Army Corps of Engineers, Los Angeles District (1996). Section 7 Study for Modified Roosevelt Dam, Arizona (Theodore Roosevelt Dam): Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam.

11. U.S. Army Corps of Engineers, Los Angeles District (2011). Tres Rios Environmental Restoration Project: Design Documentation Report (DDR) for Flood Control North Levee.

12. WEST Consultants, Inc., 2002, Rio Salado Oeste Study: Without Project Final Hydraulic Analysis Report, Prepared for U.S. Army Corps of Engineers, Los Angeles District.

13. WEST Consultants, Inc., 2003, Preconstruction Engineering and Design (PED) Hydraulic Design of Tres Rios North Levee-2D Model Analysis, Prepared for U.S. Army Corps of Engineers, Los Angeles District.

# Appendix B: General Documentation and Correspondence

## B.1 Special Problem Reports

WEST
CONSULTANTS, INC.

**Arizona**
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Suite 210
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503-946-8536
503-946-8537FAX

**Washington**
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425-646-8806
425-646-0570 FAX

**River Measurement**
**A Division of WEST Consultants**
811 NE 154th Street
Vancouver, WA 98685

360.571.2290
360.571.2291 Fax

**www.westconsultants.com**

February 7, 2011

ATTN: Richard Harris
Tres Rios North Levee LOMR Project Manager
FCDMC

Subject: Tres Rios North Levee Phase 1C Construction Delay

Dear Mr. Harris:

The LOMR for the Tres Rios North Levee cannot be completed until the completion of construction of the Phase 1C features of the levee project. The primary feature of the Tres Rios North Levee Phase 1C is the floodwall on the west side of El Mirage Road. This construction has recently been delayed by the City of Phoenix for an indeterminate amount of time due to right-of-way acquisition along El Mirage Road.

Please let me know if you have any questions or comments.

Sincerely,

Brian Wahlin, Ph.D., P.E., D.WRE

# Appendix B: General Documentation and Correspondence

B.2 Contact (telephone) Reports

*(None for the summary report)*

# Appendix B: General Documentation and Correspondence

B.3 Meeting Minutes or Reports

# TRES RIOS TOPOGRAPHY DATASETS
## TECHNICAL MEMORANDUM

## FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
## TRES RIOS LOMR PROJECT

Date: September 22, 2010

To: Richard Harris – FCDMC

Cc: Amir Motamedi – FCDMC

From: Brian Wahlin, Project Manager – WEST Consultants, Inc.
Chuck Davis – WEST Consultants, Inc.

### INTRODUCTION

The purpose of this Technical Memorandum is to describe the topography that WEST currently has for the Tres Rios LOMR project. WEST developed a Triangulated Irregular Network (TIN) of the topography in the Tres Rios reach for the previous Tres Rios Preconstruction Engineering and Design (PED) modeling study performed for the USACE by WEST. The figures below explain the following issues regarding this TIN topography:

- The first figure shows the differentiation between the USACE topography data WEST received for the Tres Rios PED study and the topography that WEST appended to the USACE topography data in order to contain the 100-year flow in the model cross sections. The pastel polygons are the boundaries of the individual USACE topography datasets WEST received for PED, and the extents of all of these polygons are the total extent of this dataset. The remaining area of the TIN shown (with green and tan elevation contour colors and blue breaklines) would have been developed using supplementary data provided from a modeling study completed previously by WEST. In addition, the thick red line shown in this figure is the proposed levee alignment that WEST received from USACE during the PED modeling study. As can be seen in this figure, the levee alignment is contained entirely within the extents of the USACE topography, and does not cross into the topography appended by WEST.

- The second figure shows the same topography differentiation as the first figure, but the cross sections from the PED modeling study are shown on top of the polygons and TIN in order to show how much of those cross sections were taken from USACE topography data and how much were taken from the topography data that WEST appended. As can be seen from this figure, the area to the north of the levee in the right overbank was the largest area included in the PED model from the appended data.

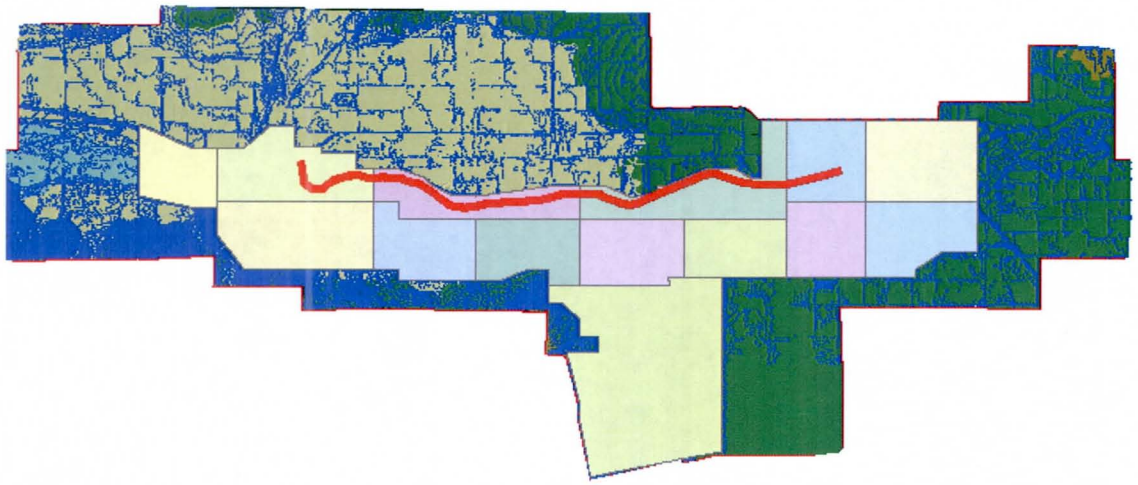

**Figure 1.** Pastel polygons indicate USACE topography data from the PED modeling study, and the underlying TIN represents the entire topography dataset. Therefore, any area of the TIN not covered by the polygons was based on data that WEST appended to the dataset from a previous modeling study. The red line shows the proposed levee alignment that WEST received from USACE for the PED model.

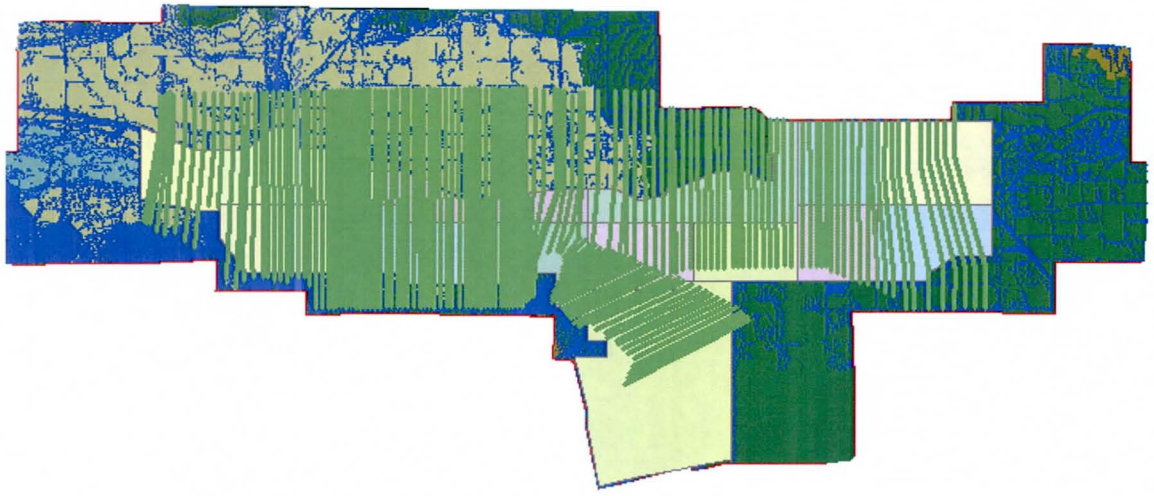

**Figure 2.** This figure is the same as Figure 1 with the cross sections from the PED model (shown in neon green) overlaying the topography data. This figure highlights the portions of the model cross sections developed from the two different data sources.

Date: October 18, 2010

A teleconference was held on October 12th at 9:30 a.m. with Cory Brunsting, Stephen Brown, and Paul Beaver of the Los Angeles office of the US Army Corps of Engineers (COE) with regards to producing hydraulic modeling and supporting documentation that will be the basis for pending FEMA flood map revisions of the Tres Rios Levee project. Flood Control District of Maricopa County (District) staff included Richard Harris. Mr. Chuck Davis of WEST Consultants, and Gwendolyn Meyer of the Phoenix COE office also attended. The focus of the discussion was primarily to re-visit the issue of what materials were going to be made available in what time-frame and by whom in relation to a draft work schedule produced by the District and sent to the Corps on 8/12/10.

Paul said that the recently submitted DDR (listed at 90%) is not close to being finalized because data still needs to come in for phases 1b and 1c. Paul said that David Pham will be responsible for the finalization of that document. Richard said that the District will review only the part that will be applicable to the LOMR package. However, review at this time may be only cursory. Paul said that the office is still staffing up for activities related to the DDR and LER. The COE has recently finalized their process for Levee System Evaluations in their document EC 1110-2-6067. This document formalizes evaluations with regards to the NFIP, and may require deviations from the known process of the Levee Evaluation Report (LER). The document lists a report as a NFIP Levee System Evaluation (NLSE) rather than certification. It may turn out that the new document does not present any great differences from what has already been expected in the LER.

The Levee Safety Officer (LSO, per EC...6067) has the authority to sign-off the LER/NLSE, as the authority approving of the document contents. It was not known whether the LA office would have to adhere to the newly finalized document's methods for the Tres Rios Levee project or not. Paul said that the office may be told to do so, later. Paul said that a Levee Safety Officer (LSO) had not been officially designated yet – but he was acting as such at this time. Paul also mentioned that the COE is actively in the hiring process for a LSO.

The issue of the work schedule came up again and Paul said that without knowing when the needed information for finalizing the DDR would be available, he couldn't estimate completion dates for that document and subsequent others. Therefore, he couldn't provide an updated schedule at this time. Paul estimated that it would take 6 weeks to finalize the Geotechnical report [appendix] for the project.

The issue of topography certification to meet National Mapping Standards (NAMSAs) came up again, and Richard said we need to arrive at a Yes or No statement regarding the certification issue, so we may move forward and not lose any time over it. He added that it seems to be a No statement at this time, but asked the COE to continue their search for documentation. Check from WEST said he did not feel there was any record of it in their work done previously for the COE. Richard said that he would work with Eric of the District's GIS to see if there is certification of the 4' topo from the Salt/Gila FDS project. This 4' topo is likely part of the merged product. He will start with topo from contract 92-01 and investigate any updates the District may have had done.

Richard asked Chuck if he has seen the Phase 1C O & M manual, and as-built plans. Chuck said he will check into it.

Merging of the topographical data is ongoing, along with the hydraulic modeling. However, there was no progress by the COE last week due to an office move/renovation. Instructions from Van on moving forward with the modeling are still pending. Steve said he would discuss the topo mapping accuracy issue with Van, once he returns to the office. Richard mentioned a need to be able to define COE points-of-contact for any upcoming reviews. In context with the COE not knowing time-frames for submittals it appears that the COE has not formalized role responsibilities amongst it's staff at this time to establish permanent points-of-contact. The issue will be raised again once a draft hydraulic model is available for review by the District.

Chuck described a LOMR "data needs list" WEST had prepared that outlines the documentation requirements for LOMR submittals. The COE staff said they would like a copy and Chuck said he would enhance the list and then Richard would send it to them.

Paul said he expected that the hydraulic modeling would be ready in draft form by the 1st of next year. He said that David Pham was in charge of packaging up all the appendices for the DDR, and that he was in charge of only the Geotechnical part [each part is the responsibility of different people, so a coordinated effort for compiling it is necessary but sometimes slow].

Paul said that it might end up being worthwhile to use the "new" process [involving the EC...6067] anyway. He said he was in charge of the LER/NLSE. He also said that he would like to call Richard independently between the current and next scheduled call. Richard gave Paul his phone number.

Action Items:

1. Richard to send the LOMR Needs list to the COE when it becomes available
   Update: Richard sent the Data Needs List prepared by WEST to all teleconference participants on 10/18/10.

2. The COE will continue to investigate the 1' topo product for documentation proving certification.

   Update per WEST: (i) Flight date = October 23, 2001, (ii) Towill Surveying, Mapping, and GIS Services collected the aerial photography, (iii) WEST has the DTM files available on our server for the entire coverage of the 2001 topo (these files are in the DTM format for Microstation Inroads), (iv) WEST has contacted Towill regarding the mapping scale, and (v) the vertical datum of the mapping was NGVD29 and the horizontal projection was listed in our final report as being Arizona State Plane coordinates (central region), NAD 83 (this is also being confirmed with Towill).

3. COE to continue working on the hydraulic modeling
4. COE to continue working on the LER and updating the DDR draft.

5. Richard and WEST Consultants to review the DDR draft H & H appendices for the internal drainage section, and may provide the COE review comments before the next teleconference.
6. Chuck to check on the Phase 1C O & M manuals and as-built plans, and then report to Richard.

   Update: Neither the District nor WEST have the Phase 1C O & M manuals. We do have several as-built plans PDF documents (11 total PDFs) and DGN files (12 total DGNs). We also have several as-built plans for phase 1B (79 PDF documents), but we do not have the Phase 1B O & M manuals either.

7. Richard to continue investigating the 4' topo mapping that apparently came from the District (and is now part of the merged topo product) for evidence of certification.

   Update: Document titles and shape files have been given to the District's surveyor John Stock for he and his staff to determine accuracy of the 4' product.

8. Steve to discuss the 1' topo mapping accuracy issue with Van.
9. The COE to consider points of contact and otherwise role responsibilities for addressing upcoming review comments.

The next call will take place on November 2, 2010 at 9:30 a.m. Arizona time. A formal invitation will be forthcoming.

# PHONE CALL LOG

Date: November 1, 2010

To: Richard Harris (FCDMC)

From: Chuck Davis (WEST)

RE: **Cancellation of Conference Call with LACOE on 11/02/2010**
**Other salient issues relating to the Tres Rios LOMR**

FCDMC informed WEST that due to a lack of availability from the Los Angeles District of the U.S. Army Corps of Engineers (LACOE), FCDMC would reschedule the conference call originally planned for 11/02/2010 between FCDMC/WEST and LACOE to 11/09/2010 at 1:00PM. That time will allow Don Rerick (FCDMC) to be on the call. Brian Wahlin (WEST) should be available for this call.

Additional items discussed by FCDMC and WEST are provided below.

- WEST has completed the comparison of the PED study design elevations for the top of the levee to the final AS-BUILT elevations of the levee provided by LACOE. A summary of this analysis has been provided to Richard Harris as a separate Technical Memorandum. To summarize the findings of that memorandum, the minimum freeboard of the final levee elevations compared to the design levee elevations from the cross sections utilized in the original hydraulic analysis is estimated to be 2.8 feet.
- Richard was concerned about paragraph 14 in Appendix B of the 90% DDR (page 287 of 568 in the PDF document). This paragraph and Richard's concerns are reproduced below.
  *14. Least Damage Levee Overtopping Location. The most feasible location would be downstream of the existing mining pit located along the north bank downstream from the 116th Avenue Bridge (River Mile 197.87 through 198.08). At these locations, the levee height was reduced to a level so flows in excess of the 100-year flow could inundate the floodplain on the north bank. This location is preliminary but will be finalized in the next project phase.*

    - Is having a "least damage levee overtopping location" standard practice for USACE levee designs?
    - When they say that "the levee height was reduced to a level so flows in excess of the 100-year flow could inundate the floodplain on the north bank," are they referring to the 100-year water surface elevation or the 100-year water surface elevation plus some amount of freeboard (2.0' as required by FEMA or 3.0' as recommended in the PED study by WEST)?

8950 S. 52nd St., Suite 210, Tempe, AZ 85284
(480) 345-2155 (480) 345-2156 *fax*

    - If this is reduced all the way down to the 100-year water surface elevation, what will FEMA do about that? Will they allow for a shaded zone X mapping if there is no freeboard at this least damage location?
- WEST inquired if they should follow up with Hoskin-Ryan or with MCDOT regarding the newer topographic data available for the study reach. Richard indicated that he suspects this topography is not as extensive as was first expected. We may only have a few hundred linear feet of the river with new topography as opposed to the several thousand feet we originally expected. Richard will follow up with his contacts regarding this information.

Action items from the phone call:

- Chuck will research the "least damage levee overtopping location" and Richard's concerns with this portion of the DDR.
- Richard will follow up with his contacts regarding the updated topography information.

# TRES RIOS TOPOGRAPHY DATASETS
## TECHNICAL MEMORANDUM

## FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
## TRES RIOS LOMR PROJECT

Date: November 1, 2010

To: Richard Harris – FCDMC

From: Brian Wahlin, Project Manager – WEST Consultants, Inc.
Chuck Davis – WEST Consultants, Inc.

### INTRODUCTION

The purpose of this Technical Memorandum is to describe the results of an investigation performed by WEST comparing the suggested levee elevations from the PED Hydraulic Design of Tres Rios North Levee study completed by WEST in 2002 to the actual constructed levee elevations based on the AS-BUILT plans provided by the Los Angeles District of the U.S. Army Corps of Engineers (LACOE).

Table 1 below is a reproduction of a portion of "Table 6-1: Levee Heights for Tres Rios North Levee" from the final report for the PED study. Only a portion of the table was reproduced because the final design and construction of the Tres Rios North Levee did not cover as much longitudinal distance of the river as the original anticipated design analyzed in the PED study. In this table, the X-Section numbering refers to the original HEC-RAS cross section numbers developed for the PED study. It should be noted that the PED study designed for 3.0 feet or more of Freeboard throughout the portion of levee that was eventually constructed (see the heading title of the last column of Table 1).

Table 2 below compares the design levee height values from the PED study to the levee heights from the AS-BUILT plans provided by LACOE (Environmental Restoration Flood Control North Levee Phase 1A Plan and Profile AS-BUILT construction drawings, Dec 17, 2007; Environmental Restoration Flood Control North Levee Phase 1B Plan and Profile AS-BUILT construction drawings, Aug 9, 2007). As can be seen from this table, the greatest difference between the design levee heights and the constructed levee heights with the constructed levee height being lower than the design height is 0.2 feet. Since the original levee design utilized 3.0 feet of Freeboard, the minimum freeboard in the levee based on the original hydraulic analysis is estimated to be 2.8 feet.

**Table 1**. A portion of "Table 6-1: Levee Heights for Tres Rios North Levee" reproduced from the final report for the PED Hydraulic Design of Tres Rios North Levee study

| X-Section | Thalweg Elevation (ft) | Existing Ground (ft) | Computed WSE (ft) | | WSE Increase w/ Levee (ft) | Height With 3-feet Freeboard |
|---|---|---|---|---|---|---|
| | | | Existing | Future-Levee | | |
| . | . | . | . | . | . | . |
| . | . | . | . | . | . | . |
| . | . | . | . | . | . | . |
| 198.4 | 922.23 | 939.47 | 935.34 | 935.85 | 0.51 | 938.85 |
| 198.45 | 922.19 | 939.9 | 936.39 | 936.69 | 0.3 | 939.69 |
| 198.49 | 922.46 | 939.75 | 936.82 | 937.1 | 0.28 | 940.1 |
| 198.54 | 922.67 | 940.51 | 937.13 | 937.35 | 0.22 | 940.35 |
| 198.6 | 923.3 | 940.47 | 937.34 | 937.57 | 0.23 | 940.57 |
| 198.65 | 923.88 | 940.66 | 937.74 | 937.94 | 0.2 | 940.94 |
| 198.7 | 923.9 | 940.81 | 938.07 | 938.25 | 0.18 | 941.25 |
| 198.76 | 923.9 | 940.98 | 938.27 | 938.45 | 0.18 | 941.45 |
| 198.8 | 923.9 | 940.92 | 938.58 | 938.71 | 0.13 | 941.71 |
| 198.83 | 923.9 | 941.5 | 938.8 | 939.01 | 0.21 | 942.01 |
| 198.88 | 923.9 | 942.19 | 939.03 | 939.23 | 0.2 | 942.23 |
| 198.93 | 923.9 | 942.1 | 939.41 | 939.63 | 0.22 | 942.63 |
| 198.97 | 925.1 | 942.5 | 939.53 | 939.75 | 0.22 | 942.75 |
| 198.99 | 925.1 | 942.5 | 940.05 | 940.22 | 0.17 | 943.22 |
| 199.02 | 925.4 | 942.52 | 940.15 | 940.31 | 0.16 | 943.31 |
| 199.06 | 925.4 | 943.67 | 940.76 | 940.87 | 0.11 | 943.87 |
| 199.11 | 925.4 | 943.54 | 941.64 | 941.78 | 0.14 | 944.78 |
| 199.18 | 925.4 | 940.08 | 942.02 | 942.18 | 0.16 | 945.18 |
| 199.21 | 927.64 | 940.1 | 942.74 | 942.96 | 0.22 | 945.96 |
| 199.31 | 928.11 | 946.63 | 943.29 | 943.48 | 0.19 | 946.48 |
| 199.38 | 926.6 | 947.85 | 943.84 | 943.98 | 0.14 | 946.98 |
| 199.47 | 926.6 | 948.13 | 944.92 | 945.06 | 0.14 | 948.06 |
| 199.55 | 931.65 | 946.74 | 946.25 | 946.35 | 0.1 | 949.35 |
| 199.69 | 931.79 | 943.07 | 947.65 | 947.84 | 0.19 | 950.84 |
| 199.86 | 931.12 | 944.68 | 948.65 | 948.99 | 0.34 | 951.99 |
| 199.98 | 932.56 | 945.59 | 948.88 | 949.24 | 0.36 | 952.24 |
| 200.02 | 931.98 | 945.44 | 949.25 | 949.6 | 0.35 | 952.6 |
| 200.11 | 931.98 | 945.83 | 949.53 | 949.88 | 0.35 | 952.88 |
| 200.22 | 931.78 | 945.58 | 950.04 | 950.39 | 0.35 | 953.64* |
| 200.31 | 931.67 | 948.57 | 950.4 | 950.77 | 0.37 | 954.02* |
| 200.4 | 931.55 | 949.27 | 950.87 | 951.21 | 0.34 | 954.46* |
| 200.47 | 931.67 | 949.8 | 951.15 | 951.46 | 0.31 | 954.71* |
| 200.52 | 932.45 | 949.94 | 951.31 | 951.61 | 0.3 | 954.81** |
| . | . | . | . | . | . | . |
| . | . | . | . | . | . | . |
| . | . | . | . | . | . | . |

**3.25 feet of Freeboard*
***Raised 0.2 feet to transition upstream*

**Table 2.** A comparison of the design levee heights from Table 1 to the AS-BUILT plan levee heights

| X-Section | Computed WSE (ft) | | WSE Increase w/ Levee (ft) | Height With 3-feet Freeboard | **AS-BUILT Plans Levee Height** | **Difference btwn design and construction†** |
|---|---|---|---|---|---|---|
| | Existing | Future-Levee | | | | |
| 198.4 | 935.34 | 935.85 | 0.51 | 938.85 | 939.4 | 0.55 |
| 198.45 | 936.39 | 936.69 | 0.3 | 939.69 | 939.7 | 0.01 |
| 198.49 | 936.82 | 937.1 | 0.28 | 940.1 | 940.1 | 0 |
| 198.54 | 937.13 | 937.35 | 0.22 | 940.35 | 940.46 | 0.11 |
| 198.6 | 937.34 | 937.57 | 0.23 | 940.57 | 940.86 | 0.29 |
| 198.65 | 937.74 | 937.94 | 0.2 | 940.94 | 940.93 | -0.01 |
| 198.7 | 938.07 | 938.25 | 0.18 | 941.25 | 941.24 | -0.01 |
| 198.76 | 938.27 | 938.45 | 0.18 | 941.45 | 941.44 | -0.01 |
| 198.8 | 938.58 | 938.71 | 0.13 | 941.71 | 941.7 | -0.01 |
| 198.83 | 938.8 | 939.01 | 0.21 | 942.01 | 942.0 | -0.01 |
| 198.88 | 939.03 | 939.23 | 0.2 | 942.23 | 942.23 | 0 |
| 198.93 | 939.41 | 939.63 | 0.22 | 942.63 | 942.63 | 0 |
| 198.97 | 939.53 | 939.75 | 0.22 | 942.75 | 942.74 | -0.01 |
| 198.99 | 940.05 | 940.22 | 0.17 | 943.22 | 943.21 | -0.01 |
| 199.02 | 940.15 | 940.31 | 0.16 | 943.31 | 943.3 | -0.01 |
| 199.06 | 940.76 | 940.87 | 0.11 | 943.87 | 943.87 | 0 |
| 199.11 | 941.64 | 941.78 | 0.14 | 944.78 | 944.78 | 0 |
| 199.18 | 942.02 | 942.18 | 0.16 | 945.18 | 946.5 | 1.32 |
| 199.21 | 942.74 | 942.96 | 0.22 | 945.96 | 946.84 | 0.88 |
| 199.31 | 943.29 | 943.48 | 0.19 | 946.48 | 947.41 | 0.93 |
| 199.38 | 943.84 | 943.98 | 0.14 | 946.98 | 947.81 | 0.83 |
| 199.47 | 944.92 | 945.06 | 0.14 | 948.06 | 948.44 | 0.38 |
| 199.55 | 946.25 | 946.35 | 0.1 | 949.35 | 949.35 | 0 |
| 199.69 | 947.65 | 947.84 | 0.19 | 950.84 | 950.84 | 0 |
| 199.86 | 948.65 | 948.99 | 0.34 | 951.99 | 951.8 | -0.19 |
| 199.98 | 948.88 | 949.24 | 0.36 | 952.24 | 952.24 | 0 |
| 200.02 | 949.25 | 949.6 | 0.35 | 952.6 | 952.6 | 0 |
| 200.11 | 949.53 | 949.88 | 0.35 | 952.88 | 952.88 | 0 |
| 200.22 | 950.04 | 950.39 | 0.35 | 953.64* | 953.64 | 0 |
| 200.31 | 950.4 | 950.77 | 0.37 | 954.02* | 954.0 | -0.02 |
| 200.4 | 950.87 | 951.21 | 0.34 | 954.46* | 954.46 | 0 |
| 200.47 | 951.15 | 951.46 | 0.31 | 954.71* | 954.71 | 0 |
| 200.52 | 951.31 | 951.61 | 0.3 | 954.81** | 954.61 | -0.2 |

**3.25 feet of Freeboard*

***Raised 0.2 feet to transition upstream*

*†Positive values indicate additional Freeboard over the design values, negative values indicate less Freeboard*

# 90% DDR Interior Drainage Design Notes
## Technical Memorandum

## Flood Control District of Maricopa County
## Tres Rios LOMR Project

Date: November 8, 2010

To: Richard Harris – FCDMC

From: Brian Wahlin, Project Manager – WEST Consultants, Inc.
Chuck Davis – WEST Consultants, Inc.

The following notes were taken directly from the 90% Draft Design Documentation Report (DDR) for the Tres Rios Flood Control North Levee provided by the Los Angeles District of the U.S. Army Corps of Engineers (LACOE). The page number of the DDR and the corresponding page number in the report itself of each section are provided for each note for reference. This information will aid in the discussion of remaining information required to allow WEST to complete the detailed technical review of the Interior Drainage Analysis.

## Main text of the DDR Report

From Section 1.11, Subsection a. (i)., "Interior Drainage" (page 19 of 568 in the DDR, page 12 in the report)

"Interior drainage. In cooperation with the Maricopa County Flood Control District, the City of Phoenix Wastewater Treatment Plant and Holly Acres Community's representative, The U.S Army Corps of Engineers has conducted a detailed study of the interior drainage. A refinement of the interior drainage plan was developed for incorporation into the project including collector channels; catch basins and storm drain channels."

From Section 2.4, "Interior Drainage" (page 21 of 568 in the DDR, page 14 in the report)

"A detailed interior drainage study was not completed. However, results from a previous study done by Dibble and Associates for the FCDMC and information generated to determine the quantity of urban runoff for the Rio Salado Study were used to formulate a preliminary interior drainage analysis. The estimated interior area peak discharge and associated 24-hour runoff volume were based upon drainage area versus discharge relationships."

**WEST Note: In Section 1.11, Subsection a. (i)., the DDR states that a detailed study of interior drainage was completed. In Section 2.4, the DDR states that a detailed interior drainage study was not completed. This discrepancy should be corrected.**

## Notes from the Hydraulic and Hydrologic Analysis Appendix (Appendix B)

From Section 6, "Hydrology and Design Discharges" (pages 285-286 of 568 in the DDR, pages 1-2 of the appendix)

"The following table summarizes the discharges that were analyzed for the project. The methodologies and assumptions used to determine these discharges are documented in the Hydrology Appendix of the Tres Rios Feasibility Report (2000). Appendix A2 gives a detailed description of the hydrology used in the Sedimentation Analysis."

Table 1. Discharge-Frequency Values

| Location | Return Period (Years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 5 | 10 | 20 | 50 | 100 | 200 | 500 |
| Salt R. above Gila R. | 19,500 cfs | 49,000 cfs | 82,000 cfs | 130,000 cfs | 162,000 cfs | 198,000 cfs | 235,000 cfs |
| Gila R. below Salt R. | 23,500 cfs | 57,000 cfs | 92,000 cfs | 185,000 cfs | 227,000 cfs | 243,000 cfs | 285,000 cfs |

U.S. Army Corps of Engineers, Los Angeles District. 2000. "Tres Rios, Arizona, Feasibility Study," Los Angeles, CA.

**WEST Note: The hydrology reported herein does not match the FIS hydrology, which is 164,000 cfs in the Salt River above the Gila River confluence.**

## Notes from the Hydrologic Analysis for Design of Interior Drainage Feature Appendix (Appendix A1 of Appendix B, was this mislabeled?)

From Paragraph 1 of the "Introduction" section (page 331 of 568 in the DDR, page 1-2 of the appendix)

"There appear to be three sources of surface water runoff from the interior areas to the rivers along the line-of-protection

a. Excess Rainfall (i.e. incident precipitation in excess of the infiltration rate of the soil/land surfaces);

b. Irrigation Return Flow (water delivered to the farms for irrigation in excess of demand due to antecedent/coincident precipitation, and cycled applied-irrigation water);

c. Stormwater Runoff Conveyed Within Irrigation Canals And Or Wasteways (off-site water which may have been conveyed to line-of-protection via delivery/wasteway systems).

At a minimum the project must ensure that interior flooding is not aggravated by the levee construction."

From Paragraph 6 of the "Introduction" section (page 332 of 568 in the DDR, page 1-3 of the appendix)

"The draft report for the Durango area [the Master Drainage Plan for the Durango Area prepared by Dibble and Associates Consulting Engineers] (flow paths and contributing drainage areas) provided by FCDMC was then used to estimate peak discharges from the interior area along the line-of-protection as well as volumetric data. The procedure followed was one developed by the LAD for the Rio Salado Interior Drainage study, and was considered applicable to this area as well because of similar meteorology and topography. **Note: peak discharge and volume relationships for the Rio Salado Interior Drainage study were developed from an 8-drain sample of urbanized drainage areas in the Phoenix vicinity. As a consequence, the peak flow rates and volumes estimated using the relationships developed from this data overstate runoff from the existing, mostly agricultural areas.** As a consequence, the rainfall-runoff modeling procedure for the 8-drain study was modified to represent rural/agricultural drainage rather than urban drainage by adjusting the loss rates. Regression curves for estimation of peak flow rates and 24-hour flood volumes, developed for the Rio Salado Study, were likewise modified to reflect the rural/agricultural makeup of the contributing areas. These modified regression curves were then utilized to make interior runoff estimates for the Tres Rios Project levee design."

**WEST Note: The table below provides all of the reports associated with the Durango ADMP that were provided from the FCDMC site. The report referenced after the table is the Rio Salado Draft Drainage Master Plan completed by Wood, Patel, but from the DDR, it appears that the interior drainage study completed for the Rio Salado area was completed in house by LACOE.**

| # | Call Number | Title | Author | ID | Date |
|---|---|---|---|---|---|
| 1 | CDA565.2 | Durango Area Drainage Master Plan, Data Collection Report (ADMP) | Dibble and Assoc. in Cooperation with McCloskey Peltz, Inc. and SWCA Environmental Consult. for Flood Control District of Maricopa County-FCD | FCD 99-41 | 2000 |
| 2 | A565.901S | Durango Area Drainage Master Plan, Data Collection Report (ADMP) | Dibble and Assoc. in Cooperation with McCloskey Peltz, Inc. and SWCA Environmental Consult., Inc. for Flood Control District of Maricopa County-FCD | FCD 99-41 | 2000 |
| 3 | CDA565.1 | Durango Area Drainage Master Plan, Alternatives Analysis Report (PDF on CD) (ADMP) | Dibble and Assoc. in Cooperation with McCloskey Peltz, Inc. and SWCA Environmental Consult. for Flood Control District of Maricopa County-FCD | FCD 99-41 | 2001 |
| 4 | A565.902S | Durango Area Drainage Master Plan, Alternatives Analysis Report (ADMP) | Dibble and Assoc. in Cooperation with McCloskey Peltz, Inc. and SWCA Environmental Consult., Inc. for Flood Control District of Maricopa County-FCD | FCD 99-41 | 2001 |

| # | Call Number | Title | Author | ID | Date |
|---|---|---|---|---|---|
| 5 | CDA565.4 | Durango Area Drainage Master Plan, Recommended Design Report (ADMP) | Dibble and Assoc. in Cooperation with McCloskey Peltz, Inc. and SWCA Environmental Consult., Inc. for Flood Control District of Maricopa County-FCD | FCD 99-41 | 2002 |
| 6 | A565.601S | Durango Area Drainage Master Plan, Recommended Design Report (ADMP) | Dibble and Assoc. in Cooperation with McCloskey Peltz, Inc. and SWCA Environmental Consult., Inc. for Flood Control District of Maricopa County-FCD | FCD 99-41 | 2002 |
| 7 | CDA565.3 | Durango Area Drainage Master Plan, Hydrology Report, Revised April, 2003 (ADMP) | Dibble and Assoc. for Flood Control District of Maricopa County-FCD | FCD 99-41 | 2001 |
| 8 | A565.701S | Durango Area Drainage Master Plan, Hydrology Report, Revised April, 2003 (ADMP) | Dibble and Assoc. for Flood Control District of Maricopa County-FCD | FCD 99-41 | 2003 |

Call Number: A124.301S

Title: Rio Salado Drainage Master Plan, Draft (DMP)

Author: Wood, Patel and Assoc., Inc. for Rio Salado Project and City of Tempe

ID: WP# 97644

Date: 1997

From Paragraph 7 of the "Precipitation" section (pages 333-334 of 568 in the DDR, pages 1-4 and 1-5 of the appendix)

"This is in agreement with NOAA Atlas 2 precipitation duration isopluvials for the Phoenix area that indicate the 5-year, 24-hour precipitation depth is 2.0 inches." **Question: Is the entire interior drainage design based on the 5-year event? Does this conform to a City of Phoenix standard (it isn't the FCD standard)?Please check and if not clear, will become a comment for the LACOE to address in the DDR.**

**WEST Note: How would this compare to NOAA Atlas 14 information? WEST compared these numbers quickly, and found that the NOAA Atlas 14 5-yr, 24-hr precipitation depth is 1.91 inches.**

**From the DDR, only the sizing of the catch basins is based on the 5-year event. The outlet culvert sizing is based on the 100-yr event.**

**The ADWR state standard for stormwater detention/retention is based on the 100-yr, 1-hr storm. The FCDMC design manual specifies the 100-yr, 2-hr storm (City of Phoenix has adopted the FCDMC standard as well). For comparison, the NOAA Atlas 14 data for the area is 2.44 inches for the 100-yr, 1-hour storm, and 2.73 inches for the 100-yr, 2-hour storm.**

**As a note, another engineer at WEST who has completed many LOMR packets does not think this will be an issue for the FEMA review because these are defined as "catch basins" and not "retention basins." Since their only design feature is to attenuate flow in the specialized case when the stage in the Salt/Gila is high enough to cause the flap gates in the outlet culverts to close and not allow outflow, and not to retain the entirety of that flow until complete infiltration can be obtained as would be the case with a retention basin, that the sizing of these catch basins will not be an issue for FEMA.**

From Paragraph 16 of the "Interior Runoff: Excess Precipitation" section (page 350 of 568 in the DDR, page 1-21 of the appendix)

"The highest peak discharge from the interior area should occur during the warm-weather months, when the threat of high discharge/stage in the mainstream Salt River and Gila River is at a minimum. Hence interior drainage facilities such as collection channels, catch basins, and culverts, designed to pass the 100-year peak from the interior areas, should be sufficient to prevent flooding along the land-side of the levee project during the warm-weather months. As mentioned previously in this report (Paragraph 6), the interior drainage estimates for the Tres Rios Project were based upon an 8-drain sampling procedure developed for the Rio Salado Project; however the N-year, rainfall-runoff models developed for the 8-drain sample were modified to reflect rural/agricultural land use rather than urban land use."

**WEST Note: The DDR makes no reference of how this method was modified. If we obtain the Rio Salado Interior Drainage study to review the "8-drain method," we still do not know how this method was modified for the Tres Rios DDR.** Good point. Please make a comment in the form of a question for the LACOE.

**Question for the LACOE: Which study includes the Rio Salado Interior Drainage Study? Was this a standalone report, or was this part of another study? Could we obtain a copy of this report for the technical review of the interior drainage analysis for Tres Rios?**

**Question for the LACOE: How was the "8-drain sampling procedure" developed for the Rio Salado Interior Drainage Study modified to reflect greater agricultural land use in the interior drainage area of the Tres Rios levee?**

From Paragraph 17 of the "Interior Runoff: Excess Precipitation" section (page 352 of 568 in the DDR, page 1-23 of the appendix)

"Although interior runoff during the cold weather months should have lower peak discharges, the duration of runoff may increase. If interior runoff reaches the line-of-protection during period when spills have occurred from SRP reservoirs and/or there are significant flows from the upstream Gila River watershed, high river stages may create adverse hydraulic conditions. During such period interior runoff might pond alongside the levee for extended periods. To eliminate or reduce this undesirable condition, drainage/collector channels will be designed to direct interior runoff near the levee to catch basins designed to accommodate a substantial portion of the interior runoff. Figure A1-11 depicts the regression curve of the 5-year, 24-hour interior-runoff volume on drainage area… Even during the 100-year flood event in the Salt-Gila Rivers, the river stage is not high [sic] even to preclude side drainage from the catch basins for a time period extending beyond 24 hours. Hence, storage of 24-hours of interior runoff should be adequate to prevent exceeding the catch basin design storage during the design flood, even if interior runoff is contemporaneous with the 100-year design river stage. Tailwater restrictions are discussed more thoroughly in the Hydraulic Appendix (Appendix A)."

**WEST Note: From the Figure below (Fig A1-11 in the DDR), the depth of precipitation used is 2.0 inches. Chuck: a point of clarity would be nice if the LACOE explained that the interior drainage did not have an existing 100-year floodplain as a result of local drainage – this to stop any possible future questions about the return interval used for the interior drainage design. Is this stated anywhere in the DDR? Also, they should point out any design standards they used relative to location (I don't think they used a locally approved method), if this is what they did – how should we have them address this?**

**The DDR references the floodplain maps completed by WEST in the PED study for the 100-year flood event for without-project, with-levee only, and with-project conditions. From these maps, it is apparent that the only flooding source in the reach is the Salt and Gila Rivers, and no flooding sources or effective floodplains are present to the north of the study reach on the landward side of the levee that eventually drain into the Salt/Gila system (the only flooding sources to the north drain into the Agua Fria River). However, this is not explicitly stated anywhere in the DDR.**

**They also do not discuss any design standards they used relative to the location of the levee (ADWR, FCDMC, City of Phoenix, etc.).**

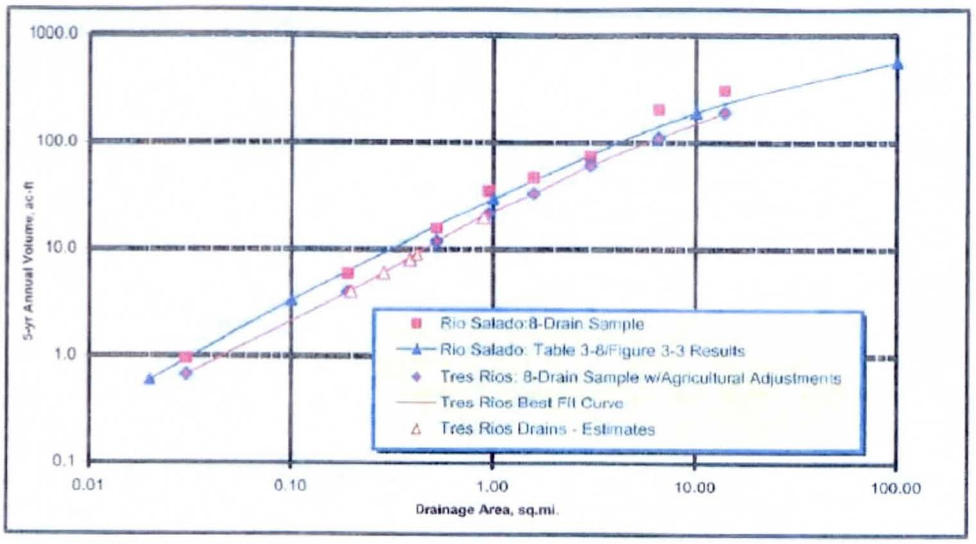


**Figure A1-11. Tres Rios Interior Drainage: Runoff Volume: 2-In, 24-Hour Storm (5-year Annual Event, 1% Annual Chance, Jan - Mar Event).**

From Paragraph 17 of the "Interior Runoff: Excess Precipitation" section (pages 353 and 354 of 568 in the DDR, pages 1-24 and 1-25 of the appendix)

"The catch basin geometry was established to enable storage of the entire 5-year, 24-hour interior-runoff volume, and result in free drainage after 24-hours. The river elevation associated with the 100-year, 1-day duration discharge (Table A1-6, 100,000 cfs) was used to design the catch basin near 99th Avenue (above the Gila River); for catch basins at 115th Avenue and Dysart Road, the 100-year, 1-day duration discharge was increased approximately 40% to allow for additional flow from the Gila River."

From Paragraphs 18 and 19 of the "Interior Runoff: Irrigation Return Flow" section (page 356 of 568 in the DDR, page 1-27 of the appendix)

"The result may be interior flooding from overflow of delivery canals and/or downstream tail water ditches."

"To offset any flooding induced by the Tres Rios Levee and Dysart Road, catch basins and collector channels will be located along land-side of the levee where tail water ditches formerly wasted water directly to the rivers. The collector channels include an allowance for the full capacity of each ditch (30 cfs per mile of field parallel to the levee), and the catch basins are sized to detain an additional volume of runoff from each tail water ditch resulting from a 1-hour duration flow at full capacity (2.5 ac-ft)."

From Paragraph 21 of the "Interior Runoff: Hydrologic Design" section (page 358 of 568 in the DDR, page 1-29 of the appendix)

"**All interior drainage collection features designed to prevent interior flooding during the levee design event will be sized to convey the 100-year peak local inflow.** In addition catch basins are included along the land-side of the levee to provide impoundment areas for interior runoff and to limit the number of levee penetrations. **Each catch basin will include a box culvert with hydraulic capacity to convey the peak 100-year inflow from the interior area to the Salt and Gila Rivers at approximately 3-feet of head. Each catch basin will be excavated to provide sufficient volume to store the entire 24-hour runoff volume anticipated to reach the levee during the 5-year, 24-hour storm.** The 5-year, 24-hour storm (2 inches of precipitation) has not been exceeded in approximately 100 station-years of record during the cold-weather months of January through March."

From Paragraph 22 of the "Interior Runoff: Hydrologic Design" section (page 359 of 568 in the DDR, page 1-30 of the appendix)

Table A1-7. Interior Drainage: Hydrologic estimates for Tres Rios collector channels

| | East side of 91st Ave to the Salt River[1] | West side of 91st Ave to CB-1 to 99th Ave[2] | Inflow to CB-2 (115th Ave)[2] | Inflow to CB-3 (El Mirage Road)[2] | Inflow to CB-4 (Dysart Road)[2] |
|---|---|---|---|---|---|
| Drainage Area, sq mi | 1.378 | 0.444 | 0.549 | 0.528 | 0.162 |
| 100-yr Peak Discharge, cfs | 620 | 320 | 380 | 365 | 175 |

Notes: data (peak estimates) based upon Figure A1-10. In addition, inflow to each catch basin has been increased to reflect agricultural waste water or offsite water delivered from drains: 30 $ft^3/s/mi.$ of field length measure parallel to levee

[1] Contributing drainage area and peak inflow based upon diversion of all interior runoff east of 91st Ave directly to the Salt River u/s of the project levee

[2] Contributing drainage areas for catch basins based upon flow paths presented in the Master Drainage Plan for the Durango area (prepared by Dibble & Associates Consulting Engineers) and verified by on-site visits.

Chuck: Does the above mentioned Figure A1-10 show the sub-basin boundaries? If not it would be best for the LACOE to provide one. Please make a comment.

Figure A1-10 (page 353 of 568 in the DDR) has been included below. This figure is a regression plot of drainage area versus peak flow, not a map showing the sub-basin boundaries. The only map provided in the interior drainage report appendix was Plate A1-1 (page 365 of 568 in the DDR), which is copied below. This is a schematic of urban drainage pathways draining to the landward side of the levee, but the detailed, delineated sub-basins are not provided in this figure either. WEST assumes this figure can be found in the Durango ADMP study report.

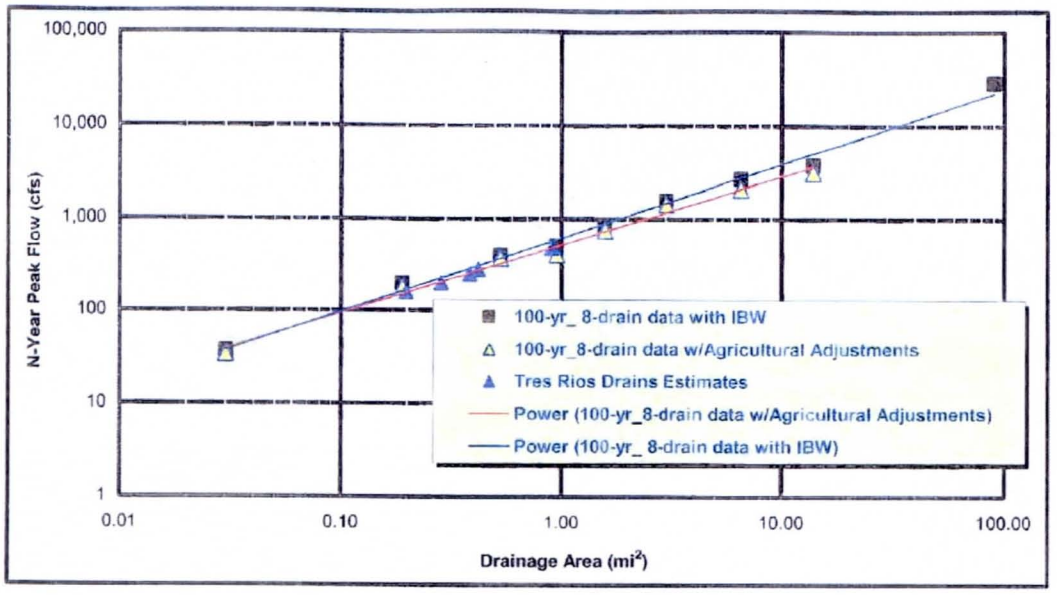


**Figure A1-10. Tres Rios Interior Drainage: 100-Year Peak Discharge versus Drainage Area, 8-Drain Urban Sample, Adjusted to Reflect Agricultural Drainage Areas.**

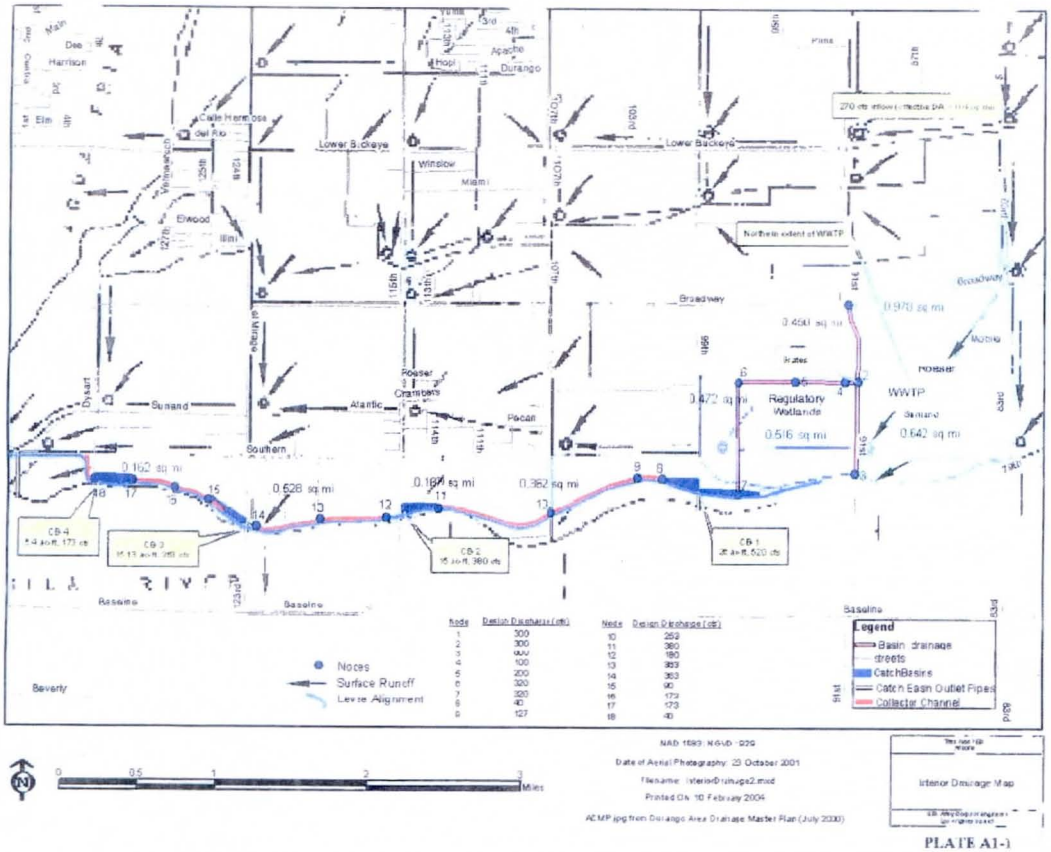
Broadway
Southern
Sunland
Atlantic
Pecan
Elwood
Lower Broadway
Winslow
Miami
Durango
Apache
Hopi
Del Rio
Dysart
Regulatory Wetlands
WWTP
Northern extent of WWTP
0.162 sq mi
0.628 sq mi
0.189 sq mi
0.362 sq mi
0.472 sq mi
0.516 sq mi
0.970 sq mi
0.642 sq mi
CB-4
CB-3
CB-2
CB-1
Legend
Basin drainage
streets
CatchBasins
Catch Basin Outlet Pipes
Collector Channel
Nodes
Surface Runoff
Levee Alignment
Beverly
Basalmo
Miles
NAD 1983 NSRS 2007
Date of Aerial Photography: 20 October 2001
Filename: InteriorDrainage2.mxd
Printed ON: 10 February 2004
ACMP jpg from Durango Area Drainage Master Plan (July 2000)
Interior Drainage Map

PLATE A1-1

Date: November 11, 2010

A teleconference was held on November 9th at 1:00 p.m. Mountain Standard Time (noon Pacific Standard Time) with Paul Beaver and David Pham of the Los Angeles District of the US Army Corps of Engineers (LACOE) with regards to producing hydraulic modeling and supporting documentation that will be the basis for pending FEMA flood map revisions of the Tres Rios Levee project. Flood Control District of Maricopa County (District) staff included Richard Harris and Don Rerick. Dr. Brian Wahlin and Mr. Chuck Davis of WEST Consultants, and Bob Upham of the City of Phoenix also attended. The focus of the discussion was primarily to re-visit the issue of what materials were going to be made available in what time-frame and by whom in order to eventually request floodplain and floodway map changes from the FEMA at the Tres Rios Levee. Discussions generally followed the below numbered list of items from the meeting invitation:

1. POCs for the upcoming reviews by District/WEST?

David Pham will be the POC for the DDR, and therefore he will receive any future comments about it, and already had received some from Don Rerick. Richard and Chuck both had a few more minor comments regarding the 90% DDR. Paul said that if we had questions about the H & H, the POC will be Van Crisostomo, and David Pham should be copied on all direct communications to Van regarding the H & H sections of the DDR since David is the POC for the entire DDR. Paul also suggested that Richard write a separate email to Van explicitly defining the models in terms of what features should be included and the modeling extents. This will be done separately.

David said that the DDR will be resubmitted in December with revisions per Don's and other District/WEST review comments. Paul said that the DDR may be finalized in January or February of 2011 (with perhaps the As-built plans for Phase 1C to be added later).

2. Status of LER or equivalent Levee Certification package. When will a draft be available for review?

Paul said he is still in the process of writing up the NLSER, which is the new document "EC…6067" acronym for LER. Paul said it will probably only consist of 5-10 pages when done, with most documentation through referencing the DDR. He said that the DDR will need to be finalized before the NLSER can be finalized. In other words, the documentation that will be referenced in the NLSER must be completed first.

3. Discussion about the LOMR Needs list from WEST – does the LACOE have any questions?

Paul asked that we go over the list and we did, writing the names of the agencies who will be expected to provide the various materials. Richard volunteered to send them the written version and then did so.

4. Status of As-builts and O & M manual for the Overbank Wetlands, and the O & M manual for Phase 1B? We need to get these – when can the LACOE provide them? Status of the Flood Wall planned for El Mirage RD? Construction to begin when?

Paul said that the wall design is near final, and that the construction was being delayed due to some difficulty regarding the right-of-way. However, he said it was going to get started soon.

5. Status of topographic mapping merged product to deliver to District? Will the LACOE provide documentation regarding certification and documentation about the way the products are being merged?

Richard discussed the accuracy standards for certification as outlined in FEMA's document: Guidelines and Specifications for Flood Hazard Mapping Partners (http://www.fema.gov/library/viewRecord.do?id=2206). The factor stated therein is the RMSE (Root-Mean Square Error), used to check accuracy, but that if the LACOE had documentation that proved accuracy otherwise we will consider it. Richard mentioned that the LACOE might have their own surveying manager or similar authority that could have checked for accuracy. Richard suggested the LACOE contact their surveying authority.

6. DDR Questions for the Interior Drainage:

   Which study includes the Rio Salado Interior Drainage Study?

   An aside conversation with Chuck led to him being assigned to investigate the above study for documentation in our library, and Don later said that there may be documentation in the local LACOE office.

   How was the "8-drain sampling procedure" developed for the Rio Salado Interior Drainage Study modified to reflect greater agricultural land use in the interior drainage area of the Tres Rios levee?

   LACOE will report back on how the 8-drain sampling procedure was modified.

   Status – time frame: when will the DDR be finalized?

Paul said possibly in January of 2011.

7. Schedule by the District updated by LACOE to fit LACOE?

8. Other?

Action Items:

1. Richard to send the LOMR Needs list to the LACOE again, but this time with the noted agency/company responsible for providing the data listed. He will also re-send the MT-2 forms and MT-2 Instructions.

   Update: Richard sent the Data Needs List prepared by WEST to all teleconference participants on 11/09/10. The list included the responding agency name for each type of needed documentation. Also included were the MT-2 forms with instructions and a State of Arizona standard for flood study documentation.

2. The LACOE will continue to investigate the 1' topo product for documentation proving certification of accuracy. David Pham of the LACOE said he will look for it by contacting the surveying manager for the LACOE.

3. LACOE to continue working on the hydraulic modeling.

4. District/WEST to send a small list of review comments to the LACOE regarding the 90% DDR.

5. LACOE to continue working on the NLSER and updating the DDR draft.

6. Richard to prepare an email for Van regarding specifics of the modeling, including what features to include and extents.

Update: The email was prepared Wednesday November 10th. The email requests Van's presence during a teleconference to be held the week of the 15th to discuss expectations and gain better information about what has been done with the H & H modeling, and what remains.

7. David to provide Richard/the District/WEST with the O & M manuals for the Overbank Wetlands, Phase 1B, and the Phase 1C floodwall. When ready he will also send the District As-built plans for both the Over-bank wetlands and Phase 1C.

8. David to investigate 1' topo mapping certification documentation by contacting head of the LACOE Survey unit.

The next call will take place with Van, hopefully as soon as November 15, 2010. A formal invitation will be forthcoming based upon Van's availability.

# COMMENTS ON THE 90% DDR INTERIOR DRAINAGE DESIGN
## TECHNICAL MEMORANDUM

## FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
## TRES RIOS LOMR PROJECT

Date: November 11, 2010

To: Richard Harris – FCDMC

From: Brian Wahlin, Project Manager – WEST Consultants, Inc.
Chuck Davis – WEST Consultants, Inc.

The following comments were made based on the 90% Draft Design Documentation Report (DDR) for the Tres Rios Flood Control North Levee provided by the Los Angeles District of the U.S. Army Corps of Engineers (LACOE). The page number of the DDR and the corresponding page number printed at the bottom of the page are provided for each comment for reference.

**Comment #1**: On the first title page of the document, "County" is misspelled.

**Comment #2**: In Section 1.11, Subsection a. (i). [page 19 of 568 in the DDR, page number 12 of the report], the DDR states that "…The U.S Army Corps of Engineers has conducted a detailed study of the interior drainage."

In Section 2.4 [page 21 of 568 in the DDR, page number 14 of the report], the DDR states that "A detailed interior drainage study was not completed."

This discrepancy should be corrected.

**Comment #3**: The numbering of some of the appendices is confusing. For example, Appendix B [page 280 of 568 in the DDR] references five appendices which are listed in the List of Appendices on page iii of Appendix B [page 282 of 568 in the DDR]. However, each of these appendices is labeled A1, A2, etc. These should be relabeled B1, B2, etc.

Similarly, Appendix C contains two sub-appendices, currently labeled A and B. These should be labeled C1 and C2 for clarity.

**Comment #4**: The following statement was taken from Paragraph 6 of sub-appendix A1 (interior drainage design) of Appendix B [page 332 of 568 in the DDR, page 1-3 of the appendix]. Emphasis in the text has been added.

"The draft report for the Durango area [the Master Drainage Plan for the Durango Area prepared by Dibble and Associates Consulting Engineers] (flow paths and contributing drainage areas) provided by FCDMC was then used to estimate peak discharges from the interior area along the line-of-protection as well as volumetric data. The procedure followed was one developed by the LAD for the Rio Salado Interior Drainage study, and was considered applicable to this area as well because of similar meteorology and topography. **Note: peak discharge and volume relationships for the Rio Salado Interior Drainage study were developed from an 8-drain sample of urbanized drainage areas in the Phoenix vicinity.** As a consequence, the peak flow rates and volumes estimated using the relationships developed from this data overstate runoff from the existing, mostly agricultural areas. **As a consequence, the rainfall-runoff modeling procedure for the 8-drain study was modified to represent rural/agricultural drainage rather than urban drainage by adjusting the loss rates. Regression curves for estimation of peak flow rates and 24-hour flood volumes, developed for the Rio Salado Study, were likewise modified to reflect the rural/agricultural makeup of the contributing areas.** These modified regression curves were then utilized to make interior runoff estimates for the Tres Rios Project levee design."

**Comment 4-1**: The DDR should present a reference for the Rio Salado Interior Drainage study that is referenced in this section of the text. This reference was not found in the DDR. Was this a standalone report, or was this a part of another report?

**Comment 4-2**: Brief discussions should be presented of (i) the fundamentals of the "8-drain sample" method for determining peak flows and volumes for the Rio Salado interior drainage area and (ii) the modification of this method for greater agricultural land use in the Tres Rios interior drainage area compared to the Rio Salado interior drainage area.

**Comment 4-3**: A brief discussion of the modification of the regression curves should be included as well. Were these regression curves generated from the output of the "8-drain sample" method?

**Comment #5**: The catch basin interior drainage features were sized based on the 5-year, 24-hour precipitation depth of 2.0 inches. Paragraph 17 of the "Interior Runoff: Excess Precipitation" section of the interior drainage sub-appendix A1 of Appendix B [pages 353 and 354 of 568 in the DDR, pages 1-24 and 1-25 of the appendix] states that "The catch basin geometry was established to enable storage of the entire 5-year, 24-hour interior-runoff volume, and result in free drainage after 24-hours."

The local standard (Flood Control District of Maricopa County and City of Phoenix) for detention/retention basins is storage of the 100-yr, 2-hr storm. For comparison, the NOAA Atlas 14 data for the site estimates a depth of 2.73 inches for the 100-yr, 2-hour storm. The DDR should address why a local standard was not considered in the design of these basins.

**Comment #6**: The reviewers could not identify any discussion in the interior drainage study appendix regarding existing 100-year floodplains as the result of local drainage, probably because no local flooding sources that are mapped by FEMA or regulated by FCDMC are present on the landward side of the levee. However, this should be stated explicitly in the DDR.

**Comment #7**: Plate A1-1 [pages 365 and 366 of 568 in the DDR] does not show the actual basin boundaries and drainage areas of the hydrologic analysis for the Master Drainage Plan for the Durango Area prepared by Dibble and Associates Consulting Engineers. The figure from the report for the Master Drainage Plan for the Durango Area showing the entire interior drainage area should be included in the DDR.

**Comment #8**: Paragraph 14 of Appendix B [page 287 of 568 in the DDR, page 3 of the appendix] states that "Least Damage Levee Overtopping Location: The most feasible location would be downstream of the existing mining pit located along the north bank downstream from the 116th Avenue Bridge (River Mile 197.87 through 198.08). At these locations, the levee height was reduced to a level so flows in excess of the 100-year flow could inundate the floodplain on the north bank. This location is preliminary but will be finalized in the next project phase."

The river miles that are mentioned in the DDR are actually just downstream of the 123rd Avenue Bridge, not the 116th Avenue Bridge. The least damage levee overtopping location as it was designed in the PED report was downstream of the 123rd Ave Bridge (between the river miles that are mentioned in the DDR) in a portion of the original planned levee alignment that was never constructed.

The AS-BUILT drawings show less freeboard (approximately 2.5' instead of the 3.0' of freeboard everywhere else) for a section of the levee downstream of the 116th Avenue Bridge. However, the top of levee elevations in this section of the levee match the top of levee elevations from the PED report which were designed with 3.0' of freeboard in this reach. Therefore, the water surface elevations in this portion of the AS-BUILT drawings are shown on the plans approximately 0.5' higher than the water surface elevations calculated in the PED report. There had to have been additional hydraulic analysis done in house by the LACOE or by another AE firm to determine the changes of the new levee alignment on the water surface profile, and that may have bumped up the water surface elevations in this reach by half a foot. However, the design of the levee apparently did not change after this additional hydraulic analysis, since this still matches the PED report very closely.

The following issues should be addressed in the DDR: (1) the location of the correct river miles for the final constructed least damage levee overtopping location and (2) the reason for lower freeboard (i.e., 2.5 feet instead of 3.0 feet) between approximately levee stations 150+40 and 115+40 downstream of 116th Avenue.

# WEST ACTION ITEMS FROM THE 11/09 CONFERENCE CALL
## TECHNICAL MEMORANDUM

## FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
## TRES RIOS LOMR PROJECT

Date: November 15, 2010

To: Richard Harris – FCDMC

From: Brian Wahlin, Project Manager – WEST Consultants, Inc.
Chuck Davis – WEST Consultants, Inc.

From Richard's meeting minutes on the conference call held on November 9, 2010, between LACOE, the District, and WEST, one action item was developed for WEST to complete. This action item has been copied from the meeting minutes below.

> *Which study includes the Rio Salado Interior Drainage Study?*
>
> *An aside conversation with Chuck led to him being assigned to investigate the above study for documentation in our library, and Don later said that there may be documentation in the local LACOE office.*

WEST investigated the reports on the following page from the District's library. Findings of this search are summarized below.

- The Durango ADMP (Dibble and Associates) assessed hydrology in the drainage area on the landward side of the levee using HEC-1 only. No mention of outlet drains in the development of urban runoff regression equations was made in this study.
- The draft report for the Rio Salado Drainage Master Plan (Wood, Patel and Associates) does not develop these regressions either.

| # | Call Number | Title | Author | ID | Date |
|---|---|---|---|---|---|
| 1 | A565.901S | Durango Area Drainage Master Plan, Data Collection Report (ADMP) | Dibble and Assoc. in Cooperation with McCloskey Peltz, Inc. and SWCA Environmental Consult., Inc. for FCD | FCD 99-41 | 2000 |
| 2 | A565.902S | Durango Area Drainage Master Plan, Alternatives Analysis Report (ADMP) | Dibble and Assoc. in Cooperation with McCloskey Peltz, Inc. and SWCA Environmental Consult., Inc. for FCD | FCD 99-41 | 2001 |
| 3 | A565.601S | Durango Area Drainage Master Plan, Recommended Design Report (ADMP) | Dibble and Assoc. in Cooperation with McCloskey Peltz, Inc. and SWCA Environmental Consult., Inc. for FCD | FCD 99-41 | 2002 |
| 4 | CDA565.3 | Durango Area Drainage Master Plan, Hydrology Report, Revised April, 2003 (ADMP) | Dibble and Assoc. for FCD | FCD 99-41 | 2001 |
| 5 | A124.301S | Rio Salado Drainage Master Plan, Draft (DMP) | Wood, Patel and Assoc., Inc. for Rio Salado Project and City of Tempe | WP# 97644 | 1997 |

Date: November 16, 2010

A teleconference was held on November 15th at 2:30 p.m. Mountain Standard Time (1:30 p.m. Pacific Standard Time) with Van Crisostomo of the Los Angeles District of the US Army Corps of Engineers (LACOE) with regards to producing hydraulic modeling and supporting documentation that will be the basis for pending FEMA flood map revisions of the Tres Rios Levee project. Flood Control District of Maricopa County (District) staff included Richard Harris and Don Rerick. Dr. Brian Wahlin and Mr. Chuck Davis of WEST Consultants also attended. The focus of the discussion was the status of the hydraulic modeling products being developed by LACOE and in what time-frame these products would be made available for the request of floodplain and floodway map changes from the FEMA at the Tres Rios North Levee. Discussions generally followed the list of items below:

1. Current status of the hydraulic model.

   Model Extents: The model extends from approximately 83rd Avenue on the upstream end to below the Agua Fria/Gila confluence on the downstream end. There is also an approximately 1-1/2 mile section of the Gila River upstream of the Gila/Salt confluence included in the model.

   Levee: The entirety of the levee (Phase 1A AS-BUILT, Phase 1B AS-BUILT, and Phase 1C design drawings) have been incorporated into the hydraulic model. It is difficult to include a floodwall perpendicular to flow as Phase 1C has been designed in a 1-D hydraulic model, but this feature has been included. The Phase III Environmental Restoration features (i.e., low-flow channel and plantings) are not included in the current hydraulic modeling deliverable because the LOMR is concerned with the "with levee only" geometry. However, the previous grade work completed for the overbank wetlands should be included in the topography of this hydraulic model. Van confirmed that the current grade work for the overbank wetland has been included in the topography for this hydraulic model.

   Additional structural features: The guide dikes are currently not in the model. The District has requested that LACOE include these structures in the current model.

   Estimated delivery date: Van indicated that HNTB, the A/E firm working on the Phase III Environmental Restoration hydraulic model, is currently reviewing the final hydraulic model that the LACOE has developed for two reasons: (i) to validate and modify Manning's n values in the model based on recent aerial photography and field conditions and (ii) to validate and modify ineffective flow areas based on the updated levee geometry and recent aerial photography. LACOE had them complete this review to ensure that the final hydraulic model for the LOMR package with the "with levee only" geometry was identical to the starting hydraulic model for the Phase III modeling effort before adding in the low-flow channel and plantings associated with the Phase III design plans. Van indicated that HNTB should have this review completed soon, and the final model should be available for the District within 3 weeks.

2. Least Damage Levee Overtopping Location

   In the DDR, the discussion of the least damage overtopping location is a remnant of the PED report and the original design alignment, because the DDR indicates that the least damage overtopping location is in a portion of the levee downstream of El Mirage road that was never constructed. This should be corrected in the DDR. Van indicated that off-line storage within the overbank wetlands upstream of the 105th Avenue alignment and within the sand and gravel mining pit downstream of El Mirage Road would provide enough hydrograph attenuation that the river stage would be less likely to overtop the final levee alignment; therefore, a least damage overtopping location along the levee alignment was not constructed.

   In the AS-BUILT plans for Phase 1A and Phase 1B, there seems to be a discrepancy in the amount of freeboard along the levee downstream of the 116th Avenue Bridge (between stations 150+40 and 115+40). In this section, the freeboard is shown on the AS-BUILTS to be approximately 2.3 feet or less, but the levee elevations match the levee design elevations from the PED report. Was the water surface elevation drawn incorrectly on the AS-BUILTS?

3. Status of topographic mapping merged product to deliver to District? Will the LACOE provide documentation regarding certification and documentation about the way the products are being merged?

   Van indicated that David Pham and Paul Beaver would be handling the certification of the topographic mapping product, but he said that he would discuss this topic with both David and Paul again.

4. Discussion about the LOMR Needs list from WEST – does the LACOE have any questions?

   Van said that he has been working on the data needs requests that he has been sent. Richard asked if the LACOE would be providing Work Maps, and Van indicated that his group was not planning to provide these. Richard also said that these are typically provided for Floodplain studies during the review process. Additional questions regarding the specific needs for the LOMR submittal can be discussed once the hydraulic model is completed and delivered to the District.

   Another issue that was mentioned regarding LOMR data needs is the conversion from the current hydraulic model cross sectional numbering scheme to match the effective model cross sectional numbering scheme. WEST volunteered to complete this task.

5. DDR Questions for the hydrologic methodology incorporated for the Interior Drainage Design: Which study includes the Rio Salado Interior Drainage Study? And how was the "8-drain sampling procedure" developed for the Rio Salado Interior Drainage Study modified to reflect greater agricultural land use in the interior drainage area of the Tres Rios levee?

   Van said that he would post the technical appendices document for the Rio Salado Feasibility Report which includes the discussion of the 8-drain methodology to the LACOE ftp site.

   Update: Van posted this PDF document to the LACOE ftp site on the afternoon of November 15th. WEST retrieved a copy of this report at that time.

Action Items:

1. Van and LACOE to ensure that the guide dikes are included in the hydraulic model either with ineffective flow areas or blocked obstructions. These may turn out to be "shadow" applications if the existing cross sections fall near but not exactly along guide dike crests.

2. Van to follow up with HNTB to ensure the estimated delivery of the hydraulic model in 3 weeks is met.

3. Van to post the technical appendices document for the Rio Salado Feasibility Report to the LACOE ftp site. *Update: Van posted this PDF document to the LACOE ftp site on the afternoon of November 15th. WEST retrieved a copy of this report at that time.*

4. Chuck to send Van and Richard red-lined versions of the AS-BUILT drawings showing the locations of lower freeboard downstream of the 116th Avenue Bridge.

5. Van to remind David and Paul to investigate 1' topo mapping certification documentation.

The next call will take place on Tuesday, November 30, 2010. A formal invitation will be forthcoming from Richard.

Update: The invitation has been sent.

Date: December 7, 2010

A teleconference was held on November 30th at 9:30 a.m. Mountain Standard Time (8:30 a.m. Pacific Standard Time) with Greg Dombrosky, David Pham, and Van Crisostomo of the Los Angeles District of the US Army Corps of Engineers (LACOE) with regards to the status of producing hydraulic modeling and supporting documentation as the basis for pending FEMA flood map revisions for the Tres Rios Levee project. Flood Control District of Maricopa County (District) staff included Richard Harris and Don Rerick. Dr. Brian Wahlin and Mr. Chuck Davis of WEST Consultants also attended. Bob Upham of the City of Phoenix was present.

The focus of the discussion was the status of the hydraulic modeling products being developed by LACOE with regards to previous discussions, and in what time-frame these products would be made available by the LACOE for a LOMR request package of floodplain and floodway map changes from the FEMA at the Tres Rios North Levee. Discussions generally followed the list of items below:

What is the Current status of the hydraulic model and related products?

Van said that HNTB is finishing up their review of the modeling input parameters such as the roughness values and ineffective flow areas in relation to existing conditions. Don verified that the model the District will receive from the LACOE will not include any Phase III design (clearing with low flow channel and environmental restoration), and Van confirmed. Van said that once the modeling is returned to the LACOE, there will be an internal review before transferring it to the District in a few weeks.

The group discussed the list of up to five hydraulic models and who will provide each, per previous discussion. It turned out the WEST is going to provide the majority of the models, with this being possible since they worked on the PED and it already included modeling the existing condition. Therefore, it is apparent that the LACOE may provide only the "with project" modeling scenario.

Richard brought up the study work maps, an item which is normally required for such studies, and Van said that the LACOE will provide these. Brian reminded us that WEST has already sent the LACOE examples of the work maps for reference.

Richard asked David Pham about the status of the DDR revisions, and David said they were underway. David expected to be able to resubmit the revised report by 1/31/11.

There were questions about the status of As-built (AB) plans and the O & M manual for the Overbank Wetlands (OBW), located east of the levee between @105$^{th}$ avenue and 91$^{st}$ avenue. While this is part of Phase II, it will still be included because there has already been considerable grading in the main Salt/Gila conveyance area as a result and therefore it is considered part of the existing condition. Bob Upham of the City said that the City"owns" it, in terms of maintenance. However, the AB plans should still come from the LACOE, and it is assumed that the LACOE have already created an O & M manual for it. The District has not received either the AB plans or the O & M manual for the OBW, yet.

> Update: David Pham of the LACOE posted the OBW and FRW O & M manuals on ftp @ 12/06/10. The document has since been downloaded.

Van initiated discussion about the freeboard (FB) depiction on the AB plans that WEST prepared, and Van said that between 115th avenue and 123rd avenue the FB depicted was not accurate. Van said he will discuss this with David, and will ask him to revise the AB plans and re-scan them.

Richard asked the status of any new documentation for certification of the topographic mapping. David said he had found the surveying report and will send it this week.

> Update: David uploaded the Survey report and alleged AB plans for the OBW to an ftp on 12/01/10. The survey report is for the 1' topo only, and has since been downloaded. Per contract, the District is having WEST review it in context with national mapping standards, and to check for product accuracy in context with floodplain/floodway delineation study requirements. It turned out that the OBW plans were not the AB plans and David has subsequently said the AB plans will be ready in about two weeks (@ 12/16/10).
>
> Note from teleconference 11/15/10: Van indicated that David Pham and Paul Beaver would be handling the certification of the topographic mapping product, but he said that he would discuss this topic with both David and Paul again.

The WEST review of the survey report is not expected to constitute certification of either the 1' topo or the merged product. The WEST review has only to do with reviewing the 1' CI mapping documentation product to determine if it contains basic certification documentation. The LACOE should continue to be regarded as the certifying authority for these products. The survey report may contain certification documentation by Towhill (the originating photogrammetry company), but the merged contour mapping product may require a separate certification. The LACOE is expected to remain responsible for this.

David said he will make sure to include the AB plans for the OBW by 12/23/10 .

A question came up about the Emergency Action Plan and if it had been prepared by the LACOE, yet. Don remarked that the District had previously sent the LACOE examples of EAPs for their reference. Don said that Gwendolyn Meyers will have to be contacted about this, after hearing the LACOE say they are awaiting authorization for funding before they start preparing the document.

> Update: Gwendolyn has since been contacted and she said that the LACOE has prepared similar documents for structures that they operate (maintain), but that the entire TRL project is being or has been turned over for operation to the District and/or the City. By deduction this means that one or both of those entities may have to prepare the EAP.

Richard asked about the status of the LER/NLSER, aka Levee Certification. Greg said he would have to talk to Paul about it.

Action Items:

1. Once the LACOE receives the hydraulic modeling from HNTB, the LACOE to check the model input values and ensure that the guide dikes are included. The LACOE to then send the hydraulic modeling package to the District/WEST for further review. This is expected to happen within a few weeks.

2. The LACOE to continue working on the AB plans for the OBW and provide them by 12/23/10.
3. Van to remind David and Paul to investigate 1' topo mapping certification documentation.
4. WEST to review the survey report for the 1' topo product from the LACOE, and make comments by 12/10/10.
5. The LACOE to revise the AB plans for the levee and re-scan them in terms of the Freeboard plot. David Pham to be the lead. This product may be sent to the District ahead of other revisions but will not be received later than 12/23/10.
6. THE LACOE to continue with revisions to the DDR and work on the LER/NLSER. The updated DDR should be delivered to the District by 1/31/11.
7. The District and the City to look into who will do the EAP production.
8. Update: LACOE uploaded OBW O&M Manual on its FTP site on Monday morning 6 Dec 10. The next call will take place on Monday, December 13, 2010. At 9:30 AZ time (8:30 CA time).A formal invitation has been sent.

# USACE Topography Certification
## Technical Memorandum

## Flood Control District of Maricopa County
## Tres Rios LOMR Project

Date: December 9, 2010

To: Richard Harris – FCDMC

Cc: Amir Motamedi – FCDMC
Don Rerick – FCDMC

From: Brian Wahlin, Project Manager – WEST Consultants, Inc.
Chuck Davis – WEST Consultants, Inc.

### Introduction

The purpose of this Technical Memorandum is to evaluate whether the 1-foot topography collected by Towill Survey, Mapping and GIS Services (Towill) on behalf of the US Army Corps of Engineers (USACE) is certifiable. WEST reviewed the Towill's *Field Survey Record Data, Notes, and Calculations* report for the Tres Rios Project to determine if the survey is certifiable to FEMA standards. Towill's report consists of the following sections:

- Project location map
- Survey report
- Coordinate spreadsheets
- Record control
- Level GPS control
- Description of horizontal control station
- Bridge notes and photos

Because the topography collected by Towill in the Tres Rios area was for a USACE project, Towill followed USACE standards for topographic mapping (i.e., EM 1110-1-1000, *Photogrammetric Mapping*). It appears that Towill did follow appropriate standards based on the following statement taken from their Survey Report section:

> *"The results of the final least squares adjustment of the horizontal and vertical control networks were analyzed and approved by the Project Manager (Jim Kor of Towill) prior to commencement of photogrammetric work. The results were suitable for digital topographic mapping and digital terrain modeling (DTM) using photogrammetric techniques, for the map scale and contour interval requested."*

Based on the information given in Towill's report, the topography appears to meet FEMA standards; however, there is no backup information to support this claim:

- The report is not sealed by a licensed RLS, which is common for USACE projects.
- The RMSE values are not reported.
- The metadata for the survey information has not been located.

From WEST's experience in these matters, it appears that the Towill topography will pass as certified; however, there is no guarantee. At this point, there appears to be two ways to rectify the survey certification situation:

- USACE requests that Towill provide RMSE values for the survey.
- Discuss the survey certification with FEMA Regional IX Engineer (Ed Curtis) to get his approval of the topography before the LOMR is submitted.

Date: December 13, 2010

A teleconference was held on December 13th at 9:30 a.m. Mountain Standard Time (8:30 a.m. Pacific Standard Time) with David Pham of the Los Angeles District of the US Army Corps of Engineers (LACOE) with regards to the status of producing hydraulic modeling and supporting documentation as the basis for pending FEMA flood map revisions for the Tres Rios Levee project. Flood Control District of Maricopa County (District) staff included Richard Harris and Don Rerick. Dr. Brian Wahlin and Mr. Chuck Davis of WEST Consultants also attended.

The focus of the discussion was topographic survey certification, the status of the hydraulic modeling products being developed by the LACOE with regards to previous discussions, and in what time-frame these products would be made available by the LACOE for a LOMR request package of floodplain and floodway map changes from the FEMA at the Tres Rios North Levee. Discussions generally occurred as follows:

What is the current status of the hydraulic model and related products?

David said that he couldn't speak for Van about the status of the modeling work, and that Van will be back on the 3rd of January. Don had a question about whether Van is planning on sealing and signing the study work maps. David said another teleconference call will be needed to discuss this with Van.

Richard asked the status of certification for the topographic mapping. David mentioned a need to discuss this topic with the Survey Section Chief, Alan Nichols. Don suggested Richard write to Alan to seek certification or ask him to seek certification. The LACOE should continue to be regarded as the certifying authority for this product. The merged 1' and 4' contour mapping product may require a separate certification. The LACOE is expected to remain responsible for this.

Update: The extent of topographic mapping products with regards to effective FEMA FP/FW boundaries was evaluated during a post-conference call discussion with WEST Consultants. It appears that the 1' topographic mapping extends well beyond those boundaries in most locations except along the north bank both above and below the ends of the levee structure as constructed. The potential for the updated FP/FW to exceed the 1' topographical mapping boundary in those areas will be brought up with Van for future discussion during the next call.

Update: David sent Alan Nichols email address to Richard, and Richard sent an email sent to Alan Nichols on 12/13/10 explaining our request and inviting him to call Richard directly, and to attend the next teleconference to be held Wednesday, 01/05/11, at 9:00 a.m. Pacific time.

Richard asked David Pham about the status of the DDR revisions, and David said they were underway. David expected to be able to resubmit a revised report by 1/31/11.

Discussion about the EAP came up and David related his knowledge about an EAP for a LACOE levee system called the Santa Maria Levee (SML) in Santa Barbara County, California. David said that that levee was operated by the local FCD, there, and he thought that the EAP had been prepared by the LACOE. This seemed in contradiction to what Gwendolyn Meyers of the COE said in a previous email. She stated that it is the responsibility of the owner/operator to produce the EAP. This issue is not

settled, and David was asked to investigate the SML production and send/post a pdf copy of the SML EAP for FCDMC review. This will be a topic of further discussion.

David said that the AB plans for the OBW will be finished between now and the end of the year.

Discussion continued regarding the final design plans and construction of the phase 1C floodwall. David said that the final design plans will be ready sometime this week, and that the time frame for starting construction is still around April, 2011. He said the construction pace should be rapid once it has begun. Richard said that the hydraulic modeling should not be held up but should proceed using the final design plans. The DDR, however, may have to contain the As-built (AB) plans, so that the DDR (and related LER) finalization may not occur until the AB plans are finished.

Richard asked about the status of the LER/NLSER. David referred to a time frame from a teleconference held several weeks ago, saying that the LER should still be ready in March, 2011. However, as described above the LER may not be complete until all AB plans and therefore the DDR are completed. The LER preparation remains the responsibility of Paul Beavers.

Action Items:

1. The LACOE to continue working on the AB plans for the OBW and provide them by the end of this year (2010).
2. The LACOE to continue work towards certifying the topographical mapping. The LACOE to consider topographical mapping certification in context with the email Richard sent to Alan Nichols, LACOE Survey Section Chief on 12/13/2010.
3. The LACOE to continue with revisions to the DDR and work on the LER/NLSER. An updated DDR should be delivered to the District by 1/31/11. The LER may come in March or even later.
4. David to investigate the Santa Maria Levee EAP and upload a copy for downloading by the District and WEST consultants. The LACOE to revise the AB plans for the levee and re-scan them in terms of the Freeboard plot. David Pham to be the lead. This product may be sent to the District ahead of other revisions but will not be received later than 12/23/10.
5. The next call will take place on Wednesday, January 5, 2011. At 10:00 MS time (9:00 PS time).A formal invitation has been sent.

Date: January 5, 2011

A teleconference was held on January 5th at 10:00 a.m. Mountain Standard Time (9:00 a.m. Pacific Standard Time) with Paul Beaver and Alan Nichols of the Los Angeles District of the US Army Corps of Engineers (LACOE) with regards to the status of producing hydraulic modeling and supporting documentation as the basis for pending FEMA flood map revisions for the Tres Rios Levee project. Flood Control District of Maricopa County (District) staff included Richard Harris and Don Rerick. Dr. Brian Wahlin and Mr. Chuck Davis of WEST Consultants also attended.

The focus of the discussion was topographic survey certification, and the status of the hydraulic modeling products being developed by the LACOE with regards to previous discussions, and in what time-frame these products would be made available by the LACOE for a LOMR request package of floodplain and floodway map changes from the FEMA at the Tres Rios North Levee. Discussions generally occurred as follows:

What is the Current status of the hydraulic model and related products?

Paul said that he couldn't speak for Van about the status of the modeling work (there had been discussion amongst WEST and the District ahead of the call about the latest deliverable by HNTB, and it was agreed that there is an immediate need to discuss the item with Van).

*Update: WEST Consultants personnel spoke with Van on 1/6/11 in regards to the primary question related to the latest HEC-RAS model deliverable by HNTB: what portions of Phases I and II were included in the topography for this HEC-RAS model? Van stated that only the grading completed by November 2010 for the Overbank Wetlands (OBW) was included for the Phase II features; in-channel vegetation clearing and plantings were not included in this model. However, the HNTB technical memorandum indicated that the model represented all project features for Phases I and II. This should be clarified in the technical memorandum. Van asked WEST to forward their review comments on the HNTB technical memorandum to himself.*

The Survey Section Chief, Alan Nichols, joined in regarding the topographic mapping certification issue. There was discussion over past emails from Alan that included a draft survey certification letter that Harvey Beverly, former survey chief, would sign stating the mapping met national mapping standards. Further discussion occurred over whether or not such a letter would need to be sealed by an RLS per FEMA requirements, and Alan stated he would only do it if it were 100% necessary. Alan said that the mapping project manager at Towill, the mapping company, had died and the company was not readily going to provide certification documentation without him. Brian said he and his staff will look into what are the FEMA requirements by contacting Ray Lenaburg of FEMA Region IX and Michael Baker Jr. Engineering staff (Region IX reviewer). Paul discussed some related verbiage that may be needed for the LER with Alan, and Paul said once obtained he will send a draft to us for review (this verbiage may be useful in fine-tuning a certification statement letter, also). Paul questioned if there might be caveats to the regular FEMA requirements that gave Federal Agencies some leeway for their own projects.

*Update: Alan has provided a letter signed by Harvey Beverly that the topography developed by Towill meets the USACE standards for vertical accuracy.*

*Update: WEST Consultants personnel spoke with two FEMA reviewers, Stephanie Routh from Dewberry and Mark Delorey from Baker, on 1/6/11 regarding this issue. They both agreed that the letter provided by Alan and Harvey from the LACOE will be sufficient to certify the topography because it comes from the LACOE, a federal agency. Stephanie and Mark both said that if a county or city tried to submit a similar letter, it would not be accepted. They also both stated that for non-FEMA funded projects, such as this one, FEMA does not tend to look at the topography with the strictness that it does with FEMA funded projects. In non-FEMA funded projects, FEMA realizes that the topography used is probably better than the existing topography; thus, they have a tendency to be a little lax on the certification requirements for the non-FEMA funded projects. Note that this information is from an informal conversation and does not reflect "official" FEMA policy. In addition, the FEMA reviewers will be looking for a PE or RLS stamp on the MT-2 forms, the workmaps, and the As-builts. Of course, if the LACOE does the As-built plans, there does not have to be a stamp because they are the LACOE. As long as the stamps for the MT-2 forms and workmaps are in the right place and the letter signed by Harvey is provided, there should be no issue with the topography in regards to LOMR acceptance for the Tres Rios North Levee.*

Richard asked Paul about the status of the DDR revisions, and Paul said they were still planning to resubmit a revised report by 1/31/11.

Discussion about the EAP came up and Brian said he did not believe it was necessary for a LOMR package. He said he will review the FEMA standards/MT-2 forms to determine this for good.

*Update: WEST Consultants personnel reviewed the MT-2 forms, and no mention of an EAP requirement for a levee is made in these forms. The MT-2 forms request a copy of the Operations and Maintenance Plan for the levee, but there is no request for an EAP.*

Paul said that a discussion regarding the status of the AB plans for the OBW would have to wait until David Pham could join the conversation, and Paul said he will send David an email regarding this. Paul said that internal discussion had resulted in the re-organization of the DDR so that the As-built plans may not be included in it, but with an understanding that the LOMR package will need them.

Discussion continued regarding the final design plans and construction of the phase 1C floodwall. Don said that the City was still maneuvering to obtain right-of-way construction easements from Mr. Harper, property owner on the West side of El Mirage Road where the wall will be constructed. Don said Mr. Harper was not happy with the current design and he didn't feel the current design could be "put out" for construction yet. Richard asked Paul to contact David Pham about the status of the final phase 1C design.

Paul said he will send us a draft of the LER for review.

Next conference call is scheduled for Tuesday, January 25 at 9:00 am California time, 10:00 am Arizona time.

Action Items:

1. WEST to contact Region IX and Baker for topographic mapping certification requirements.
   *Update: WEST Consultants completed this task on 1/6/11 as mentioned above.*
2. Paul will ask David Pham about the As-built plans status for the Overbank Wetlands.

3. WEST to send Richard an e-file of the EAP proposal.
   *Update: WEST Consultants completed this task on 1/7/11.*
4. WEST to verify whether or not an EAP is needed for the LOMR package.
   *Update: WEST Consultants completed this task on 1/6/11 as mentioned above.*
5. WEST to contact Van at the LACOE regarding the JE Fuller report/modeling that apparently has been developed and preceded the recent revision and deliverables by HNTP. Also to discuss the HNTB deliverable.
   *Update: WEST Consultants contacted Van on 1/6/11 as mentioned above. A technical memorandum commenting on the HNTB deliverable will be sent to Van the week of 1/10/11.*
6. WEST to review the HNTB deliverables and provide comments by next call 01/25/11 at 9 a.m., PST (10 MST). Preferably these will be prepared in advance and transferred to Van for his review before the call.
7. Paul to contact David Pham regarding the status of the final design for Phase 1C.
8. Paul to send a draft of the LER for review when ready. It is understood that it may be very basic initially.

Date: January 26, 2011

A teleconference was held on January 25th at 10:00 a.m. Mountain Standard Time (9:00 a.m. Pacific Standard Time) with Gwendolyn Meyer of the Phoenix office of the US Army Corps of Engineers and Bob Upham of the City of Phoenix, with regards to the status of producing hydraulic modeling and supporting documentation as the basis for pending FEMA flood map revisions for the Tres Rios Levee project. Unfortunately no one from the LACOE attended. Flood Control District of Maricopa County (District) staff included Richard Harris. Dr. Brian Wahlin and Mr. Chuck Davis of WEST Consultants also attended.

Bob told us that the final design and construction for Phase 1C, the floodwall along El Mirage Rd., was on hold because the design had been rejected by an S & G operator who currently owns the needed land. The floodwall is a feature necessity to ensure that flows will not back up behind the levee along the western end of it.

We asked Bob if he could meet with us regarding the floodwall issue (in relation to Don Rerick's recent email regarding the City's key role) but he said he would have to determine who else at the City may need to attend such a meeting and will get back to us, later.

Gwen tried to contact Paul and left a voice message for him. She also said that David Pham is being deployed to Afghanistan. Paul Beaver later confirmed this by email and said that he will have to determine who will fill-in for David in LA. David has been in charge of finalizing the DDR, so it may be that another person will accomplish this instead while David is gone.

Update from David Pham per email: Ms. Roxanne Vidaurre was designated to continue my work on the DDR. She can be reached at (213) 452-3643 or Roxanne.R.Vidaurre@USACE.Army.Mil. Please keep her in your future emails.

Post-call discussion occurred between Richard and WEST regarding their preliminary findings during review of the JE Fuller hydraulic model, and the draft Summary Report they are revising for the District (the Final Summary Report will outline what has been made available to them and what remains to be done towards preparation of the LOMR package).

Update: Today, 01/26/11 Richard spoke with Paul and he said he will be sending the District the Geotechnical Appendix of the DDR for review. It is at a 90-95% completion, and Richard told Paul that Don Rerick should receive it and Richard would like to be copied. Paul also suggested Richard send an email to David regarding the issue of any certifiable levee-like structures east of the main levee (@ the OBW), and another email to Roxanne Vidaurre of the LACOE regarding the OBW as-built plans status.

Update: The Geotechnical report has since been received and transferred to WEST for review. See further update below in Action Items.

Action Items:

1. Bob will notify Richard about having a meeting over the Phase 1C floodwall feature once it is known who from the City should attend other than himself.
2. WEST to finalize the draft Final Summary Report for the District to better reflect the form and general content of an Arizona State Standards Technical Data Notebook, and to provide initial cost estimates for TDN development tasks.
   Update: A draft of these materials has been provided to Richard, who is currently reviewing it.
3. Richard to send an email to David regarding a question of any levee-like structures to be certified east of the main levee, and to send an email to Roxanne regarding the status of the Overbank Wetlands as-built plans.

   Update: The two above-described emails were sent, and David referred Richard to Van insofar as understanding the LACOE intentions about the levee-like structures east of the main levee. This resulted in an email forward to Van, resulting in a total three emails. Also, per Don's request Richard have re-sent teleconference invitations to stress the importance of discussions regarding the OBW features and floodplain containment in and around them. Richard forwarded the Geotechnical appendix of the DDR to WEST requesting their review and comment.

   Second Update: WEST has reported that the Geotechnical appendix appears to be a revision of another project and still apparently contains remnants of that project in the text. They have also declined to review the Geotechnical data aspects of the document.

Date: February 15, 2011

A teleconference was held on February 15, 2011 at 10:00 a.m. Mountain Standard Time (9:00 a.m. Pacific Standard Time) with Paul Beaver, Van Crisostomo, and Roxanne Vidaurre of the LACOE, Gwendolyn Meyer of the Phoenix office of the US Army Corps of Engineers, and Bob Upham of the City of Phoenix, with regards to the status of producing hydraulic modeling and supporting documentation as the basis for pending FEMA flood map revisions for the Tres Rios Levee project. Flood Control District of Maricopa County (District) staff included Richard Harris and Don Rerick. Dr. Brian Wahlin and Mr. Chuck Davis of WEST Consultants also attended.

Richard confirmed with Van that the model recently obtained from the HNTB ftp site is the same as the one Van sent yesterday. Van said it was. Richard commented that some minor issues still remained such as the use of artificial levees in non-certifiable embankment areas, but that WEST will review the model and later provide review comments. Van reaffirmed that they will provide study work maps in conjunction with modeling, and he said that the maps should be ready by the next call (@ 2-3 weeks). Richard asked about the geometry used in the Overbank Wetlands (OBW) area in the HNTB model and Van said it was based upon design information. Richard asked if WEST could check the effects of the as-built (AB) geometry for that area once it becomes available. Roxanne said the AB plans for the OBW should be ready by tomorrow.

Richard brought up what AB plans remain, including the update to the phase 1B plans to show a more accurate plot of the water surface based upon a comment made during past calls. WEST will send the related "blurb" to Richard, who will in turn send it to the LACOE. Don asked who is going to show Roxanne what needs to be changed and someone mentioned David, and that there were ways to still contact him....

*Update: WEST forwarded an email sent previously to Van regarding the discussion of the seemingly erroneous water surface elevations on the Phase 1B as-builts to Roxanne on 2/17. This email included the original Phase 1B as-builts in PDF format with comments from WEST provided electronically within the PDF files.*

There was a discussion about what was partially reviewed of the Geotechnical appendix to the DDR, and Paul clarified it was extracted from a project near Tucson that also had "Tres Rios..." as part of its name. Paul said that revisions to that appendix and therefore the entire DDR are occurring within the LACOE and it will be reviewed internally. He estimated the DDR, and shortly thereafter the LER, to be completed by late spring this year (end of May). He reminded all that the phase 1C must be finalized before the DDR is complete, and at present this phase is in limbo due to apparent design issues that the respective land owner has with the City and the LACOE. Bob said that the City needed to have a conversation with Tim Phillips of the District and MCDOT regarding the option to raise the profile of El Mirage road as a design alternative to the flood wall. This may prove difficult given the perception of a flood control structure in the form of a road, with attendant Operations issues. Also, under such a scenario the road may have to become a certified embankment. This may not appeal to MCDOT but Don said he will manage setting up a meeting. Bob explained later that the current design has resulted in the

land owner seeking to move a batch plant, and this is not acceptable to the City. Don told Bob that MCDOT will want to see that "every rock has been turned over" first, before they will accept the design idea of raising the roadway, and Bob said he is ready for such a challenge.

At this point Richard referred to a list he had made of six critical items that must be provided for the project to move forward:

1. There must be two post-project models provided by the LACOE, one with all AB features, and a second without the non-certifiable features. This second model will not likely provide the results that the LOMR request will be based upon, but must be provided in order to satisfy FEMA requirements to investigate structure failure scenarios.
2. Study work maps, described above.
3. Supporting documentation for all AB features, described above.
4. Levee Certification documentation, described above.
5. Phase 1C feature construction – Don reminded LACOE and the City that they must be responsible for getting this feature, or its alternative, built. The District will facilitate meetings towards that end.
6. DDR report and LER, described above.

Van restated that the LACOE still intends to provide the modeling and related documentation, and Richard mentioned a need to obtain electronic drawing files along with the study sheets. Brian said he will provide a list of files that will be needed, and it was decided that the LACOE will not be responsible for conforming to the District's HIS standards of file format – WEST will eventually provide this. Richard mentioned a need to also get FIS data, and Van asked more about what that was. Brian mentioned the flood profiles, and Van said he will have to check on who in his unit will provide that. Van said they have new interns that are going to be charged with producing this type of information. Richard re-stated that the artificial levee routine should not be used for non-certifiable structures, but AB geometry and ineffective flow areas are more acceptable modeling approaches, such as along the south embankment of the Salt/Gila @ the 115th Avenue Bridge.

Richard asked it the LACOE were going to commit to having a team set up to handle District and FEMA review comments over a period of time that may last up to 2 years. Paul said they will be formulating an internal team for this. Richard asked if it might be an advantage for the LACOE to hire a consultant to provide the bulk of study documentation and respond to comments because the experience the District has had shows a consultant team may be more cohesive over the long term. The LACOE declined the idea, and Don mentioned that this project is to be a learning opportunity for them to produce things in-house. Paul asked about what is the process for FEMA review and Richard described that the FEMA headquarters is in Virginia, but reviews may take place in Maryland or Colorado. Paul mentioned a desire to "sit down and talk" to FEMA either at the time of submittal or when their review comments are first available. Richard said such a talk may likely be by phone, and Don recalled a talk with FEMA some months ago wherein some people were not in attendance – an ongoing issue. Paul asked for a type of list of what to provide FEMA, and Richard asked WEST to provide such a list again and he will

forward it on to the LACOE. WEST will also send Richard the Data Collection Report and Summary Report once the AB plans for the OBW are received and recorded in it.

The point-of-contact issue regarding future FEMA review comments was brought up by Richard, and Don clarified that the LACOE will serve in this role because they are going to provide the data to support the LOMR.

Don told Bob he will set up the meeting regarding the phase 1C feature alternative designs. Richard asked WEST to review the latest RAS models from HNTB and to provide comments to the District. He also asked that they report on their findings using the AB OBW information @ 105th avenue, and note any changed boundary effects @ El Mirage road. WEST will provide review comments regarding this.

Action Items:

1. WEST to review HNTB models in context with responding to their comments, and check the effects of the AB OBW plans and any notable conditions @ El Mirage Rd (both sides of the river).
2. WEST to send comments and FEMA study document requirement list to Richard, along with the Data Collection Report and Summary Report, and he will forward all on to the LACOE staff Van, Alan, Roxanne, and Paul.
3. WEST to send a list of GIS files that will be required in the review of the study maps to Richard, and he will forward on to the LACOE staff Van, Alan, Roxanne, and Paul.
4. Don to set up meeting between the Corps and MCDOT to consider what to do next regarding the phase 1C flood wall.
5. WEST to send Richard the "blurb" about updating the phase 1B plans, and Richard will forward to the LACOE.
6. Roxanne to check on the AB plans for the OBW and make sure they are available soon.

The next call is planned for March 8th, 10:00 a.m, MST, and 9:00 a.m., PST. A formal invitation will follow.

# Appendix B: General Documentation and Correspondence

B.4 General Correspondence

*(None for the summary report)*

# Appendix B: General Documentation and Correspondence

## B.5 Contract Documents

My Copy

FLOOD CONTROL DISTRICT of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009
(602) 506-1501
Fax (602) 506-4601

**LETTER OF TRANSMITTAL**

TO: Brian Wahlin, Vice President
WEST Consultants, Inc.
8950 South 52nd Street, #210
Tempe, AZ 85284

September 13, 2010

SUBJECT: Contract No. 2010C027
Assignment No. 2
Tres Rios Levee Floodplain and Floodway Re-dlineation Project

WE ARE SENDING YOU THE FOLLOWING ITEMS:
( ) Enclosed ( ) Under separate cover

| | | | | |
|---|---|---|---|---|
| | Shop Drawings | Prints | Legal Description | Samples |
| | Specification | Change Order | Copy of Letter | Plans |
| X | Notice to Proceed | | | |
| X | Certificate of Performance | | | |
| X | Scope of Work | | | |

THESE ARE TRANSMITTED:

| | | |
|---|---|---|
| | For Approval | Approved as submitted |
| X | For your use | Approved as noted |
| | As requested | Returned for corrections |
| | Resubmit ( ) copies for approval | For review and comments |
| | Submit ( ) copies for distribution | Return ( ) corrected prints |
| | FOR ESTIMATE DUE: | Borrowed prints being returned |

**Remarks: Please specify assignment number on all correspondence.**

SIGNED: Richard P. Harris

Richard P. Harris, P.E., CFM
Project Manager

Included in FY 10 Budget for Tres Rios (126.01.31). CSV 9/10

Copy to: LMM (Finance)
COORD: MRB CGF DJR LMM CSV
INFO: AMM kAG
FILE: 2010C027

CSV 9/10

FLOOD CONTROL DISTRICT of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009
(602) 506-1501
Fax (602) 506-4601

**NOTICE TO PROCEED**

TO: Brian Wahlin, Vice President
WEST Consultants, Inc.
8950 South 52nd Street, #210
Tempe, AZ 85284

September 13, 2010

| SUBJECT: | | | | |
|---|---|---|---|---|
| | PCN | 126.01.31 | Low Org | 6975 |
| | FCD Contract No. | 2010C027 | | |
| | Assignment No. | 2 | | |

Tres Rios Levee Floodplain and Floodway Re-dlineation Project

Your not-to-exceed cost estimate of $36,294.40 for Assignment No. 2 has been received and accepted for this project with a completion date of 3/14/2011. You are hereby authorized to proceed with the work for the referenced project as originally described in the Scope of Work. Please specify the contract title, contract number, assignment number, and the dates of the completed service on all related correspondence, including the invoice. Send the invoices and certificates of performance to the attention of Finance Department, Flood Control District of Maricopa County. The certificate of performance must be dated on or after the final invoice date and must accompany the final invoices.

The purpose of this assignment is to collect and develop project data with an ultimate goal to update the Zone AE floodplain and floodway delineations of the Gila River in context with the Tres Rios Levee Phases Ia, 1b, and 1c construction features. The location of this project is roughly from 91st avenue extending westward to 123rd avenue along the Gila River alignment, a distance of nearly six (6) miles. The project data will be reviewed and categorized with relevance to a LOMR request package that will be produced under another (future) work assignment. All work will proceed as described in the attached Scope of Work and be processed within the time frame of the attached schedule. Variations to this will be permitted only by written request and District authorization. The schedule is subject to variation because related work will be influenced to some degree by the ability of the Corps of Engineers to provide the data.

If at any time during the project assignment a material change in the scope of services to be provided occurs, causing an increase in the original cost estimate shown here, you must provide the District with a written explanation of the additional work along with an estimate of additional costs. No additional work shall commence prior to written authorization by the District. No claims for additional work shall be accepted that have not received prior District approval.

SIGNED: _____ _____

Richard P. Harris, P.E., CFM
Project Manager

Timothy S. Phillips, P.E.
Chief Engineer and General Manager

**Certificate of Performance of Engineering Open Order Contract and Payment of All Claims**

I, _____, hereby certify to the Flood Control District of Maricopa County (FCDMC) that all lawful claims for labor, rental of equipment, material used, and any other claims by company, or its subcontractors in connection with the specific assignment described below and as authorized by the terms of the FCDMC Contract 2010C027 have been paid.

Company understands that with receipt of payment for previously invoiced amounts plus any retained funds, that this is a settlement of all claims of every nature and kind against the FCDMC arising out of the performance of the FCDMC's specific assignment through FCDMC Contract 2010C027 for Assignment No. 2 relating to the material, equipment, and work covered in and required by the contract.

The undersigned hereby certifies that to his/her knowledge, no contractual disputes exist in regard to this contract and that he/she has no knowledge of any pending or potential claims in regard to this contract.

Upon submission of this document and a separate invoice for any retained funds to the FCDMC, invoice processing will be completed within forty-five (45) calendar days.

Signed the _____ day of _____, 200__.

_____

Signature

Title: _____

WEST Consultants, Inc.

# SCOPE OF WORK

## CONTRACT FCD 2010C027 Work Assignment #2

## Tres Rios Zone AE Floodplain and Floodway Re-Delineation Study: Coordination, Data Collection and Summary Reports

### GENERAL SCOPE OF WORK

The purpose of this work assignment is to collect and categorize available data in context with a LOMR package development and submittal that will result in a re-delineation of the Salt River and Gila River Floodplain and Floodway from approximately 91st Avenue to 123rd Avenue in context with the Army Corps of Engineers (COE) Tres Rios Levee construction project. The work will include reviewing public notification to date, leading to a Coordination Report that will guide further notification and produce results to satisfy FEMA requirements for public notification of changes in Floodplain and Floodway. The collected data will be reviewed and a plan of action will be prepared for further data collection and data production that will ultimately result in a Data Collection Report and a Summary Report recommending further documentation development. These Reports should then lead to a future work assignment to provide services leading to a LOMR and FIS updates for the area.

Tasks will include but not be limited to reviewing and checking of modeling and documents provided by the COE relative to a conventional re-delineation study and Levee Certification, reviewing previous activities towards developing a plan for public information, legal advertising in context with FEMA requirements, and any other tasks relevant to Public Information and Data Collection that normally occur during a floodplain delineation study, in order to determine to what extent existing data will be sufficient to meet FEMA standards, or, to what extent additional activities must be performed before sending a LOMR package to FEMA.

This COE study re-delineated approximately 6 linear-miles of existing Zone AE Floodplains and Floodways using recent 1-foot-contour topographic mapping that the COE will provide to the Flood Control DISTRICT of Maricopa County (DISTRICT), as the mapping basis.

The CONSULTANT will check hydraulic models prepared by the COE to validate that they meet FEMA criteria and/or to develop a strategy to develop models that would meet those requirements. The CONSULTANT must use sound engineering judgment in the development of the models. The CONSULTANT must analyze the results of the models carefully and make refinements to the input parameters in order to obtain the most realistic results. The CONSULTANT will also check the Levee Evaluation Report produced by the COE to verify that it will meet FEMA standards.

All work must meet the requirements of the DISTRICT's Consultant Guidelines, Third Edition - December 1, 2003 - Revision 1. All work must also meet the latest versions of the Arizona Department of Water Resources (ADWR) Standards and the Federal Emergency Management Agency (FEMA) Guidelines and Specifications for floodplain delineations. Prior to the finalization of this assignment all items called for in this Scope of Work must be delivered, reviewed, and approved by the DISTRICT.

1.5 The CONSULTANT will be responsible for investigating and reporting what level of public notification remains to be done and will provide guidance to the DISTRICT in the form of a Coordination report. This report will be in context with FEMA requirements defined within the MT-2 instructions manual and will relate the re-delineation study/flood map change goals.. This report must be submitted to the DISTRICT within sixty (60) days of the NTP. The DISTRICT will be responsible for placing legal advertising at the beginning of the study and any additional notification recommended by the Consultant. The advertisement will be run in a widely circulated newspaper. A display advertisement will also be run twice in a local newspaper that serves the area being studied, with approximately one (1) week between runs. The DISTRICT also will be responsible for placing any legal advertisements for any public open house meetings if they are recommended.

1.6 The DISTRICT has prepared a separate set of guidelines for CONSULTANT on conducting public involvement and public information activities for the DISTRICT. A copy of these guidelines is available from the Public Information Office and shall be used by the CONSULTANT if or when preparing public information related materials in conjunction with FEMA requirements.

1.7 The CONSULTANT shall plan and conduct public involvement and prepare information as required in the following public involvement activities and in accordance with the DISTRICT Public Involvement and Information Guidelines.

1.8 The DISTRICT will create a critical path calendar for planning any public open house meetings.

1.9 The DISTRICT will generate mailing lists of the residents and property owners located within the study area boundary and which have properties that will be affected by the study results once the results become available.

1.10 The CONSULTANT shall provide the preliminary language for inclusion in a brochure mailing that will be developed by the DISTRICT. The mailing will be to notify affected property owners of the study results and to provide invitations to any open house meetings, if they are to be held.

1.11 The DISTRICT will prepare (design) the text of the mailing described in task 1.10. The Notification of Study Results brochure will be mailed out after the DISTRICT has approved draft floodplains. The DISTRICT will be responsible for mailing out the brochure.

1.12. The DISTRICT may develop PDFs of the brochures for placement on District's Web site if such an activity is recommended by the Consultant.

1.13 The CONSULTANT shall also be responsible for providing images (PDF) of the study area for the District's website to be used as part of the project description within the Projects and Structures folder. The DISTRICT shall post the images and project information on the District's Web site.

1.14 For any open house meetings, The DISTRICT will secure the public meeting venue and certificate(s) of insurance.

1.15 The CONSULTANT shall be responsible for producing approximately two (2) study area display images for the public open house meeting, if they are to be held. The DISTRICT will be responsible for mounting the displays and providing sign-in sheets, comment sheets, name tags, etc., and any additional handouts regarding the study at the meetings.

1.16 The CONSULTANT shall assist in the development of any PowerPoint presentations (layout and content) for any open house meeting, if this type of format is deemed appropriate for the meeting venue.

## TASK 3 - TOPOGRAPHIC MAPPING

3.1 Topographic mapping, with 1-foot contour intervals, will be provided by the Corps to the DISTRICT. This mapping will then be turned over to the CONSULTANT for review and analysis. It is expected that this mapping will be in the Arizona State Plane Coordinate System Central Zone, 1983 North American Datum (NAD), horizontally; and the North American Vertical Datum 1988 (NAVD 88), vertically. It is hoped that the projection is also with respect to the HARN. If it is not, the CONSULTANT will report on what needs to be done in order to bring the mapping up to these standards. The CONSULTANT will also review any provided accuracy checks to verify that the topographical mapping upon which the Hydraulic analyses are based meets FEMA's standards for Floodplain Delineation Studies, and can therefore be used for any further hydraulic modeling that may be necessary in the upcoming Work Assignment #3. The CONSULTANT will report on any data deficiencies that would otherwise be included to verify the mapping accuracy, and provide recommendations to verify accuracy. These recommendations will be included in the Summary Report, and may include field survey data to verify the ground control used to produce the mapping and spot elevation data collection to verify the appropriate RMSE. The outcome of these recommendations may require further cross sectional surveys and subsequent topographical mapping certification.

**EXHIBIT C**
**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY**
**CONSULTANT/SUBCONSULTANT ESIMATED MANHOURS AND DIRECT LABOR**

**CONSULTANT/SUBCONSULTANT NAME** WEST Consultants, Inc. **CONTRACT NO:** 2010C027 Assignment #2

**PROJECT NAME:** Tres Rios Zone AE Floodplain and Floodway Re-Delineation Study: Coordination, Data Collection, and Summary Reports

**DATE:** August 23, 2010

**DIRECT LABOR CLASSIFICATION**

| CONTRACT TASK/PHASE | PRINCIPAL $ 60.61 | PROJECT MANAGER $ 48.54 | PROJECT ENGINEER $ 41.66 | DESIGN ENGINEER $ 29.08 | DRAFTER/ TECHNICIAN $ 20.11 | CLERICAL $ 15.06 | ($/HR) | ($/HR) | TOTAL MANHOURS | TOTAL LABOR |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| 1. COORDINATION | | 46 | | | | | | | 46 | $ 2,233 |
| 2. DATA COLLECTION | 2 | 40 | 52 | 126 | 10 | 15 | | | 245 | $ 8,320 |
| 3. TOPOGRAPHIC MAPPING | 1 | 4 | 14 | 30 | 10 | 5 | | | 64 | $ 1,987 |
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| | | | | | | | | | | |
| TOTAL | 3 | 90 | 66 | 156 | 20 | 20 | | | 355 | $ 12,539.87 |

| | | |
|---|---|---|
| Overhead | 1.6312 | $ 20,455.04 |
| Total | | $ 32,994.91 |
| Profit | 0.1 | $ 3,299.49 |
| **Total Assignment** | | **$ 36,294.40** |

# Appendix B: General Documentation and Correspondence

B.6 Public Notices

*(None for the summary report)*

# Appendix B: General Documentation and Correspondence

B.7 FEMA Correspondence

*(None for the summary report)*

# Appendix C: Survey Data and Field Notes

## C.1 Survey Data and Field Notes for Aerial Mapping

Subject: Mapping of Tres Rios

In regards to the Tres Rios mapping of 2001 for the Corps of Engineers performed by our contractor Towill. This survey was performed for engineering design purposes. A review of the final product by the Corps of Engineer's Survey Section for the Los Angeles District determined that the mapping met National Map Accuracy Standards for one foot contour interval mapping.

Horizontal coordinates are referenced to the North American Datum of 1983 (NAD83), Arizona Central Zone, epoch 1992. Elevations are referenced to the North American Vertical Datum of 1988 (NAVD 88).

National Geodetic Vertical Datum of 1929 elevations on NGS benchmarks with NAVD 88 elevations were determined by holding the datum shift of 2.19' at the project benchmark to each NGS benchmark.

Mapping was compiled in NGVD 29.

Harvey W. Beverly 1/5/2011

Harvey W. Beverly
Chief, Survey Section (Retired 2003)
Los Angeles District
Corps of Engineers

# Appendix C: Survey Data and Field Notes

## C.2 Survey Data and Field Notes for Hydrologic Modeling

*(None for the summary report)*

# Appendix C: Survey Data and Field Notes

## C.3 Survey Data and Field Notes for Hydraulic Modeling

*(None for the summary report)*

# Appendix D: Hydrologic Analysis Supporting Documentation

## D.1 Precipitation Data

*(None for the summary report)*

# Appendix D: Hydrologic Analysis Supporting Documentation

## D.2 Physical Parameter Calculations

*(None for the summary report)*

# Appendix D: Hydrologic Analysis Supporting Documentation

D.3 Hydrograph Routing Data

*(None for the summary report)*

# Appendix D: Hydrologic Analysis Supporting Documentation

D.4 Reservoir Routing Data

*(None for the summary report)*

# Appendix D: Hydrologic Analysis Supporting Documentation

D.5 Flow Splits and Diversions Data

*(None for the summary report)*

# Appendix D: Hydrologic Analysis Supporting Documentation

D.6 Hydrologic Calculations

*(None for the summary report)*

# Appendix E: Hydraulic Analysis Supporting Documentation

## E.1 Roughness Coefficient Estimation

*(None for the summary report)*

# Appendix E: Hydraulic Analysis Supporting Documentation

## E.2 Cross-Section Plots

*(None for the summary report)*

# Appendix E: Hydraulic Analysis Supporting Documentation

## E.3 Expansion and Contraction Coefficients

*(None for the summary report)*

# Appendix E: Hydraulic Analysis Supporting Documentation

## E.4 Analysis of Structures

*(None for the summary report)*

# Appendix E: Hydraulic Analysis Supporting Documentation

E.5 Hydraulic Calculations

*(None for the summary report)*

# Appendix F: Erosion and Sedimentation Transport Analysis Supporting Documentation

*(None for the summary report)*

# Appendix G: Exhibit Maps (Study Work Maps and Annotated FIRMs)

*(None for the summary report)*

# Appendix H: Supporting Documentation from the LACOE

*(None for the summary report)*