DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 377TH AIR BASE WING (AFMC)

ENTERED

27 OCT 1997

RECEIVED OCT 1997

MEMORANDUM FOR MR. LARRY BLAIR
AMAFCA
2600 PROSPECT NE
ALBUQUERQUE, NM 87107

FROM: 377 ABW/EMR
2000 Wyoming Blvd SE, Suite D-6
Kirtland AFB NM 87117-5659

SUBJECT: 100-Year and Design Flows for LF-02

1. I am forwarding you a copy of a Technical Memorandum, prepared by our contractor Foster Wheeler Environmental, evaluating 100-year and peak discharge flows in Tijeras Arroyo in the area of IRP site Landfill 2. The data will be utilized for the design and installation of a system which will prevent erosion of the bank along the common boundary between the landfill and Tijeras Arroyo. FWE is recommending the project design for a peak discharge of 26,915 cfs downstream of Coyote del Arroyo's confluence with Tijeras Arroyo. KAFB agrees with this estimate and has requested FWE proceed with the design phase.

2. If you have any questions or need any additional information on this project, please contact Jerry Sillerud at 846-9004 or me at 846-0053.

CHRISTOPHER B. DeWITT, R.P.G.
Chief, Restoration Branch
Environmental Management Division

Attachment:
100-Year and Design Flows for LF-02 Studies

cc:
City of Albuquerque (Mr. L. Meinz)
NMED, HRMB (Mr. S. Pullen)
NMED, SWQB (Mr. G. Saums)
SNL (Mr. G. Valdez)
FWE (Mr. S. Weber)
USACE, Omaha (Mr. S. Rowe)

KAFB1897

FOSTER WHEELER ENVIRONMENTAL CORPORATION

October 24, 1997
TERC-013.007-97X-044

Mr. Steven M. Rowe, P.E.
U.S. Army Corps of Engineers, Omaha District
ATTN: CENWO-ED-EA (ROWE)
215 North 17th Street
Omaha, NE 68102-4978

**SUBJECT: 100-YEAR AND DESIGN FLOWS FOR LF-02 STUDIES
KIRTLAND AIR FORCE BASE, NEW MEXICO
TERC CONTRACT NO. DACW45-94-D-0003, DELIVERY ORDER NO. 13, WORK AUTHORIZATION DIRECTIVE NOS. 7 & 9**

Dear Mr. Rowe:

Enclosed for your review please find a Technical Memorandum prepared by Foster Wheeler Environmental regarding the selection of 100-year and design flows for the LF-02 studies project. As presented in the memorandum, the recommended design discharge for the Tijeras Arroyo along the study area is 26,915 cfs. This value will be used for development of the HEC-RAS model and our assessment of corrective measures.

Kindly review the memorandum and call me at (505)878-8912 or Tom Martin at (206) 688-3838 if you have any comments or concerns.

Very truly yours,

Steven B. Weber, P.E.
Delivery Order Manager

Enclosures

cc: C. DeWitt, Kirtland AFB
J. Sillerud, Kirtland AFB
S. Purdy, USACE-Albuquerque
TERC Project File

6605 Uptown Boulevard, N.E., Suite 220
Albuquerque, New Mexico 87110

FOSTER WHEELER ENVIRONMENTAL CORPORATION

Technical Memorandum

Date: September 30, 1997

To: Steve Weber

From: Tom Martin

RE: SUMMARY OF DOCUMENTS AND INFORMATION REGARDING 100-YEAR AND PROJECT DESIGN FLOWS FOR THE TIJERAS ARROYO

This memorandum provides a basis to select the appropriate 100-year discharge to be used in the design of Tijeras Arroyo bank stabilization measures at Landfill 2 within KAFB. Foster Wheeler estimates that the Tijeras Arroyo 100-year peak discharge just downstream of the confluence of the Arroyo del Coyote is 26,915 cfs, and recommends that this discharge be adopted as the design discharge.

The objective of this technical memorandum is to provide an annotated list of hydrologic studies of the Tijeras Arroyo, to summarize the estimates of 100-year discharges along the arroyo, and to discuss the hydrologic data and analysis methods used in the studies and the certainty of these estimates. Foster Wheeler Environmental contacted several sources of water resources information on the Tijeras Arroyo. Most of the sources were identified during the April 10, 1997 meeting of Kirtland Air Force Base (KAFB), U.S. Army Corps of Engineers (COE), Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA), and the City of Albuquerque (City), held at the Albuquerque office of Foster Wheeler Environmental. Prior to this meeting, KAFB provided several key reports by Leedshill-Herkenhoff (LH) containing hydrologic, hydraulic, and sediment transport analyses and results. These reports were reviewed by local agencies who commented that the results were good. AMAFCA confirmed that the LH analysis of the Tijeras Arroyo basin was the most accurate (Browning, 1997). Instead of conducting a redundant hydrologic analysis, Foster Wheeler Environmental reviewed the LH methods.

<u>Summary of Studies</u>

KAFB, New Mexico, Hydrology. COE, July 1979.
This hydrology report is referenced in subsequent reports, but it is not available at this time for this review. The 100-year peak discharge was estimated as 23,850 cfs below Arroyo del Coyote (Beach, 1997).

AMAFCA Tijeras Drainage Management Plan, Bovay Engineers, 1981.
The COE estimated 100-year peak discharges which are reported in this report (Beach, 1997). The peak 100-year discharge was 22,600 cfs upstream of Arroyo del Coyote and 22,700 cfs below its confluence with Tijeras Arroyo.

Tijeras Arroyo Draft Management Plan (TADMP), Phase I. LH, 1987.
This report includes the hydrologic and hydraulic evaluation of the Tijeras Arroyo for the development of the 100-year and Standard Project Flood (SPF) flood plain limits. Both discharges are based on a hypothetical precipitation event. The 100-year discharge is based on precipitation statistics, whereas the SPF discharge is based on an estimate of probable maximum precipitation. Details of the hydrologic and hydraulic characteristics of the arroyo are included in the report. A HEC-1 hydrologic model was built to simulate the present and future runoff resulting from the selected precipitation events. The model results indicated that the 100-year peak discharge under future land use conditions just downstream of the mouth of Arroyo del Coyote would be 22,216 cfs and the SPF would be 102,504 cfs peak discharge just downstream of Four Hills Road (at the site of the USGS gauge station) was calculated at 18,063 cfs.

A hydraulic analysis using HEC-2 model was conducted for Phase I. The 100-year peak discharge computed using the Phase I HEC-1 model was not used in the HEC-2 model. Instead, the peak 100-year discharge from the 1981 AMAFCA Tijeras Drainage Master Plan was used.

TADMP, Phase II. LH, 1990.
This Phase II report builds upon Phase I by providing peak discharges for the 2-, 5-, 10-, 25-, 50- and 100-year return storm events for two sub-basins which include proposed land developments in the Four Hills/Juan Tabo area, Sandia National Lab, and KAFB areas. The Phase I Study HEC-1 model was used, but it was updated by sub-dividing sub-basins in these developing areas and new 100-year peak discharges were computed. The Phase II report shows values for the updated sub-basin 100-year peak discharges, but not for mainstem.

The report contains a characterization of some of the unique hydrologic features of the arroyo that introduces additional complexity to the analysis. The report notes that the total flood volume is attenuated in the downstream reaches based on data from the gage at the South Diversion channel. This is due to complex factors such as basin shape, storm patterns, and spatial extent of the storms. It is common during storm events that only a portion of the watershed receives the bulk of the rainfall. In fact, in many cases, when flow was recorded in the upstream and downstream gages, no precipitation was recorded at any of the three nearby weather stations.

Tijeras Arroyo Corridor Plan. City Planning (Albuquerque), September, 1990.
The summary of the Tijeras Arroyo hydrology referenced studies done by Federal Emergency Management Agency (FEMA), the COE, and LH. The flows calculated by LH were presented and used in this report (pgs. 29-32).

Tijeras Arroyo Bank Stabilization at South Eubank Landfill, Final Summary Report. New Mexico Commissioner of Public Lands, 1994.
For the hydraulic analysis associated with corrective measures at this site, which is about 9,000 feet downstream from the Four Hills Road and upstream from the KAFB property boundary, a 100-year peak discharge of 24,860 cfs was used. This flow is based on the 1981 COE 100-year peak discharge of 22,600 cfs upstream of Arroyo del Coyote (Beach, 1997). As required by FEMA for areas with a high sediment yield, this flow includes a 10 percent bulking factor applied to the peak discharge, which is appropriate for the Tijeras Arroyo.

Albuquerque Arroyos Sedimentation Study, Numerical Model Investigation. Ronald Copeland, Waterways Experiment Station, COE, 1995.
This study focused on the metropolitan Albuquerque area, where numerous arroyos have been channelized or modified in some way. The hydrologic analysis should be broadly applicable to the Tijeras Arroyo area. The study evaluates the effects of flood flows on sediment transport and the 100-year flood was chosen as the design event for improvements to the arroyo system. The 100-year peak flow for the North Diversion channel was calculated at 15,000 cfs (drainage area is unknown).

Flood Insurance Study, Bernalillo County, New Mexico and Incorporated Areas. FEMA; September, 1996.
The 100-year discharge calculated for the Tijeras Arroyo agreed within 10 percent of the standard Water Resources Council log-Pearson Type III analysis (USGS, 1952-78; U.S. Water Resources Council, 1977) of the Tijeras Arroyo at Albuquerque USGS streamflow gage (USGS No. 08330500), located near the Four Hills Road crossing. The resulting 100-year discharge of 14,300 cfs was calculated for this gage, which is located about 1 mile upstream of the upstream KAFB boundary crossing.

Drainage Management Plan for Sandia National Labs. Molzen-Corbin & Associates, September 1996.
The 100-year peak discharge to the Tijeras Arroyo from Tech Areas I, II, and IV at Sandia National Labs was reported to be 1800 cfs (Aldez, 1997).

Middle Rio Grande Water Assessment, Final Report. U.S. Bureau of Reclamation, 1997.
This report does not specifically deal with flooding issues. Most of the document describes and addresses geologic and groundwater attributes of the basin. Mention is made of a groundwater recharge window at the confluence of the Tijeras Arroyo and Arroyo del Coyote where there is concern that contaminants could enter into the groundwater (pg. 2-16). The appendix to the report contains summaries of individual technical study reports. Technical study report number 18, "Permeability, Porosity, and Grain-Size Distribution in Representative Hydrostratigraphic and Lithofacies Units at Potential Recharge Areas", discusses grain size distributions and permeabilities of local soils and sediments. These may be useful in groundwater sediment transport related studies conducted at the KAFB.

Implementing FEMA Regulations with AHYMO Computer Program Development. Clifford E. Anderson, PE, PS. AMAFCA.
Changes in hydrology procedures used in the Albuquerque area caused AMAFCA to create AHYMO, which is a redevelopment of the USDA's HYMO computer program. As part of the testing and verification process for the AHYMO program, models were run using the SCS Curve Number (CN) methodology as well as a methodology know as initial abstraction/uniform infiltration (IA/INF). The IA/INF method for predicting infiltration losses produced superior results over SCS CN procedures when used with a realistic rainfall. AMAFCA provided certification of review, testing, and acceptance as required by FEMA regulations.

Summary of Discharge Estimates

The 100-year and SPF discharge estimates made during the above studies for Tijeras Arroyo just downstream of Arroyo del Coyote are summarized in Table 1.

Table 1. Comparison of calculated discharge for Tijeras Arroyo downstream of junction with Arroyo del Coyote.

Source	100-YEAR Peak (cfs)	Standard Project Flood (cfs)
Bovay Engineers, 1981	22,700	
LH, 1987 (future)	22,216	102,504
COE, 1979	23,850	
FEMA FIS, 1996	14,700	
S.Eubank Landfill Study, 1994 (at Four Hills Road)	24,860 (bulked)	

Per the recommendation of Larry Blair (AMAFCA, Executive Engineer), we contacted Bruce Beach, hydrologist with the COE, Albuquerque District, (Beach, 1997). He stated that the 100-year flows calculated using gaged flows and the log-Pearson III method give flows which are lower than expected and there is agreement among other involved parties regarding this. Bruce Beach also stated that he felt the 100-year flows developed by the COE (COE, 1979) were a bit high. Other involved parties seem to agree with this as reflected in meeting minutes of a Community Coordination Meeting for the Albuquerque FEMA Re-Study II (Resource Technology, Inc., 1996) where it was agreed not to use the COE flow rates, but instead use the LH flows developed for the Drainage Management Plan.

Summary of Methods

Log-Pearson Type III Distribution.
This method was suggested by Pearson (Pearson, 1930) and is widely used to describe the distribution of flood peaks. It is a skew distribution bounded on the left and therefore of the general shape of most hydrologic distributions. The skew parameter can be fitted to most data sets, however, reliable estimates of skew require very large data sets. The method is applied to annual flood peaks to determine the discharge as a function of return period (e.g. 10-, 25-, and 100-year).

KAFB, New Mexico, Hydrology. COE, July 1979.
Methods were not available at this time for this review.

KAFB, Drainage Management Plan. Bovay Engineers, 1981.
Methods were not available at this time for this review.

TADMP, Phase I. LH, 1987.
The HEC-1 rainfall-runoff model was used by LH to estimate flood discharges. The modeling process involves collecting rainfall, drainage basin and channel parameter data, delineating sub-basins, determining a storm precipitation intensity pattern, calculating storm runoff hydrographs for each sub-basin, and flood routing of the runoff downstream through the channel network. According to the City of Albuquerque's Development Process Manual, the precipitation volume used in the hydrologic analysis is from a 6-hour storm event; however, this volume is distributed over a duration of only 2 hours. The 6-hour precipitation volume for the 10- and 100-year events were estimated using the NOAA precipitation-frequency atlas. The 2-hour distribution pattern of these volumes were developed by Professor Richard Heggen at University of New Mexico. Three distribution patterns, or "zones," were shown in the report. "Zone 4" was chosen. The only description of this zone is that it is "South of Central Ave, Above 5200' elevation". The distribution of precipitation is shown in Figure 12 of the report. The SPF was based on 40% of the Probable Maximum Precipitation. The assumption was based on a COE report which was not directly referenced; however, it is probably the July 1979 report. The values for the PMP were then "arranged to create the most critical rainfall distribution." The SCS "curve-number" method included in HEC-1 was used to generate the runoff for each of the 13 basins that were delineated. There is no discussion in the report about the flood routing method used or why the magnitude of the 100-year event (and the 10-year event) decreases downstream between the junction with Arroyo del Coyote and the Interstate. However, this issue is addressed in the TADMP Phase II report as described above. Flood discharges were calculated at several points along the arroyo and appear in Appendix A.

LH used the HEC-1 model to estimate 100-year peak discharges for present and future conditions. They represented future conditions by adjusting the SCS curve numbers in the HEC-1 model. The maximum change in the SCS curve number for these areas was 3 which was for the Cedro Canyon sub-basin (TIJ 3) in the Manzanita Mountains . The minimum change was -1 in the South Juan Tabo/Eubank sub-basin (TIJ 5) in the foothills, which implies a more pervious land surface condition in the future. (The documentation of the curve number calculations appear in Appendix, Volume I, Section A of the Phase I report, but they were not available at the time of this review.) The maximum change in curve number was consistent with the planned land development of the East Mountain area. LH identified the northern periphery of the watershed near KAFB and Sandia Nation Labs as an area where continued growth in commercial and industrial land use is predicted. Of the two sub-basins in the HEC-1 model that include this area, only one had its future SCS curve number increased. The increase was only by 1. The minimum change in curve number is not consistent with the land development plans because additional moderate to high density development is expected in the Four Hills area, which is in sub-basin TIJ5. This development would tend to increase the SCS curve number, rather than decrease it as was done in the model. These changes in the SCS curve numbers are small and not always consistent with proposed future land surface conditions.

HEC-1 parameters other than SCS curve numbers could have been adjusted to represent future land surface conditions. The small curve number changes alone may not have resulted in the change from present to future computed peak discharges. The percent impervious HEC-1 parameter can also be used to represent land surface conditions. The values for this parameter were not shown in the Phase I report, and they could have had the greatest influence on the increase in peak discharges for future conditions. There is some uncertainty regarding the cause of the reported increase from present to future peak discharges.

TADMP, Phase II. LH, 1990.
This Phase II report builds upon Phase I and uses the same methods (i.e. 6-hour precipitation and the HEC-1 model); however, the drainage basin delineations were refined in Phase II in areas where future land developments were planned. These areas include parts of KAFB, Sandia Nation Labs, and Four Hills.

The SCS curve numbers shown in the Phase I and Phase II reports were compared. There is no direct comparison that can be made between curve numbers used in all sub-basins because some sub-basins where revised in the Phase II model; however, the curve numbers of overlapping basins can be compared. For the Phase II study, LH redelineated the TIJ 5 and TIJ 7 Phase I model sub-basins into several smaller sub-basins. The TIJ 5 sub-basin covers KAFB near the confluence of the Arroyo del Coyote, and TIJ 7 covers the Four Hills area. The future conditions SCS curve numbers shown in the Phase I report for TIJ 5 and TIJ 7 were 71 and 78, respectively. The curve numbers shown in the Phase II report for new sub-basins within the Phase I TIJ 5 sub-basin ranged from 65 to 72 for the 100-year storm. The curve numbers for the new sub-basins within TIJ 7 ranged from 76 to 88 for the 100-year storm.

The reason for the differences between is uncertain, but the new Phase II sub-basins with higher future conditions SCS curve numbers are an improvement over those used in the Phase I. The future conditions curve numbers for some of the Phase II sub-basins are less than the corresponding Phase I present condition curve numbers. This reduction in SCS curve number is not consistent with proposed land developments, which adds more uncertainty to the LH HEC-1 model results.

Tijeras Arroyo Corridor Plan. City Planning (Albuquerque), September, 1990.
The flows calculated in the LH report were presented and used in this report.

Tijeras Arroyo Bank Stabilization at South Eubank Landfill, Final Summary Report. New Mexico Commissioner of Public Lands, 1994.
The base 100-year peak discharge of 22,600 cfs was taken from the LH report. This discharge applies to the reach upstream (east) of the junction with Arroyo del Coyote. As required by FEMA for areas with a high sediment yield, flows were increased by a 10 percent bulking factor.

Albuquerque Arroyos Sedimentation Study, Numerical Model Investigation. Ronald Copeland, Waterways Experiment Station, COE, 1995.

The "numerical model" referred to in the title is TABS-1, a one dimensional sedimentation program developed by the COE in the 60's and 70's. The program is compatible with HEC-6 version 4.1, and simulates the response of the riverbed profile to sediment inflow, bed-material gradation, and hydraulic parameters. It simulates a series of steady-state discharge events and their effects on the sediment transport capacity at cross sections and resulting degradation or aggradation.

The hydrological input to the model was similar to that in the TADMP. Copeland used HEC-1 to develop 100-year flood frequency hydrographs. He used theoretical data, and positioned the storm center to achieve the maximum runoff in the North Diversion Channel and the Embudo Arroyo watershed. Also, Copeland used precipitation data from July 1988 to produce a flood hydrograph tied to real data, again using HEC-1. The calculated peak discharge was much higher (no mention as to how much higher) than the gaged discharge of 7,250 cfs. The COE determined in a separate study (U.S. Army Corps of Engineers, 1995) that the discrepancy was due to gaging errors.

Flood Insurance Study, Bernalillo County, New Mexico and Incorporated Areas. FEMA, September, 1996.

Flood flows for the insurance study were determined using a regional rainfall-runoff model, HYdrologic MOdeling (HYMO), which uses an SCS curve number approach to determine rainfall characteristics and the variable storage coefficient (VSC) flood routing method. A 1-hour intense thunderstorm type rainfall distribution was used.

Discussion

After reviewing the available documentation and information it is apparent that several differing conclusions have been reached amongst the interested parties regarding the magnitude of flood flows in the Tijeras Arroyo. However, there has been some agreement as to which studies give flows which are too low or too high. The 100-year discharge at the USGS gauge near the Four Hills bridge estimates based on the log-Pearson III method are considered too low, and the COE flow estimates are considered too high. LH and the City agreed to adopt flows of 22,600-22,700 cfs for use in hydraulic analyses (LH, 1987). In the 1996 FEMA Re-Study II, (Resource Technology Inc., 1996) several agencies including AMAFCA, the City, Bernalillo County, and Resource Technology, Inc., agreed that 100-year peak flows calculated in the LH hydrologic analysis were the most appropriate for the Re-Study II. These flows are listed in Appendix A. The range of 100-year and SPF discharges presented here provides a basis for reaching a similar agreement on the design discharge to be used for the Landfill 2 bank stabilization.

LH raised the issue of the variation of the peak discharge with distance from the mouth in their Phase II report. This is an issue that adds uncertainty to the model results. The LH HEC-1 model simulates the rainfall-runoff and flood routing processes. According to the LH description of certain coincident rainfall and discharge observations in the Tijeras Arroyo basin, rainfall is not directly related to discharge in the arroyo. Most rainfall-runoff models would not be able to simulate this complicating factor; however, during extreme events, such as the 100-year storm, rainfall is expected to be more closely related to runoff. The timing of runoff from the tributaries with respect to the mainstem arroyo is another complicating factor. Given an extreme storm event, peak tributary discharges occur earlier than the mainstem peak. Typically, the time lag between peaks increases in the downstream direction. This process is shown in Appendix A where the sum of peak tributary discharges between Four Hill bridge and the confluence of the Arroyo del Coyote is greater than the difference between mainstem peak discharges at the locations. The HEC-1 model flood routing simulations appear to properly account for the complexities due to runoff timing. Given, that the 100-year storm is the event being considered for the design discharge for this project, the HEC-1 rainfall-runoff and flood routing modeling paradigm is appropriate.

The LH discharges were calculated using a HEC-1 model and the SCS method for estimating storm runoff. This method is reasonable and widely used, but Tijeras Arroyo has some hydrologic complexities. The consistency of changes in SCS curve numbers used to represent surface conditions of future land developments raise some uncertainty regarding both the gauging information and the computed discharges. Phase II of the LH studies describes future developments in the KAFB and Four Hills areas. These future developments were included in a revised Phase II HEC-1 model; however, the resulting peak flows are not clearly reported. Foster Wheeler Environmental estimates that the future peak runoff computed by LH in Phase II is greater than that of Phase I by 273 cfs and 406 cfs for Four Hills and KAFB areas, respectively.

Specific proposed land use developments by the City and Sandia National Labs do not appear to have been included in the computation of peak flows by LH in Phase II. The City expects to discharge into the Tijeras Arroyo a peak flow of 472 cfs from an industrial/residential area near Juan Tabo and Eubank Boulevards upstream of Pennsylvania Avenue Bridge. Sandia National Labs expects to discharge a peak flow of 1800 cfs through a baffle chute and unlined ditch and into the arroyo just downstream of the Pennsylvania Avenue bridge, which is upstream of the Arroyo del Coyote (Aldaz, 1997). The Sandia National Labs discharge is approximately 4.5 times greater than the future discharge computed by LH in Phase II for the KAFB developments in the drainage area upstream from the baffle chute. The future discharge computed by LH in Phase II for this area is approximately 1.5 times greater than their Phase I estimates. The reason for the discrepancy between LH Phase I and Phase II estimates could be due to the difference in SCS curve numbers as previously discussed. The reason for the discrepancy between the LH Phase II and the Sandia estimates is probably due to a greater drainage area and percent impervious area specified in Sandia model. The HYMO model was used to calculate the peak discharge for the Sandia drainage (Aldaz, 1997). The HYMO model typically results in discharge estimates that are greater than those of HEC-1 for small basins. Foster Wheeler Environmental estimates that the additional discharge to the Tijeras Arroyo upstream of the confluence of the Arroyo del Coyote not accounted for in the LH Phase I HEC-1 model includes 1523 cfs from Sandia/KAFB, 273 cfs from the Four Hills area, and 472 cfs from the Tabo/Eubank Avenues area. Assuming that these peak discharges are coincident with the peak discharge in the Tijeras Arroyo, the total additional future condition flow in the mainstem is 2268 cfs.

The AHYMO computer program is also an acceptable model that is extensively applied to Albuquerque area. AMAFCA developed this model specifically for Albuquerque. They have also shown that using the SCS method predicts lower peak flood discharges than the IA/INF method when using either the AHYMO or HEC-1 programs (Anderson, 1992). AMAFCA accepts the use of either the HEC-1 or the AHYMO models (Browning, 1997).

Recommendation

The design discharge recommended for Tijeras Arroyo bank stabilization at Landfill 2 within KAFB is based on the discharge reported by LH in their Phase I report (LH, 1987). This discharge is derived from the LH 100-year computed discharge from their HEC-1 model. This HEC-1 model is recommended because, according to AMAFCA, it is the most accurate hydrologic model of the Tijeras Arroyo basin. Appendix A shows the LH HEC-1 model results as discharges at various points along the arroyo and for existing and future conditions. The 100-year discharge under future conditions is 22,200 cfs downstream of the Arroyo del Coyote. The confluence of the Arroyo del Coyote and the Tijeras Arroyo is at Landfill 2. In order to adjust for some of the uncertainties in the LH model, the computed peak 100-year discharge at the confluence of the Arroyo del Coyote was increased by 2268 cfs to account for the runoff from future developments in and around the Eubank/Tabo, Four Hills, KAFB and Sandia National Labs areas. As in the selection of a design flow for the South Eubank Landfill, the design flow for this project should have a 10 percent bulking factor applied to it; therefore, the recommended design flow is 1.1 times greater than the adjusted LH future conditions 100-year discharge downstream of Arroyo del Coyote. The recommended design discharge is therefore 26,915 cfs.

The SPF discharge estimate is not recommended for the design discharge for this project. Estimates of the SPF are overly conservative because they are based on probable maximum precipitation, rather than on actual streamflow records. The 100-year discharges are based on actual streamflow records; however, the records used are of a period shorter than 100 years. Nevertheless, the SPF discharges are about 5 times greater than the 100-year discharges as shown in Table 1. With conservatism added by applying the 10 percent bulking factor, the recommended modified 100-year discharge is preferable to the SPF.

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APPENDIX A

Calculated peak discharges for Tijeras Arroyo by Leedshill-Herkenhoff (LH, 1987)

Location	100-year Flow (cfs)	Standard Project Flood (cfs)
At Four Hills Road		
Existing	16,700	70,500
Future	17,900	71,700
Tramway Diversion		
Existing	1,800	4,500
Future	1,700	4,400
Arroyo del Coyote		
Existing	6,800	31,800
Future	6,800	31,800
Tijeras Arroyo (downstream of junction with Coyote)		
Existing	21,000	101,200
Future	22,200	102,500
Western Boundary, KAFB		
Existing	20,700	103,900
Future	21,800	105,200
At Junction with South Diversion		
Existing	19,800	105,000
Future	20,800	106,300