US Army Corps
of Engineers
Los Angeles District

TANQUE VERDE CREEK, PIMA COUNTY, ARIZONA LIMITED REEVALUATION REPORT AND ENVIRONMENTAL ASSESSMENT

TECHNICAL APPENDICES

AUGUST 2002

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PLANNING DIVISION, WATER RESOURCES BRANCH
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HYDRAULICS

TANQUE VERDE CREEK
CRAYCROFT ROAD TO SABINO ROAD
BANK PROTECTION AND
RIPARIAN PRESERVE PROJECT
LIMITED REEVALUATION REPORT (LRR)
FEASIBILITY LEVEL ENGINEERING ANALYSIS

Prepared for:

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I. INTRODUCTION

This report summarizes the results of a hydraulic and geomorphic analysis of the Tanque Verde Creek from its confluence with the Rillito River, at Craycroft Road upstream to Sabino Canyon Road (see Figure 1). The study reach extends a short distance downstream of Craycroft Road and a short distance upstream of Sabino Canyon Road. The project reach is better defined as the unprotected portion of the Tanque Verde Creek located between Craycroft Road and Sabino Canyon Road. The project reach extends from Craycroft Road upstream approximately 8,000 feet, and represents the downstream three-quarters of the overall reach lying between Craycroft Road and Sabino Canyon Road.

1.1 Purpose

The purpose of this analysis was to investigate the impact of flooding during the 100-year event (peak discharge: 34,000 cfs) and to evaluate the erosion potential from both a qualitative and quantitative standpoint. It is intended that this document, either in whole or in part, be incorporated into a Limited Reevaluation Report (LRR) that will also address the results of the economic analysis and the issue of environmental acceptability. The purpose of the LRR is to determine the current economic feasibility of providing flood-control and erosion-control solutions within the study reach, in contrast to a 1987 Corps of Engineers report (Reference 1) that found no economically justified solutions to the area's problems. The LRR will specifically address the proposed Tanque Verde Creek bank stabilization and riparian area preserve project, as outlined in a preliminary report prepared by Pima County in December 1996 (Reference 2).

1.2 Project Formulation

The County's project report briefly discusses the recent history of flooding in the area, and provides the cost of repairs from damages sustained during the January 1993 flood. All of the damages are related to bank erosion (or lateral migration) and scour along the channel bed. There were no damages attributed to overbank flooding. In January 1993, two significant discharges impacted the study reach. On January 8th, the peak discharge was estimated to be approximately 24,500 cfs by the US Geological Survey (Reference 3). This discharge approximates the current 50-year peak discharge (24,000 cfs) as noted in Reference 4. On January 18th, the peak discharge was estimated to be 10,600 cfs. This discharge approximates the current 10-year peak discharge (10,500 cfs). The aerial photograph provided as Figure 2 was taken on January 9, 1993 (i.e., the day after the largest flow on record).

In addition to their concern of continued erosion along the study reach, the County expressed concern that the south approach to the Craycroft Road bridge could be washed out during a catastrophic event. According to the County, there is historic evidence of channel migration approximately 1000 feet south of the Craycroft Road bridge. They also attribute periodic repairs to both the roadway embankment and to a sewer interceptor in this area to

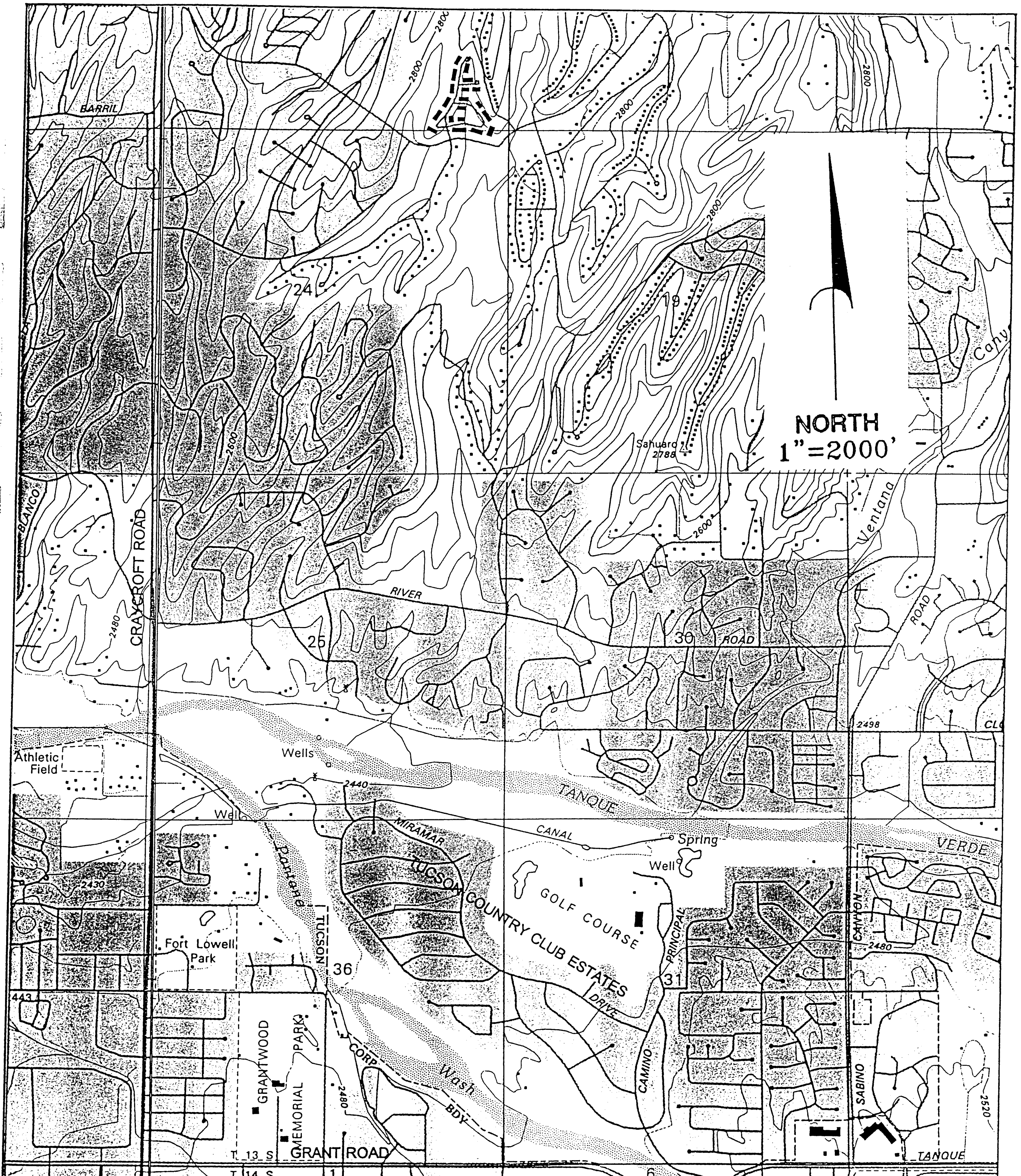

FIGURE 1
SITE LOCATION MAP

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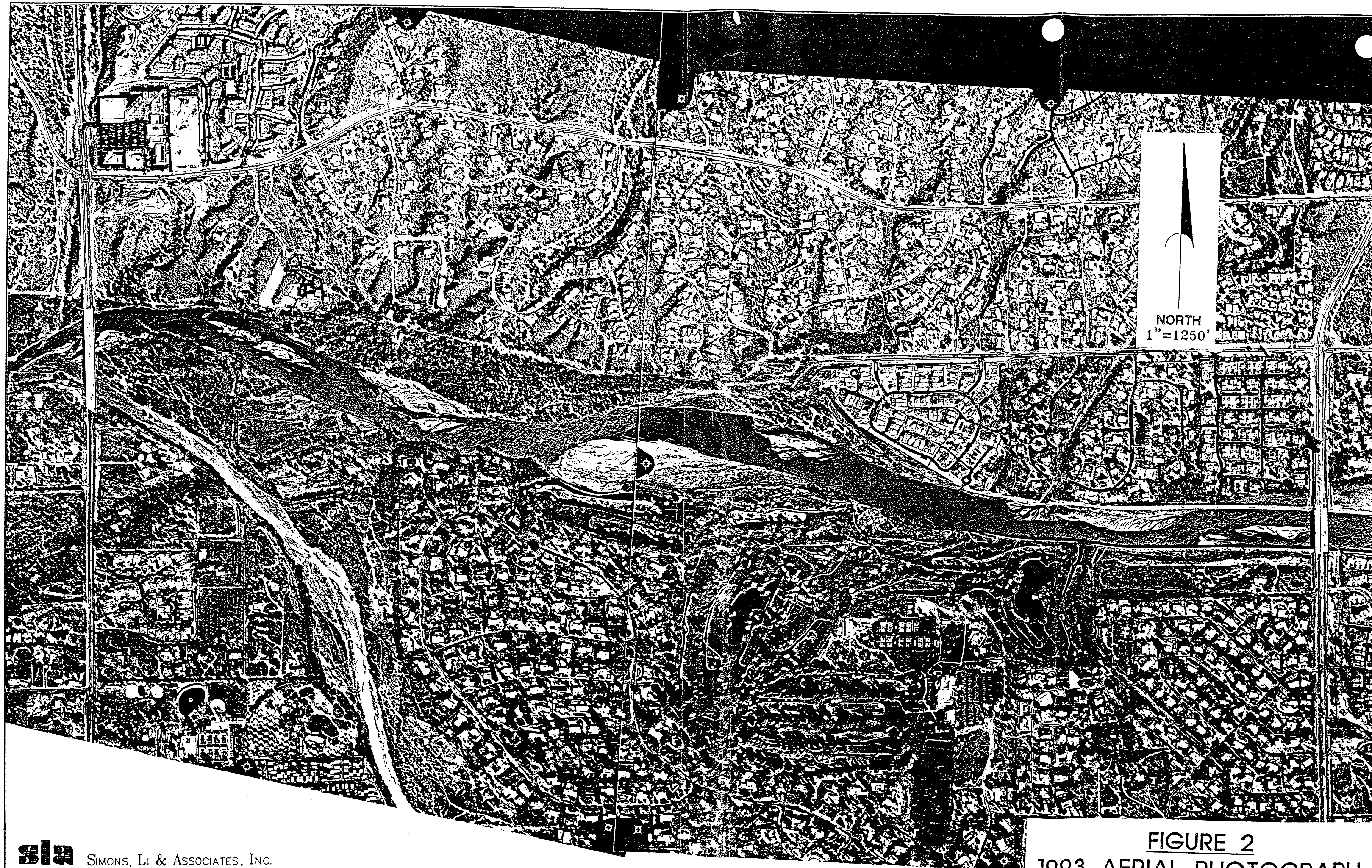

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FIGURE 2
1993 AERIAL PHOTOGRAPH

subsurface flows that follow this meander path. Since the meander scar lies within the 500-year flood plain, they are concerned that, during an extreme flow event, inundation and erosion along the study reach could impact several subdivisions and the Fort Lowell Historic District, which are located adjacent to the south approach of the Craycroft Road bridge.

The County's proposed solution to the problem requires the installation of approximately 8,600 linear feet of soil-cement bank protection and the establishment of a riparian preserve, which will act as an erosion buffer for the unprotected overbank areas. Figures 7 and 8 of the County's preliminary design report (Reference 2) shows the approximate location and the extent of these design features. Of the proposed 8,600 linear feet of bank protection, approximately 1,550 linear feet is required along the north bank immediately upstream of Craycroft Road in order to protect the north bridge abutment, and approximately 7,050 linear feet is required along the south bank to complete protection of the entire south bank. The riparian preserve will be located within the north overbank area between the upstream terminus of the proposed north abutment protection for Craycroft Road and the downstream terminus of the existing bank protection that extends approximately 4,550 feet upstream to Sabino Canyon Road. No grade stabilizers along the streambed were included in the County's proposed design.

1.3 Scope and Methodology

Collectively, the scope of the hydraulic and geomorphic analysis was formulated to address four major areas of concern. These four areas are (1) the potential for bank erosion, lateral migration, and channel migration along the project reach; (2) the relative stability of the Craycroft Road and Sabino Canyon Road bridges; (3) the flooding potential along the study reach during a 100-year event; and (4) the potential threat, if any, that the project might pose on the recently completed Rillito River bank stabilization project.

Using the methodology described in the Reference 1, an average-annual erosion rate relative to the existing bank was defined as the ratio of the recommended development set-back distance to the 50-year life of the proposed project. The development set-back distance was determined using the combined results of a qualitative and quantitative geomorphic analysis. The qualitative analysis compared changes in the location of the banks as documented by a series of photographs taken between 1936 and 1996. Flow records from the US Geological Survey were used to correlate noted changes in bank locations to a particular flow event. The quantitative analysis used empirical relationships to estimate the expected long-term migration distance (Reference 5) and the limiting width of channel meanders along the project reach (Reference 6).

In addition to evaluating the potential for bank erosion, migration, and channel meanders, scour calculations were performed to estimate adequate design toe-down depths for the proposed bank protection, and to verify the stability, under project conditions, of the existing bank protection and bridges. The scour components included in the analysis were general scour, bed-form scour, bend scour, local scour, and the potential for long-term degradation. The relationships provided in Reference 5 and Reference 7 were used for this purpose. A low-flow channel incisement component, which was assumed to be two feet, was also included in the analysis. The potential for long-term degradation was determined using the equilibrium slopes provided in Reference 8. For the most part, these procedures are consistent with the ones outlined in Reference 9.

The flooding potential along the study reach was determined using the HEC-2 water-surface profile model as described in Reference 9. The analysis was based on topographic information obtained in August 1993. To accurately model existing conditions, portions of the topography were revised to reflect the bank protection constructed by Pima County in 1994. With-project conditions were analyzed using the information provided on Figures 7 and 8 of Reference 2.

II. WITHOUT-PROJECT CONDITIONS

2.1 Erosion/Meander Potential

As previously noted, the qualitative geomorphic analysis of the study reach was based on an evaluation of 60 years of photographic records. The series of photographs used in the analysis were 1936, 1953, 1960, 1967, 1971, 1979, 1983, 1993, and 1996. USGS peak discharge records were used in an attempt to correlate movements of the channel or the banks to specific flow events. Table 2.1a summarizes the most significant discharges that occurred over the observed time period. Records obtained for the Rillito River and the Pantano Wash were also obtained to supplement missing records for the Tanque Verde Creek. Although the 1983 and 1993 photographs were taken immediately following the two largest flows on record for the Rillito River system, significant flow events also occurred in 1965 and 1978. In addition to bank erosion (or lateral migration), the photographs document other historical changes along the Tanque Verde Creek, including changes in land-use and vegetation—both of which have a significant influence on erosion potential. Land-use changes adjacent to and immediately upstream of the study reach have been especially dramatic during the last 45 years.

Prior to 1953, lands along the north and south banks of the Tanque Verde Creek between Craycroft Road and Sabino Canyon Road were mostly undeveloped, with the exception of agricultural uses. The 1936 photograph indicates that most of the geologic floodplain to the south was being farmed. However, on the north bank, only the confluence area between the Ventana Canyon Wash and the Tanque Verde Creek was being farmed. Immediately upstream of Sabino Canyon Road, most of the geologic flood plain was being farmed.

By 1953, development on the south bank began with the initial phases of the Tucson Country Club Estates. The golf course was already constructed, and the subdivision roads were being paved to make way for residential development. However, the north bank remained undeveloped until the late 1960's. By the early 1970's, development intensity increased on parcels adjacent to the east of the Country Club, along the north bank immediately upstream of Sabino Canyon Road. By 1979, developments spread to the north bank within the boundary of the study reach; however, most of this development was centered around the confluence region of the Ventana Canyon Wash.

Prior to the October 1983 flood, the Craycroft Road bridge was constructed at the downstream end of the study reach, and soil-cement bank protection was installed along both banks at the upstream end of the reach. In 1990, development began on another major subdivision that currently occupies a large portion of the northern bank immediately downstream of the Ventana Canyon confluence. Soil-cement bank protection also protects this subdivision and is currently a requirement for all subdivisions that encroach within 500 feet of the existing channel banks (i.e., the current setback requirement imposed by Pima County). However, the Tucson Country Club and the remaining residential properties located within 500-feet of the banks were permitted before the potential for channel migration along alluvial channels was fully recognized.

Table 2.1a Summary of Relevant Peak Discharges from USGS Gaging Stations

Date	Peak Discharge (cfs)				
	Tanque Verde Creek	Pantano Wash	Rillito River		
	Sabino Canyon Rd.	Tanque Verde Rd.	Dodge Blvd.	First Ave.	La Cholla Blvd.
13-Aug-40	6400	9200			13200
30-Dec-40	9000				
31-Dec-40					9900
03-Jul-50					9490
25-Jul-51					9500
12-Aug-58		20000			8930
01-Sep-64					9420
22-Dec-65	12200				12400
06-Sep-70	7340				7000
02-Aug-71					9290
1979 (1)		1530			16400
18-Dec-78	12700			16400	
01-Oct-83		11000			
02-Oct-83					29700
08-Jan-93	24500		24100		
11-Jan-93	9690				
13-Jan-93	4910				
18-Jan-93	10600				

(1) water year (01-Oct-78 to 30-Sep-79)

Aerial photographs taken prior to land-use changes reveal a geologic floodplain along the study reach that has an average width of approximately 3000 feet. The northern boundary is well defined where it meets the foothills of the Santa Catalina Mountain Range. With the exception of the developments that occupy the area near the Ventana Canyon Wash confluence, the majority of the area between the northern bank and the northern geologic boundary has remained undeveloped. However, the southern geologic boundary is not as well defined, and development of the area began with the establishment of Tucson Country Club Estates back in the early 1950's. At that time, the main channel remained very close to the northern geologic boundary of the flood plain.

From 1936 to 1993, the creek has been actively adjusting its channel geometry within the geologic floodplain. A comparison of the 1936 and 1993 photographs reveal that channel meanders and/or bank migrations have shifted the south bank by as much as 650 feet. However, movement of the north bank has been limited to approximately 200 feet over this same 60-year time period. In fact, prior to 1993, most of the north bank remained relatively unchanged. Consequently, channel migration and bank erosion has been most pronounced along the south bank.

A comparison of photographs from the successive years investigated reveal that the largest lateral shift occurred between 1960 and 1967. Evidence of this change first appears on the 1967 photographs. Sometime between 1960 and 1967, flows overtopped the south bank of the main channel and created a secondary channel that in essence resulted in the formation of a small island in the middle of the watercourse. It is likely that this shift probably occurred during the December 1965 flood. The 1967 photographs also reveal signs of excavation in the vicinity of the south bank, as well as the creation of a third channel through the center of the island. These efforts appear to be related to an attempt to minimize the erosion potential along the south bank by diverting flow towards the north.

As one might expect, the maximum change in channel geometry typically occurs during large flow events. Although there is no recorded flow data for the period 1953 to 1960, large flows were recorded in 1965, 1979, 1983 and 1993. The maximum lateral migration and/or erosion along the south bank occurred during these periods. The largest peaks on the Tanque Verde Creek occurred during the floods of October 1983 and January 1993.

In addition to lateral migration, the main channel throughout the study reach has widened considerably, and has correspondingly adjusted its profile through both aggradation and degradation. In 1953, the channel width ranged from 80 feet at its narrowest point to 260 feet at its widest point. By 1993, the channel width ranged from 200 to 850 feet. A review of river bed profiles from 1983 to 1993 indicates that the main channel has degraded approximately three feet at the upstream limit of the study reach. The trend towards degradation was evident within the upstream half of the reach, while the downstream half showed a tendency towards aggradation. The average depth of aggradation along the downstream reach was approximately 0.65 feet.

The following paragraphs provide a brief summary of the changes that occurred between the successive years of photographic record.

<u>**1936 - 1953**</u> The most significant change noted during this period was the abandonment of some of the secondary low-flow channels that hugged the south bank in favor of the low-flow channels along the north bank. However, at one location—immediately downstream of Sabino Canyon Road—the south bank appears to have sifted in a southwesterly direction approximately 100 feet. This change could probably be attributed to the December 1940 flow event that approximated the 10-year flood by today's standards.

<u>**1953 - 1960**</u> In 1953, the width of the main channel ranged from 80 feet to 260 feet along the study reach. In 1960, channel widths ranged from 80 feet to 400 feet. During this 7-year period, a portion of the south bank migrated approximately 200 feet. This shift occurred within the midsection of the study reach. The lower half of the study reach remained relatively unchanged. Although no recorded flow data is available for the Tanque Verde Wash during this period, it appears that several significant flow events occurred along the Pantano Wash.

<u>**1960 - 1967**</u> Again, little or no change was noted along the north bank during this time period. However, increased development was occurring along the south bank. By 1967, the width of the main channel along the study reach ranged between 150 feet and 870 feet. The widest section was located in the midsection, where an island had formed due to overtopping flows from the main channel that existed in 1960. This bifurcation of the main channel relocated the active south bank approximately 650 feet from its original location. The lower half of the study reach remained relatively unchanged during this period. Flow records indicate only one significant flow event during this period. A peak discharge of 12,200 cfs was recorded on December 22, 1965.

<u>**1967 - 1971**</u> Between 1967 and 1971, no significant change can be observed in the relative location of the respective banks. In addition, the relative width of the main channel remained unchanged. However, earlier attempts to straighten the active midsection proved successful in the sense that a well-defined straight channel predominated within this section of the study reach during the noted time period. Flow records indicate that no significant flow events occurred during this time period.

<u>**1971 - 1979**</u> With the exception of a 100-foot lateral shift in the main channel at one isolated location, the channel geometry remained relatively unchanged during this time period. However, one significant flow event did take place on December 18, 1978. The peak discharge during this event was estimated to be approximately 12,700 cfs.

<u>**1979 - 1983**</u> As previously mentioned, one of the largest events to impact the Rillito River system occurred during this time period (October 1983). Although no flow records were available

for the Tanque Verde Creek, significant bank erosion was noted. A review of the flow records for the Rillito River and the Pantano Wash suggests that the peak discharge on the Tanque Verde Creek exceeded a 25-year event (i.e., ±17,000 cfs). Portions of the north and the south bank eroded between 100 and 200 feet. The largest shift occurred along the south bank adjacent to the Tucson Country Club Estates golf course. Since bank protection had been installed along the most upstream portion of the study reach, no erosion occurred in this area. However, the cause and effect relationship that typically surrounds piece-meal bank-protection projects probably contributed to the increased erosion that occurred along the unprotected downstream banks. Most of the damage from the October 1983 flood was isolated to the dynamic midsection, since the downstream one-third of study reach remained relatively unaffected by the flood. In 1983, the width of midsection channel increased to approximately 920 feet.

1983 - 1993 The largest flood on record (i.e., 24,500 cfs) occurred during this time period (January 1993). Although the most extensive erosion noted (approximately 150 feet) occurred on the north bank just upstream of Craycroft Road bridge, approximately 100 feet of bank was lost along a portion of the south bank that had been reclaimed after the October 1983 flood. Since the homes is this area were now located within 150 feet of the bank, and a major sewer line that traverses the area had been exposed, Pima County again reclaimed the bank and installed approximately 1600 feet of soil-cement bank protection. After the January 1993 flood, the most constrictive width in the main channel became 200 feet.

Figure 3 provides an illustrative summary of the changes that have occurred along the study reach between 1953 and 1993. The approximate location of the bank following the October 1983 flood is included, since some reclamation occurred between 1983 and 1993.

The results of the qualitative geomorphic analysis indicate that lateral shifts on the order of 650 feet in the banks of the main channel of the Tanque Verde Creek are not unusual over a 50-year time period. This distance correlates very closely to the long-term migration distance (652 feet) computed using the building setback relationship contained in Reference 5 in conjunction with a bank-full discharge of 17,000 cfs. Consequently, in contrast to the 500-foot building setback currently applied by Pima County, a 650-foot setback would seem more reasonable at some locations considering the dynamic nature of the main channel within the study reach. Likewise, over the 50-year project life, an average annual erosion rate of 13 feet per year appears to be a reasonable estimation of the erosion potential within the project area. Since the main channel along the study reach continues to occupy the northern third of the geologic flood plain, this erosion rate could result in 650 feet of erosion relative to the south bank. However, erosion to the north bank would be limited by the northern boundary of the geologic flood plain. For the most part, the northern boundary of the geologic flood plain corresponds to the northern boundary of the 100-year flood plain, as defined by this study.

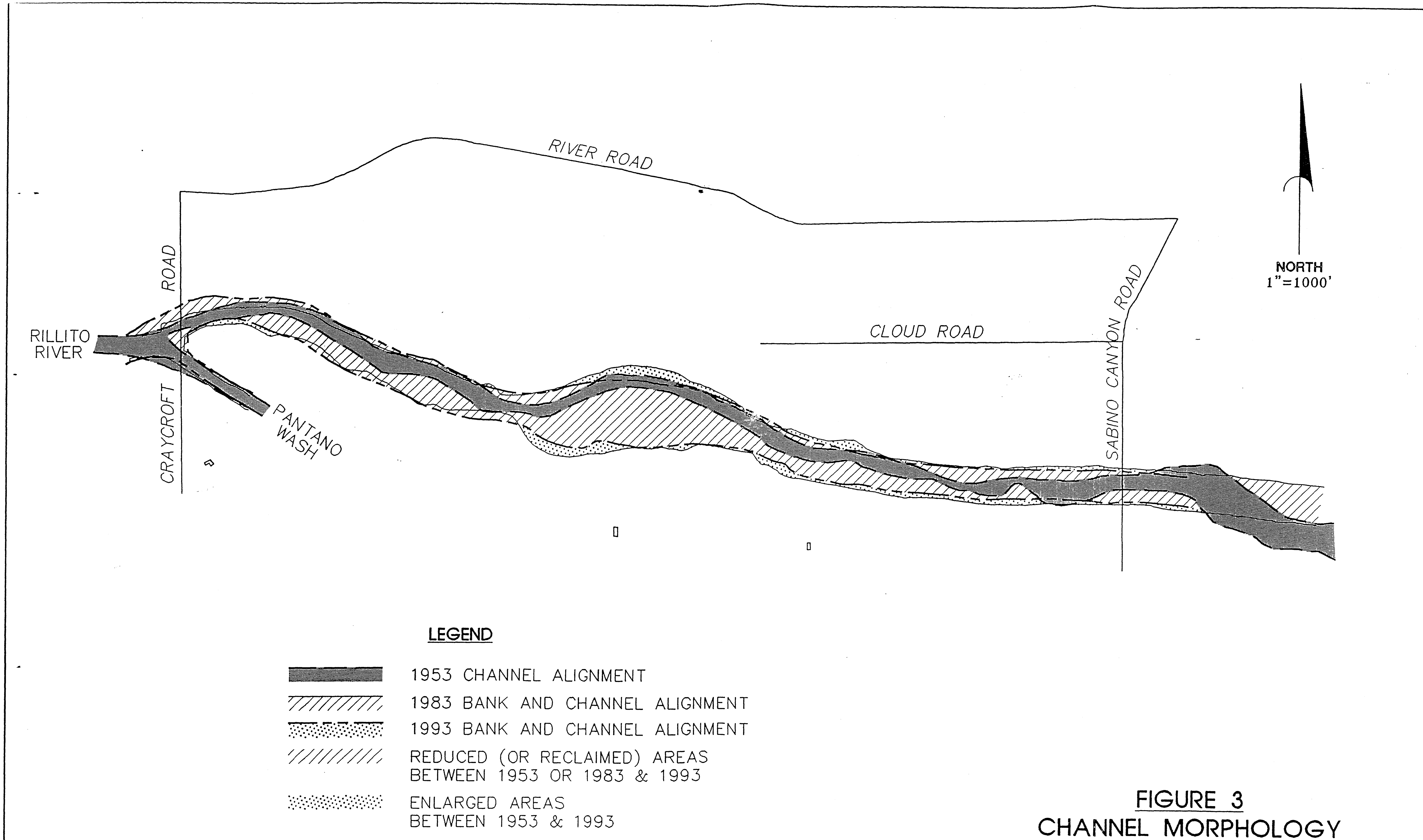

FIGURE 3
CHANNEL MORPHOLOGY ALONG THE TANQUE VERDE CREEK BETWEEN 1953 AND 1993

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2.2 100-Year Flood Plain

An analysis of the 100-year floodplain was conducted using a 1993 topographic base map provided by Pima County in conjunction with the HEC-2 water-surface profile model (Reference 10). The cross-sections used in the analysis are shown on Figure 4 (Sheets 1 and 2). The computed 100-year floodplain boundaries are also shown on Figure 4.

Two assumptions were made during the course of the analysis which have for the most part provided a conservative estimate of the 100-year flood plain and associated water-surface elevations. The first assumption is related to the starting water-surface elevation that was used in the analysis. This elevation was obtained using Reference 4 as a guide. Consequently, it is based on a backwater analysis relative to the confluence region that considers the combined effect of flows from the Pantano Wash and Tanque Verde Creek. However, this assumption only applies to the selected starting water-surface elevation at Cross Section 1. The entire floodplain model is based on a single discharge, 34,000 cfs, which is the current regulatory discharge for the Tanque Verde Creek. Although this assumption will produce higher water-surface elevations in the immediate vicinity of the confluence, the influence is limited to the extreme downstream portion of the study reach, which is currently undeveloped.

The second assumption applies to the unprotected levee that exists along a portion of the south bank. It appears that this levee was intended to protect the Tucson Country Club golf course from inundation during moderate flow events. However, the results of preliminary analyses indicate that the levees are high enough to contain the 100-year peak discharge under the assumption of stable levee conditions. Since the contained analysis produced higher water-surface elevations than the uncontained analysis, the flood plain was delineated using the water-surface elevations associated with the contained analysis. This approach provides the most conservative estimate of the limits of the 100-year flood plain.

The results of the 'without-project conditions' floodplain analysis are summarized in Table 2.2a. The complete HEC-2 input/output listing is provided in Appendix A.

With the exception of what appears to be a secondary structure to the primary residence on a single lot, there are no residential structures located within the 100-year flood plain of the Tanque Verde Creek. The Tucson Country Club Estates' golf course appears to be the only developed property located in the 100-year flood plain.

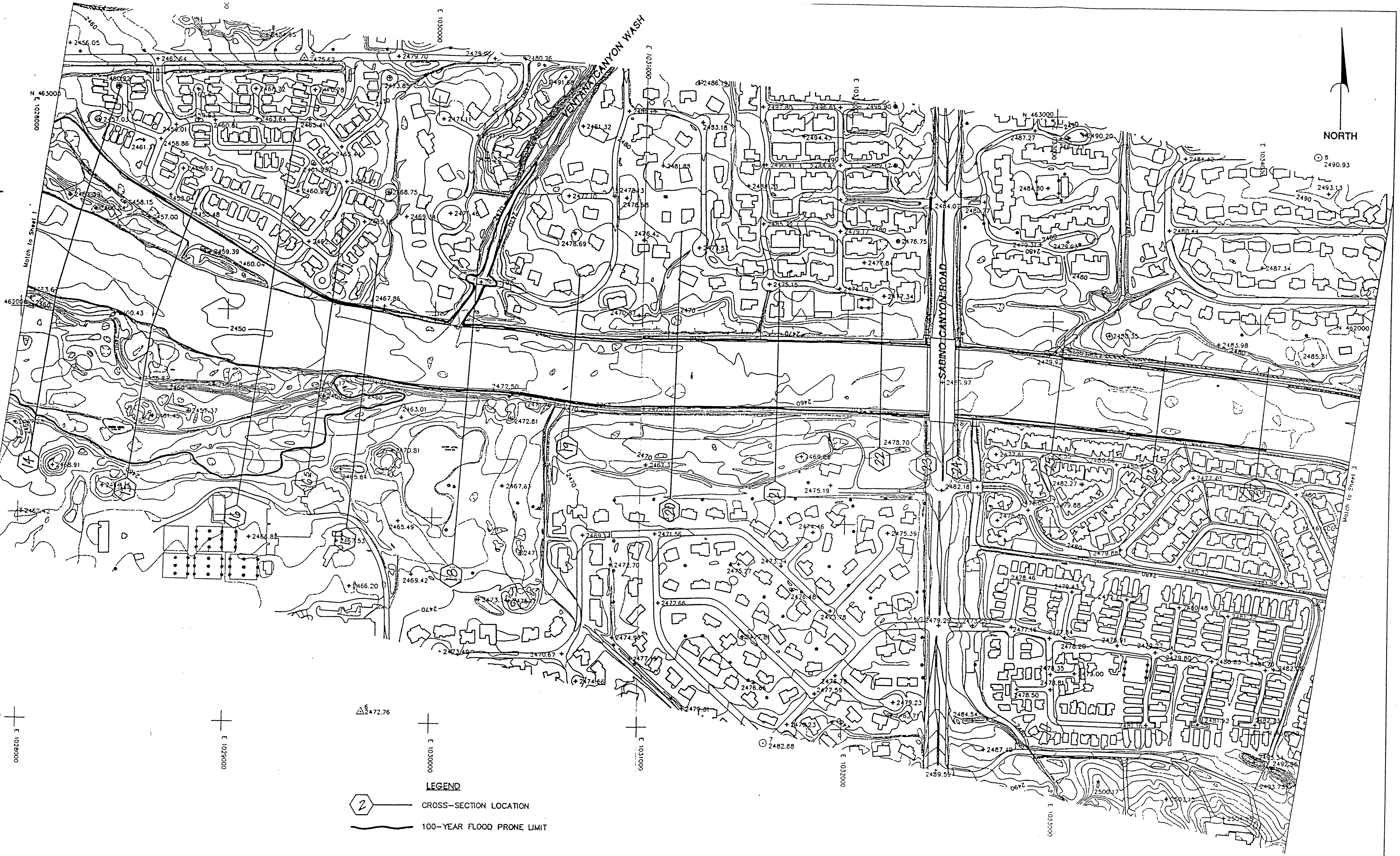

Photo Date - August 10, 1993

Contour Interval = 2 foot

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FIGURE 4
100-YEAR FLOOD PLAIN MAP
TANQUE VERDE CREEK
CRAYCROFT ROAD TO SABINO CANYON ROAD
SHEET: 2 OF 2

Photo Date - August 10, 1993

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FIGURE 4
100-YEAR FLOOD PLAIN MAP
TANQUE VERDE CREEK
CRAYCROFT ROAD TO SABINO CANYON ROAD
SHEET: 1 OF 2

Table 2.2a Summary of Without-Project Floodplain Conditions

Section Number	Distance (1) (ft)	Water Surface Elevation (ft)	Max. Flow Depth (ft)	Top Width (ft)	Channel Velocity (fps)
1.0	100.0	2433.20	11.20	604	11.46
2.0	550.0	2434.04	10.04	910	13.79
3.0	1050.0	2437.17	10.67	1136	7.75
4.0	1550.0	2437.85	9.85	1293	8.01
5.0	2000.0	2438.54	9.04	1508	8.83
6.0	2500.0	2439.68	7.68	1118	11.22
7.0	3000.0	2442.22	8.22	1053	12.40
8.0	3500.0	2444.71	8.71	841	12.91
9.0	4000.0	2447.61	9.61	948	8.31
10.0	4500.0	2448.76	8.76	1049	6.43
11.0	5000.0	2449.46	8.16	1147	6.16
12.0	5500.0	2450.24	6.74	854	9.20
13.0	6000.0	2451.98	7.98	738	10.10
14.0	6470.0	2453.65	7.15	459	12.15
15.0	6970.0	2456.10	8.10	596	13.05
16.0	7490.0	2458.80	8.80	584	10.53
16.5	7790.0	2459.56	7.56	423	14.32
17.0	7990.0	2460.71	7.91	323	15.09
18.0	8490.0	2464.40	9.50	322	12.79
19.0	8990.0	2466.72	9.72	344	11.18
20.0	9490.0	2468.08	9.08	332	11.75
21.0	9990.0	2469.64	9.64	323	12.00
22.0	10490.0	2471.54	10.54	328	10.32
23.0	10710.0	2471.98	9.98	349	10.48
23.1	10730.0	2472.05	10.05	350	10.40
23.2	10850.0	2472.78	10.28	353	10.29
24.0	10870.0	2472.84	10.34	354	10.21
25.0	11370.0	2473.81	9.81	331	11.66
26.0	11870.0	2475.35	9.85	335	12.47
27.0	12370.0	2477.15	9.75	306	13.97

Notes: (1) Relative to the upstream face of the Craycroft Road bridge.

2.3 Scour/Stability Analysis

The scour/stability analysis was performed on a sub-reach-by-sub-reach basis. The study reach, excluding the bridge at Sabino Canyon Road, was broken down into six subreaches. The number of subreaches selected and the grouping of consecutive sections within a particular subreach are primarily a function of similarities in hydraulic properties and sediment transport characteristics. By grouping a number of cross sections together and considering their properties as a single unit, local effects surrounding a single cross section are reduced. The average hydraulic properties for each subreach were then used to compute the individual scour components. The total computed scour depth, which was used to estimate adequate design toe-down depths for the project's bank protection, represent the sum of the individual scour components times a safety factor (1.3) to account for irregularities in hydraulic properties and sediment distributions created by a nonuniform flow distribution.

Table 2.3a summarizes the results of the without-project scour analysis. As previously noted, the scour analysis was performed using empirical equations obtained from References 5 and 7. With the exception of the anticipated depth of the low-flow channel, all scour components, including general scour, were estimated using the appropriate relationship from these references. The depth of the low-flow channel was assumed to be two feet, which is consistent with observed conditions along the study reach. Since the results of the general scour analysis were consistent with the results of the detailed sediment routing analysis performed in conjunction with the Rillito River bank protection study (Reference 9), the computed values shown in Table 2.3a were used to estimate the total single-event scour depth. The individual scour computation sheets for each subreach, including a summary of the hydraulic properties used in the analysis, are provided in Appendix B. Each computation sheet shows the equation used and its source.

Table 2.3a Summary of the Without-Project Single-Event Scour Analysis

Reach	Applicable	Scour Components (ft)							Total
	Sections	General	Bed-Form	Bend	Local	Subtotal	Low-Flow	Long-Term	Depth
1	1 - 4	1.2	1.4	0.0	18.3	27.2	2.0	0.0	29.2
2	5 - 9	1.0	1.6	3.4	0.0	7.7	2.0	0.0	9.7
3	10 - 13	0.4	0.9	1.7	0.0	3.8	2.0	0.0	5.8
4	14 - 18	1.4	2.3	1.9	0.0	7.3	2.0	0.0	9.3
5	19 - 23	1.4	1.7	0.0	0.0	4.0	2.0	0.0	6.0
6	24 - 27	1.5	2.0	0.0	18.2	28.2	2.0	0.0	30.2

Notes: The safety factor is included in the subtotal depth.
Local scour shown in reaches 1 and 6 would primarily occur in the vicinity of the bridges

It should be noted that the long-term degradation depth for all subreaches was assumed to be zero. Although this may appear to be contrary to the results of the qualitative geomorphic analysis, which noted a degradation depth of approximately 3.0 feet at the upstream limit, it is a function of the results of a comparison made between the existing bed slope and the projected equilibrium slope as presented in Reference 8. The existing bed slope between the observed pivot point (Section 18) and the upstream limit of the study reach (Section 27) is approximately 0.32 percent. The projected equilibrium slope was determined to be 0.35 percent. Consequently, it was assumed that the upstream reach has achieved a relative state of equilibrium, based on the most current information available. It is interesting to note that based on the results of the qualitative geomorphic analysis the downstream reach showed a tendency towards aggradation. The existing slope within the downstream reach (Section 1 to Section 18) was determined to be approximately 0.39 percent. The projected equilibrium slope for the downstream reach was 0.41 percent. Again, it appears that the bed profile along downstream reach has also obtained a relative state of equilibrium.

One additional component of the scour/stability analysis involved a determination of the limiting meander potential. The results of the qualitative geomorphic analysis indicate that a potential for erosion and/or migration of the channel banks exists within the boundary of the geologic flood plain. However, hydraulic engineers recognize that a limiting meander potential also exists. If the meander potential is not limited by a physical feature (i.e., rock formation or similar geologic feature), it will be limited from a geometric standpoint, as pointed out in Reference 6, in that an upper limit of development exists at which point a cutoff eliminates the meander. Using the bank-full discharge of 17,000 cfs and an average top width of 380 feet, the computed upper limit of meandering relative to the study reach was determined to be approximately 1,600 feet along either the north or south bank of the Tanque Verde Creek (i.e., a total meander width of ±3,200 feet).

With respect to the stability of the Craycroft Road bridge and the Sabino Canyon Road bridge, the results of the scour analysis indicate that the total scour potential is approximately 29 feet and 30 feet, respectively. These values include the addition of local scour at the bridge piers, but do not include abutment scour, since conditions conducive to abutment scour were not applicable along the study reach. According to the as-built plans for the bridges, the bottom of the bridge piles are set at approximately 2375.0 feet and 2409.0 feet, respectively. The existing flow line elevation of the Tanque Verde Creek at Craycroft Road is approximately 2422.0 feet. At Sabino Canyon Road, the flow line elevation is approximately 2462.0 feet. Therefore, approximately 18 feet of the Craycroft Road bridge piles and approximately 23 feet of the Sabino Canyon Road bridge piles will be below the anticipated scour zone. If this depth is adequate to retain stability during the flood hydrograph, the bridges can be considered stable.

In should be noted that the existing bank-protected reaches within the study reach have toe-downs on the order of ten feet. Since the maximum computed scour depth outside the 'zone of influence' associated with the bridge piers was 9.7 feet, this toe-down depth is adequate.

However, based on a review of the as-built plans for both bridges, the toe-down depth for the bank protection at Craycroft Road was limited to 13 feet, and the toe-down depth for the bank protection at Sabino Canyon Road was limited to 10 feet. To ensure that these toe-down depths would be adequate, the local scour 'zone of influence' associated with the bridge piers was estimated. If the vertical plane of the bank protection enters this zone, the toe-down depths for the bank protection must be increased to consider the overlapping influence of local scour from the adjacent piers.

Typically, this zone is assumed to resemble an inverted cone surrounding the pier. Based on a 3:1 side slope for the cone, a minimum toe-down depth of 10 feet for the bank protection, a maximum pier diameter of nine feet (i.e., a five-foot pier, plus four feet of debris), and a maximum scour depth of 30 feet at the bridge piers, the radius of the inverted base of the cone would be approximately 73.5 feet. Therefore, if the vertical plane for the bank protection, adjacent to the abutment, is less than 73.5 feet from the center-line of the nearest pier, additional toe-down depths are required to ensure the stability of the bank protection. However, since this threshold value is exceeded at both locations (i.e., the bank protection is more than 73.5 feet from the piers), the overlapping influence of pier scour need not be considered. Therefore, the toe-down depths for the bank protection beneath the bridges are adequate under existing (without-project) conditions.

With respect to the Pima County's concern that channel migration could result in damage to (1) the south approach to the Craycroft Road bridge; (2) an adjacent sewer interceptor; and (3) the neighboring subdivisions, the results of the qualitative geomorphic analysis do not support this concern, since the width of the confluence region exceeds the projected 650-foot width to be applied over the life of the project. In addition, the historic meander scar mentioned in Reference 2 is located approximately 1600 feet south of the south bank for the Tanque Verde Creek at the bridge crossing. The 1000-foot distance mentioned in Reference 2 applies to the south bank of the Pantano Wash. In addition, if some of the damages noted under existing conditions are caused by subsurface flows from the Tanque Verde Creek, the proposed bank protection project will not eliminate subsurface flows unless the toe-down depths are increased to prevent the conveyance of flow along this subterrian channel. Even if this could be accomplished, the embankment would still be subject to flows conveyed along the Pantano Wash. Therefore, it appears that the project as proposed will do little to address this specific problem area.

III. WITH-PROJECT CONDITIONS

3.1 Impact on the 100-Year Flood Plain

Using the design information provided in Reference 2, the without-project conditions HEC-2 model was revised to reflect the approximate alignment and top-of-bank elevations associated with the proposed project. The results of the analysis are summarized in Table 3.1a. A complete input/output listing is provided in Appendix C. The relative impact of the project is summarized in Table 3.1b.

The results of the analysis indicate that the project will, for the most part, eliminate overbank flooding along the south bank between Sections 9 and 17, with little or no adverse impact on adjacent properties. In addition, the width of the flood plain will be reduced at several locations. Although the majority of the reductions are less than 55 feet, reductions in excess of 100 feet occur at four locations. The maximum reduction noted was approximately 250 feet. However, there are no significant increases in the width of the flood plain. Although the project will produce significant increases in the water-surface elevations at selected locations, sufficient freeboard exists at these locations to prevent overtopping of the main channel. However, it is recommended that Pima County "fine-tune" the final design to minimize the increase. This can be accomplished by eliminating the bottleneck condition created in the immediate vicinity of Section 16.5.

Table 3.1a Summary of With-Project Floodplain Conditions

Section Number	Distance (1) (ft)	Water Surface Elevation (ft)	Max. Flow Depth (ft)	Top Width (ft)	Channel Velocity (fps)
1.0	100.0	2433.20	11.20	604	10.42
2.0	550.0	2434.18	10.18	911	10.14
3.0	1050.0	2435.36	8.86	930	10.32
4.0	1550.0	2437.11	9.11	1238	8.83
5.0	2000.0	2438.03	8.53	1472	9.63
6.0	2500.0	2439.54	7.54	1104	12.31
7.0	3000.0	2442.57	8.57	1090	11.52
8.0	3500.0	2444.56	8.56	815	13.26
9.0	4000.0	2447.64	9.64	944	8.28
10.0	4500.0	2448.62	8.62	1040	7.59
11.0	5000.0	2449.56	8.26	902	6.96
12.0	5500.0	2450.45	6.95	839	8.94
13.0	6000.0	2452.01	8.01	746	9.96
14.0	6470.0	2453.60	7.10	442	12.49
15.0	6970.0	2456.16	8.16	600	12.83
16.0	7490.0	2458.44	8.44	394	14.61
16.5	7790.0	2460.15	8.15	309	15.13
17.0	7990.0	2462.51	9.71	327	11.98
18.0	8490.0	2464.15	9.25	321	13.18
19.0	8990.0	2466.71	9.71	344	11.20
20.0	9490.0	2468.08	9.08	332	11.76
21.0	9990.0	2469.64	9.64	323	12.00
22.0	10490.0	2471.55	10.55	328	10.32
23.0	10710.0	2471.98	9.98	349	10.48
23.1	10730.0	2472.05	10.05	350	10.40
23.2	10850.0	2472.78	10.28	353	10.29
24.0	10870.0	2472.85	10.35	354	10.21
25.0	11370.0	2473.81	9.81	331	11.66
26.0	11870.0	2475.35	9.85	335	12.47
27.0	12370.0	2477.14	9.74	306	13.97

Notes: (1) Relative to the upstream face of the Craycroft Road bridge.

Table 3.1b Summary of the Relative Impact of the Project on the 100-Year Floodplain

	Change in Primary Flow Characteristics taken from the HEC-2 Analysis		
Section Number	Water Surface Elevation Δ (ft)	Flood Plain Top Width Δ (ft)	Main Channel Velocity Δ (fps)
1.0	0.00	0	-1.04
2.0	0.14	0	-3.65
3.0	-1.81	-206	2.57
4.0	-0.74	-55	0.82
5.0	-0.51	-35	0.80
6.0	-0.14	-14	1.09
7.0	0.35	36	-0.88
8.0	-0.15	-27	0.35
9.0	0.03	-5	-0.03
10.0	-0.14	-9	1.16
11.0	0.10	-245	0.80
12.0	0.21	-15	-0.26
13.0	0.03	8	-0.14
14.0	-0.05	-17	0.34
15.0	0.06	4	-0.22
16.0	-0.36	-190	4.08
16.5	0.59	-114	0.81
17.0	1.80	5	-3.11
18.0	-0.25	-1	0.39
19.0	-0.01	-0	0.02
20.0	0.00	-0	0.01
21.0	0.00	0	0.00
22.0	0.01	0	0.00
23.0	0.00	0	0.00
23.1	0.00	0	0.00
23.2	0.00	0	0.00
24.0	0.01	0	0.00
25.0	0.00	0	0.00
26.0	0.00	0	0.00
27.0	-0.01	0	0.00

3.2 Scour/Stability Impact

A scour analysis consistent with the one described in Section 2.3 was again performed using the hydraulic conditions associated with the project to determine the relative impact of the project. In addition, the results were used to determine if the toe-down depth for the proposed bank protection is adequate to ensure the overall stability of the project.

The results of the single-event scour analysis are summarized in Table 3.2a. The individual scour-computation sheets, including a summary of the hydraulic properties used in the analysis, are provided in Appendix D.

Table 3.2a Summary of the With-Project Single-Event Scour Analysis

Reach	Applicable	Scour Components (ft)							Total
	Sections	General	Bed-Form	Bend	Local	Subtotal	Low-Flow	Long-Term	Depth
1	1 - 4	1.2	1.4	0.0	17.8	26.4	2.0	0.0	28.4
2	5 - 9	1.1	1.7	3.4	0.0	7.9	2.0	0.0	9.9
3	10 - 13	0.5	1.0	1.7	0.0	4.2	2.0	0.0	6.2
4	14 - 18	1.5	2.5	2.0	0.0	7.8	2.0	0.0	9.8
5	19 - 23	1.4	1.7	0.0	0.0	4.0	2.0	0.0	6.0
6	24 - 27	1.5	2.0	0.0	18.2	28.2	2.0	0.0	30.2

Note: The safety factor is included in the subtotal depth.

Based on the results of the scour analysis, the minimum recommended toe-down depth for the bank protection would be ten feet. The average toe-down depth proposed by Pima County is eight feet. Since it is recommended that the ten-foot depth be applied, the estimated cost for the bank protection should be increased accordingly. However, the additional cost associated with the additional toe-down requirement could be offset somewhat by reducing the proposed top-of-bank elevation of the bank protection along the golf course. Since overbank flooding under existing (without-project) conditions does not result in the inundation of any residential structures along the south bank, it is not necessary to contain the 100-year discharge at this location. Consequently, the preliminary top-of-bank profile provided in Reference 2 could be lowered to reduce the quantity of material required for the bank protection. However, it is unlikely that a reduction in the top-of-bank profile will completely offset the additional quantity of material that will be required to accommodate the recommended toe-down depths.

Since the project will not significantly alter the flow characteristics along the study reach, the overall sediment-transport characteristics should remain essentially unchanged. Therefore, it is not anticipated that the project will increase the degradation or aggradation tendency either within or immediately upstream or downstream of the study reach.

3.3 Additional Stability Considerations

Overall, the proposed project will have little or no adverse impact on the stability of existing bank protection or channel features either upstream or downstream of the project reach. However, additional stability questions can be raised in conjunction with the proposed project. These include the increased erosion potential to the proposed riparian preserve and the potential for the project's bank protection to be outflanked at the downstream limit by bank erosion and/or migration along the Pantano Wash.

There are plenty of examples locally of the relative impact of piece-meal bank protection on the adjacent unprotected banks. Although the proposed riparian preserve will provide an adequate erosion buffer for neighboring properties, it is safe to assume that the erosion potential for the area will be increased as a result of the project. If it is intended that the area be maintained periodically to retain its natural character, then the cost of the project should be increased to include either maintenance of the area or any recreational features associated with the area. If preservation of the area, as it currently exists, is one of Pima County's project goals, then they should consider the possibility of providing, at some point in the immediate future, low-level bank protection along the channel side of the preserve in order to prevent its ultimate demise due to erosion.

Previous geomorphic studies of the Pantano Wash, including References 1 and 8, have determined that the erosion potential between the Rillito River confluence and Tanque Verde Road is somewhat similar to the erosion potential associated with the study reach. Therefore, it is safe to assume that the downstream limit of the proposed bank protection will ultimately be damaged as a result of bank erosion along the Pantano Wash. In lieu of providing bank protection along the entire south bank, including the confluence region, Pima County should consider the possibility of terminating the proposed bank protection project at the downstream limit of the properties that are currently developed. The adopted Rillito Corridor Study plan (Reference 1) indicates that the confluence region will ultimately be set aside as a regional park. Therefore, the confluence could be added to the project's overall riparian preserve area, in which case, it too would serve as an erosion buffer for the south approach to the Craycroft Road bridge.

IV. SUMMARY OF RESULTS

Based on the results of the qualitative geomorphic analysis, the average annual erosion rate for a fifty-year period is approximately 13 feet per year. The approach used in the determination of this rate is consistent with the methodology outlined in Reference 1. During any given flow event that approximates or exceeds the 10-year event, the unprotected banks can be expected to migrate on the order of 100 to 200 feet. The limiting meander potential was determined to be either the boundary of the geologic flood plain or a distance equal to approximately 1,600 feet from the projected centerline of the meander loop. Along the project reach, the centerline of the loop corresponds to a straight line projected upstream from the centerline of the Craycroft Road bridge crossing to the centerline of the channel at the downstream limit of the existing bank protection (i.e., Section 17 on Figure 4). Consequently, the limiting meander potential for the north bank corresponds to the northern boundary of the geologic flood plain. The limiting meander potential for the south bank is an imaginary line located approximately 1,600 feet south of the projected centerline of the meander loop. Since the south bank is located approximately 500 feet from this centerline, the limiting meander potential for the south bank is approximately 1,100 feet.

The results of the hydraulic analysis—in combination with the single-event scour analysis, the long-term degradation analysis, and the qualitative geomorphic analysis—indicate that the Craycroft Road bridge, the existing bank protection downstream of Craycroft Road, and the Sabino Canyon Road bridge are stable under both existing (without-project) and with-project conditions. In addition, the results of the 100-year overflow analysis indicate that little or no flood hazards exist within the study area for both existing (without-project) and with-project conditions. The extent of flooding noted is limited to the Tucson Country Club golf course, the rear yards of some developed lots within the associated subdivision, and the undeveloped properties that flank both sides of the existing watercourse.

The results of the overall analysis do not support Pima County's concern that the south approach to the Craycroft Road bridge will be undermined and damaged from channel migration along the Tanque Verde Creek. It appears that this area possess a greater risk of inundation and damage from erosion due to flows conveyed along the Pantano Wash than from the Tanque Verde Creek.

The proposed project will effectively curtail future damages from erosion along the unprotected banks and the proposed riparian preserve will act as an effective erosion buffer for properties located along the northern limit of the geologic flood plain. However, portions of the proposed project may be subject to failure from bank erosion along the Pantano Wash. In addition, if the riparian preserve is not afforded some protection from channel migration, any recreational amenities within the area will potentially be lost due to streambank erosion.

V. REFERENCES

1. U.S. Army Corps of Engineers, "Rillito River & Associated Streams, Survey Report & Environmental Assessment, Tucson, Arizona," Los Angeles District, Revised February 13, 1987.

2. Pima County, "Rillito River & Associated Streams, Bank Stabilization and Riparian Area Preserve, Tanque Verde Creek," Department of Transportation and Flood Control District, Flood Control Engineering Division, December 1996.

3. U.S. Geological Survey, "Water Resources Data - Arizona, Water Year 1993," Water-Data Report AZ 93-1, Water Resources Division, Tucson, Arizona.

4. Federal Emergency Management Agency, "Flood Insurance Study, Pima County, Arizona, Unincorporated Areas," Community Number - 040073, September 30, 1992.

5. City of Tucson, "Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona," Department of Transportation, Engineering Division, December 1989.

6. Morris, H.M., and Wiggert, J.M., Applied Hydraulics in Engineering, 2nd Edition, 1972.

7. Federal Highway Administration, "Evaluating Scour at Bridges," HEC-18, Second Edition, April 1993.

8. Simons, Li & Associates, Inc., "Sediment Transport Analysis of Rillito River and Tributaries for the Tucson Urban Study - Final Report," April 9, 1982.

9. U.S. Army Corps of Engineers, "Design Memorandum - Rillito River, Tucson, Arizona - Bank Protection," Los Angeles District, October 1992.

10. U.S. Army Corps of Engineers, "HEC-2: Water Surface Profiles, Users Manual," September, 1990.

APPENDIX A

HEC-2 INPUT/OUTPUT LISTING, EXISTING (WITHOUT-PROJECT) CONDITIONS

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*********************************************                    ****************************************
*  HEC-2 WATER SURFACE PROFILES             *                    *  U.S. ARMY CORPS OF ENGINEERS        *
*********************************************                    ****************************************

                                    X     X  XXXXXXX   XXXXX           XXXXX
                                    X     X  X        X     X         X     X
                                    X     X  X        X                     X
                                    XXXXXXX  XXXX     X          XXXXX  XXXXX
                                    X     X  X        X                X
                                    X     X  X        X     X          X
                                    X     X  XXXXXXX   XXXXX           XXXXXXX
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 *************************************
 HEC-2 WATER SURFACE PROFILES

 Version   4.6.2;  May 1991
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T1     LIMITED RE-EVALUATION REPORT FOR THE PROPOSED RILLITO RIVER AND
T2     ASSOCIATED STREAMS, BANK STABILIZATION AND RIPARIAN AREA PRESERVE,
T3     TANQUE VERDE CREEK (CRAYCROFT RD BRIDGE TO SABINO CANYON RD BRIDGE)
T4     EXISTING CONDITIONS - APRIL 1998 - SLA JOB #: PAZ-COE32-TASK 2

J1  ICHECK    INQ      NINV     IDIR     STRT     METRIC    HVINS      Q       WSEL      FQ

      -1        2        0        0    0.0000       0          0       0     2433.2      0

J2  NPROF    IPLOT    PRFVS    XSECV    XSECH      FN      ALLDC     IBW     CHNIM     ITRACE

      1                 -1                                                              15


J3  VARIABLE CODES FOR SUMMARY PRINTOUT

     38        1       55       26       56       13       14       15        8        4
     53       54        0       38        1        2        3       11       12       42
      5       33       39       67       68

J6  IHLEQ    ICOPY    SUBDIV   STRTDS    RMILE

      1


NC     0.08     0.08    0.030      0.1      0.3
QT        1    34000
X1        1       11     1200     1490        0        0        0
GR     2432      910     2432     1060     2430     1200     2422     1230     2422     1420
GR     2424     1460     2432     1490     2434     1530     2436     1580     2440     1630
GR     2450     1700

X1        2       19     1430     1685      350      520      450
X3                                 820
GR     2430       40     2432      240     2434      525     2436      590     2438      600
GR     2434      640     2428      660     2426      690     2426      800     2434      820
GR     2434     1140     2432     1370     2430     1430     2424     1450     2424     1650
GR     2430     1685     2432     1720     2434     1730     2440     1750
1
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X1        3       27     1360     1790      420      500      500
X3                                 670
GR     2432      160     2434      340     2436      430     2440      450     2438      460
GR     2436      490     2430      500     2428      530     2428      660     2430      665
GR     2436      670     2436      830     2434      950     2434     1240     2433     1280
GR     2433     1320     2432     1360     2430     1390     2428     1405     2427     1470
GR   2426.5     1520     2428     1610     2427     1700     2427     1740     2428     1765
GR     2432     1790     2440     1815

X1        4       24     1330     1750      500      570      500
X3                                 640
GR     2434      320     2440      360     2440      380     2438      400     2430      420
GR     2428      430     2428      540     2434      560     2436      570     2438      640
GR     2436      780     2434      900     2434     1330     2430     1340     2428     1430
GR     2429     1545   2429.5     1570     2429     1620     2429     1660     2430     1740
GR     2434     1750     2434     1930     2440     1950     2450     1980

X1        5       22     1290     1710      500      450      450
X3                                 585
GR     2441      420     2441      550     2440      600     2436      720     2435      750
GR     2435     1100     2436     1250     2436     1290     2430     1310   2429.5     1330
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GR	2429.5	1450	2430	1485	2432	1650	2434	1710	2436	1750
GR	2436	1770	2436	1810	2436	1840	2436	1930	2436	2050
GR	2440	2210	2442	2260						
X1	6	16	900	1340	550	500	500			
GR	2444	200	2444	420	2442	570	2440	610	2438	680
GR	2434	900	2434	905	2432	930	2432	1060	2434	1180
GR	2436	1330	2438	1340	2438	1630	2440	1760	2442	1910
GR	2450	2020								
X1	7	20	740	1170	500	500	500			
GR	2446	210	2446	330	2444	420	2443.5	500	2443	560
GR	2442	660	2442	661	2440.5	740	2435	750	2434	850
GR	2434	890	2436	900	2437.2	950	2437.2	1040	2438	1090
GR	2438	1160	2440	1170	2440	1560	2440	1685	2450	1715
X1	8	19	790	1140	530	450	500			
GR	2450	380	2448	420	2446	560	2444	730	2443	740
GR	2443	790	2437	800	2436	880	2436	930	2436.5	970
GR	2436.5	1030	2438	1060	2440	1070	2442	1140	2442.2	1270
GR	2444	1450	2446	1620	2448	1770	2450	1780		
NC	.06	.08	.030	.1	.3					
X1	9	21	730	1180	500	500	500			
GR	2454	30	2452	380	2450	580	2448	700	2446	730
GR	2440	740	2440	930	2438	980	2438	1030	2438.5	1130
GR	2440	1170	2442	1175	2444	1180	2443.5	1270	2443.5	1430
GR	2443.5	1440	2444	1510	2446	1630	2448	1660	2450	1700
GR	2460	1750								

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X1	10	15	540	1310	500	500	500			
GR	2454	110	2452	380	2450	440	2448	540	2442	690
GR	2443	810	2443	940	2442	985	2440	1000	2440	1280
GR	2444	1310	2446	1460	2448	1540	2450	1570	2452	1600
X1	11	25	560	1420	500	500	500			
GR	2456	20	2454	200	2452	390	2450	410	2448	560
GR	2444	610	2444	650	2444	665	2444	675	2444	695
GR	2444	720	2444	870	2445	900	2445	930	2444	970
GR	2442	990	2441.3	1010	2442	1210	2441.5	1310	2441.5	1340
GR	2442	1400	2448	1420	2448	1510	2450	1630	2456	1660
X1	12	27	720	1430	500	500	500			
X3	10			720						
GR	2458	30	2456	180	2454	260	2452	290	2452	540
GR	2450	650	2450	720	2447	725	2447	900	2446	930
GR	2444	940	2444	1080	2444.5	1120	2444.5	1180	2444	1240
GR	2443.5	1300	2443.5	1350	2444	1390	2446	1410	2450	1430
GR	2450	1500	2450	1530	2450	1565	2450	1570	2452	1600
GR	2454	1710	2458	1730						
X1	13	21	800	1380	500	500	500			
X3	10			795						
GR	2458	0	2456	170	2454	285	2452	390	2450	430
GR	2450	620	2450	650	2452	680	2452	760	2456	790
GR	2456	800	2450	830	2448	920	2446	1010	2444	1100
GR	2444	1230	2446	1350	2450	1380	2452	1560	2454	1690
GR	2458	1850								
X1	14	20	690	1175	420	520	470			
X3	10			690						
GR	2460	120	2452	190	2452	540	2454	660	2460	690
GR	2450	730	2448	740	2447	830	2447	910	2448	950
GR	2448	1010	2446.5	1060	2446.5	1130	2448	1160	2454	1175
GR	2456	1200	2456	1340	2456	1460	2456	1480	2460	1800
X1	15	23	790	1160	500	500	500			
X3	10			590						
GR	2460	90	2454	130	2454	300	2456	310	2456	490
GR	2460	520	2460	560	2458	640	2456	760	2456	790
GR	2450	800	2448	860	2448	890	2449.5	950	2449.5	990
GR	2448	1050	2448	1080	2450	1150	2454	1160	2454	1290
GR	2456	1350	2458	1352	2460	1490				
X1	16	28	810	1205	550	480	520			
X3	10			700						
GR	2464	215	2460	260	2458	410	2456	430	2454	550
GR	2454	570	2454	590	2456	640	2460	660	2462	670
GR	2462	705	2460	710	2458	715	2458	810	2452	820
GR	2451	870	2451	930	2450	970	2450	1000	2451	1050
GR	2450.6	1100	2450.6	1120	2452	1200	2456	1205	2456	1290
GR	2460	1300	2462	1420	2464	1920				

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 X1     16.5          8         830        1190         300         300         300           0           0           0
 GR   2460.0      760.0      2458.0       770.0      2458.0       830.0      2452.5       850.0      2452.0       945.0
 GR   2453.0     1090.0      2454.0      1180.0      2464.0      1190.0

 X1       17         15         840        1190         200         200         200
 X3       10                                830
 GR     2464        180        2462         260        2462         690        2460         720        2460         760
 GR     2464        800        2466         820        2466         840        2464         855        2454         860
 GR   2452.8        920      2453.1        1050        2454        1110        2456        1170        2466        1190

   VENTANA CANYON WASH TRIBUTARY

 X1       18         15         850        1185         500         500         500
 X3       10                                845
 GR     2466          0        2466         500        2466         680        2464         730        2464         830
 GR     2468        840        2468         850        2462         860        2460         870        2456         875
 GR   2454.9        970      2454.9        1030        2456        1100        2458        1170        2470        1185

 X1       19         10         810        1180         500         500         500
 GR     2474        790        2472         810        2458         850        2457         860        2457        1080
 GR     2458       1100        2458        1150        2472        1180        2472        1370        2474        1460

 X1       20         22         820        1160         500         500         500
 X3       10                                810
 GR     2474        390        2472         510        2470         525        2468         540        2468         560
 GR     2470        580        2470         720        2472         720        2472         820        2460         840
 GR     2459        850        2459        1145        2460        1150        2470        1160        2472        1185
 GR     2470       1190        2472        1200        2472        1290        2470        1300        2474        1340
 GR     2476       1520        2478        1690

 X1       21         17         830        1170         500         500         500
 X3       10                                820
 GR     2474        490        2472         500        2472         760        2470         790        2470         800
 GR     2472        810        2472         830        2470         840        2460         860        2460        1000
 GR   2460.5       1010      2460.5        1140        2472        1170        2472        1185        2470        1200
 GR     2470       1230        2476        1280

 X1       22         13         830        1180         500         500         500
 X3       10                                825
 GR     2476        650        2474         700        2474         800        2476         820        2476         830
 GR     2462        850        2461         870        2461        1150        2476        1170        2476        1180
 GR     2474       1200        2474        1250        2476        1310

 X1       23          6         825        1160         220         220         220
 GR     2480        790        2470         825        2462         840        2462        1150        2470        1160
 GR     2478       1190

  SABINO CANYON RD BRIDGE
1
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 X1     23.1                                            20          20          20
 X3       10

 SB     1.25        1.6         2.6         400         315          24        5693           1      2462.5        2462
 X1     23.2          8         800        1160         120         120         120
 X2                               1      2480.9     2486.97
 X3       10
 GR     2480        760        2478         800        2463         830      2462.5         850      2462.5        1050
 GR     2464       1140        2472        1160        2480        1200

 X1       24                                            20          20          20

 X1       25          7         830        1170         500         500         500
 GR     2476        830        2466         840      2464.7         860      2464.9         940        2464        1110
 GR     2466       1150        2478        1170

 X1       26         11         820        1170         500         500         500
 GR     2482        800        2480         820        2468         840      2466.5        1025        2466        1060
 GR   2465.5       1080        2466        1115        2468        1150        2480        1170        2480        1190
 GR     2484       1200

 X1       27          9         840        1175         500         500         500
 GR     2482        790        2480         820        2480         840        2468         920      2467.4         960
 GR   2467.4       1030        2468        1080        2470        1150        2482        1175
1
   14APR98      08:37:06                                                                                      PAGE     6

    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


 *PROF 1
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 IHLEQ = 1.  THEREFORE FRICTION LOSS (HL) IS CALCULATED AS A FUNCTION OF
 PROFILE TYPE, WHICH CAN VARY FROM REACH TO REACH.  SEE DOCUMENTATION FOR
 DETAILS.
0

 CCHV=     .100 CEHV=     .300
 *SECNO 1.000
 3280 CROSS SECTION      1.00 EXTENDED      1.20 FEET

     1.000     11.20   2433.20       .00   2433.20   2435.20      2.00       .00       .00   2430.00
   34000.0     671.4   33319.1       9.5     488.0    2908.0      14.4        .0        .0   2432.00
       .00      1.38     11.46       .66      .080      .030      .080      .000   2422.00    910.00
   .002499        0.        0.        0.         0         0         0       .00    604.00   1514.00


 FLOW DISTRIBUTION FOR SECNO=      1.00          CWSEL=   2433.20

 STA=      910.    1060.    1200.    1490.    1514.
   PER Q=       .6       1.4     98.0       .0
    AREA=   180.0    308.0   2908.0     14.4
     VEL=     1.0      1.6     11.5       .7
   DEPTH=     1.2      2.2     10.0       .6

 *SECNO 2.000

 3301 HV CHANGED MORE THAN HVINS


 3470 ENCROACHMENT STATIONS=       820.0    1750.0  TYPE=      1  TARGET=      -820.000
     2.000     10.04   2434.04   2433.09       .00   2436.90      2.87      1.44       .26   2430.00
   34000.0     729.8   32998.8     271.4     431.0    2393.8     116.6      31.9       6.8   2430.00
       .01      1.69     13.79      2.33      .080      .030      .080      .000   2424.00    820.00
   .003939      350.      450.      520.         4        11         0       .00    910.11   1730.11


 FLOW DISTRIBUTION FOR SECNO=      2.00          CWSEL=   2434.04

 STA=      820.    1370.    1430.    1685.    1720.    1730.
   PER Q=       .8       1.3     97.1       .8       .0
    AREA=   248.9    182.1   2393.8    106.2     10.3
     VEL=     1.1      2.4     13.8      2.4      1.2
   DEPTH=      .5      3.0      9.4      3.0      1.0

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     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 *SECNO 3.000

 3301 HV CHANGED MORE THAN HVINS


 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.79


 3470 ENCROACHMENT STATIONS=       670.0    1815.0  TYPE=      1  TARGET=      -670.000
     3.000     10.67   2437.17       .00       .00   2438.03       .86       .93       .20   2432.00
   34000.0    2564.8   31385.5      49.7    1867.1    4048.0      41.8      80.8      17.4   2432.00
       .03      1.37      7.75      1.19      .080      .030      .080      .000   2426.50    670.00
   .001235      420.      500.      500.         3         0         0       .00   1136.15   1806.15


 FLOW DISTRIBUTION FOR SECNO=      3.00          CWSEL=   2437.17

 STA=      670.     830.     950.    1240.    1280.    1320.    1360.    1790.    1806.
   PER Q=       .4       .8      3.8       .7       .8      1.0     92.3       .1
    AREA=   187.1    260.4    919.2    146.8    166.8    186.8   4048.0     41.8
     VEL=      .7      1.1      1.4      1.6      1.7      1.8      7.8      1.2
   DEPTH=     1.2      2.2      3.2      3.7      4.2      4.7      9.4      2.6

 *SECNO 4.000

 3470 ENCROACHMENT STATIONS=       640.0    1980.0  TYPE=      1  TARGET=      -640.000
     4.000      9.85   2437.85       .00       .00   2438.71       .86       .68       .00   2434.00
   34000.0    3470.3   29289.8    1239.8    2121.0    3658.0     718.8     152.9      31.5   2434.00
       .05      1.64      8.01      1.72      .080      .030      .080      .000   2428.00    650.12
   .001465      500.      500.      570.         2         0         0       .00   1292.73   1942.85


 FLOW DISTRIBUTION FOR SECNO=      4.00          CWSEL=   2437.85

 STA=      650.     780.     900.    1330.    1750.    1930.    1943.
   PER Q=       .2      1.4      8.5     86.1      3.6       .1
    AREA=   120.5    342.7   1657.9   3658.0    694.0     24.8
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      VEL=        .7        1.4       1.7       8.0       1.7       1.1
    DEPTH=        .9        2.9       3.9       8.7       3.9       1.9

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     14APR98       08:37:06                                                                             PAGE     8

      SECNO       DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
      Q           QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
      TIME        VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
      SLOPE       XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 *SECNO 5.000

 3470 ENCROACHMENT STATIONS=       585.0     2260.0  TYPE=       1  TARGET=      -585.000
      5.000       9.04    2438.54        .00        .00    2439.57       1.03        .81        .05    2436.00
    34000.0     3659.9    28735.8     1604.3     1982.4     3254.1     1031.1      221.2       46.7    2434.00
        .06       1.85       8.83       1.56       .080       .030       .080       .000    2429.50     643.90
    .002079       500.       450.       450.          2          0          0        .00    1507.56    2151.46


 FLOW DISTRIBUTION FOR SECNO=        5.00            CWSEL=    2438.54

 STA=       644.     1100.     1290.     1710.     2050.     2151.
   PER Q=       7.9       2.8      84.5       4.3        .4
    AREA=    1425.4     557.0    3254.1     902.5     128.7
     VEL=       1.9       1.7       8.8       1.6       1.0
   DEPTH=       3.1       2.9       7.7       2.7       1.3

 *SECNO 6.000

 3301 HV CHANGED MORE THAN HVINS


 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =    .68

      6.000       7.68    2439.68    2439.18        .00    2441.45       1.77       1.66        .22    2434.00
    34000.0     2464.9    30572.5      962.6      859.3     2724.7      579.4      282.7       62.3    2438.00
        .08       2.87      11.22       1.66       .080       .030       .080       .000    2432.00     621.16
    .004516       550.       500.       500.          4         15          0        .00    1118.12    1739.27


 FLOW DISTRIBUTION FOR SECNO=        6.00            CWSEL=    2439.68

 STA=       621.      680.      900.     1340.     1630.     1739.
   PER Q=        .2       7.1      89.9       2.5        .3
    AREA=      49.5     809.9    2724.7     487.5      91.9
     VEL=       1.1       3.0      11.2       1.8       1.1
   DEPTH=        .8       3.7       6.2       1.7        .8

 *SECNO 7.000
 7185 MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
1
     14APR98       08:37:06                                                                             PAGE     9

      SECNO       DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
      Q           QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
      TIME        VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
      SLOPE       XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


      7.000       8.22    2442.22    2442.22        .00    2444.41       2.19       3.00       -.27    2440.50
    34000.0      108.2    31088.6     2803.2       78.9     2507.5     1148.8      328.0       74.8    2440.00
        .09       1.37      12.40       2.44       .080       .030       .080       .000    2434.00     638.37
    .006002       500.       500.       500.          2          8          0        .00    1053.28    1691.65


 FLOW DISTRIBUTION FOR SECNO=        7.00            CWSEL=    2442.22

 STA=       638.      740.     1170.     1560.     1685.     1692.
   PER Q=        .3      91.4       6.2       2.0        .0
    AREA=      78.9    2507.5     864.4     277.0       7.4
     VEL=       1.4      12.4       2.4       2.4       1.5
   DEPTH=        .8       5.8       2.2       2.2       1.1

 *SECNO 8.000
      8.000       8.71    2444.71    2444.45        .00    2447.19       2.47       2.69        .08    2443.00
    34000.0      192.3    32430.2     1377.5      119.4     2512.2      651.8      367.3       85.2    2442.00
        .10       1.61      12.91       2.11       .080       .030       .080       .000    2436.00     669.36
    .004941       530.       500.       450.          6          8          0        .00     841.27    1510.64


 FLOW DISTRIBUTION FOR SECNO=        8.00            CWSEL=    2444.71

 STA=       669.      730.      740.      790.     1140.     1270.     1450.     1511.
   PER Q=        .0        .1        .5      95.4       2.5       1.5        .0
    AREA=      21.6      12.1      85.7    2512.2     339.7     290.4      21.6
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   VEL=        .7       1.5       1.9      12.9       2.5       1.8        .7
 DEPTH=        .4       1.2       1.7       7.2       2.6       1.6        .4

CCHV=     .100 CEHV=      .300
*SECNO 9.000

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   1.71

     9.000      9.61   2447.61       .00       .00   2448.59       .98      1.26       .15   2446.00
   34000.0      17.1   30986.4    2996.5      19.5    3730.1    1649.6     417.2      95.5   2444.00
       .12       .88      8.31      1.82      .060      .030      .080      .000   2438.00    705.83
   .001689      500.      500.      500.         2         0         0       .00    948.34   1654.17
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     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST

FLOW DISTRIBUTION FOR SECNO=       9.00          CWSEL=   2447.61

STA=      706.      730.     1180.     1270.     1430.     1440.     1510.     1630.     1654.
  PER Q=        .1      91.1       1.9       3.8        .2       1.5       1.3        .0
   AREA=      19.5    3730.1     347.5     657.8      41.1     270.3     313.4      19.5
    VEL=        .9       8.3       1.9       2.0       2.0       1.9       1.4        .7
  DEPTH=        .8       8.3       3.9       4.1       4.1       3.9       2.6        .8

*SECNO 10.000
    10.000      8.76   2448.76       .00       .00   2449.38       .62       .75       .04   2448.00
   34000.0       6.9   32921.0    1072.1      14.4    5116.4     708.7     481.7     107.0   2444.00
       .14       .48      6.43      1.51      .060      .030      .080      .000   2440.00    502.08
   .001352      500.      500.      500.         2         0         0       .00   1049.29   1551.37

FLOW DISTRIBUTION FOR SECNO=      10.00          CWSEL=   2448.76

STA=      502.      540.     1310.     1460.     1540.     1551.
  PER Q=        .0      96.8       2.7        .4        .0
   AREA=      14.4    5116.4     563.7     140.7       4.3
    VEL=        .5       6.4       1.7       1.0        .4
  DEPTH=        .4       6.6       3.8       1.8        .4

*SECNO 11.000
    11.000      8.16   2449.46       .00       .00   2450.05       .59       .67       .00   2448.00
   34000.0      58.4   33792.6     149.1      80.2    5484.9     195.8     548.3     119.6   2448.00
       .16       .73      6.16       .76      .060      .030      .080      .000   2441.30    450.30
   .001310      500.      500.      500.         2         0         0       .00   1147.46   1597.76

FLOW DISTRIBUTION FOR SECNO=      11.00          CWSEL=   2449.46

STA=      450.      560.     1420.     1510.     1598.
  PER Q=        .2      99.4        .3        .1
   AREA=      80.2    5484.9     131.6      64.2
    VEL=        .7       6.2        .9        .5
  DEPTH=        .7       6.4       1.5        .7

*SECNO 12.000
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     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =    .58


3470 ENCROACHMENT STATIONS=       720.0     1730.0  TYPE=       1  TARGET=      -720.000
    12.000      6.74   2450.24       .00       .00   2451.56      1.31      1.29       .22   2450.00
   34000.0        .0   33984.9      15.1        .0    3693.1      34.1     602.7     131.1   2450.00
       .18       .00      9.20       .44      .000      .030      .080      .000   2443.50    720.00
   .003842      500.      500.      500.         2         0         0       .00    853.60   1573.60
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 FLOW DISTRIBUTION FOR SECNO=      12.00          CWSEL=    2450.24

 STA=      720.    1430.    1500.    1565.    1574.
   PER Q=    100.0       .0       .0       .0
    AREA=   3693.1     16.8     15.6      1.6
     VEL=      9.2       .4       .4       .4
   DEPTH=      5.2       .2       .2       .2

 *SECNO 13.000

 3470 ENCROACHMENT STATIONS=      795.0    1850.0  TYPE=       1  TARGET=     -795.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      2456.00 ELREA=      2450.00

     13.000       7.98   2451.98       .00       .00   2453.55      1.57      1.92       .08   2456.00
    34000.0         .0   33799.3     200.7        .0    3346.9     175.8     644.3     140.2   2450.00
        .19        .00     10.10      1.14      .000      .030      .080      .000   2444.00    820.12
    .003836       500.      500.      500.         2         0         0       .00    737.77   1557.89


 FLOW DISTRIBUTION FOR SECNO=      13.00          CWSEL=    2451.98

 STA=      820.    1380.    1558.
   PER Q=     99.4       .6
    AREA=   3346.9    175.8
     VEL=     10.1      1.1
   DEPTH=      6.0      1.0

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     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 *SECNO 14.000

 3301 HV CHANGED MORE THAN HVINS


 3470 ENCROACHMENT STATIONS=      690.0    1800.0  TYPE=       1  TARGET=     -690.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      2460.00 ELREA=      2454.00

     14.000       7.15   2453.65       .00       .00   2455.95      2.29      2.18       .22   2460.00
    34000.0         .0   34000.0        .0        .0    2797.3        .0     678.5     146.7   2454.00
        .20        .00     12.15       .00      .000      .030      .000      .000   2446.50    715.39
    .005433       420.      470.      520.         2         0         0       .00    458.74   1174.13


 FLOW DISTRIBUTION FOR SECNO=      14.00          CWSEL=    2453.65

 STA=      715.    1175.
   PER Q=    100.0
    AREA=   2797.3
     VEL=     12.2
   DEPTH=      6.1

 *SECNO 15.000

 3470 ENCROACHMENT STATIONS=      590.0    1490.0  TYPE=       1  TARGET=     -590.000
     15.000       8.10   2456.10   2455.50       .00   2458.55      2.45      2.56       .05   2456.00
    34000.0        1.3   33326.0     672.7       3.5    2629.2     340.1     711.6     152.8   2454.00
        .21        .37     12.68      1.98      .060      .030      .080      .000   2448.00    753.64
    .004836       500.      500.      500.         4         8         0       .00    596.46   1350.11


 FLOW DISTRIBUTION FOR SECNO=      15.00          CWSEL=    2456.10

 STA=      754.     790.    1160.    1290.    1350.
   PER Q=       .0     98.0      1.7       .3
    AREA=      3.5   2629.2    273.8     66.4
     VEL=       .4     12.7      2.1      1.4
   DEPTH=       .1      7.1      2.1      1.1

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     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 *SECNO 16.000
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 3301 HV CHANGED MORE THAN HVINS


 3470 ENCROACHMENT STATIONS=        700.0    1920.0  TYPE=       1  TARGET=      -700.000
      16.000       8.80   2458.80       .00       .00   2460.61      1.81      1.99       .06   2458.00
     34000.0       91.1   33403.2     505.6      76.4    3068.4     247.4     749.4     159.8   2456.00
         .23       1.19     10.89      2.04      .060      .030      .080      .000   2450.00    713.01
     .003172       550.      520.      480.         2         0         0       .00    583.98   1296.99


 FLOW DISTRIBUTION FOR SECNO=      16.00          CWSEL=    2458.80

 STA=      713.      810.     1205.     1290.     1297.
   PER Q=        .3      98.2       1.5        .0
    AREA=      76.4    3068.4     237.7       9.8
     VEL=       1.2      10.9       2.1       1.2
   DEPTH=        .8       7.8       2.8       1.4

 *SECNO 16.500

 3301 HV CHANGED MORE THAN HVINS

 7185 MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
      16.500       7.56   2459.56   2459.56       .00   2462.70      3.14      2.01      -.13   2458.00
     34000.0      265.1   33734.9        .0      99.5    2364.4        .0     769.5     163.2   2464.00
         .23       2.66     14.27       .00      .060      .030      .000      .000   2452.00    762.21
     .006710       300.      300.      300.         2        11         0       .00    423.35   1185.56


 FLOW DISTRIBUTION FOR SECNO=      16.50          CWSEL=    2459.56

 STA=      762.      770.      830.     1190.
   PER Q=        .0        .7      99.2
    AREA=       6.1      93.5    2364.4
     VEL=       1.7       2.7      14.3
   DEPTH=        .8       1.6       6.6

1
    14APR98      08:37:06                                                                        PAGE    14


      SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
      Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
      TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
      SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 *SECNO 17.000
 7185 MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED

 3470 ENCROACHMENT STATIONS=        830.0    1190.0  TYPE=       1  TARGET=      -830.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=     2466.00 ELREA=    100000.00

      17.000       7.91   2460.71   2460.71       .00   2464.25      3.54      1.42       .08   2466.00
     34000.0         .0   34000.0        .0        .0    2252.5        .0     780.4     164.9 100000.00
         .24        .00     15.09       .00      .000      .030      .000      .000   2452.80    856.65
     .007115       200.      200.      200.         2         8         0       .00    322.77   1179.42


 FLOW DISTRIBUTION FOR SECNO=      17.00          CWSEL=    2460.71

 STA=      857.     1190.
   PER Q=     100.0
    AREA=    2252.5
     VEL=      15.1
   DEPTH=       7.0

 *SECNO 18.000

 3301 HV CHANGED MORE THAN HVINS


 3470 ENCROACHMENT STATIONS=        845.0    1185.0  TYPE=       1  TARGET=      -845.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=     2468.00 ELREA=    100000.00

      18.000       9.50   2464.40       .00       .00   2466.93      2.54      2.59       .10   2468.00
     34000.0         .0   34000.0        .0        .0    2659.9        .0     808.6     168.6 100000.00
         .25        .00     12.78       .00      .000      .030      .000      .000   2454.90    856.01
     .004063       500.      500.      500.         2         0         0       .00    321.99   1177.99


 FLOW DISTRIBUTION FOR SECNO=      18.00          CWSEL=    2464.40

 STA=      856.     1185.
   PER Q=     100.0
    AREA=    2659.9
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      VEL=     12.8
    DEPTH=      8.3
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1
     14APR98       08:37:06                                                                                                    PAGE   15

       SECNO       DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
       Q           QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
       TIME        VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
       SLOPE       XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST

  *SECNO 19.000

  3301 HV CHANGED MORE THAN HVINS

       19.000       9.72    2466.72        .00        .00    2468.66       1.94       1.66        .06    2472.00
      34000.0         .0    34000.0         .0         .0     3041.3         .0      841.3      172.5    2472.00
          .26        .00      11.18        .00       .000       .030       .000       .000    2457.00     825.08
      .002820       500.       500.       500.          2          0          0        .00     343.60    1168.69

  FLOW DISTRIBUTION FOR SECNO=      19.00          CWSEL=    2466.72

  STA=      825.     1180.
    PER Q=     100.0
     AREA=    3041.3
      VEL=      11.2
    DEPTH=       8.9

  *SECNO 20.000

  3470 ENCROACHMENT STATIONS=       810.0     1690.0   TYPE=        1   TARGET=      -810.000

  3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=       2472.00 ELREA=       2470.00

       20.000       9.08    2468.08        .00        .00    2470.22       2.14       1.51        .06    2472.00
      34000.0         .0    34000.0         .0         .0     2893.9         .0      875.3      176.3    2470.00
          .27        .00      11.75        .00       .000       .030       .000       .000    2459.00     826.54
      .003202       500.       500.       500.          2          0          0        .00     331.54    1158.08

  FLOW DISTRIBUTION FOR SECNO=      20.00          CWSEL=    2468.08

  STA=      827.     1160.
    PER Q=     100.0
     AREA=    2893.9
      VEL=      11.7
    DEPTH=       8.7

  *SECNO 21.000

  3470 ENCROACHMENT STATIONS=       820.0     1280.0   TYPE=        1   TARGET=      -820.000
1
     14APR98       08:37:06                                                                                                    PAGE   16

       SECNO       DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
       Q           QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
       TIME        VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
       SLOPE       XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST

  3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=       2472.00 ELREA=       2472.00

       21.000       9.64    2469.64        .00        .00    2471.88       2.24       1.62        .03    2472.00
      34000.0         .0    34000.0         .0         .0     2833.6         .0      908.2      180.1    2472.00
          .28        .00      12.00        .00       .000       .030       .000       .000    2460.00     840.72
      .003298       500.       500.       500.          2          0          0        .00     323.12    1163.84

  FLOW DISTRIBUTION FOR SECNO=      21.00          CWSEL=    2469.64

  STA=      841.     1170.
    PER Q=     100.0
     AREA=    2833.6
      VEL=      12.0
    DEPTH=       8.8

  *SECNO 22.000

  3301 HV CHANGED MORE THAN HVINS

  3470 ENCROACHMENT STATIONS=       825.0     1310.0   TYPE=        1   TARGET=      -825.000

  3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=       2476.00 ELREA=       2476.00
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      22.000      10.54   2471.54       .00       .00   2473.20      1.65      1.27       .06   2476.00
     34000.0         .0   34000.0        .0        .0    3293.4        .0     943.4     183.8   2476.00
         .30        .00     10.32       .00      .000      .030      .000      .000   2461.00    836.36
     .002056       500.      500.      500.         2         0         0       .00    327.70   1164.06

 FLOW DISTRIBUTION FOR SECNO=      22.00          CWSEL=    2471.54

 STA=      836.    1180.
   PER Q=    100.0
    AREA=   3293.4
     VEL=     10.3
   DEPTH=     10.1

1
    14APR98      08:37:06                                                                                     PAGE   17

      SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
      Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
      TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
      SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 *SECNO 23.000
      23.000       9.98   2471.98       .00       .00   2473.68      1.71       .47       .02   2470.00
     34000.0        7.7   33986.1       6.2       6.8    3242.5       7.3     959.9     185.5   2470.00
         .30       1.13     10.48       .85      .060      .030      .080      .000   2462.00    818.08
     .002212       220.      220.      220.         2         0         0       .00    349.34   1167.42

 FLOW DISTRIBUTION FOR SECNO=      23.00          CWSEL=    2471.98

 STA=      818.      825.    1160.    1167.
   PER Q=       .0     100.0       .0
    AREA=      6.8    3242.5      7.3
     VEL=      1.1      10.5       .8
   DEPTH=      1.0       9.7      1.0

 *SECNO 23.100
      23.100      10.05   2472.05       .00       .00   2473.73      1.68       .04       .00   2470.00
     34000.0        8.4   33984.8       6.8       7.4    3267.5       7.9     961.4     185.7   2470.00
         .30       1.14     10.40       .86      .060      .030      .080      .000   2462.00    817.82
     .002156        20.       20.       20.         2         0         0       .00    349.88   1167.70

 FLOW DISTRIBUTION FOR SECNO=      23.10          CWSEL=    2472.05

 STA=      818.      825.    1160.    1168.
   PER Q=       .0     100.0       .0
    AREA=      7.4    3267.5      7.9
     VEL=      1.1      10.4       .9
   DEPTH=      1.0       9.8      1.0

 SPECIAL BRIDGE

 SB  XK        XKOR       COFQ       RDLEN      BWC        BWP        BAREA      SS         ELCHU      ELCHD
       1.25       1.60       2.60     400.00     315.00      24.00    5693.00       1.00   2462.50   2462.00

 *SECNO 23.200
 CLASS A LOW FLOW

 3420 BRIDGE W.S.=     2471.79 BRIDGE VELOCITY=      11.86     CALCULATED CHANNEL AREA=       2788.
1
    14APR98      08:37:06                                                                                     PAGE   18

      SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
      Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
      TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
      SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


  EGPRS      EGLWC        H3       QWEIR       QLOW       BAREA    TRAPEZOID      ELLC       ELTRD       WEIRLN
                                                                     AREA
        .00    2474.42       .72         0.     34000.      5693.      5693.    2480.90    2486.97          0.


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      2478.00 ELREA=      2472.00

      23.200      10.28   2472.78       .00       .00   2474.42      1.64       .69       .00   2478.00
     34000.0         .0   33999.3        .7        .0    3303.9       1.5     970.5     186.7   2472.00
         .31        .00     10.29       .46      .000      .030      .080      .000   2462.50    810.45
     .002191       120.      120.      120.         0         0         0       .00    353.43   1163.88

 FLOW DISTRIBUTION FOR SECNO=      23.20          CWSEL=    2472.78
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```
 STA=     810.    1160.     1164.
   PER Q=    100.0        .0
    AREA=   3303.9       1.5
     VEL=     10.3        .5
   DEPTH=      9.5        .4

 *SECNO 24.000
    24.000      10.34   2472.84       .00       .00   2474.47      1.62       .04       .00   2478.00
   34000.0        .0    33999.1        .9        .0    3328.1       1.8     972.0     186.8   2472.00
       .31       .00     10.22        .48      .000      .030      .080      .000   2462.50    810.31
   .002140       20.       20.        20.         2         0         0       .00    353.91   1164.22


 FLOW DISTRIBUTION FOR SECNO=      24.00          CWSEL=    2472.84

 STA=     810.    1160.     1164.
   PER Q=    100.0        .0
    AREA=   3328.1       1.8
     VEL=     10.2        .5
   DEPTH=      9.5        .4

 *SECNO 25.000
    25.000       9.81   2473.81       .00       .00   2475.92      2.11      1.31       .15   2476.00
   34000.0        .0    34000.0        .0        .0    2916.3        .0    1007.9     190.8   2478.00
       .32       .00     11.66       .00      .000      .030      .000      .000   2464.00    832.19
   .003110      500.      500.       500.         2         0         0       .00    330.84   1163.02
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    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST

 FLOW DISTRIBUTION FOR SECNO=      25.00          CWSEL=    2473.81

 STA=     832.    1170.
   PER Q=    100.0
    AREA=   2916.3
     VEL=     11.7
   DEPTH=      8.8

 *SECNO 26.000
    26.000       9.85   2475.35       .00       .00   2477.76      2.41      1.75       .09   2480.00
   34000.0        .0    34000.0        .0        .0    2726.9        .0    1040.3     194.6   2480.00
       .33       .00     12.47       .00      .000      .030      .000      .000   2465.50    827.75
   .003925      500.      500.       500.         2         0         0       .00    334.50   1162.25


 FLOW DISTRIBUTION FOR SECNO=      26.00          CWSEL=    2475.35

 STA=     828.    1170.
   PER Q=    100.0
    AREA=   2726.9
     VEL=     12.5
   DEPTH=      8.2

 *SECNO 27.000

 3301 HV CHANGED MORE THAN HVINS

    27.000       9.75   2477.15       .00       .00   2480.17      3.03      2.23       .18   2480.00
   34000.0        .0    34000.0        .0        .0    2434.4        .0    1069.9     198.3   2482.00
       .34       .00     13.97       .00      .000      .030      .000      .000   2467.40    859.03
   .005053      500.      500.       500.         2         0         0       .00    305.85   1164.89

 FLOW DISTRIBUTION FOR SECNO=      27.00          CWSEL=    2477.15

 STA=     859.    1175.
   PER Q=    100.0
    AREA=   2434.4
     VEL=     14.0
   DEPTH=      8.0
```



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                                                                  THIS RUN EXECUTED 14APR98    08:37:06
 ************************************
 HEC-2 WATER SURFACE PROFILES

 Version   4.6.2;  May 1991
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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

TANQUE VERDE CREEK (CRAY

SUMMARY PRINTOUT

	SECNO	CWSEL	VLOB	VCH	VROB	QLOB	QCH	QROB	DEPTH	TOPWID	SSTA	ENDST
	1.000	2433.20	1.38	11.46	.66	671.41	33319.09	9.50	11.20	604.00	910.00	1514.00
	2.000	2434.04	1.69	13.79	2.33	729.77	32998.81	271.41	10.04	910.11	820.00	1730.11
*	3.000	2437.17	1.37	7.75	1.19	2564.76	31385.55	49.69	10.67	1136.15	670.00	1806.15
	4.000	2437.85	1.64	8.01	1.72	3470.34	29289.83	1239.83	9.85	1292.73	650.12	1942.85
	5.000	2438.54	1.85	8.83	1.56	3659.85	28735.80	1604.34	9.04	1507.56	643.90	2151.46
*	6.000	2439.68	2.87	11.22	1.66	2464.92	30572.52	962.56	7.68	1118.12	621.16	1739.27
*	7.000	2442.22	1.37	12.40	2.44	108.24	31088.60	2803.17	8.22	1053.28	638.37	1691.65
	8.000	2444.71	1.61	12.91	2.11	192.33	32430.18	1377.48	8.71	841.27	669.36	1510.64
*	9.000	2447.61	.88	8.31	1.82	17.13	30986.40	2996.47	9.61	948.34	705.83	1654.17
	10.000	2448.76	.48	6.43	1.51	6.86	32920.99	1072.15	8.76	1049.29	502.08	1551.37
	11.000	2449.46	.73	6.16	.76	58.38	33792.55	149.07	8.16	1147.46	450.30	1597.76
*	12.000	2450.24	.00	9.20	.44	.00	33984.91	15.09	6.74	853.60	720.00	1573.60
	13.000	2451.98	.00	10.10	1.14	.00	33799.34	200.66	7.98	737.77	820.12	1557.89
	14.000	2453.65	.00	12.15	.00	.00	34000.00	.00	7.15	458.74	715.39	1174.13
	15.000	2456.10	.37	12.68	1.98	1.31	33325.99	672.70	8.10	596.46	753.64	1350.11
	16.000	2458.80	1.19	10.89	2.04	91.15	33403.23	505.62	8.80	583.98	713.01	1296.99
*	16.500	2459.56	2.66	14.27	.00	265.12	33734.88	.00	7.56	423.35	762.21	1185.56

	SECNO	CWSEL	VLOB	VCH	VROB	QLOB	QCH	QROB	DEPTH	TOPWID	SSTA	ENDST
*	17.000	2460.71	.00	15.09	.00	.00	34000.00	.00	7.91	322.77	856.65	1179.42
	18.000	2464.40	.00	12.78	.00	.00	34000.00	.00	9.50	321.99	856.01	1177.99
	19.000	2466.72	.00	11.18	.00	.00	34000.00	.00	9.72	343.60	825.08	1168.69
	20.000	2468.08	.00	11.75	.00	.00	34000.00	.00	9.08	331.54	826.54	1158.08
	21.000	2469.64	.00	12.00	.00	.00	34000.00	.00	9.64	323.12	840.72	1163.84
	22.000	2471.54	.00	10.32	.00	.00	34000.00	.00	10.54	327.70	836.36	1164.06
	23.000	2471.98	1.13	10.48	.85	7.71	33986.08	6.21	9.98	349.34	818.08	1167.42
	23.100	2472.05	1.14	10.40	.86	8.40	33984.83	6.77	10.05	349.88	817.82	1167.70
	23.200	2472.78	.00	10.29	.46	.00	33999.31	.69	10.28	353.43	810.45	1163.88
	24.000	2472.84	.00	10.22	.48	.00	33999.15	.85	10.34	353.91	810.31	1164.22
	25.000	2473.81	.00	11.66	.00	.00	34000.00	.00	9.81	330.84	832.19	1163.02
	26.000	2475.35	.00	12.47	.00	.00	34000.00	.00	9.85	334.50	827.75	1162.25
	27.000	2477.15	.00	13.97	.00	.00	34000.00	.00	9.75	305.85	859.03	1164.89

TANQUE VERDE CREEK (CRAY

SUMMARY PRINTOUT

SECNO	CWSEL	CRIWS	EG	HL	OLOSS	ELMIN	10*KS	K*CHSL	XLCH	SHEAR	FRCH

	1.000	2433.20	.00	2435.20	.00	.00	2422.00	24.99	.00	.00	1.56	.64
	2.000	2434.04	2433.09	2436.90	1.44	.26	2424.00	39.39	4.44	450.00	2.31	.79
*	3.000	2437.17	.00	2438.03	.93	.20	2426.50	12.35	5.00	500.00	.73	.45
	4.000	2437.85	.00	2438.71	.68	.00	2428.00	14.65	3.00	500.00	.80	.48
	5.000	2438.54	.00	2439.57	.81	.05	2429.50	20.79	3.33	450.00	1.01	.56
*	6.000	2439.68	2439.18	2441.45	1.66	.22	2432.00	45.16	5.00	500.00	1.75	.79
*	7.000	2442.22	2442.22	2444.41	3.00	-.27	2434.00	60.02	4.00	500.00	2.18	.90
	8.000	2444.71	2444.45	2447.19	2.69	.08	2436.00	49.41	4.00	500.00	2.21	.85
*	9.000	2447.61	.00	2448.59	1.26	.15	2438.00	16.89	4.00	500.00	.87	.51
	10.000	2448.76	.00	2449.38	.75	.04	2440.00	13.52	4.00	500.00	.56	.44
	11.000	2449.46	.00	2450.05	.67	.00	2441.30	13.10	2.60	500.00	.52	.43
*	12.000	2450.24	.00	2451.56	1.29	.22	2443.50	38.42	4.40	500.00	1.25	.71
	13.000	2451.98	.00	2453.55	1.92	.08	2444.00	38.36	1.00	500.00	1.43	.73
	14.000	2453.65	.00	2455.95	2.18	.22	2446.50	54.33	5.32	470.00	2.07	.87
	15.000	2456.10	2455.50	2458.55	2.56	.05	2448.00	48.36	3.00	500.00	2.14	.84
	16.000	2458.80	.00	2460.61	1.99	.06	2450.00	31.72	3.85	520.00	1.54	.69
*	16.500	2459.56	2459.56	2462.70	2.01	-.13	2452.00	67.10	6.67	300.00	2.78	.98
*	17.000	2460.71	2460.71	2464.25	1.42	.08	2452.80	71.15	4.00	200.00	3.10	1.01
	18.000	2464.40	.00	2466.93	2.59	.10	2454.90	40.63	4.20	500.00	2.09	.78
	19.000	2466.72	.00	2468.66	1.66	.06	2457.00	28.20	4.20	500.00	1.56	.66
	20.000	2468.08	.00	2470.22	1.51	.06	2459.00	32.02	4.00	500.00	1.74	.70
	21.000	2469.64	.00	2471.88	1.62	.03	2460.00	32.98	2.00	500.00	1.80	.71
	22.000	2471.54	.00	2473.20	1.27	.06	2461.00	20.56	2.00	500.00	1.29	.57
	23.000	2471.98	.00	2473.68	.47	.02	2462.00	22.12	4.55	220.00	1.34	.59

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SECNO	CWSEL	CRIWS	EG	HL	OLOSS	ELMIN	10*KS	K*CHSL	XLCH	SHEAR	FRCH
23.100	2472.05	.00	2473.73	.04	.00	2462.00	21.56	.00	20.00	1.31	.59
23.200	2472.78	.00	2474.42	.69	.00	2462.50	21.91	4.17	120.00	1.29	.59
24.000	2472.84	.00	2474.47	.04	.00	2462.50	21.40	.00	20.00	1.27	.58
25.000	2473.81	.00	2475.92	1.31	.15	2464.00	31.10	3.00	500.00	1.71	.69
26.000	2475.35	.00	2477.76	1.75	.09	2465.50	39.25	3.00	500.00	2.00	.77
27.000	2477.15	.00	2480.17	2.23	.18	2467.40	50.53	3.80	500.00	2.51	.87

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SUMMARY OF ERRORS AND SPECIAL NOTES

WARNING SECNO= 3.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 6.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO= 7.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 7.000 PROFILE= 1 MINIMUM SPECIFIC ENERGY

WARNING SECNO= 9.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 12.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO= 16.500 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 16.500 PROFILE= 1 MINIMUM SPECIFIC ENERGY

CAUTION SECNO= 17.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 17.000 PROFILE= 1 MINIMUM SPECIFIC ENERGY

APPENDIX B

SCOUR ANALYSIS SUMMARY SHEETS, EXISTING (WITHOUT-PROJECT) CONDITIONS

Existing (Without-Project) Conditions

Section Properties		Reach 6				Sabino Rd. Bridge			Reach 5					
Section No.	27	26	25	24	average	23.2	23.1	average	23	22	21	20	19	average
W.S. Elev (ft)	2477.17	2475.37	2473.84	2472.89		2472.82	2472.05		2471.98	2471.55	2469.64	2468.08	2466.72	
E.G. Slope (ft/ft)	0.0050	0.0039	0.0031	0.0021	0.0035	0.0022	0.0022	0.0022	0.0022	0.0021	0.0033	0.0032	0.0028	0.0027
Max Chl Dpth (ft)	9.77	9.87	9.84	10.39	9.97	10.32	10.05	10.19	9.98	10.55	9.64	9.08	9.72	9.79
Min Ch El (ft)	2467.40	2465.50	2464.00	2462.50		2462.50	2462.00		2462.00	2461.00	2460.00	2459.00	2457.00	
Alpha	1.00	1.00	1.00	1.00		1.00	1.01		1.01	1.00	1.00	1.00	1.00	
Frctn Loss (ft)	2.22	1.75	1.30	0.04			0.04		0.47	1.27	1.62	1.51	1.67	
C & E Loss (ft)	0.18	0.09	0.15	0.00			0.00		0.01	0.06	0.03	0.06	0.06	
Main Channel Properties														
Wt. n-Val.	0.030	0.030	0.030	0.030		0.030	0.030		0.030	0.030	0.030	0.030	0.030	
Flow Area (sq ft)	2442	2735	2925	3343	2861	3320	3268	3294	3244	3293	2834	2895	3040	3061
Flow (cfs)	34000	34000	34000	33999	34000	33999	33985	33992	33986	34000	34000	34000	34000	33997
Top Width (ft)	306	335	331	350	330	350	335	342	335	328	323	332	344	332
Avg. Vel. (ft/s)	13.92	12.43	11.62	10.17	12.04	10.24	10.40	10.32	10.48	10.33	12.00	11.74	11.19	11.15
Hydr. Depth (ft)	7.98	8.17	8.84	9.56	8.64	9.49	9.75	9.62	9.68	10.05	8.77	8.73	8.85	9.22
Wetted Per. (ft)	308	339	336	354	334	354	340	347	340	334	327	337	347	337
Shear (lb/sq ft)	2.48	1.96	1.67	1.24	1.84	1.27	1.29	1.28	1.32	1.27	1.78	1.71	1.54	1.52
Stream Power (lb/ft s)	34.47	24.38	19.43	12.65	22.73	12.96	13.46	13.21	13.80	13.07	21.40	20.13	17.28	17.14

Section Properties				Reach 4						Reach 3		
Section No.	18	17	16.5	16	15	14	average	13	12	11	10	average
W.S. Elev (ft)	2464.39	2460.72	2459.60	2458.80	2456.11	2453.65		2451.98	2450.24	2449.46	2448.76	
E.G. Slope (ft/ft)	0.0041	0.0071	0.0066	0.0032	0.0048	0.0054	0.0052	0.0038	0.0038	0.0013	0.0014	0.0026
Max Chl Dpth (ft)	9.49	7.92	7.60	8.80	8.11	7.15	8.18	7.98	6.74	8.16	8.76	7.91
Min Ch El (ft)	2454.90	2452.80	2452.00	2450.00	2448.00	2446.50		2444.00	2443.50	2441.30	2440.00	
Alpha	1.00	1.00	1.06	1.16	1.20	1.00		1.09	1.02	1.08	1.18	
Frctn Loss (ft)	2.59			1.99	2.57	2.18		1.92	1.29	0.66	0.75	
C & E Loss (ft)	0.10			0.06	0.05	0.22		0.08	0.22	0.00	0.04	
Main Channel Properties												
Wt. n-Val.	0.030	0.030	0.030	0.030	0.030	0.030		0.030	0.030	0.030	0.030	
Flow Area (sq ft)	2658	2255	2378	3069	2629	2797	2631	3348	3694	5487	5116	4411
Flow (cfs)	34000	34000	33726	33403	33326	34000	33742	33799	33985	33792	32921	33624
Top Width (ft)	322	323	356	395	370	459	371	560	710	860	770	725
Avg. Vel. (ft/s)	12.79	15.08	14.18	10.88	12.67	12.16	12.96	10.10	9.20	6.16	6.44	7.98
Hydr. Depth (ft)	8.26	6.99	6.69	7.77	7.11	6.10	7.15	5.98	5.20	6.38	6.64	6.05
Wetted Per. (ft)	327	328	359	398	373	461	374	560	712	861	771	726
Shear (lb/sq ft)	2.07	3.04	2.72	1.53	2.13	2.06	2.26	1.43	1.24	0.52	0.56	0.94
Stream Power (lb/ft s)	26.47	45.86	38.64	16.61	27.01	25.05	29.94	14.43	11.44	3.21	3.61	8.17

Section Properties

	Reach 2						Reach 1				
Section No.	9	8	7	6	5	average	4	3	2	1	average
W.S. Elev (ft)	2447.61	2444.69	2442.26	2439.68	2438.54		2437.85	2437.17	2434.04	2433.20	
E.G. Slope (ft/ft)	0.0017	0.0050	0.0058	0.0045	0.0021	0.0038	0.0015	0.0012	0.0039	0.0025	0.0023
Max Chl Dpth (ft)	9.61	8.69	8.26	7.68	9.04	8.66	9.85	10.67	10.04	11.20	10.44
Min Ch El (ft)	2438.00	2436.00	2434.00	2432.00	2429.50		2428.00	2426.50	2424.00	2422.00	
Alpha	1.59	1.48	1.71	1.71	2.26		2.03	1.71	1.38	1.29	
Frctn Loss (ft)	1.26	2.67		1.66	0.81		0.68	0.93	1.44		
C & E Loss (ft)	0.15	0.10		0.22	0.05		0.00	0.20	0.26		
Main Channel Properties											
Wt. n-Val.	0.030	0.030	0.030	0.030	0.030		0.030	0.030	0.030	0.030	
Flow Area (sq ft)	3732	2505	2528	2726	3255	2949	3654	4048	2394	2908	3251
Flow (cfs)	30984	32450	31024	30568	28731	30752	29300	31386	32997	33319	31750
Top Width (ft)	450	350	430	440	420	418	420	430	255	290	349
Avg. Vel. (ft/s)	8.30	12.96	12.27	11.21	8.83	10.71	8.02	7.75	13.78	11.46	10.25
Hydr. Depth (ft)	8.29	7.16	5.88	6.20	7.75	7.06	8.70	9.41	9.39	10.03	9.38
Wetted Per. (ft)	453	352	432	440	421	420	422	431	256	292	350
Shear (lb/sq ft)	0.87	2.22	2.13	1.74	1.00	1.59	0.80	0.72	2.29	1.55	1.34
Stream Power (lb/ft s)	7.21	28.77	26.10	19.53	8.85	18.09	6.38	5.62	31.62	17.79	15.35

SCOUR CALCULATIONS

Tanque Verde Creek Bank Protection and Riparian Preserve Project - Reach 1

HYDRAULIC PARAMETERS

Qmc, main channel discharge [1] =	31750	cfs
Se or So, energy/bed slope [2] =	0.0023	ft/ft
Yh, hydraulic depth =	9.38	ft.
Ym, maximum flow depth =	10.44	ft.
Vmc, main channel velocity =	10.25	fps
TW, top width of flow =	349.00	ft.
Amc, main channel flow area =	3097.56	sq. ft.
qmc, main channel unit discharge (mc) =	107.01	cfs/ft

note: [1] the discharge in the main channel (Qmc) and its hydraulic parameters are used if Qmc is less than the design discharge, otherwise the design discharge and its parameters are used.

[2] the bed slope (So) is used under uniform-flow conditions and the energy slope (Se) is used when the hydraulic parameters are obtained from a HEC-2 analysis.

GENERAL-SCOUR DEPTH

[Ys1 = Ym*(((0.0685*Vmc^0.8)/(Yh^0.4*So^0.3))-1), Reference 5]

for:	Se or So =	0.0023	ft/ft
	Yh =	9.38	ft.
	Ym =	10.44	ft.
	Vmc =	10.25	fps

	Ys1, general-scour depth =	1.1898	ft.

BED-FORM OR ANTIDUNE-SCOUR DEPTH

[Ys2 = 0.0137*Vmc^2, Reference 5]

for:	Vmc =	10.25	fps

	Ys2, bedform or antidune-scour depth =	1.4372	ft.

BEND-SCOUR DEPTH

(computation of depth as a function of the impingement angle)

[Ys3 = (0.0685*Ym*Vmc^0.8*(2.1*((sin^2(Ai/2)/cos(Ai))^0.2)-1))/(Yh^0.4*So^0.3), Reference 5]

impingement angle =	0.00	degrees
Rc, radius of curvature =	straight reach	ft.
TW, top width of flow =	349.00	ft.
Rc/TW =	n/c	
Se or So, energy/bed slope [1] =	0.0023	ft/ft
Yh, hydraulic depth =	9.38	ft.
Ym, maximum flow depth =	10.44	ft.
Vmc, main channel velocity =	10.25	fps

Ys3, bend-scour depth =	0.0000	ft.

Note: The computations are limited to an Rc/TW ratio that is > 0.5, but < 10.21. (that is, 0.5 < Rc/Tw < 10.21)

LOCAL-SCOUR DEPTH FOR BRIDGE PIERS AND SIMILAR OBSTRUCTIONS

[scour depth using CSU's equation, Ys = Y1*(2.0*K1*K2*(a/Y1)^0.65*Fr^0.43) , Reference 7]

Y1, maximum flow depth =	10.44 ft.
Fr, froude no. =	0.59
a, width of obstruction =	9.00 ft.
K1, pier shape coefficient or correction factor =	1.10
K2, correction factor for angle of attack =	1.00
composite coefficient (2.0*K1*K2) =	2.20

Ys, local-scour depth =	16.62 ft.

Pier Nose Shape	Coefficient (K1)
square nose	1.1
round nose	1.0
cylinder	1.0
sharp nose	0.9
group of cylinders	1.0

Angle of Attack (degrees)	Pier Length/Width Ratio (K2)		
	L/a = 4	L/a = 8	L/a = 12
0	1.0	1.0	1.0
15	1.5	2.0	2.5
30	2.0	2.75	3.5
45	2.3	3.3	4.3
90	2.5	3.9	5.0

<u>Comments</u>

a) If the obstruction width includes debris accumulation, use a pier shape coefficient (K1) of 1.1; otherwise use the appropriate coefficient listed above.

b) CSU's equation, as outlined above, was obtained from HEC-18. It is the same procedure used by ADWR and the City of Tucson. However, the ADWR and COT procedures are approached in a slightly different manner. A composite coefficient of 2.2 is the default condition. Reduction factors are then applied to adjust for different pier nose shapes. This table is provided below.

Pier Nose Shape	Reduction Factor
square nose	1.0
round nose	0.9
cylinder	0.9
sharp nose	0.8
group of cylinders	0.9

c) HEC-18 makes use of a third correction coefficient to account for variations in bed form and sediment transport. The associated factors are listed below. The computed scour depth obtained using this third correction factor is also provided.

Bed Condition	Dune Height, H (ft)	Coefficient (K3)
clear-water scour	n/a	1.1
plane bed and antidune flow	n/a	1.1
small dunes	10 > H < 2	1.1
medium dunes	30 > H > 10	1.1 to 1.2
large dunes	H > 30	1.3

K3, correction factor for bed condition =	1.10
composite coefficient (2.0*K1*K2*K3) =	2.42

Ys, local-scour depth =	18.28 ft.

HYDRAULIC PARAMETERS

Qmc, main channel discharge [1] =	30752	cfs
Se or So, energy/bed slope [2] =	0.0038	ft/ft
Yh, hydraulic depth =	7.06	ft.
Ym, maximum flow depth =	8.66	ft.
Vmc, main channel velocity =	10.71	fps
TW, top width of flow =	418.00	ft.
Amc, main channel flow area =	2871.34	sq. ft.
qmc, main channel unit discharge (mc) =	92.75	cfs/ft

note: [1] the discharge in the main channel (Qmc) and its hydraulic parameters are used if Qmc is less than the design discharge, otherwise the design discharge and its parameters are used.

[2] the bed slope (So) is used under uniform-flow conditions and the energy slope (Se) is used when the hydraulic parameters are obtained from a HEC-2 analysis.

GENERAL-SCOUR DEPTH

[Ys1 = Ym*(((0.0685*Vmc^0.8)/(Yh^0.4*So^0.3))-1), Reference 5]

for:	Se or So =	0.0038	ft/ft
	Yh =	7.06	ft.
	Ym =	8.66	ft.
	Vmc =	10.71	fps

	Ys1, general-scour depth =	0.9690	ft.

BED-FORM OR ANTIDUNE-SCOUR DEPTH

[Ys2 = 0.0137*Vmc^2, Reference 5]

for:	Vmc =	10.71	fps

	Ys2, bedform or antidune-scour depth =	1.5691	ft.

BEND-SCOUR DEPTH

(computation of depth as a function of the impingement angle)

[Ys3 = (0.0685*Ym*Vmc^0.8*(2.1*((sin^2(Ai/2)/cos(Ai))^0.2)-1))/(Yh^0.4*So^0.3), Reference 5]

impingement angle =	35.00	degrees
Rc, radius of curvature =	946.67	ft.
TW, top width of flow =	418.00	ft.
Rc/TW =	2.26	
Se or So, energy/bed slope [1] =	0.0038	ft/ft
Yh, hydraulic depth =	7.06	ft.
Ym, maximum flow depth =	8.66	ft.
Vmc, main channel velocity =	10.71	fps

Ys3, bend-scour depth =	3.3842	ft.

Note: The computations are limited to an Rc/TW ratio that is > 0.5, but < 10.21.
(that is, 0.5 < Rc/Tw < 10.21)

SCOUR CALCULATIONS

Tanque Verde Creek Bank Protection and Riparian Preserve Project - Reach 3

HYDRAULIC PARAMETERS

Qmc, main channel discharge [1] =	33624	cfs
Se or So, energy/bed slope [2] =	0.0026	ft/ft
Yh, hydraulic depth =	6.05	ft.
Ym, maximum flow depth =	7.91	ft.
Vmc, main channel velocity =	7.98	fps
TW, top width of flow =	725.00	ft.
Amc, main channel flow area =	4213.53	sq. ft.
qmc, main channel unit discharge (mc) =	63.12	cfs/ft

note: [1] the discharge in the main channel (Qmc) and its hydraulic parameters are used if Qmc is less than the design discharge, otherwise the design discharge and its parameters are used.

[2] the bed slope (So) is used under uniform-flow conditions and the energy slope (Se) is used when the hydraulic parameters are obtained from a HEC-2 analysis.

GENERAL-SCOUR DEPTH

[Ys1 = Ym*(((0.0685*Vmc^0.8)/(Yh^0.4*So^0.3))-1), Reference 5]

for: Se or So =	0.0026	ft/ft
Yh =	6.05	ft.
Ym =	7.91	ft.
Vmc =	7.98	fps

Ys1, general-scour depth =	0.3747	ft.

BED-FORM OR ANTIDUNE-SCOUR DEPTH

[Ys2 = 0.0137*Vmc^2, Reference 5]

for: Vmc =	7.98	fps

Ys2, bedform or antidune-scour depth =	0.8711	ft.

BEND-SCOUR DEPTH

(computation of depth as a function of the impingement angle)

[Ys3 = (0.0685*Ym*Vmc^0.8*(2.1*((sin^2(Ai/2)/cos(Ai))^0.2)-1))/(Yh^0.4*So^0.3), Reference 5]

impingement angle =	27.00	degrees
Rc, radius of curvature =	2963.39	ft.
TW, top width of flow =	725.00	ft.
Rc/TW =	4.09	
Se or So, energy/bed slope [1] =	0.0026	ft/ft
Yh, hydraulic depth =	6.05	ft.
Ym, maximum flow depth =	7.91	ft.
Vmc, main channel velocity =	7.98	fps

Ys3, bend-scour depth =	1.6646	ft.

Note: The computations are limited to an Rc/TW ratio that is > 0.5, but < 10.21.
(that is, 0.5 < Rc/Tw < 10.21)

SCOUR CALCULATIONS

Tanque Verde Creek Bank Protection and Riparian Preserve Project - Reach 4

HYDRAULIC PARAMETERS

Qmc, main channel discharge [1] =	33742	cfs
Se or So, energy/bed slope [2] =	0.0052	ft/ft
Yh, hydraulic depth =	7.15	ft.
Ym, maximum flow depth =	8.18	ft.
Vmc, main channel velocity =	12.96	fps
TW, top width of flow =	371.00	ft.
Amc, main channel flow area =	2603.55	sq. ft.
qmc, main channel unit discharge (mc) =	106.01	cfs/ft

note: [1] the discharge in the main channel (Qmc) and its hydraulic parameters are used if Qmc is less than the design discharge, otherwise the design discharge and its parameters are used.

[2] the bed slope (So) is used under uniform-flow conditions and the energy slope (Se) is used when the hydraulic parameters are obtained from a HEC-2 analysis.

GENERAL-SCOUR DEPTH

[Ys1 = Ym*(((0.0685*Vmc^0.8)/(Yh^0.4*So^0.3))-1), Reference 5]

for:	Se or So =	0.0052	ft/ft
	Yh =	7.15	ft.
	Ym =	8.18	ft.
	Vmc =	12.96	fps

	Ys1, general-scour depth =	1.4141	ft.

BED-FORM OR ANTIDUNE-SCOUR DEPTH

[Ys2 = 0.0137*Vmc^2, Reference 5]

for:	Vmc =	12.96	fps

	Ys2, bedform or antidune-scour depth =	2.2976	ft.

BEND-SCOUR DEPTH

(computation of depth as a function of the impingement angle)

[Ys3 = (0.0685*Ym*Vmc^0.8*(2.1*((sin^2(Ai/2)/cos(Ai))^0.2)-1))/(Yh^0.4*So^0.3), Reference 5]

impingement angle =	27.00	degrees
Rc, radius of curvature =	1516.44	ft.
TW, top width of flow =	371.00	ft.
Rc/TW =	4.09	
Se or So, energy/bed slope [1] =	0.0052	ft/ft
Yh, hydraulic depth =	7.15	ft.
Ym, maximum flow depth =	8.18	ft.
Vmc, main channel velocity =	12.96	fps

Ys3, bend-scour depth =	1.9277	ft.

Note: The computations are limited to an Rc/TW ratio that is > 0.5, but < 10.21.
(that is, 0.5 < Rc/Tw < 10.21)

SCOUR CALCULATIONS

Tanque Verde Creek Bank Protection and Riparian Preserve Project - Reach 5

HYDRAULIC PARAMETERS

Qmc, main channel discharge [1] =	33997	cfs
Se or So, energy/bed slope [2] =	0.0027	ft/ft
Yh, hydraulic depth =	9.22	ft.
Ym, maximum flow depth =	9.79	ft.
Vmc, main channel velocity =	11.15	fps
TW, top width of flow =	332.00	ft.
Amc, main channel flow area =	3049.06	sq. ft.
qmc, main channel unit discharge (mc) =	109.16	cfs/ft

note: [1] the discharge in the main channel (Qmc) and its hydraulic parameters are used if Qmc is less than the design discharge, otherwise the design discharge and its parameters are used.

[2] the bed slope (So) is used under uniform-flow conditions and the energy slope (Se) is used when the hydraulic parameters are obtained from a HEC-2 analysis.

GENERAL-SCOUR DEPTH

[Ys1 = Ym*(((0.0685*Vmc^0.8)/(Yh^0.4*So^0.3))-1), Reference 5]

for:	Se or So =	0.0027	ft/ft
	Yh =	9.22	ft.
	Ym =	9.79	ft.
	Vmc =	11.15	fps

	Ys1, general-scour depth =	1.4042	ft.

BED-FORM OR ANTIDUNE-SCOUR DEPTH

[Ys2 = 0.0137*Vmc^2, Reference 5]

for:	Vmc =	11.15	fps

	Ys2, bedform or antidune-scour depth =	1.7007	ft.

BEND-SCOUR DEPTH

(computation of depth as a function of the impingement angle)

[Ys3 = (0.0685*Ym*Vmc^0.8*(2.1*((sin^2(Ai/2)/cos(Ai))^0.2)-1))/(Yh^0.4*So^0.3), Reference 5]

impingement angle =	17.00	degrees
Rc, radius of curvature =	straight reach	ft.
TW, top width of flow =	332.00	ft.
Rc/TW =	n/c	
Se or So, energy/bed slope [1] =	0.0027	ft/ft
Yh, hydraulic depth =	9.22	ft.
Ym, maximum flow depth =	9.79	ft.
Vmc, main channel velocity =	11.15	fps

Ys3, bend-scour depth =	0.0000	ft.

Note: The computations are limited to an Rc/TW ratio that is > 0.5, but < 10.21. (that is, 0.5 < Rc/Tw < 10.21)

SCOUR CALCULATIONS

Tanque Verde Creek Bank Protection and Riparian Preserve Project - Reach 6

HYDRAULIC PARAMETERS

Qmc, main channel discharge [1] =	34000	cfs
Se or So, energy/bed slope [2] =	0.0035	ft/ft
Yh, hydraulic depth =	8.64	ft.
Ym, maximum flow depth =	9.97	ft.
Vmc, main channel velocity =	12.04	fps
TW, top width of flow =	334.00	ft.
Amc, main channel flow area =	2823.92	sq. ft.
qmc, main channel unit discharge (mc) =	120.04	cfs/ft

note: [1] the discharge in the main channel (Qmc) and its hydraulic parameters are used if Qmc is less than the design discharge, otherwise the design discharge and its parameters are used.

[2] the bed slope (So) is used under uniform-flow conditions and the energy slope (Se) is used when the hydraulic parameters are obtained from a HEC-2 analysis.

GENERAL-SCOUR DEPTH

[Ys1 = Ym*(((0.0685*Vmc^0.8)/(Yh^0.4*So^0.3))-1), Reference 5]

for:	Se or So =	0.0035	ft/ft
	Yh =	8.64	ft.
	Ym =	9.97	ft.
	Vmc =	12.04	fps

Ys1, general-scour depth =		1.5396	ft.

BED-FORM OR ANTIDUNE-SCOUR DEPTH

[Ys2 = 0.0137*Vmc^2, Reference 5]

for:	Vmc =	12.04	fps

Ys2, bedform or antidune-scour depth =		1.9830	ft.

BEND-SCOUR DEPTH

(computation of depth as a function of the impingement angle)

[Ys3 = (0.0685*Ym*Vmc^0.8*(2.1*((sin^2(Ai/2)/cos(Ai))^0.2)-1))/(Yh^0.4*So^0.3), Reference 5]

impingement angle =	17.00	degrees
Rc, radius of curvature =	straight reach	ft.
TW, top width of flow =	334.00	ft.
Rc/TW =	n/c	
Se or So, energy/bed slope [1] =	0.0035	ft/ft
Yh, hydraulic depth =	8.64	ft.
Ym, maximum flow depth =	9.97	ft.
Vmc, main channel velocity =	12.04	fps

Ys3, bend-scour depth =	0.0000	ft.

Note: The computations are limited to an Rc/TW ratio that is > 0.5, but < 10.21.
(that is, 0.5 < Rc/Tw < 10.21)

SCOUR CALCULATIONS

Tanque Verde Creek Bank Protection and Riparian Preserve Project - Reach 6

LOCAL-SCOUR DEPTH FOR BRIDGE PIERS AND SIMILAR OBSTRUCTIONS

[scour depth using CSU's equation, Ys = Y1*(2.0*K1*K2*(a/Y1)^0.65*Fr^0.43) , Reference 7]

Y1, maximum flow depth =	9.97 ft.
Fr, froude no. =	0.72
a, width of obstruction =	8.00 ft.
K1, pier shape coefficient or correction factor =	1.10
K2, correction factor for angle of attack =	1.00
composite coefficient (2.0*K1*K2) =	2.20

Ys, local-scour depth =	16.52 ft.

Pier Nose Shape	Coefficient (K1)
square nose	1.1
round nose	1.0
cylinder	1.0
sharp nose	0.9
group of cylinders	1.0

Angle of Attack (degrees)	Pier Length/Width Ratio (K2)		
	L/a = 4	L/a = 8	L/a = 12
0	1.0	1.0	1.0
15	1.5	2.0	2.5
30	2.0	2.75	3.5
45	2.3	3.3	4.3
90	2.5	3.9	5.0

<u>Comments</u>

a) If the obstruction width includes debris accumulation, use a pier shape coefficient (K1) of 1.1; otherwise use the appropriate coefficient listed above.

b) CSU's equation, as outlined above, was obtained from HEC-18. It is the same procedure used by ADWR and the City of Tucson. However, the ADWR and COT procedures are approached in a slightly different manner. A composite coefficient of 2.2 is the default condition. . Reduction factors are then applied to adjust for different pier nose shapes. This table is provided below.

Pier Nose Shape	Reduction Factor
square nose	1.0
round nose	0.9
cylinder	0.9
sharp nose	0.8
group of cylinders	0.9

c) HEC-18 makes use of a third correction coefficient to account for variations in bed form and sediment transport. The associated factors are listed below. The computed scour depth obtained using this third correction factor is also provided.

Bed Condition	Dune Height, H (ft)	Coefficient (K3)
clear-water scour	n/a	1.1
plane bed and antidune flow	n/a	1.1
small dunes	10 > H < 2	1.1
medium dunes	30 > H > 10	1.1 to 1.2
large dunes	H > 30	1.3

K3, correction factor for bed condition =	1.10
composite coefficient (2.0*K1*K2*K3) =	2.42

Ys, local-scour depth =	18.18 ft.

APPENDIX C

HEC-2 INPUT/OUTPUT LISTING, WITH-PROJECT CONDITIONS

```
 *********************************************                              ***************************************
 *  HEC-2 WATER SURFACE PROFILES             *                              * U.S. ARMY CORPS OF ENGINEERS        *
 *********************************************                              ***************************************

                                        X     X  XXXXXXX   XXXXX           XXXXX
                                        X     X  X        X     X         X     X
                                        X     X  X        X                     X
                                        XXXXXXX  XXXX     X        XXXXX   XXXXX
                                        X     X  X        X               X
                                        X     X  X        X     X         X
                                        X     X  XXXXXXX   XXXXX          XXXXXXX
1
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                                                                          THIS RUN EXECUTED 13APR98    09:46:05
 ************************************
  HEC-2 WATER SURFACE PROFILES

  Version   4.6.2;  May 1991
 ************************************


 T1      LIMITED RE-EVALUATION REPORT FOR THE PROPOSED RILLITO RIVER AND
 T2      ASSOCIATED STREAMS, BANK STABILIZATION AND RIPARIAN AREA PRESERVE,
 T3      TANQUE VERDE CREEK (CRAYCROFT RD BRIDGE TO SABINO CANYON RD BRIDGE)
 T4      WITH-PROJECT CONDITIONS; SLA JOB #: PAZ-COE32; TASK 2

 J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC     HVINS     Q         WSEL       FQ

       -1        2         0         0     0.0000       0           0       0     2433.2        0

 J2  NPROF     IPLOT     PRFVS     XSECV     XSECH      FN        ALLDC     IBW       CHNIM      ITRACE

       1                  -1                                                                      15


 J3  VARIABLE CODES FOR SUMMARY PRINTOUT

      38         1        55        26        56        13        14        15         8         4
      53        54         0        38         1         2         3        11        12        42
       5        33        39        67        68

 J6  IHLEQ     ICOPY     SUBDIV    STRTDS    RMILE

       1


 NC      0.08      0.08     0.030       0.1       0.3
 QT         1     34000
 X1         1        11      1180      1490         0         0         0
 GR      2432       910      2432      1060      2430      1180      2422      1190      2422      1420
 GR      2424      1460      2432      1490      2434      1530      2436      1580      2440      1630
 GR      2450      1700

 X1         2        19      1370      1705       350       520       450
 X3                                     820
 GR      2430        40      2432       240      2434       525      2436       590      2438       600
 GR      2434       640      2428       660      2426       690      2426       800      2434       820
 GR      2434      1140      2432      1370      2424      1380      2424      1440      2424      1650
 GR      2424      1695      2433      1705      2434      1730      2440      1750
1
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 X1         3        27      1390      1790       420       500       500
 X3                                     670
 GR      2432       160      2434       340      2436       430      2440       450      2438       460
 GR      2436       490      2430       500      2428       530      2428       660      2430       665
 GR      2436       670      2436       830      2434       950      2434      1240      2433      1280
 GR      2433      1320      2432      1360    2431.5      1390      2428      1400      2427      1470
 GR    2426.5      1520      2428      1610      2427      1700      2427      1740      2428      1780
 GR      2433      1790      2440      1815

 X1         4        24      1330      1750       500       570       500
 X3                                     640
 GR      2434       320      2440       360      2440       380      2438       400      2430       420
 GR      2428       430      2428       540      2434       560      2436       570      2438       640
 GR      2436       780      2434       900      2433      1330      2430      1340      2428      1430
 GR      2429      1545    2429.5      1570      2429      1620      2429      1660      2430      1740
 GR      2434      1750      2434      1930      2440      1950      2450      1980

 X1         5        22      1290      1710       500       450       450
 X3                                     585
 GR      2441       420      2441       550      2440       600      2436       720      2435       750
 GR      2435      1100      2436      1250      2436      1290      2430      1300    2429.5      1330
```

GR	2429.5	1450	2430	1485	2432	1650	2434	1710	2436	1750
GR	2436	1770	2436	1810	2436	1840	2436	1930	2436	2050
GR	2440	2210	2442	2260						
X1	6	18	900	1340	550	500	500			
GR	2444	200	2444	420	2442	570	2440	610	2438	680
GR	2438	885	2439	890	2439	900	2434	910	2432	930
GR	2432	1060	2434	1180	2436	1330	2438	1340	2438	1630
GR	2440	1760	2442	1910	2450	2020				
X1	7	20	740	1170	500	500	500			
GR	2446	210	2446	330	2444	420	2443.5	500	2443	560
GR	2442	660	2442	661	2440.5	740	2435	750	2434	850
GR	2434	890	2436	900	2437.2	950	2437.2	1040	2438	1090
GR	2438	1160	2440	1170	2440	1560	2440	1685	2450	1715
X1	8	19	790	1140	530	450	500			
GR	2450	380	2448	420	2446	560	2444	730	2443	740
GR	2443	790	2437	800	2436	880	2436	930	2436.5	970
GR	2436.5	1030	2438	1060	2440	1070	2442	1140	2442.2	1270
GR	2444	1450	2446	1620	2448	1770	2450	1780		
NC	.06	.08	.030	.1	.3					
X1	9	21	730	1180	500	500	500			
GR	2454	30	2452	380	2450	580	2448	700	2447	730
GR	2440	740	2440	930	2438	980	2438	1030	2438.5	1130
GR	2440	1170	2442	1175	2444	1180	2443.5	1270	2443.5	1430
GR	2443.5	1440	2444	1510	2446	1630	2448	1660	2450	1700
GR	2460	1750								

1

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X1	10	16	700	1310	500	500	500			
GR	2454	110	2452	380	2450	440	2448	540	2448	690
GR	2448	700	2443	710	2443	940	2442	985	2440	1000
GR	2440	1280	2444	1310	2446	1460	2448	1540	2450	1570
GR	2452	1600								
X1	11	25	700	1420	500	500	500			
GR	2456	20	2454	200	2452	390	2450.5	410	2450.5	560
GR	2450.5	610	2450.5	650	2450.5	665	2450.5	675	2450.5	700
GR	2444	710	2444	870	2445	900	2445	930	2444	970
GR	2442	990	2441.3	1010	2442	1210	2441.5	1310	2441.5	1340
GR	2442	1400	2448	1420	2448	1510	2450	1630	2456	1660
X1	12	28	725	1430	500	500	500			
X3	10			725						
GR	2458	30	2456	180	2454	260	2452	290	2452	540
GR	2450	650	2450	720	2452	725	2452	735	2447	745
GR	2447	900	2444	940	2444	1080	2444.5	1120	2444.5	1180
GR	2444	1240	2443.5	1300	2443.5	1350	2444	1390	2446	1410
GR	2450	1430	2450	1500	2450	1530	2450	1565	2450	1570
GR	2452	1600	2454	1710	2458	1730				
X1	13	22	810	1380	500	500	500			
X3	10			810						
GR	2458	0	2456	170	2454	285	2452	390	2450	430
GR	2450	620	2450	650	2452	680	2452	760	2456	790
GR	2456	800	2454	810	2450	820	2448	920	2446	1010
GR	2444	1100	2444	1230	2446	1350	2450	1380	2452	1560
GR	2454	1690	2458	1850						
X1	14	20	690	1175	420	520	470			
X3	10			690						
GR	2460	120	2452	190	2452	540	2454	660	2460	690
GR	2455	730	2448	740	2447	830	2447	910	2448	950
GR	2448	1010	2446.5	1060	2446.5	1130	2448	1160	2454	1175
GR	2456	1200	2456	1340	2456	1460	2456	1480	2460	1800
X1	15	23	800	1160	500	500	500			
X3	10			590						
GR	2460	90	2454	130	2454	300	2456	310	2456	490
GR	2460	520	2460	560	2458	640	2456	760	2456	790
GR	2456	800	2449	810	2448	890	2449.5	950	2449.5	990
GR	2448	1050	2448	1080	2450	1150	2454	1160	2454	1290
GR	2456	1350	2458	1352	2460	1490				
X1	16	28	900	1205	550	480	520			
X3	10			900						
GR	2464	215	2460	260	2458	410	2456	430	2454	550
GR	2454	570	2454	590	2456	640	2460	660	2462	670
GR	2462	705	2460	710	2460	715	2460	810	2460	820
GR	2460	900	2451	910	2450	970	2450	1000	2451	1050
GR	2450.6	1100	2450.6	1120	2452	1200	2456	1205	2456	1290
GR	2460	1300	2462	1420	2464	1920				

1

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```
 X1     16.5         11        875       1190        300        300        300          0          0          0
 X3                                       870
 GR   2460.0      760.0     2458.0      770.0     2458.0      830.0     2458.0        865     2462.5        870
 GR   2462.5        875     2452.0      885.0     2452.0      945.0     2453.0     1090.0     2454.0     1180.0
 GR   2464.0     1190.0

 X1       17         15        840       1190        200        200        200
 X3       10                              830
 GR     2464        180       2462        260       2462        690       2460        720       2460        760
 GR     2464        800       2466        820       2466        840       2464        855       2454        860
 GR   2452.8        920     2453.1       1050       2454       1110       2456       1170       2466       1190
   VENTANA CANYON WASH TRIBUTARY

 X1       18         15        850       1185        500        500        500
 X3       10                              845
 GR     2466          0       2466        500       2466        680       2464        730       2464        830
 GR     2468        840       2468        850       2462        860       2460        870       2456        875
 GR   2454.9        970     2454.9       1030       2456       1100       2458       1170       2470       1185

 X1       19         10        810       1180        500        500        500
 GR     2474        790       2472        810       2458        850       2457        860       2457       1080
 GR     2458       1100       2458       1150       2472       1180       2472       1370       2474       1460

 X1       20         22        820       1160        500        500        500
 X3       10                              810
 GR     2474        390       2472        510       2470        525       2468        540       2468        560
 GR     2470        580       2470        720       2472        720       2472        820       2460        840
 GR     2459        850       2459       1145       2460       1150       2470       1160       2472       1185
 GR     2470       1190       2472       1200       2472       1290       2470       1300       2474       1340
 GR     2476       1520       2478       1690

 X1       21         17        830       1170        500        500        500
 X3       10                              820
 GR     2474        490       2472        500       2472        760       2470        790       2470        800
 GR     2472        810       2472        830       2470        840       2460        860       2460       1000
 GR   2460.5       1010     2460.5       1140       2472       1170       2472       1185       2470       1200
 GR     2470       1230       2476       1280

 X1       22         13        830       1180        500        500        500
 X3       10                              825
 GR     2476        650       2474        700       2474        800       2476        820       2476        830
 GR     2462        850       2461        870       2461       1150       2476       1170       2476       1180
 GR     2474       1200       2474       1250       2476       1310

 X1       23          6        825       1160        220        220        220
 GR     2480        790       2470        825       2462        840       2462       1150       2470       1160
 GR     2478       1190
  SABINO CANYON RD BRIDGE
1
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 X1     23.1                                          20         20         20
 X3       10

 SB     1.25        1.6        2.6        400        315         24       5693          1     2462.5       2462
 X1     23.2          8        800       1160        120        120        120
 X2                              1     2480.9    2486.97
 X3       10
 GR     2480        760       2478        800       2463        830     2462.5        850     2462.5       1050
 GR     2464       1140       2472       1160       2480       1200

 X1       24                                          20         20         20

 X1       25          7        830       1170        500        500        500
 GR     2476        830       2466        840     2464.7        860     2464.9        940       2464       1110
 GR     2466       1150       2478       1170

 X1       26         11        820       1170        500        500        500
 GR     2482        800       2480        820       2468        840     2466.5       1025       2466       1060
 GR   2465.5       1080       2466       1115       2468       1150       2480       1170       2480       1190
 GR     2484       1200

 X1       27          9        840       1175        500        500        500
 GR     2482        790       2480        820       2480        840       2468        920     2467.4        960
 GR   2467.4       1030       2468       1080       2470       1150       2482       1175
1
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      SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
      Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
      TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
      SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


 *PROF 1
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 IHLEQ = 1.  THEREFORE FRICTION LOSS (HL) IS CALCULATED AS A FUNCTION OF
 PROFILE TYPE, WHICH CAN VARY FROM REACH TO REACH.  SEE DOCUMENTATION FOR
 DETAILS.
0

 CCHV=      .100 CEHV=       .300
 *SECNO 1.000
 3280 CROSS SECTION        1.00 EXTENDED       1.20 FEET

      1.000      11.20    2433.20        .00    2433.20    2434.86       1.66        .00        .00    2430.00
    34000.0      537.5    33454.0        8.5      444.0     3212.0       14.4         .0         .0    2432.00
        .00       1.21      10.42        .59       .080       .030       .080       .000    2422.00     910.00
    .001990         0.         0.         0.          0          0          0        .00     604.00    1514.00


 FLOW DISTRIBUTION FOR SECNO=        1.00            CWSEL=    2433.20

 STA=       910.     1060.     1180.     1490.     1514.
   PER Q=         .5       1.1      98.4        .0
    AREA=      180.0     264.0    3212.0      14.4
     VEL=         .9       1.4      10.4        .6
   DEPTH=        1.2       2.2      10.4        .6

 *SECNO 2.000

 3470 ENCROACHMENT STATIONS=        820.0     1750.0  TYPE=        1  TARGET=      -820.000
      2.000      10.18    2434.18        .00        .00    2435.76       1.58        .90        .01    2432.00
    34000.0      267.4    33721.6       10.9      328.4     3324.9       17.0       37.1        6.9    2433.00
        .01        .81      10.14        .64       .080       .030       .080       .000    2424.00     820.00
    .002014       350.       450.       520.          2          0          0        .00     910.60    1730.60


 FLOW DISTRIBUTION FOR SECNO=        2.00            CWSEL=    2434.18

 STA=       820.     1140.     1370.     1705.     1730.
   PER Q=         .0        .7      99.2        .0
    AREA=       57.3     271.2    3324.9      17.0
     VEL=         .3        .9      10.1        .6
   DEPTH=         .2       1.2       9.9        .7

1
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       SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
       Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
       TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
       SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 *SECNO 3.000

 3470 ENCROACHMENT STATIONS=        670.0     1815.0  TYPE=        1  TARGET=      -670.000
      3.000       8.86    2435.36        .00        .00    2436.95       1.59       1.19        .00    2431.50
    34000.0     1263.2    32726.2       10.6      842.6     3172.4       10.0       80.1       16.5    2433.00
        .03       1.50      10.32       1.06       .080       .030       .080       .000    2426.50     868.26
    .002758       420.       500.       500.          2          0          0        .00     930.17    1798.44


 FLOW DISTRIBUTION FOR SECNO=        3.00            CWSEL=    2435.36

 STA=       868.      950.     1240.     1280.     1320.     1360.     1390.     1790.     1798.
   PER Q=         .1       1.4        .3        .5        .7        .7      96.3        .0
    AREA=       55.7     395.1      74.5      94.5     114.5     108.4    3172.4      10.0
     VEL=         .8       1.2       1.5       1.7       2.0       2.3      10.3       1.1
   DEPTH=         .7       1.4       1.9       2.4       2.9       3.6       7.9       1.2

 *SECNO 4.000

 3301 HV CHANGED MORE THAN HVINS


 3470 ENCROACHMENT STATIONS=        640.0     1980.0  TYPE=        1  TARGET=      -640.000
      4.000       9.11    2437.11        .00        .00    2438.17       1.06       1.16        .05    2433.00
    34000.0     3406.7    29584.5     1008.8     1848.5     3349.9      575.9      136.9       29.1    2434.00
        .04       1.84       8.83       1.75       .080       .030       .080       .000    2428.00     702.31
    .002002       500.       500.       570.          3          0          0        .00    1238.06    1940.37


 FLOW DISTRIBUTION FOR SECNO=        4.00            CWSEL=    2437.11

 STA=       702.      780.      900.     1330.     1750.     1930.     1940.
   PER Q=         .1       1.0       8.9      87.0       2.9        .1
    AREA=       43.1     253.2    1552.2    3349.9     559.8      16.1
     VEL=         .6       1.4       2.0       8.8       1.8       1.1
   DEPTH=         .6       2.1       3.6       8.0       3.1       1.6

 *SECNO 5.000

 3470 ENCROACHMENT STATIONS=        585.0     2260.0  TYPE=        1  TARGET=      -585.000
```

```
    5.000      8.53   2438.03       .00       .00   2439.29      1.26      1.06       .06   2436.00
  34000.0    3134.1   29602.1    1263.7    1660.9    3075.2     814.0     197.4      43.8   2434.00
      .06      1.89      9.63      1.55      .080      .030      .080      .000   2429.50    659.00
  .002670      500.      450.      450.         2         0         0       .00   1472.32   2131.33

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   SECNO     DEPTH     CWSEL     CRIWS     WSELK      EG        HV        HL        OLOSS     L-BANK ELEV
   Q         QLOB      QCH       QROB      ALOB       ACH       AROB      VOL       TWA       R-BANK ELEV
   TIME      VLOB      VCH       VROB      XNL        XNCH      XNR       WTN       ELMIN     SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL     IDC       ICONT     CORAR     TOPWID    ENDST

 FLOW DISTRIBUTION FOR SECNO=       5.00           CWSEL=   2438.03

 STA=      659.    1100.     1290.     1710.     2050.     2131.
   PER Q=        6.9       2.4      87.1       3.5        .2
    AREA=     1199.6     461.3    3075.2     731.3      82.7
     VEL=        1.9       1.7       9.6       1.6       1.0
   DEPTH=        2.7       2.4       7.3       2.2       1.0

 *SECNO 6.000

 3301 HV CHANGED MORE THAN HVINS

 7185 MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
    6.000      7.54   2439.54   2439.54       .00   2441.79      2.24      2.87      -.47   2439.00
  34000.0     654.4   32415.9     929.8     368.7    2634.0     524.9     250.6      59.1   2438.00
      .07      1.77     12.31      1.77      .080      .030      .080      .000   2432.00    625.99
  .005704      550.      500.      500.         2        11         0       .00   1104.32   1730.31

 FLOW DISTRIBUTION FOR SECNO=       6.00           CWSEL=   2439.54

 STA=      626.     680.      885.      890.      900.     1340.     1630.     1730.
   PER Q=         .1       1.7        .0        .0      95.3       2.5        .3
    AREA=       41.7     316.4       5.2       5.4    2634.0     447.5      77.4
     VEL=        1.2       1.9       1.4        .9      12.3       1.9       1.2
   DEPTH=         .8       1.5       1.0        .5       6.0       1.5        .8

 *SECNO 7.000
    7.000      8.57   2442.57   2442.23       .00   2444.43      1.86      2.60       .04   2440.50
  34000.0     170.5   30625.6    3203.9     120.9    2658.9    1332.6     294.5      71.7   2440.00
      .08      1.41     11.52      2.40      .080      .030      .080      .000   2434.00    603.16
  .004791      500.      500.      500.         4         8         0       .00   1089.54   1692.71

 FLOW DISTRIBUTION FOR SECNO=       7.00           CWSEL=   2442.57

 STA=      603.     660.      740.     1170.     1560.     1685.     1693.
   PER Q=         .0        .5      90.1       7.1       2.3        .0
    AREA=       16.2     104.7    2658.9    1001.7     321.0       9.9
     VEL=         .6       1.5      11.5       2.4       2.4       1.5
   DEPTH=         .3       1.3       6.2       2.6       2.6       1.3
1
 13APR98      09:46:05                                                                        PAGE    9

   SECNO     DEPTH     CWSEL     CRIWS     WSELK      EG        HV        HL        OLOSS     L-BANK ELEV
   Q         QLOB      QCH       QROB      ALOB       ACH       AROB      VOL       TWA       R-BANK ELEV
   TIME      VLOB      VCH       VROB      XNL        XNCH      XNR       WTN       ELMIN     SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL     IDC       ICONT     CORAR     TOPWID    ENDST

 *SECNO 8.000

 3301 HV CHANGED MORE THAN HVINS

    8.000      8.56   2444.56   2444.43       .00   2447.17      2.62      2.52       .23   2443.00
  34000.0     164.9   32577.1    1258.0     101.6    2457.6     595.0     335.2      82.2   2442.00
      .09      1.62     13.26      2.11      .080      .030      .080      .000   2436.00    682.62
  .005365      530.      500.      450.         6         5         0       .00    814.75   1497.38

 FLOW DISTRIBUTION FOR SECNO=       8.00           CWSEL=   2444.56

 STA=      683.     730.      740.      790.     1140.     1270.     1450.     1497.
   PER Q=         .0        .0        .4      95.8       2.3       1.3        .0
    AREA=       13.2      10.6      77.9    2457.6     319.5     262.3      13.2
     VEL=         .6       1.4       1.8      13.3       2.5       1.7        .6
   DEPTH=         .3       1.1       1.6       7.0       2.5       1.5        .3

 CCHV=      .100 CEHV=      .300
 *SECNO 9.000
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 3301 HV CHANGED MORE THAN HVINS


 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.79

      9.000      9.64   2447.64      .00       .00   2448.62      .98      1.28       .16   2447.00
    34000.0       2.9   30970.5   3026.6       6.2    3738.4   1663.6     384.3      92.3   2444.00
        .11       .47      8.28     1.82      .060      .030     .080      .000   2438.00    710.77
    .001677      500.      500.     500.         2         0        0       .00    943.84   1654.61


 FLOW DISTRIBUTION FOR SECNO=      9.00          CWSEL=   2447.64

 STA=     711.     730.     1180.    1270.    1430.    1440.    1510.    1630.    1655.
   PER Q=      .0     91.1      1.9      3.8       .2      1.5      1.4       .0
    AREA=     6.2   3738.4    350.2    662.5     41.4    272.4    316.9     20.2
     VEL=      .5      8.3      1.9      2.0      2.0      1.9      1.5       .7
   DEPTH=      .3      8.3      3.9      4.1      4.1      3.9      2.6       .8
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      SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
      Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
      TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
      SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 *SECNO 10.000
     10.000      8.62   2448.62      .00       .00   2449.48      .86       .85       .01   2448.00
    34000.0      77.9   32796.9   1125.2     108.0    4323.1    674.5     444.6     103.7   2444.00
        .13       .72      7.59     1.67      .060      .030     .080      .000   2440.00    509.21
    .001729      500.      500.     500.         3         0        0       .00   1040.02   1549.24


 FLOW DISTRIBUTION FOR SECNO=     10.00          CWSEL=   2448.62

 STA=     509.     540.     690.     700.    1310.    1460.    1540.    1549.
   PER Q=      .0       .2       .0     96.5      2.9       .4       .0
    AREA=     9.5     92.4      6.2   4323.1    542.4    129.3      2.8
     VEL=      .5       .7       .7      7.6      1.8      1.1       .4
   DEPTH=      .3       .6       .6      7.1      3.6      1.6       .3

 *SECNO 11.000
     11.000      8.26   2449.56      .00       .00   2450.31      .75       .82       .01   2450.50
    34000.0        .0   33816.5    183.5        .0    4858.4    213.4     503.0     114.9   2448.00
        .15       .00      6.96      .86      .000      .030     .080      .000   2441.30    701.45
    .001552      500.      500.     500.         2         0        0       .00    902.16   1603.60


 FLOW DISTRIBUTION FOR SECNO=     11.00          CWSEL=   2449.56

 STA=     701.    1420.    1510.    1604.
   PER Q=    99.5       .4       .1
    AREA=  4858.4    140.4     73.0
     VEL=     7.0      1.0       .6
   DEPTH=     6.8      1.6       .8

 *SECNO 12.000

 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   .68


 3470 ENCROACHMENT STATIONS=      725.0    1730.0  TYPE=      1  TARGET=     -725.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      2452.00 ELREA=      2450.00

     12.000      6.95   2450.45      .00       .00   2451.69     1.24      1.23       .15   2452.00
    34000.0        .0   33959.9     40.1        .0    3798.1     64.1     554.3     124.9   2450.00
        .17       .00      8.94      .63      .000      .030     .080      .000   2443.50    738.11
    .003374      500.      500.     500.         2         0        0       .00    838.60   1576.71
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    13APR98      09:46:05                                                                                  PAGE    11


      SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
      Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
      TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
      SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 FLOW DISTRIBUTION FOR SECNO=     12.00          CWSEL=   2450.45

 STA=     738.    1430.    1500.    1530.    1565.    1577.
   PER Q=    99.9       .1       .0       .0       .0
    AREA=  3798.1     31.3     13.4     15.6      3.7
     VEL=     8.9       .6       .6       .6       .5
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 DEPTH=      5.5        .4        .4        .4        .3

*SECNO 13.000

3470 ENCROACHMENT STATIONS=      810.0     1850.0  TYPE=      1  TARGET=     -810.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      2454.00 ELREA=      2450.00

    13.000      8.01   2452.01       .00       .00   2453.54      1.53      1.77       .09   2454.00
   34000.0        .0   33792.2     207.8        .0    3391.8     182.2     597.0     133.9   2450.00
       .18       .00      9.96      1.14      .000      .030      .080      .000   2444.00    814.97
   .003714      500.      500.      500.         2         0         0       .00    745.81   1560.78


FLOW DISTRIBUTION FOR SECNO=      13.00          CWSEL=   2452.01

STA=      815.     1380.     1560.
  PER Q=      99.4        .6
   AREA=    3391.8     182.2
    VEL=      10.0       1.1
  DEPTH=       6.0       1.0

*SECNO 14.000

3301 HV CHANGED MORE THAN HVINS


3470 ENCROACHMENT STATIONS=      690.0     1800.0  TYPE=      1  TARGET=     -690.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      2460.00 ELREA=      2454.00

    14.000      7.10   2453.60       .00       .00   2456.02      2.42      2.21       .27   2460.00
   34000.0        .0   34000.0        .0        .0    2722.7        .0     631.1     140.5   2454.00
       .19       .00     12.49       .00      .000      .030      .000      .000   2446.50    732.00
   .005678      420.      470.      520.         2         0         0       .00    441.99   1173.99
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST

FLOW DISTRIBUTION FOR SECNO=      14.00          CWSEL=   2453.60

STA=      732.     1175.
  PER Q=     100.0
   AREA=    2722.7
    VEL=      12.5
  DEPTH=       6.2

*SECNO 15.000

3470 ENCROACHMENT STATIONS=      590.0     1490.0  TYPE=      1  TARGET=     -590.000
    15.000      8.16   2456.16   2455.58       .00   2458.67      2.50      2.62       .02   2456.00
   34000.0       3.7   33285.3     711.0       7.4    2594.3     351.3     663.6     146.4   2454.00
       .20       .50     12.83      2.02      .060      .030      .080      .000   2448.00    750.11
   .004874      500.      500.      500.         4         8         0       .00    600.05   1350.16


FLOW DISTRIBUTION FOR SECNO=      15.00          CWSEL=   2456.16

STA=      750.      800.     1160.     1290.     1350.
  PER Q=        .0      97.9       1.8        .3
   AREA=       7.4    2594.3     281.4      69.9
    VEL=        .5      12.8       2.2       1.4
  DEPTH=        .1       7.2       2.2       1.2

*SECNO 16.000

3301 HV CHANGED MORE THAN HVINS


3470 ENCROACHMENT STATIONS=      900.0     1920.0  TYPE=      1  TARGET=     -900.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      2460.00 ELREA=      2456.00

    16.000      8.44   2458.44   2458.28       .00   2461.70      3.26      2.80       .23   2460.00
   34000.0        .0   33448.6     551.4        .0    2289.2     214.7     696.0     152.3   2456.00
       .21       .00     14.61      2.57      .000      .030      .080      .000   2450.00    901.73
   .005987      550.      520.      480.         4         5         0       .00    394.36   1296.10
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      SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
      Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
      TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
      SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST

 FLOW DISTRIBUTION FOR SECNO=     16.00         CWSEL=   2458.44

 STA=      902.     1205.     1290.     1296.
   PER Q=     98.4       1.6        .0
    AREA=   2289.2     207.3       7.4
     VEL=     14.6       2.6       1.6
   DEPTH=      7.5       2.4       1.2

 *SECNO 16.500

 3470 ENCROACHMENT STATIONS=       870.0    1190.0  TYPE=       1  TARGET=      -870.000
     16.500        8.15   2460.15   2460.09       .00   2463.70      3.56      1.92       .09   2462.50
    34000.0          .0   34000.0        .0        .0    2247.0        .0     712.3     154.7 100000.00
        .22         .00     15.13       .00      .000      .030      .000      .000   2452.00    877.24
    .006794        300.      300.      300.         4         8         0       .00    308.91   1186.15

 FLOW DISTRIBUTION FOR SECNO=     16.50         CWSEL=   2460.15

 STA=      877.     1190.
   PER Q=    100.0
    AREA=   2247.0
     VEL=     15.1
   DEPTH=      7.3

 *SECNO 17.000

 3301 HV CHANGED MORE THAN HVINS


 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.42


 3470 ENCROACHMENT STATIONS=       830.0    1190.0  TYPE=       1  TARGET=      -830.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      2466.00 ELREA=     100000.00

     17.000        9.71   2462.51       .00       .00   2464.74      2.23       .90       .13   2466.00
    34000.0          .0   34000.0        .0        .0    2838.2        .0     724.0     156.1 100000.00
        .22         .00     11.98       .00      .000      .030      .000      .000   2452.80    855.74
    .003374        200.      200.      200.         4         0         0       .00    327.28   1183.02
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      SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
      Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
      TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
      SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST

 FLOW DISTRIBUTION FOR SECNO=     17.00         CWSEL=   2462.51

 STA=      856.     1190.
   PER Q=    100.0
    AREA=   2838.2
     VEL=     12.0
   DEPTH=      8.7

 *SECNO 18.000

 3470 ENCROACHMENT STATIONS=       845.0    1185.0  TYPE=       1  TARGET=      -845.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      2468.00 ELREA=     100000.00

     18.000        9.25   2464.15       .00       .00   2466.84      2.70      1.96       .14   2468.00
    34000.0          .0   34000.0        .0        .0    2579.8        .0     755.1     159.9 100000.00
        .23         .00     13.18       .00      .000      .030      .000      .000   2454.90    856.42
    .004482        500.      500.      500.         3         0         0       .00    321.26   1177.68

 FLOW DISTRIBUTION FOR SECNO=     18.00         CWSEL=   2464.15

 STA=      856.     1185.
   PER Q=    100.0
    AREA=   2579.8
     VEL=     13.2
   DEPTH=      8.0

 *SECNO 19.000

 3301 HV CHANGED MORE THAN HVINS
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      19.000       9.71    2466.71       .00        .00   2468.65      1.95      1.74       .08   2472.00
     34000.0        .0    34000.0        .0         .0     3036.9        .0     787.3     163.7   2472.00
         .25       .00      11.20       .00       .000      .030      .000      .000   2457.00    825.12
     .002832       500.      500.      500.          3         0         0       .00    343.54   1168.66

 FLOW DISTRIBUTION FOR SECNO=      19.00          CWSEL=   2466.71
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      SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
      Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
      TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
      SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 STA=      825.    1180.
   PER Q=     100.0
    AREA=    3036.9
     VEL=      11.2
   DEPTH=       8.8

 *SECNO 20.000

 3470 ENCROACHMENT STATIONS=      810.0     1690.0   TYPE=       1   TARGET=      -810.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      2472.00 ELREA=      2470.00

      20.000       9.08    2468.08       .00        .00   2470.22      2.15      1.51       .06   2472.00
     34000.0        .0    34000.0        .0         .0     2891.9        .0     821.3     167.6   2470.00
         .26       .00      11.76       .00       .000      .030      .000      .000   2459.00    826.55
     .003210       500.      500.      500.          2         0         0       .00    331.53   1158.07


 FLOW DISTRIBUTION FOR SECNO=      20.00          CWSEL=   2468.08

 STA=      827.    1160.
   PER Q=     100.0
    AREA=    2891.9
     VEL=      11.8
   DEPTH=       8.7

 *SECNO 21.000

 3470 ENCROACHMENT STATIONS=      820.0     1280.0   TYPE=       1   TARGET=      -820.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      2472.00 ELREA=      2472.00

      21.000       9.64    2469.64       .00        .00   2471.88      2.23      1.63       .03   2472.00
     34000.0        .0    34000.0        .0         .0     2834.4        .0     854.2     171.3   2472.00
         .27       .00      12.00       .00       .000      .030      .000      .000   2460.00    840.71
     .003295       500.      500.      500.          2         0         0       .00    323.14   1163.85


 FLOW DISTRIBUTION FOR SECNO=      21.00          CWSEL=   2469.64
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      SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
      Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
      TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
      SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 STA=      841.    1170.
   PER Q=     100.0
    AREA=    2834.4
     VEL=      12.0
   DEPTH=       8.8

 *SECNO 22.000

 3301 HV CHANGED MORE THAN HVINS


 3470 ENCROACHMENT STATIONS=      825.0     1310.0   TYPE=       1   TARGET=      -825.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      2476.00 ELREA=      2476.00

      22.000      10.55    2471.55       .00        .00   2473.20      1.65      1.27       .06   2476.00
     34000.0        .0    34000.0        .0         .0     3293.8        .0     889.4     175.0   2476.00
         .28       .00      10.32       .00       .000      .030      .000      .000   2461.00    836.36
     .002055       500.      500.      500.          2         0         0       .00    327.70   1164.06


 FLOW DISTRIBUTION FOR SECNO=      22.00          CWSEL=   2471.55
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 STA=      836.    1180.
   PER Q=    100.0
    AREA=   3293.8
     VEL=     10.3
   DEPTH=     10.1

 *SECNO 23.000
     23.000       9.98   2471.98        .00        .00   2473.69       1.70        .47        .02   2470.00
    34000.0        7.7   33986.1        6.2        6.9    3242.8        7.3      905.9      176.8   2470.00
        .29       1.13     10.48        .85       .060      .030       .080       .000    2462.00    818.08
    .002211       220.      220.       220.          2         0          0        .00     349.34   1167.42

 FLOW DISTRIBUTION FOR SECNO=      23.00          CWSEL=    2471.98

 STA=      818.      825.     1160.     1167.
   PER Q=        .0     100.0        .0
    AREA=       6.9    3242.8       7.3
     VEL=       1.1      10.5        .8
   DEPTH=       1.0       9.7       1.0
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     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 *SECNO 23.100
     23.100      10.05   2472.05        .00        .00   2473.73       1.68        .04        .00   2470.00
    34000.0        8.4   33984.8        6.8        7.4    3267.7        7.9      907.4      176.9   2470.00
        .29       1.14     10.40        .86       .060      .030       .080       .000    2462.00    817.82
    .002156        20.       20.        20.          2         0          0        .00     349.88   1167.70

 FLOW DISTRIBUTION FOR SECNO=      23.10          CWSEL=    2472.05

 STA=      818.      825.     1160.     1168.
   PER Q=        .0     100.0        .0
    AREA=       7.4    3267.7       7.9
     VEL=       1.1      10.4        .9
   DEPTH=       1.0       9.8       1.0


 SPECIAL BRIDGE

 SB  XK         XKOR       COFQ       RDLEN      BWC        BWP        BAREA      SS         ELCHU      ELCHD
      1.25       1.60       2.60     400.00     315.00      24.00    5693.00       1.00    2462.50    2462.00

 *SECNO 23.200
 CLASS A LOW FLOW

 3420 BRIDGE W.S.=     2471.79 BRIDGE VELOCITY=       11.86     CALCULATED CHANNEL AREA=        2788.

   EGPRS      EGLWC        H3       QWEIR       QLOW       BAREA     TRAPEZOID       ELLC       ELTRD      WEIRLN
                                                                       AREA
        .00    2474.42       .72         0.     34000.      5693.      5693.     2480.90    2486.97          0.


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=       2478.00 ELREA=        2472.00

     23.200      10.28   2472.78        .00        .00   2474.42       1.64        .69        .00   2478.00
    34000.0         .0   33999.3         .7         .0    3304.1        1.5      916.5      177.9   2472.00
        .29        .00     10.29        .46       .000      .030       .080       .000    2462.50    810.45
    .002191       120.      120.       120.          0         0          0        .00     353.43   1163.88

 FLOW DISTRIBUTION FOR SECNO=      23.20          CWSEL=    2472.78

 STA=      810.     1160.     1164.
   PER Q=    100.0        .0
    AREA=   3304.1       1.5
     VEL=     10.3        .5
   DEPTH=      9.5        .4
```



```
     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 *SECNO 24.000
```

24.000	10.35	2472.85	.00	.00	2474.47	1.62	.04	.00	2478.00
34000.0	.0	33999.1	.9	.0	3328.5	1.8	918.0	178.0	2472.00
.29	.00	10.21	.48	.000	.030	.080	.000	2462.50	810.31
.002139	20.	20.	20.	2	0	0	.00	353.92	1164.23

FLOW DISTRIBUTION FOR SECNO= 24.00 CWSEL= 2472.85

```
STA=      810.    1160.    1164.
  PER Q=    100.0        .0
   AREA=   3328.5       1.8
    VEL=     10.2        .5
  DEPTH=      9.5        .4
```

*SECNO 25.000

25.000	9.81	2473.81	.00	.00	2475.92	2.11	1.31	.15	2476.00
34000.0	.0	34000.0	.0	.0	2916.3	.0	953.9	182.0	2478.00
.30	.00	11.66	.00	.000	.030	.000	.000	2464.00	832.19
.003109	500.	500.	500.	2	0	0	.00	330.84	1163.02

FLOW DISTRIBUTION FOR SECNO= 25.00 CWSEL= 2473.81

```
STA=      832.    1170.
  PER Q=    100.0
   AREA=   2916.3
    VEL=     11.7
  DEPTH=      8.8
```

*SECNO 26.000

26.000	9.85	2475.35	.00	.00	2477.76	2.41	1.75	.09	2480.00
34000.0	.0	34000.0	.0	.0	2727.1	.0	986.3	185.8	2480.00
.32	.00	12.47	.00	.000	.030	.000	.000	2465.50	827.75
.003924	500.	500.	500.	2	0	0	.00	334.50	1162.25

FLOW DISTRIBUTION FOR SECNO= 26.00 CWSEL= 2475.35

```
STA=      828.    1170.
  PER Q=    100.0
   AREA=   2727.1
    VEL=     12.5
  DEPTH=      8.2
```

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SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 27.000

3301 HV CHANGED MORE THAN HVINS

27.000	9.74	2477.14	.00	.00	2480.17	3.03	2.23	.18	2480.00
34000.0	.0	34000.0	.0	.0	2434.2	.0	1015.9	189.5	2482.00
.33	.00	13.97	.00	.000	.030	.000	.000	2467.40	859.03
.005054	500.	500.	500.	2	0	0	.00	305.85	1164.89

FLOW DISTRIBUTION FOR SECNO= 27.00 CWSEL= 2477.14

```
STA=      859.    1175.
  PER Q=    100.0
   AREA=   2434.2
    VEL=     14.0
  DEPTH=      8.0
```

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THIS RUN EXECUTED 13APR98 09:46:05

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**************************************
 HEC-2 WATER SURFACE PROFILES

 Version   4.6.2;  May 1991
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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

TANQUE VERDE CREEK (CRAY

SUMMARY PRINTOUT

	SECNO	CWSEL	VLOB	VCH	VROB	QLOB	QCH	QROB	DEPTH	TOPWID	SSTA	ENDST
	1.000	2433.20	1.21	10.42	.59	537.52	33454.00	8.48	11.20	604.00	910.00	1514.00
	2.000	2434.18	.81	10.14	.64	267.43	33721.65	10.93	10.18	910.60	820.00	1730.60
	3.000	2435.36	1.50	10.32	1.06	1263.21	32726.19	10.59	8.86	930.17	868.26	1798.44
	4.000	2437.11	1.84	8.83	1.75	3406.67	29584.50	1008.84	9.11	1238.06	702.31	1940.37
	5.000	2438.03	1.89	9.63	1.55	3134.11	29602.14	1263.75	8.53	1472.32	659.00	2131.33
*	6.000	2439.54	1.77	12.31	1.77	654.37	32415.86	929.78	7.54	1104.32	625.99	1730.31
	7.000	2442.57	1.41	11.52	2.40	170.45	30625.61	3203.93	8.57	1089.54	603.16	1692.71
	8.000	2444.56	1.62	13.26	2.11	164.89	32577.15	1257.96	8.56	814.75	682.62	1497.38
*	9.000	2447.64	.47	8.28	1.82	2.92	30970.46	3026.61	9.64	943.84	710.77	1654.61
	10.000	2448.62	.72	7.59	1.67	77.87	32796.89	1125.23	8.62	1040.02	509.21	1549.24
	11.000	2449.56	.00	6.96	.86	.00	33816.54	183.47	8.26	902.16	701.45	1603.60
*	12.000	2450.45	.00	8.94	.63	.00	33959.93	40.07	6.95	838.60	738.11	1576.71
	13.000	2452.01	.00	9.96	1.14	.00	33792.16	207.84	8.01	745.81	814.97	1560.78
	14.000	2453.60	.00	12.49	.00	.00	34000.00	.00	7.10	441.99	732.00	1173.99
	15.000	2456.16	.50	12.83	2.02	3.69	33285.30	711.01	8.16	600.05	750.11	1350.16
	16.000	2458.44	.00	14.61	2.57	.00	33448.59	551.41	8.44	394.36	901.73	1296.10
	16.500	2460.15	.00	15.13	.00	.00	34000.00	.00	8.15	308.91	877.24	1186.15

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	SECNO	CWSEL	VLOB	VCH	VROB	QLOB	QCH	QROB	DEPTH	TOPWID	SSTA	ENDST
*	17.000	2462.51	.00	11.98	.00	.00	34000.00	.00	9.71	327.28	855.74	1183.02
	18.000	2464.15	.00	13.18	.00	.00	34000.00	.00	9.25	321.26	856.42	1177.68
	19.000	2466.71	.00	11.20	.00	.00	34000.00	.00	9.71	343.54	825.12	1168.66
	20.000	2468.08	.00	11.76	.00	.00	34000.00	.00	9.08	331.53	826.55	1158.07
	21.000	2469.64	.00	12.00	.00	.00	34000.00	.00	9.64	323.14	840.71	1163.85
	22.000	2471.55	.00	10.32	.00	.00	34000.00	.00	10.55	327.70	836.36	1164.06
	23.000	2471.98	1.13	10.48	.85	7.72	33986.06	6.22	9.98	349.34	818.08	1167.42
	23.100	2472.05	1.14	10.40	.86	8.40	33984.82	6.78	10.05	349.88	817.82	1167.70
	23.200	2472.78	.00	10.29	.46	.00	33999.31	.69	10.28	353.43	810.45	1163.88
	24.000	2472.85	.00	10.21	.48	.00	33999.15	.85	10.35	353.92	810.31	1164.23
	25.000	2473.81	.00	11.66	.00	.00	34000.00	.00	9.81	330.84	832.19	1163.02
	26.000	2475.35	.00	12.47	.00	.00	34000.00	.00	9.85	334.50	827.75	1162.25
	27.000	2477.14	.00	13.97	.00	.00	34000.00	.00	9.74	305.85	859.03	1164.89

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TANQUE VERDE CREEK (CRAY

SUMMARY PRINTOUT

SECNO	CWSEL	CRIWS	EG	HL	OLOSS	ELMIN	10*KS	K*CHSL	XLCH	SHEAR	FRCH
1.000	2433.20	.00	2434.86	.00	.00	2422.00	19.90	.00	.00	1.29	.57
2.000	2434.18	.00	2435.76	.90	.01	2424.00	20.14	4.44	450.00	1.25	.57
3.000	2435.36	.00	2436.95	1.19	.00	2426.50	27.58	5.00	500.00	1.37	.65
4.000	2437.11	.00	2438.17	1.16	.05	2428.00	20.02	3.00	500.00	1.00	.55

	5.000	2438.03	.00	2439.29	1.06	.06	2429.50	26.70	3.33	450.00	1.22	.63
*	6.000	2439.54	2439.54	2441.79	2.87	-.47	2432.00	57.04	5.00	500.00	2.13	.89
	7.000	2442.57	2442.23	2444.43	2.60	.04	2434.00	47.91	4.00	500.00	1.85	.82
	8.000	2444.56	2444.43	2447.17	2.52	.23	2436.00	53.65	4.00	500.00	2.35	.88
*	9.000	2447.64	.00	2448.62	1.28	.16	2438.00	16.77	4.00	500.00	.87	.51
	10.000	2448.62	.00	2449.48	.85	.01	2440.00	17.29	4.00	500.00	.76	.50
	11.000	2449.56	.00	2450.31	.82	.01	2441.30	15.52	2.60	500.00	.65	.47
*	12.000	2450.45	.00	2451.69	1.23	.15	2443.50	33.74	4.40	500.00	1.16	.67
	13.000	2452.01	.00	2453.54	1.77	.09	2444.00	37.14	1.00	500.00	1.39	.72
	14.000	2453.60	.00	2456.02	2.21	.27	2446.50	56.78	5.32	470.00	2.18	.89
	15.000	2456.16	2455.58	2458.67	2.62	.02	2448.00	48.74	3.00	500.00	2.19	.84
	16.000	2458.44	2458.28	2461.70	2.80	.23	2450.00	59.87	3.85	520.00	2.82	.94
	16.500	2460.15	2460.09	2463.70	1.92	.09	2452.00	67.94	6.67	300.00	3.08	.99
*	17.000	2462.51	.00	2464.74	.90	.13	2452.80	33.74	4.00	200.00	1.83	.72
	18.000	2464.15	.00	2466.84	1.96	.14	2454.90	44.82	4.20	500.00	2.25	.82
	19.000	2466.71	.00	2468.65	1.74	.08	2457.00	28.32	4.20	500.00	1.56	.66
	20.000	2468.08	.00	2470.22	1.51	.06	2459.00	32.10	4.00	500.00	1.75	.70
	21.000	2469.64	.00	2471.88	1.63	.03	2460.00	32.95	2.00	500.00	1.80	.71
	22.000	2471.55	.00	2473.20	1.27	.06	2461.00	20.55	2.00	500.00	1.29	.57
	23.000	2471.98	.00	2473.69	.47	.02	2462.00	22.11	4.55	220.00	1.34	.59

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SECNO	CWSEL	CRIWS	EG	HL	OLOSS	ELMIN	10*KS	K*CHSL	XLCH	SHEAR	FRCH
23.100	2472.05	.00	2473.73	.04	.00	2462.00	21.56	.00	20.00	1.31	.59
23.200	2472.78	.00	2474.42	.69	.00	2462.50	21.91	4.17	120.00	1.29	.59
24.000	2472.85	.00	2474.47	.04	.00	2462.50	21.39	.00	20.00	1.27	.58
25.000	2473.81	.00	2475.92	1.31	.15	2464.00	31.09	3.00	500.00	1.71	.69
26.000	2475.35	.00	2477.76	1.75	.09	2465.50	39.24	3.00	500.00	2.00	.77
27.000	2477.14	.00	2480.17	2.23	.18	2467.40	50.54	3.80	500.00	2.51	.87

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SUMMARY OF ERRORS AND SPECIAL NOTES

CAUTION SECNO= 6.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 6.000 PROFILE= 1 MINIMUM SPECIFIC ENERGY

WARNING SECNO= 9.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 12.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 17.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

APPENDIX D

SCOUR ANALYSIS SUMMARY SHEETS, WITH-PROJECT CONDITIONS

With-Project Conditions

Section Properties			Reach 6				Sabino Rd. Bridge				Reach 5			
Section No.	27	26	25	24	average	23.2	23.1	average	23	22	21	20	19	average
W.S. Elev (ft)	2477.17	2475.37	2473.84	2472.89		2472.82	2472.05		2471.98	2471.55	2469.64	2468.08	2466.71	
E.G. Slope (ft/ft)	0.0050	0.0039	0.0031	0.0021	0.0035	0.0022	0.0022	0.0022	0.0022	0.0021	0.0033	0.0032	0.0028	0.0027
Max Chl Dpth (ft)	9.77	9.87	9.84	10.39	9.97	10.32	10.05	10.19	9.98	10.55	9.64	9.08	9.71	9.79
Min Ch El (ft)	2467.40	2465.50	2464.00	2462.50		2462.50	2462.00		2462.00	2461.00	2460.00	2459.00	2457.00	
Alpha	1.00	1.00	1.00	1.00		1.00	1.01		1.01	1.00	1.00	1.00	1.00	
Frctn Loss (ft)	2.22	1.75	1.30	0.04			0.04		0.47	1.27	1.63	1.51	1.73	
C & E Loss (ft)	0.18	0.09	0.15	0.00			0.00		0.01	0.06	0.03	0.06	0.08	
Main Channel Properties														
Wt. n-Val.	0.030	0.030	0.030	0.030		0.030	0.030		0.030	0.030	0.030	0.030	0.030	
Flow Area (sq ft)	2442	2735	2925	3343	2861	3320	3268	3294	3244	3293	2834	2894	3037	3060
Flow (cfs)	34000	34000	34000	33999	34000	33999	33985	33992	33986	34000	34000	34000	34000	33997
Top Width (ft)	306	335	331	350	330	350	335	342	335	328	323	332	344	332
Avg. Vel. (ft/s)	13.92	12.43	11.62	10.17	12.04	10.24	10.40	10.32	10.48	10.33	12.00	11.75	11.19	11.15
Hydr. Depth (ft)	7.98	8.17	8.84	9.56	8.64	9.49	9.75	9.62	9.68	10.05	8.77	8.73	8.84	9.21
Wetted Per. (ft)	308	339	336	354	334	354	340	347	340	334	327	337	347	337
Shear (lb/sq ft)	2.48	1.96	1.67	1.24	1.84	1.27	1.29	1.28	1.32	1.27	1.78	1.72	1.55	1.53
Stream Power (lb/ft s)	34.47	24.38	19.43	12.66	22.74	12.96	13.46	13.21	13.80	13.07	21.41	20.15	17.32	17.15

Section Properties				Reach 4						Reach 3		
Section No.	18	17	16.5	16	15	14	average	13	12	11	10	average
W.S. Elev (ft)	2464.39	2460.72	2459.60	2458.80	2456.11	2453.65		2451.98	2450.24	2449.46	2448.76	
E.G. Slope (ft/ft)	0.0041	0.0071	0.0066	0.0032	0.0048	0.0054	0.0052	0.0038	0.0038	0.0013	0.0014	0.0026
Max Chl Dpth (ft)	9.49	7.92	7.60	8.80	8.11	7.15	8.18	7.98	6.74	8.16	8.76	7.91
Min Ch El (ft)	2454.90	2452.80	2452.00	2450.00	2448.00	2446.50		2444.00	2443.50	2441.30	2440.00	
Alpha	1.00	1.00	1.06	1.16	1.20	1.00		1.09	1.02	1.08	1.18	
Frctn Loss (ft)	2.59			1.99	2.57	2.18		1.92	1.29	0.66	0.75	
C & E Loss (ft)	0.10			0.06	0.05	0.22		0.08	0.22	0.00	0.04	
Main Channel Properties												
Wt. n-Val.	0.030	0.030	0.030	0.030	0.030	0.030		0.030	0.030	0.030	0.030	
Flow Area (sq ft)	2658	2255	2378	3069	2629	2797	2631	3348	3694	5487	5116	4411
Flow (cfs)	34000	34000	33726	33403	33326	34000	33742	33799	33985	33792	32921	33624
Top Width (ft)	322	323	356	395	370	459	371	560	710	860	770	725
Avg. Vel. (ft/s)	12.79	15.08	14.18	10.88	12.67	12.16	12.96	10.10	9.20	6.16	6.44	7.98
Hydr. Depth (ft)	8.26	6.99	6.69	7.77	7.11	6.10	7.15	5.98	5.20	6.38	6.64	6.05
Wetted Per. (ft)	327	328	359	398	373	461	374	560	712	861	771	726
Shear (lb/sq ft)	2.07	3.04	2.72	1.53	2.13	2.06	2.26	1.43	1.24	0.52	0.56	0.94
Stream Power (lb/ft s)	26.47	45.86	38.64	16.61	27.01	25.05	29.94	14.43	11.44	3.21	3.61	8.17

Section Properties

	Reach 2						Reach 1				
Section No.	9	8	7	6	5	average	4	3	2	1	average
W.S. Elev (ft)	2447.61	2444.69	2442.26	2439.68	2438.54		2437.85	2437.17	2434.04	2433.20	
E.G. Slope (ft/ft)	0.0017	0.0050	0.0058	0.0045	0.0021	0.0038	0.0015	0.0012	0.0039	0.0025	0.0023
Max Chl Dpth (ft)	9.61	8.69	8.26	7.68	9.04	8.66	9.85	10.67	10.04	11.20	10.44
Min Ch El (ft)	2438.00	2436.00	2434.00	2432.00	2429.50		2428.00	2426.50	2424.00	2422.00	
Alpha	1.59	1.48	1.71	1.71	2.26		2.03	1.71	1.38	1.29	
Frctn Loss (ft)	1.26	2.67		1.66	0.81		0.68	0.93	1.44		
C & E Loss (ft)	0.15	0.10		0.22	0.05		0.00	0.20	0.26		
Main Channel Properties											
Wt. n-Val.	0.030	0.030	0.030	0.030	0.030		0.030	0.030	0.030	0.030	
Flow Area (sq ft)	3732	2505	2528	2726	3255	2949	3654	4048	2394	2908	3251
Flow (cfs)	30984	32450	31024	30568	28731	30752	29300	31386	32997	33319	31750
Top Width (ft)	450	350	430	440	420	418	420	430	255	290	349
Avg. Vel. (ft/s)	8.30	12.96	12.27	11.21	8.83	10.71	8.02	7.75	13.78	11.46	10.25
Hydr. Depth (ft)	8.29	7.16	5.88	6.20	7.75	7.06	8.70	9.41	9.39	10.03	9.38
Wetted Per. (ft)	453	352	432	440	421	420	422	431	256	292	350
Shear (lb/sq ft)	0.87	2.22	2.13	1.74	1.00	1.59	0.80	0.72	2.29	1.55	1.34
Stream Power (lb/ft s)	7.21	28.77	26.10	19.53	8.85	18.09	6.38	5.62	31.62	17.79	15.35

SCOUR CALCULATIONS

Tanque Verde Creek Bank Protection and Riparian Preserve Project - Reach 1 (w/ Project)

HYDRAULIC PARAMETERS

Qmc, main channel discharge [1] =	32371	cfs
Se or So, energy/bed slope [2] =	0.0022	ft/ft
Yh, hydraulic depth =	9.05	ft.
Ym, maximum flow depth =	9.84	ft.
Vmc, main channel velocity =	9.93	fps
TW, top width of flow =	366.00	ft.
Amc, main channel flow area =	3259.92	sq. ft.
qmc, main channel unit discharge (mc) =	97.71	cfs/ft

note: [1] the discharge in the main channel (Qmc) and its hydraulic parameters are used if Qmc is less than the design discharge, otherwise the design discharge and its parameters are used.

[2] the bed slope (So) is used under uniform-flow conditions and the energy slope (Se) is used when the hydraulic parameters are obtained from a HEC-2 analysis.

GENERAL-SCOUR DEPTH

[Ys1 = Ym*(((0.0685*Vmc^0.8)/(Yh^0.4*So^0.3))-1), Reference 5]

for:	Se or So =	0.0022	ft/ft
	Yh =	9.05	ft.
	Ym =	9.84	ft.
	Vmc =	9.93	fps

Ys1, general-scour depth =		1.1465	ft.

BED-FORM OR ANTIDUNE-SCOUR DEPTH

[Ys2 = 0.0137*Vmc^2, Reference 5]

for:	Vmc =	9.93	fps

Ys2, bedform or antidune-scour depth =		1.3489	ft.

BEND-SCOUR DEPTH

(computation of depth as a function of the impingement angle)

[Ys3 = (0.0685*Ym*Vmc^0.8*(2.1*((sin^2(Ai/2)/cos(Ai))^0.2)-1))/(Yh^0.4*So^0.3), Reference 5]

impingement angle =	0.00	degrees
Rc, radius of curvature =	straight reach	ft.
TW, top width of flow =	366.00	ft.
Rc/TW =	n/c	
Se or So, energy/bed slope [1] =	0.0022	ft/ft
Yh, hydraulic depth =	9.05	ft.
Ym, maximum flow depth =	9.84	ft.
Vmc, main channel velocity =	9.93	fps

Ys3, bend-scour depth =	0.0000	ft.

Note: The computations are limited to an Rc/TW ratio that is > 0.5, but < 10.21.
(that is, 0.5 < Rc/Tw < 10.21)

SCOUR CALCULATIONS

Tanque Verde Creek Bank Protection and Riparian Preserve Project - Reach 1 (w/ Project)

LOCAL-SCOUR DEPTH FOR BRIDGE PIERS AND SIMILAR OBSTRUCTIONS

[scour depth using CSU's equation, Ys = Y1*(2.0*K1*K2*(a/Y1)^0.65*Fr^0.43) , Reference 7]

Y1, maximum flow depth =	9.84	ft.
Fr, froude no. =	0.58	
a, width of obstruction =	9.00	ft.
K1, pier shape coefficient or correction factor =	1.10	
K2, correction factor for angle of attack =	1.00	
composite coefficient (2.0*K1*K2) =	2.20	

Ys, local-scour depth =	16.18	ft.

Pier Nose Shape	Coefficient (K1)
square nose	1.1
round nose	1.0
cylinder	1.0
sharp nose	0.9
group of cylinders	1.0

Angle of Attack (degrees)	Pier Length/Width Ratio (K2)		
	L/a = 4	L/a = 8	L/a = 12
0	1.0	1.0	1.0
15	1.5	2.0	2.5
30	2.0	2.75	3.5
45	2.3	3.3	4.3
90	2.5	3.9	5.0

Comments

a) If the obstruction width includes debris accumulation, use a pier shape coefficient (K1) of 1.1; otherwise use the appropriate coefficient listed above.

b) CSU's equation, as outlined above, was obtained from HEC-18. It is the same procedure used by ADWR and the City of Tucson. However, the ADWR and COT procedures are approached in a slightly different manner. A composite coefficient of 2.2 is the default condition. Reduction factors are then applied to adjust for different pier nose shapes. This table is provided below.

Pier Nose Shape	Reduction Factor
square nose	1.0
round nose	0.9
cylinder	0.9
sharp nose	0.8
group of cylinders	0.9

c) HEC-18 makes use of a third correction coefficient to account for variations in bed form and sediment transport. The associated factors are listed below. The computed scour depth obtained using this third correction factor is also provided.

Bed Condition	Dune Height, H (ft)	Coefficient (K3)
clear-water scour	n/a	1.1
plane bed and antidune flow	n/a	1.1
small dunes	10 > H < 2	1.1
medium dunes	30 > H > 10	1.1 to 1.2
large dunes	H > 30	1.3

K3, correction factor for bed condition =	1.10	
composite coefficient (2.0*K1*K2*K3) =	2.42	

Ys, local-scour depth =	17.80	ft.

SCOUR CALCULATIONS

Tanque Verde Creek Bank Protection and Riparian Preserve Project - Reach 2 (w/ Project)

HYDRAULIC PARAMETERS

Qmc, main channel discharge [1] =	31234	cfs
Se or So, energy/bed slope [2] =	0.0040	ft/ft
Yh, hydraulic depth =	6.97	ft.
Ym, maximum flow depth =	8.57	ft.
Vmc, main channel velocity =	10.99	fps
TW, top width of flow =	420.00	ft.
Amc, main channel flow area =	2842.04	sq. ft.
qmc, main channel unit discharge (mc) =	94.18	cfs/ft

note: [1] the discharge in the main channel (Qmc) and its hydraulic parameters are used if Qmc is less than the design discharge, otherwise the design discharge and its parameters are used.

[2] the bed slope (So) is used under uniform-flow conditions and the energy slope (Se) is used when the hydraulic parameters are obtained from a HEC-2 analysis.

GENERAL-SCOUR DEPTH

[Ys1 = Ym*(((0.0685*Vmc^0.8)/(Yh^0.4*So^0.3))-1), Reference 5]

for:	Se or So =	0.0040	ft/ft
	Yh =	6.97	ft.
	Ym =	8.57	ft.
	Vmc =	10.99	fps

	Ys1, general-scour depth =	1.0585	ft.

BED-FORM OR ANTIDUNE-SCOUR DEPTH

[Ys2 = 0.0137*Vmc^2, Reference 5]

for:	Vmc =	10.99	fps

	Ys2, bedform or antidune-scour depth =	1.6522	ft.

BEND-SCOUR DEPTH

(computation of depth as a function of the impingement angle)

[Ys3 = (0.0685*Ym*Vmc^0.8*(2.1*((sin^2(Ai/2)/cos(Ai))^0.2)-1))/(Yh^0.4*So^0.3), Reference 5]

impingement angle =	35.00	degrees
Rc, radius of curvature =	951.20	ft.
TW, top width of flow =	420.00	ft.
Rc/TW =	2.26	
Se or So, energy/bed slope [1] =	0.0040	ft/ft
Yh, hydraulic depth =	6.97	ft.
Ym, maximum flow depth =	8.57	ft.
Vmc, main channel velocity =	10.99	fps

Ys3, bend-scour depth =	3.3840	ft.

Note: The computations are limited to an Rc/TW ratio that is > 0.5, but < 10.21.
(that is, 0.5 < Rc/Tw < 10.21)

SCOUR CALCULATIONS

Tanque Verde Creek Bank Protection and Riparian Preserve Project - Reach 3 (w/ Project)

HYDRAULIC PARAMETERS

Qmc, main channel discharge [1] =	33592	cfs
Se or So, energy/bed slope [2] =	0.0026	ft/ft
Yh, hydraulic depth =	6.34	ft.
Ym, maximum flow depth =	7.96	ft.
Vmc, main channel velocity =	8.36	fps
TW, top width of flow =	646.00	ft.
Amc, main channel flow area =	4018.18	sq. ft.
qmc, main channel unit discharge (mc) =	66.55	cfs/ft

note: [1] the discharge in the main channel (Qmc) and its hydraulic parameters are used if Qmc is less than the design discharge, otherwise the design discharge and its parameters are used.

[2] the bed slope (So) is used under uniform-flow conditions and the energy slope (Se) is used when the hydraulic parameters are obtained from a HEC-2 analysis.

GENERAL-SCOUR DEPTH

[Ys1 = Ym*(((0.0685*Vmc^0.8)/(Yh^0.4*So^0.3))-1), Reference 5]

for:	Se or So =	0.0026	ft/ft
	Yh =	6.34	ft.
	Ym =	7.96	ft.
	Vmc =	8.36	fps

	Ys1, general-scour depth =	0.5326	ft.

BED-FORM OR ANTIDUNE-SCOUR DEPTH

[Ys2 = 0.0137*Vmc^2, Reference 5]

for:	Vmc =	8.36	fps

	Ys2, bedform or antidune-scour depth =	0.9560	ft.

BEND-SCOUR DEPTH

(computation of depth as a function of the impingement angle)

[Ys3 = (0.0685*Ym*Vmc^0.8*(2.1*((sin^2(Ai/2)/cos(Ai))^0.2)-1))/(Yh^0.4*So^0.3), Reference 5]

impingement angle =	27.00	degrees
Rc, radius of curvature =	2640.48	ft.
TW, top width of flow =	646.00	ft.
Rc/TW =	4.09	
Se or So, energy/bed slope [1] =	0.0026	ft/ft
Yh, hydraulic depth =	6.34	ft.
Ym, maximum flow depth =	7.96	ft.
Vmc, main channel velocity =	8.36	fps

Ys3, bend-scour depth =	1.7064	ft.

Note: The computations are limited to an Rc/TW ratio that is > 0.5, but < 10.21.
(that is, 0.5 < Rc/Tw < 10.21)

SCOUR CALCULATIONS

Tanque Verde Creek Bank Protection and Riparian Preserve Project - Reach 4 (w/ Project)

HYDRAULIC PARAMETERS

Qmc, main channel discharge [1] =	33788	cfs
Se or So, energy/bed slope [2] =	0.0052	ft/ft
Yh, hydraulic depth =	7.49	ft.
Ym, maximum flow depth =	8.47	ft.
Vmc, main channel velocity =	13.37	fps
TW, top width of flow =	344.00	ft.
Amc, main channel flow area =	2527.15	sq. ft.
qmc, main channel unit discharge (mc) =	113.24	cfs/ft

note: [1] the discharge in the main channel (Qmc) and its hydraulic parameters are used if Qmc is less than the design discharge, otherwise the design discharge and its parameters are used.

[2] the bed slope (So) is used under uniform-flow conditions and the energy slope (Se) is used when the hydraulic parameters are obtained from a HEC-2 analysis.

GENERAL-SCOUR DEPTH

[Ys1 = Ym*(((0.0685*Vmc^0.8)/(Yh^0.4*So^0.3))-1), Reference 5]

for:	Se or So =	0.0052	ft/ft
	Yh =	7.49	ft.
	Ym =	8.47	ft.
	Vmc =	13.37	fps

	Ys1, general-scour depth =	1.5274	ft.

BED-FORM OR ANTIDUNE-SCOUR DEPTH

[Ys2 = 0.0137*Vmc^2, Reference 5]

for:	Vmc =	13.37	fps

	Ys2, bedform or antidune-scour depth =	2.4453	ft.

BEND-SCOUR DEPTH

(computation of depth as a function of the impingement angle)

[Ys3 = (0.0685*Ym*Vmc^0.8*(2.1*((sin^2(Ai/2)/cos(Ai))^0.2)-1))/(Yh^0.4*So^0.3), Reference 5]

impingement angle =	27.00	degrees
Rc, radius of curvature =	1406.08	ft.
TW, top width of flow =	344.00	ft.
Rc/TW =	4.09	
Se or So, energy/bed slope [1] =	0.0052	ft/ft
Yh, hydraulic depth =	7.49	ft.
Ym, maximum flow depth =	8.47	ft.
Vmc, main channel velocity =	13.37	fps

Ys3, bend-scour depth =	2.0088	ft.

Note: The computations are limited to an Rc/TW ratio that is > 0.5, but < 10.21.
(that is, 0.5 < Rc/Tw < 10.21)

SCOUR CALCULATIONS

Tanque Verde Creek Bank Protection and Riparian Preserve Project - Reach 5 (w/ Project)

HYDRAULIC PARAMETERS

Qmc, main channel discharge [1] =	33997	cfs
Se or So, energy/bed slope [2] =	0.0027	ft/ft
Yh, hydraulic depth =	9.21	ft.
Ym, maximum flow depth =	9.79	ft.
Vmc, main channel velocity =	11.15	fps
TW, top width of flow =	332.00	ft.
Amc, main channel flow area =	3049.06	sq. ft.
qmc, main channel unit discharge (mc) =	109.16	cfs/ft

note: [1] the discharge in the main channel (Qmc) and its hydraulic parameters are used if Qmc is less than the design discharge, otherwise the design discharge and its parameters are used.

[2] the bed slope (So) is used under uniform-flow conditions and the energy slope (Se) is used when the hydraulic parameters are obtained from a HEC-2 analysis.

GENERAL-SCOUR DEPTH

[Ys1 = Ym*(((0.0685*Vmc^0.8)/(Yh^0.4*So^0.3))-1), Reference 5]

for:	Se or So =	0.0027	ft/ft
	Yh =	9.21	ft.
	Ym =	9.79	ft.
	Vmc =	11.15	fps

Ys1, general-scour depth =		1.4090	ft.

BED-FORM OR ANTIDUNE-SCOUR DEPTH

[Ys2 = 0.0137*Vmc^2, Reference 5]

for:	Vmc =	11.15	fps

Ys2, bedform or antidune-scour depth =		1.7007	ft.

BEND-SCOUR DEPTH

(computation of depth as a function of the impingement angle)

[Ys3 = (0.0685*Ym*Vmc^0.8*(2.1*((sin^2(Ai/2)/cos(Ai))^0.2)-1))/(Yh^0.4*So^0.3), Reference 5]

impingement angle =	17.00	degrees
Rc, radius of curvature =	straight reach	ft.
TW, top width of flow =	332.00	ft.
Rc/TW =	n/c	
Se or So, energy/bed slope [1] =	0.0027	ft/ft
Yh, hydraulic depth =	9.21	ft.
Ym, maximum flow depth =	9.79	ft.
Vmc, main channel velocity =	11.15	fps

Ys3, bend-scour depth =	0.0000	ft.

Note: The computations are limited to an Rc/TW ratio that is > 0.5, but < 10.21.
(that is, 0.5 < Rc/Tw < 10.21)

SCOUR CALCULATIONS

Tanque Verde Creek Bank Protection and Riparian Preserve Project - Reach 6 (w/ Project)

HYDRAULIC PARAMETERS

Qmc, main channel discharge [1] =	34000	cfs
Se or So, energy/bed slope [2] =	0.0035	ft/ft
Yh, hydraulic depth =	8.64	ft.
Ym, maximum flow depth =	9.97	ft.
Vmc, main channel velocity =	12.04	fps
TW, top width of flow =	330.00	ft.
Amc, main channel flow area =	2823.92	sq. ft.
qmc, main channel unit discharge (mc) =	120.04	cfs/ft

note: [1] the discharge in the main channel (Qmc) and its hydraulic parameters are used if Qmc is less than the design discharge, otherwise the design discharge and its parameters are used.

[2] the bed slope (So) is used under uniform-flow conditions and the energy slope (Se) is used when the hydraulic parameters are obtained from a HEC-2 analysis.

GENERAL-SCOUR DEPTH

[Ys1 = Ym*(((0.0685*Vmc^0.8)/(Yh^0.4*So^0.3))-1), Reference 5]

for:	Se or So =	0.0035	ft/ft
	Yh =	8.64	ft.
	Ym =	9.97	ft.
	Vmc =	12.04	fps

	Ys1, general-scour depth =	1.5396	ft.

BED-FORM OR ANTIDUNE-SCOUR DEPTH

[Ys2 = 0.0137*Vmc^2, Reference 5]

for:	Vmc =	12.04	fps

	Ys2, bedform or antidune-scour depth =	1.9830	ft.

BEND-SCOUR DEPTH

(computation of depth as a function of the impingement angle)

[Ys3 = (0.0685*Ym*Vmc^0.8*(2.1*((sin^2(Ai/2)/cos(Ai))^0.2)-1))/(Yh^0.4*So^0.3), Reference 5]

impingement angle =	17.00	degrees
Rc, radius of curvature =	straight reach	ft.
TW, top width of flow =	330.00	ft.
Rc/TW =	n/c	
Se or So, energy/bed slope [1] =	0.0035	ft/ft
Yh, hydraulic depth =	8.64	ft.
Ym, maximum flow depth =	9.97	ft.
Vmc, main channel velocity =	12.04	fps

Ys3, bend-scour depth =	0.0000	ft.

Note: The computations are limited to an Rc/TW ratio that is > 0.5, but < 10.21.
(that is, 0.5 < Rc/Tw < 10.21)

LOCAL-SCOUR DEPTH FOR BRIDGE PIERS AND SIMILAR OBSTRUCTIONS

[scour depth using CSU's equation, Ys = Y1*(2.0*K1*K2*(a/Y1)^0.65*Fr^0.43) , Reference 7]

Y1, maximum flow depth =	9.97	ft.
Fr, froude no. =	0.72	
a, width of obstruction =	8.00	ft.
K1, pier shape coefficient or correction factor =	1.10	
K2, correction factor for angle of attack =	1.00	
composite coefficient (2.0*K1*K2) =	2.20	

Ys, local-scour depth =	16.52	ft.

Pier Nose Shape	Coefficient (K1)
square nose	1.1
round nose	1.0
cylinder	1.0
sharp nose	0.9
group of cylinders	1.0

Angle of Attack (degrees)	Pier Length/Width Ratio (K2)		
	L/a = 4	L/a = 8	L/a = 12
0	1.0	1.0	1.0
15	1.5	2.0	2.5
30	2.0	2.75	3.5
45	2.3	3.3	4.3
90	2.5	3.9	5.0

<u>Comments</u>

a) If the obstruction width includes debris accumulation, use a pier shape coefficient (K1) of 1.1; otherwise use the appropriate coefficient listed above.

b) CSU's equation, as outlined above, was obtained from HEC-18. It is the same procedure used by ADWR and the City of Tucson. However, the ADWR and COT procedures are approached in a slightly different manner. A composite coefficient of 2.2 is the default condition. Reduction factors are then applied to adjust for different pier nose shapes. This table is provided below.

Pier Nose Shape	Reduction Factor
square nose	1.0
round nose	0.9
cylinder	0.9
sharp nose	0.8
group of cylinders	0.9

c) HEC-18 makes use of a third correction coefficient to account for variations in bed form and sediment transport. The associated factors are listed below. The computed scour depth obtained using this third correction factor is also provided.

Bed Condition	Dune Height, H (ft)	Coefficient (K3)
clear-water scour	n/a	1.1
plane bed and antidune flow	n/a	1.1
small dunes	10 > H < 2	1.1
medium dunes	30 > H > 10	1.1 to 1.2
large dunes	H > 30	1.3

K3, correction factor for bed condition =	1.10	
composite coefficient (2.0*K1*K2*K3) =	2.42	

Ys, local-scour depth =	18.18	ft.