# Santa Cruz County, Arizona
# DIRM and Map
# Modernization Project

## TDN Section 4 – Hydrology

Stantec

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**Santa Cruz County**
**DIRM and Map Modernization Project**

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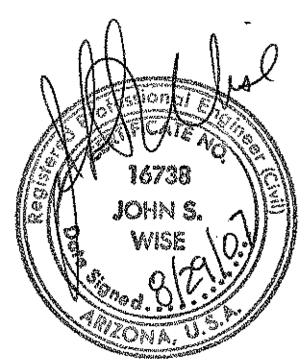

## SECTION 4: HYDROLOGY

### 4.1 Method Description

The hydrologic methodology employed for the overall study was separated into two groups: limited detailed study reaches and their associated contributing watersheds and detailed study reaches and their associated contributing watersheds. Peak discharges for the 100-year event were determined for each stream reach. Additional discharges for the 10-, 50- and 500-year storm events were determined for detail study streams which have multiple profiles in the existing Flood Insurance Studies (FIS) for Santa Cruz County, Arizona (FEMA, August 23, 2000) and the City of Nogales, Arizona (FEMA, October 15, 1980).

#### 4.1.1 Limited Detailed Study Reaches

Peak discharges for limited detail study reaches, with the exception of Puerto Canyon, were determined utilizing USGS regional regression equations (USGS) and Arizona Department of Water Resources State Standard (SS) 02-96 (ADWR) for Region 13, multiplied by a factor of 1.6. Experience indicated that regional regression equations alone produce low values for peak discharges in Santa Cruz County. This phenomenon is attributed to a lack of an adequate sample of gaged streams in Santa Cruz County. In addition, the average standard error for 100-year peak discharges determined by the regression equation is ±48 %. The factor was determined based upon a comparison of peak discharges determined by HEC modeling developed for two (2) watersheds within Santa Cruz County and peak discharges determined by Pima County methodology for three (3) representative watersheds of variable area in Santa Cruz County. The 100-year peak discharge for Puerto Canyon was determined from a previous study, utilizing HEC-1 (C.L. Williams). Peak flows for limited detail streams within a detail study watershed were determined utilizing the following HEC-1 methodology.

### 4.1.2 Detailed Study Reaches

Peak discharges for detailed study streams with the exception of Nogales Wash (Potrero Creek) and the Santa Cruz River, were determined utilizing HEC-1. The physical processes were determined by the following components.

- Rainfall - NOAA Atlas 14
- Rainfall Distribution – Hypothetical
- Rainfall Losses – Green and Ampt
- Rainfall Transformation – Clark Unit Hydrograph
- Rainfall Translation – Modified Puls

These components are consistent with the Hydrologic Modeling Guidelines State Standard (SS10-07) developed by the Arizona Department of Water Resources State Standards Work Group.

Peak discharges for Portero Creek and Nogales Wash (including the portion downstream of the confluence with Potrero Creek, which is currently called Potrero Creek) and the Santa Cruz River were determined from US Army Corps of Engineers 2001 and 2003 studies (see References).

## 4.2 Parameter Estimation

Contributing watershed area is the only hydrologic parameter required for the limited detail reaches. This is the only parameter required for the Region 13 Regression Equation used for this study group.

The estimation of hydrologic parameters for the detailed reaches was performed in accordance with guidelines provided within SS10-07.

### 4.2.1 Drainage Area Boundaries

The limits of the overall study area are generally those regions contributing runoff to the Santa Cruz River which drains north into Pima County. One study stream, Lyle Canyon drains east into Cochise County. In general, the majority of those regions contributing runoff to the Santa Cruz River are located within Santa Cruz County Nogales Wash, and Ephriam Canyon Wash have headwaters in Sonora, Mexico; south of Santa Cruz County. The Santa Cruz Rivers has headwaters in eastern Santa Cruz County, however the stream drains south into Mexico and reenters Santa Cruz County east of Nogales. Nearly 75 percent of the region that contributes runoff to Sopori Wash is located within the eastern portion of Pima County.

The total watershed area evaluated under this study, excluding the Santa Cruz River and Nogales Wash watersheds is approximately 750 square miles. Of the total area evaluated, nearly 677 square miles is accounted for within the detailed study reach group.

Watershed characteristics vary throughout the study areas and can be segmented into two broad general characteristics: steep and shallow watersheds. Steep watersheds are those with the majority of the hydraulic flow path (often called the Tc Path) having slopes greater than 200 feet per mile. Shallow watersheds have a majority of the Tc Path(s) with a slope less than 200 feet per mile. Vegetative coverage for both of these types of systems tends to be within a range of 20-40 percent. Soil types are predominately sandy loam.

### 4.2.2 Watershed Work Maps

Work maps were developed using LIDAR point data developed for this project and 7.5-minute quadrangles as published by the United States Geological Survey. Watershed maps for Detail streams are shown in

Appendix B.

### 4.2.3 Gage Data

Gage data is limited within the study area, and the reliability of associated statistical 100-year peak discharges values are "uncertain, and potential errors are large" (Pope). One gage, Sopori Wash at Amando, Arizona (09481750), has been inactive since 1978 and the length of recorded data is only 30 years. The estimate of the peak discharge, during the 100-year event, is 17,100 (Pope). A gage on Sonoita Creek near Patagonia (09481500) has records for 1930-72, 1978 and 1984. The estimate for 100-year peak discharge is 15,100 cfs. The 100-year peak discharge for Calabasas Canyon near Nogales, Arizona (09481700) is 2540 cfs. for records from 1963-76 and 1978. Gages for the Santa Cruz River were considered within the Corps study.

### 4.2.4 Statistical Parameters

In general there are no significant periods of rainfall and stream flow available.

### 4.2.5 Precipitation

Precipitation data for the centroid of the watershed was obtained from the National Oceanic & Atmospheric Administration data server which utilizes NOAA Atlas 14 data applicable to Arizona (NOAA). In accordance with SS10-07 guidance, a hypothetical storm is developed in HEC-1 based on the storm duration, reduction factor, area of the specific watershed, and Depth-Duration-Frequency (DDF) data.

No comparison of the hypothetical rainfall pattern to rainfall patterns on record or by other hydrologic study was performed given the lack of available information.

### 4.2.6 Physical Parameters

#### 4.2.6.1 Rainfall Losses

Rainfall loss methodology consists of an estimation of surface retention (IA) based on land use type(s) and rainfall infiltration losses by the Green-Ampt loss equation. Surface retention loss values are based on land use conditions (e.g., rangeland, mountain, hillside, developed...etc.).

Soil horizon information was obtained through review of the Natural Resources Conservation Service Soil Surveys (NRCS, 1979 and 1993). Land use conditions were obtained by the USGSS Gap Analysis (USGS 2005).

Green-Ampt equation parameters are estimated as a function of soil texture. Parameters consist of porosity (DTHETA), saturated hydraulic conductivity (XKSAT), and the wetting front soil suction head (PSIF). Hydraulic conductivity is adjusted based on vegetative ground cover. Typical values for these parameters are provided within the ADOT guidelines. Hydrologic modeling also took into consideration the percent of impervious area due to land use types. Impervious regions are those regions that have no rainfall losses (RTIMP). Values of impervious areas, soil characteristics, and vegetative coverage were taken from several references along with field investigation.

#### 4.2.6.2 Unit Hydrograph

SS10-07 methodology utilizes the Clark Unit Hydrograph. The unit hydrograph is solely based on physical basin parameters as shown in the following equations.

$T_c = 2.4\,A^{0.1}\,L^{0.25}\,L_{ca}^{0.25}\,S^{-0.2}$ (Desert/Mountain, SS10-07, eq. 3.2 )

$T_c = 3.2\ A^{.1}\ L^{.25}\ L_{ca}^{.25}\ S^{-.14}\ RTIMP^{-.36}$ (Urban, SS10-07, eq. 3.4)

Where;

- $T_c$ – Time of Concentration in hours
- $A$ – Area in square miles
- $L$ – Length of the flow path to the hydraulically most distance point in miles
- $L_{ca}$ – Length along L to a point opposite the centroid in miles
- $S$ – Average slope of L in feet per mile, adjusted per FCDMC methodology
- RTIMP effective impervious area, in percent.

A storage coefficient is also computed and is a Clark Unit Hydrograph parameter that relates the effects of direct storage in the watershed to unit hydrograph shape.

$R = 0.37\,T_c^{1.11}\,A^{-0.57}\,L^{0.80}$ (SS10-07 eq. 3.5)

Where,

R is in hours and the variables are as defined for the $T_c$ equations.

The time-area relation is a graphical unit hydrographic parameter that specifies the accumulated area of the watershed that is contributing runoff to the outlet of the watershed at any time. The ADOT Dimensionless Synthetic Time-Area Relations as specified in SS10-07 were utilized.

Per SS10-07 guidelines, the hydrograph duration, used for modeling was the 3-hour, 6-hour or 24-hour period, based on the Time of Concentration (Tc) for the entire stream watershed under consideration.

#### 4.6.2.3 Channel Routing

The Modified-Puls methodology was employed for channel routing.

## 4.3 Problems Encountered During the Study

No problems were encountered during the analyses.

### 4.3.1 Modeling Warning and Error Messages

No errors were encountered during the analysis.

Warning messages were encountered during channel routing operations for several concentration points within each hydrologic model (i.e., HEC-1). The following is an example of the warning message encountered.

```
*** WARNING *** MODIFIED PULS ROUTING MAY BE NUMERICALLY UNSTABLE
FOR OUTFLOWS BETWEEN  0. TO  1005672. THE ROUTED HYDROGRAPH SHOULD
BE EXAMINED FOR OSCILLATIONS OR OUTFLOWS GREATER THAN PEAK INFLOWS.
THIS CAN BE CORRECTED BY DECREASING THE TIME INTERVAL OR INCREASING
STORAGE (USE A LONGER REACH.)
```

A close examination of each routed hydrograph found that no unusual irregularities or oscillations occurred, therefore, no solution or additional steps appeared warranted.

### 4.4 Calibration

Once modeling results were obtained and reviewed calibration of the models were not performed given the limited information (e.g., gage data, previous FEMA or other hydrologic studies) available for this region.

### 4.5 Final Results

A summary of the peak discharges for the limited detail and detail streams in included in Appendix A. HEC-1 input and output data for detail streams is provided on CD in Appendix C.

### 4.6 References

Arizona Department of Water Resources (ADWR), July 1996, "Requirement for Floodplain and Floodway Delineation in Riverine Environments", State Standard (SS) 2-96.

Arizona Department of Water Resources (ADWR), May 2007 (Draft), "Hydrologic Modeling Guidelines", State Standard (SS) 10-07.

Arizona Department of Water Resources (ADWR), November 1997, "Requirement for Flood Study Technical Documentation", State Standard (SS)1-97.

C.L. Williams Consulting, Inc., September 30, 2004, "Concept Study Report, Balderrain Wash, Conceptual Drainage Solutions."

Federal Emergency Management Agency (FEMA), Federal Insurance Administration, August 23, 2000, "Flood Insurance Study, Santa Cruz County, Arizona", Community Number 040090.

Federal Emergency Management Agency (FEMA), Federal Insurance Administration, October 15, 1980, "Flood Insurance Study, City of Nogales, Arizona, Santa Cruz County", Community Number 040091.

National Oceanic & Atmospheric Administration (NOAA) data server: http://hdsc.nws.noaa.gov/hdsc/pfds/sa/az_pfds.html

Natural Resources Conservation Service (NRCS), April 1979, "Soil Survey of Santa Cruz and Parts of Cochise and Pima Counties, Arizona".

Natural Resources Conservation Service (NRCS), 1993, "Soil Survey of Pima County, Arizona, Eastern Part".

Pope, G.L., RIGAS P.D, and Smith, C.F., United States Geological Survey, 1998, "Statistical Summaries of Streamflow Data and Characteristics of Drainage Basins for_Selected Streamflow-Gaging Stations in Arizona through Water Year 1996", Water-Resources Investigations Report 98-4225.

United States Geological Survey (USGS), 1997, "Methods for Estimating Magnitude and Frequency of Floods in the Southwestern United States", Water-Supply Paper 2433.

United States Geological Survey (USGS), October 13, 2005, "The Southwest Regional Gap Analysis Project, Final Report on Land Cover Mapping Methods" .

United States Army Corps of Engineers. August 2001, "Gila River, Santa Cruz River Watershed, Pima County, Arizona, Final Feasibility Report".

United States Army Corps of Engineers, August 2003, "Nogales Wash & Tributaries, Nogales, Arizona, Limited Reevaluation Report and Environmental Evaluation, Final".

# APPENDIX A

## Peak Discharge Summaries

**SANTA CRUZ MAP MODERNIZATION**

Peak Discharge

Summary Table

| Reach Name | Study Type | Location | Conc. Point | Sub basin | Regional Regression Equation* | Regional Regression with Factor^ | HEC-1 | | | | Drainage Area |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 100 YR (cfs) | 100 YR (cfs) | 500 YR (cfs) | 100 YR (cfs) | 50 YR (cfs) | 10YR (cfs) | (sq.mi.) |
| Agua Fria | D | Downstream | C009 | --- | --- | --- | 14192 | 9861 | 7958 | 6538 | 44.60 |
| | | West Frontage Road | C008 | --- | --- | --- | 14186 | 9863 | 7955 | 6535 | 44.46 |
| | | - - - | C007 | --- | --- | --- | 13839 | 9651 | 7795 | 6407 | 42.41 |
| | | - - - | C006 | --- | --- | --- | 13593 | 9500 | 7689 | 6327 | 40.33 |
| | | - - - | C004 | --- | --- | --- | 12388 | 8722 | 7101 | 5853 | 35.14 |
| | | Upstream | C003 | --- | --- | --- | 5266 | 3508 | 2885 | 2343 | 11.06 |
| Agua Fria Canyon Tributary 1 | LD | Above Confluence | --- | --- | 1818 | 2909 | --- | 500 | --- | --- | 1.77 |
| Al Harrison Wash | LD | Upstream | --- | --- | 268 | 429 | --- | --- | --- | --- | 0.13 |
| Al Harrison Wash | D | Downstream | --- | --- | 1373 | 2197 | na | na | na | na | 1.14 |
| Calabasas Canyon | LD | Above Confluence with Santa Cruz | --- | --- | 4784 | 7654 | --- | --- | --- | --- | 9.8 |
| Caralampi Canyon | LD | Above Confluence with Santa Cruz | --- | --- | 3064 | 4902 | --- | --- | --- | --- | 4.26 |
| Caralampi Canyon Trib 2 | LD | Downstream (above confluence) | --- | --- | 1309 | 2094 | --- | --- | --- | --- | 1.06 |
| Caralampi Canyon Trib 3 | LD | Downstream (above confluence) | --- | --- | 1164 | 1862 | --- | --- | --- | --- | 0.89 |
| Ephriam Canyon | D | Upstream Grand (Culvert Inlet) | 25 | --- | --- | --- | 5272 | 3763 | 3115 | 1744 | 7 |
| | | Downstream I-19 | 14 | --- | --- | --- | 4799 | 3460 | 2903 | 1610 | 6 |
| | | Upstream Highway 189 | 6 | --- | --- | --- | 4417 | 3160 | 2681 | 1473 | 5.4 |
| | | International Boundary | 3 | --- | --- | --- | 3898 | 2753 | 2326 | 1277 | 4.79 |
| Farosa Canyon | D | Above confluence with Lyle | J12 | --- | --- | --- | 2032 | 1388 | 1100 | 595 | 2.3 |
| Harshaw Creek | D | Above confluence with Red Rock Canyon | J32 | 28 | --- | --- | 6683 | 4155 | 3149 | 1390 | 32.5 |
| | D | Confluence with Red Rock Canyon | J32 | | --- | --- | 14217 | 8601 | 6725 | 2955 | 64.1 |
| Josephine Canyon | D | Confluence with Santa Cruz | 30 | --- | --- | --- | 28657 | 19594 | 15919 | 8211 | 49.1 |
| | D | Upstream Limit | 25 | --- | --- | --- | 23137 | 16036 | 13103 | 7075 | 39.6 |
| Josephine Canyon Trib 1 | LD | Downstream | --- | --- | --- | --- | na | 630 | na | na | 1.28 |
| Josephine Canyon Trib 5 | LD | Downstream | --- | --- | --- | --- | na | 672 | na | ns | 1.6 |
| Kino Springs Wash | LD | Upstream | --- | --- | 1682 | 2691 | --- | --- | --- | --- | 1.56 |
| | LD | Downstream | --- | --- | 1878 | 3005 | --- | --- | --- | --- | 1.86 |

## SANTA CRUZ MAP MODERNIZATION
Peak Discharge
Summary Table

| Reach Name | Study Type | Location | Conc. Point | Sub basin | Regional Regression Equation* 100 YR (cfs) | Regional Regression with Factor^ 100 YR (cfs) | HEC-1 500 YR (cfs) | HEC-1 100 YR (cfs) | HEC-1 50 YR (cfs) | HEC-1 10YR (cfs) | Drainage Area (sq.mi.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lyle Canyon | D | Lyle Canyon (U/S Confl w/ Farosa) | J13 | --- | --- | --- | 10730 | 7527 | 6258 | 3498 | 23 |
| | D | Lyle (Confluence w/ Farosa Canyon) | J12 | --- | --- | --- | 12029 | 8426 | 6986 | 3789 | 25.3 |
| | D | Lyle Canyon (Below Conflu w/ Woodward) | J15 | --- | --- | --- | 13067 | 9090 | 7466 | 3964 | 27.1 |
| | LD | County Boundary | J19 | --- | --- | --- | 16121 | na | na | na | 32 |
| Maria Santisima Del Carmen Wash | LD | Above Split | --- | --- | 742 | 1187 | --- | --- | --- | --- | 0.47 |
| | LD | Above Confluence with 41.2.1 | --- | --- | 967 | 1547 | --- | --- | --- | --- | 0.68 |
| | LD | Confluence with 41.2.1 | --- | --- | 1190 | 1904 | --- | --- | --- | --- | 0.92 |
| | LD | Confluence with Santa Cruz | --- | --- | 4048 | 6477 | --- | --- | --- | --- | 7.1 |
| Negro Canyon | LD | Above Confluence with Santa Cruz | --- | --- | 2658 | 4253 | --- | | | | 3.32 |
| Peck Canyon | D | Interstate 19 | C009 | --- | --- | --- | 25570 | 18315 | 15700 | 9632 | 47.49 |
| | | - - - | C008 | --- | --- | --- | 25373 | 18220 | 15624 | 9614 | 46.29 |
| | | - - - | C007 | --- | --- | --- | 24710 | 17798 | 15248 | 9477 | 43.70 |
| | | - - - | C006 | --- | --- | --- | 23595 | 17095 | 14621 | 9223 | 40.24 |
| | | Upstream | C005 | --- | --- | --- | 19184 | 13876 | 11891 | 7520 | 32.26 |
| Peck Canyon Tributary 1 | LD | Above Confluence | --- | --- | 1431 | 2289 | --- | --- | --- | --- | 1.21 |
| Potrero Creek Trib 1 | LD | Downstream | --- | --- | 1451 | 2322 | --- | --- | --- | --- | 1.24 |
| Puerto Wash | LD | Interstate 19 | --- | --- | --- | --- | na | 6500 | na | na | 7 |
| Ramanote Canyon | LD | Above Confluence with Peck Canyon | --- | --- | --- | --- | 3300 | na | na | na | 7.50 |
| Red Rock Canyon | D | Above Confluence with Harshaw | J32 | 32 | --- | --- | 8905 | 5497 | 4208 | 1832 | 31.6 |
| Santa Cruz River Trib 14 | LD | Upstream | --- | --- | 1309 | 2094 | --- | --- | --- | --- | 1.06 |
| Santa Cruz River Tributary 15 | LD | --- | --- | --- | 1633 | 2613 | --- | --- | --- | --- | 1.49 |
| Santa Cruz River Trib 16 | LD | Confluence w/tributary | --- | --- | 1988 | 3181 | --- | --- | --- | --- | 2.04 |
| Santa Cruz River Trib 17 | LD | Downstream | --- | --- | 2172 | 3475 | --- | --- | --- | --- | 2.36 |
| Santa Cruz River Trib 17 | LD | Downstream | --- | --- | 1064 | 1702 | --- | --- | --- | --- | 0.78 |

# SANTA CRUZ MAP MODERNIZATION

Peak Discharge
Summary Table

| Reach Name | Study Type | Location | Conc. Point | Sub basin | Regional Regression Equation* | Regional Regression with Factor^ | HEC-1 | | | | Drainage Area |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 100 YR (cfs) | 100 YR (cfs) | 500 YR (cfs) | 100 YR (cfs) | 50 YR (cfs) | 10YR (cfs) | (sq.mi.) |
| Santa Cruz River Trib 18 | LD | Downstream | --- | --- | 1267 | 2027 | --- | --- | --- | --- | 1.01 |
| Santa Cruz River Trib 19 | LD | Upstream | --- | --- | 947 | 1515 | --- | --- | --- | --- | 0.66 |
| Santa Cruz River Trib 20 | LD | Downstream | --- | --- | 1082 | 1731 | --- | --- | --- | --- | 0.8 |
| Santa Cruz River Trib 21 | LD | Upstream | --- | --- | 1225 | 1960 | --- | --- | --- | --- | 0.96 |
| Santa Cruz River Trib 22 | LD | Downstream | --- | --- | 1325 | 2120 | --- | --- | --- | --- | 1.08 |
| Santa Cruz River Trib 24 | LD | Upstream | --- | --- | 1511 | 2418 | --- | --- | --- | --- | 1.32 |
| Santa Cruz River Trib 25 | LD | Downstream | --- | --- | 1853 | 2965 | --- | --- | --- | --- | 1.82 |
| Santa Cruz River Trib 28 | LD | Upstream | --- | --- | 977 | 1563 | --- | --- | --- | --- | 0.69 |
| Santa Cruz River Trib 29 | LD | Downstream | --- | --- | 1155 | 1848 | --- | --- | --- | --- | 0.88 |
| Santa Cruz River Trib 29 | LD | Upstream | --- | --- | 1155 | 1848 | --- | --- | --- | --- | 0.88 |
| Santa Cruz River Trib 30 | LD | Downstream | --- | --- | 1381 | 2210 | --- | --- | --- | --- | 1.15 |
| Santa Cruz River Trib 39.1 | LD | Upstream Trib 39.3 | --- | --- | 947 | 1515 | --- | --- | --- | --- | 0.66 |
| Santa Cruz River Trib 39.2 | LD | Above Confluence with 39.3 | --- | --- | 1276 | 2042 | --- | --- | --- | --- | 1.02 |
| Santa Cruz River Trib 39.3 | LD | Confluence with 39.3 | --- | --- | 1682 | 2691 | --- | --- | --- | --- | 1.56 |
| Santa Cruz River Trib 39.3 | LD | Upstream Confluence with 39.1 | --- | --- | 821 | 1314 | --- | --- | --- | --- | 0.54 |
| Santa Cruz River Trib 41.2.1 | LD | Above Confluence with | --- | --- | 445 | 712 | --- | --- | --- | --- | 0.24 |
| Santa Cruz River Trib 41.2.2 | LD | Maria Santisima Del Carmen Wash | --- | --- | | | | | | | |
| Sonoita Creek | D | Confluence w/ Harshaw and Red Rock | 31 | --- | --- | --- | 27660 | 17253 | 12879 | 5374 | 137.8 |
| | LD | Downstream Patagonia | 44 | --- | --- | --- | 35406 | 21038 | 15584 | 7193 | 205.2 |
| | LD | Patagonia Lake | 46 | --- | --- | --- | 36139 | 22124 | 15664 | 7390 | 215.5 |
| | D | Upstream Limit Detail Study | 52 | --- | --- | --- | 34309 | 20451 | 15373 | 6701 | 246.2 |
| | D | Confluence w/Santa Cruz | 55 | --- | --- | --- | 34477 | 20514 | 15389 | 6705 | 258.3 |
| Sonoita Tributary 1 | D | At Confluence with Sonoita Creek | --- | 33.5 | --- | --- | 1080 | 821 | 710 | 461 | 2.01 |

## SANTA CRUZ MAP MODERNIZATION

Peak Discharge
Summary Table

| Reach Name | Study Type | Location | Conc. Point | Sub basin | Regional Regression Equation* | Regional Regression with Factor^ | HEC-1 | | | | Drainage Area |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 100 YR (cfs) | 100 YR (cfs) | 500 YR (cfs) | 100 YR (cfs) | 50 YR (cfs) | 10YR (cfs) | (sq.mi.) |
| Sopori Wash | D | Downstream | C011 | --- | --- | --- | 19044 | 12338 | 9779 | 4965 | 166.79 |
| | | Interstate 19 | C010 | --- | --- | --- | 19052 | 12341 | 9817 | 4992 | 166.01 |
| | | - - - | C009 | --- | --- | --- | 19003 | 12305 | 9805 | 4986 | 162.00 |
| | | - - - | C008 | --- | --- | --- | 17409 | 9671 | 9142 | 4727 | 137.56 |
| | | Upstream | C007 | --- | --- | --- | 14757 | 7846 | 7846 | 4210 | 111.05 |
| Teruno Canyon | LD | Above Confluence with Agua Fria | --- | --- | --- | --- | 600 | na | na | na | 3.29 |
| Tinaja Canyon | LD | Above Confluence with Santa Cruz | --- | --- | 1910 | 3057 | --- | --- | --- | --- | 1.91 |
| Tumacacori Canyon | LD | Above Confluence with Santa Cruz | --- | --- | 2799 | 4478 | --- | --- | --- | --- | 3.63 |
| Woodward Canyon | D | Above confluence with Lyle Canyon | J15 | --- | --- | --- | 2075 | 1504 | 1264 | 737 | 1.8 |
| Yerba Buena Canyon | LD | Upstream | --- | --- | 1405 | 2248 | --- | --- | --- | --- | 1.18 |
| | LD | Downstream (Falls Wash) | --- | --- | 3032 | 4851 | --- | --- | --- | --- | 4.18 |

# SANTA CRUZ MAP MODERNIZATION

Peak Discharges

Summary Table

| Reach Name | Conc. Point | Flooding Source | 500-Year Peak (cfs) | 100-Year Peak (cfs) | 50-Year Peak (cfs) | 10-Year Peak (cfs) | Drainage Area (sq.mi.) |
|---|---|---|---|---|---|---|---|
| Santa Cruz 07 | 1 | International Border* | 76800 | 32000 | 23040 | 11200 | 532 |
| | 2 | Highway 82 Bridge | 78000 | 32500 | 23400 | 11380 | 574 |
| | 2a | Downstream of Cumero Canyon | 79200 | 33000 | 23760 | 11550 | 603 |
| Santa Cruz 06 | 2b | Downstream of Burro Canyon | 79560 | 33150 | 23870 | 11600 | 610 |
| | 2c | D/S of Guevavi Canyon (U/S of Ruby Rd.) | 79920 | 33300 | 23980 | 11660 | 620 |
| Santa Cruz 05 | 3 | Railroad Bridge near RR S. Industrial Park | 83760 | 34900 | 25130 | 12220 | 722 |
| | 4 | Rio Rico Drive | 93600 | 39000 | 28080 | 13650 | 1000 |
| Santa Cruz 04 | 5 | Confluence with Agua Fria Wash | 95280 | 39700 | 28580 | 13900 | 1045 |
| | 6 | Confluence with Peck Canyon Wash | 97200 | 40500 | 29160 | 14180 | 1097 |
| Santa Cruz 03 | 7 | Confluene with Joesphine Canyon Wash | 99360 | 41400 | 29810 | 14490 | 1163 |
| Santa Cruz 02 | 8 | Bridge Road in Tubac | 100800 | 42000 | 30240 | 14700 | 1209 |
| Santa Cruz 01 | 9 | Amado-Montosa Road | 103200 | 43000 | 30960 | 15050 | 1279 |
| | 10 | Pima/Santa Cruz County Line* | 108000 | 45000 | 32400 | 15750 | 1448 |
| | | | | | | | |
| Upper Nogales | --- | International Boundary | 32400 | 13500 | 9720 | 3780 | 27.4 |
| | --- | Nogales Covered Floodway | 6000 | 6000 | 6000 | 2350 | --- |
| | --- | Arroyo Covered Floodway | 2060 | 1600 | 1500 | 590 | --- |
| | --- | Overland Flow Total | 24340 | 5900 | 2220 | 840 | --- |
| | --- | Overland Flow West of RR | 14114 | 3360 | 1353 | 540 | --- |
| | --- | At Ephriam Canyon | 36240 | 15100 | 10870 | 4230 | 35.8 |
| | --- | At 4.083 miles | 38640 | 16100 | 11590 | 4510 | 40.9 |
| | --- | At Mariposa Canyon | 45120 | 18800 | 13540 | 5260 | 56.5 |
| | --- | At Railroad bridge | 45840 | 19100 | 13750 | 5350 | 58.4 |
| | --- | City Limits (just u/s Potrero) | 46800 | 19500 | 14040 | 5460 | 61 |
| Potrero 01 | P3 | At Potrero Creek | 52320 | 21800 | 15700 | 6690 | 76.1 |
| | P4 | Downstream of S. River Rd. | 54840 | 22850 | 16450 | 7010 | 83.25 |
| | P5 | At Pickrell Bridge (Old Tucson) | 57120 | 23800 | 17140 | 7310 | 90.3 |
| | P6 | At Santa Cruz River | 58080 | 24200 | 17420 | 7430 | 93.4 |

# SANTA CRUZ MAP MODERNIZATION

Peak Discharges
Summary Table

| Reach Name | Conc. Point | Flooding Source | 500-Year Peak (cfs) | 100-Year Peak (cfs) | 50-Year Peak (cfs) | 10-Year Peak (cfs) | Drainage Area (sq.mi.) | |
|---|---|---|---|---|---|---|---|---|
| | | | | COE | | | JEF | FIS |
| Potrero 02 | P3 | Upstream of Nogales Wash | 17760 | 7400 | 5330 | 2070 | 14.06 | n/a |
| | P2 | At U.S. Highway 89 Bridge | 17040 | 7100 | 5110 | 1990 | 13.51 | 14.4 |
| | P1a | At Western Corporate Limits | 14640 | 6100 | 4390 | 1710 | 11.58 | 11.3 |
| | P1a | Proposed u/s limit of study | 13200 | 5500 | 3960 | 1540 | 10.5 | n/a |

**Note**: Based on results of the HEC-1 analysis, which generated discharges that were generally less than the COE value at US 89, the discharges at the remaining concentration points were defined using a Discharge to Area (Q/A) ratio relative to the COE value a US 89 and JEF's drainage areas.

# APPENDIX B

## Watershed Maps

## For Detail Study Reaches

# APPENDIX C

HEC-1 Models

HEC-1 MODELS

| | 100YR | 500YR | 50YR | 10YR | | |
|---|---|---|---|---|---|---|
| Stream Reach | | | | | Input | Output |
| Agua Fria | AGUA100YR | AGUA500YR | AGUA50YR | AGUA10YR | .IH1 | .OH1 |
| Ephriam Canyon | EPH100YR | EPH500YR | EPH50YR | EPH500YR | .DAT | .OUT |
| Josephine Canyon | JOS100YR | JOS500YR | JOS50YR | JOS10YR | .DAT | .OUT |
| Lyle Canyon | LY100YR | LY500YR | LY50YR | LY10YR | .DAT | .OUT |
| Peck Canyon | PEC100YR | PEC500YR | PEC50YR | PEC10YR | .IH1 | .OH1 |
| Sonoita Creek | SON100FINAL | SON500FINAL | SON50FINAL | SON10FINAL | .DAT | .OUT |
| Sopori Wash | SOP100YRS | SOP500YRS | SOP50YRS | SOP10YRS | .IH1 | .OH1 |