ELECTRONIC COPY OF FINAL DOCUMENT
ORIGINAL SEALED DOCUMENT WITH
ROBERT L. SHAND, P.E. (CIVIL), NO. 24026

# FLOODPLAIN STUDY
# FOR
# FLECHA CAIDA RANCH ESTATES # 9

## INCLUDING PORTIONS OF
## FLECHA CAIDA RANCH ESTATES #1 AND #2
## AND
## LAS LOMAS DE CATALINA

**SECTIONS 15 & 22, TOWNSHIP 13 SOUTH, RANGE 14 EAST**
**PIMA COUNTY, ARIZONA**

Prepared for:

Pima County Regional Flood Control District
97 E. Congress Street, 3rd Floor
Tucson, Arizona 85701
520-791-4724

By:

JE Fuller Hydrology & Geomorphology Inc.
40 East Helen Street
Tucson, Arizona 85705
520-623-3112

Registered Professional Engineer (Civil)
CERTIFICATE NO. 24026
ROBERT L. SHAND
Date Signed 4-8-08
ARIZONA U.S.A.

January 8, 2008
Revised April 8, 2008

EXPIRES 06/30/2010

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

TABLE OF CONTENTS

I. INTRODUCTION ........................................................................................1

Background ........................................................................................1
Purpose ........................................................................................3

II. HYDROLOGY ........................................................................................5

Valley View Wash ........................................................................................5
St Thomas Church ........................................................................................7

III. FLOODPLAIN ANALYSIS ........................................................................................8

Regulatory Flood Plain ........................................................................................8
Flood Prone Structures ........................................................................................11
Erosion and Sedimentation ........................................................................................14

IV. FLOOD HAZARD MITIGATION ........................................................................................16

Flood Prone Structures ........................................................................................17
Erosion and Sedimentation ........................................................................................18

V. REFERENCES ........................................................................................20

LIST OF APPENDICES
*(Provided on Compact Disk in PDF format)*

Appendix A Subdivision Plat/Historic Study Excerpts/Historic Study Reports/Exhibits

Appendix B NOAA Atlas 2, Volume VIII (1973) Hydrologic Data Sheets

Appendix C NOAA Atlas 14, Volume I (2006) Hydrologic Data Sheets

Appendix D Development Plans for St. Thomas Church

Appendix E 2007 Topographic Survey Sheets (Cardinal Land Surveying, Inc.)

Appendix F Scour Computation Sheets

Appendix G Guides to Retrofitting Flood Prone Structures

## LIST OF FIGURES


Figure 1 Location Map ....................21

Figure 2 1941 Aerial Photograph ....................22

Figure 3 2007 Topography/2007 Aerial Photograph ....................23

Figure 4 Flood Hazard Map ....................26

Figure 5 1998 Streambed Profile versus 2007 Profile (Ranch Estates #9) ....................29


## LIST OF TABLES


Table 2.1 Pre- and Post-Development Hydrology (100-year) ....................5

Table 2.2 Updated Hydrology (100-year) ....................6

Table 2.3 Updated Hydrology (multi-frequency) ....................7

Table 3.1a Regulatory Discharges and Water-Surface Elevations for the Main Corridor of the Valley View Wash within Ranch Estates #9 ....................9

Table 3.1b Regulatory Discharges and Water-Surface Elevations for the West Channel of the Valley View Wash within Ranch Estates #9 ....................9

Table 3.2 Regulatory Discharges and Water-Surface Elevations for the Valley View Wash Downstream of Ranch Estates #9 ....................10

Table 3.3 Lateral Weir Quantities and Hydraulic Properties ....................11

Table 3.4 Comparison of FFE to W.S. Elevation and Existing Grade within Ranch Estates No. 9 ....................12

Table 3.5 Comparison of FFE to W.S. Elevation and Existing Grade within Ranch Estates No. 9 ....................13


## LIST OF EXHIBITS

*(Provided in Appendix A5 in PDF format)*


Revised Drainage Basin Exhibit

Flood Plain Comparison Exhibit

Streambed Profile Exhibit (Ranch Estates #1 and #2 and Las Lomas de Catalina)

# I. INTRODUCTION

## Background

The development of Flecha Caida Ranch Estates began in 1956. The subdivision plat for the 40-acre parcel currently known as Flecha Caida Ranch Estates #9 was prepared in December 1959 and recorded in February 1960 (Book 14 at Page 44). The subdivision plats for Flecha Caida Ranch Estates #1 (Book 11 at Page 74) and #2 (Book 12 at Page 69) were prepared and recorded in 1956 and 1957, respectively. The subdivision plat for Las Lomas de Catalina was prepared and recorded in 1978. Copies of the recorded plats are included in Appendix A. The subdivisions occupy portions of Sections 15 and 22 of Township 13 South, Range 14 East, Gila River Base and Meridian, Pima County, Arizona. Portions of the four subdivisions are impacted by the Valley View Wash, which is situated between Valley View Road and Pontatoc Road on the west and Swan Road on the east. This floodplain study of the Valley View Wash begins approximately one-half mile south of Sunrise Drive and extends downstream (south) to North Flecha Drive (see Figure 1).

Within the study reach, the Valley View Wash is a natural, privately-owned, unprotected watercourse that is subject to periodic flooding. In addition, since most of the soils within the foothills and valley region are unconsolidated alluvium, the Valley View Wash watercourse is subject to natural dynamic forces that cause localized erosion and sedimentation. Within the study reach, Flecha Caida Ranch Estates #9 is the most problematic area. Previous studies have determined that approximately one half of the 24 lots that comprise the subdivision are located in the 100-year flood plain for the Valley View Wash. Consequently, numerous drainage-related problems have been noted over the years. Common problems include overbank flooding, inundation of existing homes and secondary structures, bank erosion and degradation along the primary flow paths, and limited access to some lots during times of flooding. Although isolated portions of Flecha Caida Ranch Estates #1 and #2 and Las Lomas de Catalina have, to a lesser degree, experienced similar problems, the primary focus of this study was the sub-reach of the Valley View Wash that traverses the Ranch Estates #9 subdivision.

In response to the concerns of Ranch Estates #9 homeowners following a significant flow event on June 27, 1984, the Pima County Department of Transportation and Flood Control District (the District) commissioned an initial assessment of flooding problems in the subdivision, which was documented in a report prepared by Simons, Li and Associates (SLA) in 1984 (Reference 1). Homeowners at that time were concerned that new commercial developments within the area surrounding the Swan Road-Sunrise Drive intersection had contributed to the flooding observed on June 27th, which was estimated by SLA to be a 5 to 10-year storm event (530 cfs). Although SLA noted that the higher density developments had increased the discharge potential during the 100-year event by approximately five percent, the impact on the depth of flooding was minimal. SLA concluded that drainage problems are inherent to the area primarily because a portion of the subdivision was built in the natural flood plain for the Valley View Wash. This is best illustrated by overlaying a 2007 footprint of the subdivision on the 1941 aerial photograph (Figure 2).

Recognizing the impact a 5 to 10-year storm event had on the Ranch Estates #9 subdivision, the District commission a second study in 1985 to establish regulatory (100-year) discharges and 100-year flood plain maps for several Catalina foothills washes, including the Valley View Wash. This study was completed by SLA in 1986 (Reference 2). A detailed hydrology study was performed for the study using precipitation depths from Reference 3. A copy of the 1986 floodplain map that covers Ranch Estates #9 is included in Appendix A1 along with copies of the relevant hydrologic data sheets.

Between 1985 and 1988, Pima County attempted to address flooding problems on a lot by lot basis and on a regional basis. Two soil-cement berms were constructed along portions of Calle del Pantera and Cerco del Corazon to protect Lots 495, 496, 498, and 499 from all flows up to and including the 5-year event (i.e., the more-frequent flow events). Localized channel improvements, including channel widening, rock riprap bank protection, and two earthen berms were also constructed to provide flood and erosion protection for Lots 500 and 501. Most of these mitigation measures were constructed in 1985 and 1986. To address flooding on a regional basis, the District commissioned a third study in 1988 to evaluate the feasibility of either constructing a regional detention basin within the Tucson Water reservoir site to the north or channelizing a portion of the Valley View Wash to eliminate the flood hazards . This study was the direct result of the 1986 study that identified 15 flood prone structures within the Valley View Wash flood plain, including eight within Ranch Estates #9, five within Ranch Estates #1, and one in Ranch Estates #2. The study also included: (1) a more-detailed analysis of the upstream watershed to determine the relative impact of roadway/storm drain improvements (both existing and proposed) on the flood hazards associated with the subdivision; and (2) a more-detailed floodplain study within the boundary of the subdivision itself. This study was completed by SLA in 1989 (Reference 4). Copies of the revised drainage basin map and the revised floodplain map from the 1989 report for Ranch Estates #9 are included in Appendix A1. Appendices A2 through A4 provide archived copies of the 1984, 1986, and 1989 reports

The 1989 study concluded that regional solutions (i.e., detention and/or channelization) were not cost effective and that roadway/storm drain improvements would have little impact on the flooding. Consequently, the primary focus of the study's recommendations was erosion mitigation on a site by site basis and the purchase of residential flood insurance. Long-term degradation was identified as the most significant erosion problem and seven sites were specifically addressed. Two of the sites were upstream of the neighborhood on Tucson Water property, and five of the sites were within the neighborhood. The five sites and the problems noted at each site are summarized as follows:

| Site No. | Description | Problem Noted |
|---|---|---|
| 3 | Downstream of Calle del Pantera, adjacent to northwest corner of Lot 498 | 1-foot (or less) drop in streambed profile on downstream side relative to roadway. |
| 4 | Downstream of access drive to Lot 501 | 1-foot (or less) drop in streambed profile on downstream side relative to roadway. |
| 5 | Downstream of Cerco de Corazon Circle, north boundary of Lot 497 | 2 to 3-foot drop in streambed profile on downstream side relative to roadway. |
| 6 | Downstream of access drive to Lot 503 | 2 to 3-foot drop in streambed profile on downstream side relative to roadway. |
| 7 | Downstream of Cerco de Corazon Circle, south boundary of Lot 497, north boundary Lot 504 | 2 to 3-foot drop in streambed profile on downstream side relative to roadway. |

Given the severity of the problems noted and their potential to worsen as a result of their location relative to downstream control points, the order-of-concern was Site 6, 7, 5, 4, and 3. The long-term or ultimate degradation depth associated with each site was eight, seven, three, three, and eleven feet, respectively. The recommended short-term solution at Sites 5 through 7 was a gabion cut-off wall. The long-term solution included the addition of bank protection and aprons to the short-term structures. Gabions were selected as opposed to conventional cut-off walls or plunge basis to facilitate the addition of the long-term components. A wait and see approach was recommended for Sites 3 and 4.

It should be noted that between 1984 and 1989, the eastern flow path along Calle del Pantera was considered the primary flow path for the more frequent flow events and the western low-flow channel was considered the secondary flow path. In addition, the 1989 study did not specifically address the home on Lot 502, which was constructed in 1986, since it appears that most of the field data (i.e., topographic information and finish-floor elevations) were collected between 1984 and 1986, and initial development of the St Thomas Apostle church occurred in 1987, with additional improvements in 1997.

Subsequent to the 1989 study, some drainage/erosion-mitigation measures were constructed in the neighborhood, including (1) a concrete cut-off wall between Sites 3 and 4; (2) a concrete cut-off wall between the access drive to Lot 502 and 503 (Site 6); (3) a concrete cut-off wall on the downstream side of the access drive to Lot 502; (4) a drainage structure beneath the access drive to Lot 503; and, (5) grouted rock/gunite channel lining immediately downstream of the access drive to Lot 503. It appears that the cut-off wall between Sites 3 and 4 was constructed in conjunction with the 1997 improvements to the church. However, the other mitigation measures appear to have been constructed by the individual property owners.

## Purpose

Recent flooding and erosion within the Ranch Estates #9 subdivision during the 2007 summer monsoon season raised the concerns of numerous homeowners who were not aware of the historical drainage problems inherent to the area. The Pima County Regional Flood Control District commissioned this study to (1) address the impact of recent improvements in the drainage area upstream of the study area; (2) provide updated flood-hazard mapping for the area from just upstream of Calle del Pantera to North Flecha Drive, which is where the Federal Emergency Management Administration (FEMA) flood plain for the Valley View Wash begins; and (3) identify mitigation measures that could be implemented by the affected homeowners to address their flood/erosion hazards.

The key elements of the study as outlined in the scope-of-work are summarized as follows:

- Data collection and field investigation.
- Aerial topographic mapping at 1"=40', one-foot contour interval, including digital aerial photography and ground control. Obtain finish-floor elevations (FFEs) of flood prone structures within the Ranch Estates #9 subdivision. Use the newly acquired topographic information to estimate FFEs for the remaining floodprone structures.
- Revisit 1984 hydrology using NOAA 14 rainfall depths, including multiple return intervals. Compare results to 1984 study.
- Remap 100-year flood plain using new topography. Provide a comparison with the expanded mapping completed in 1989. Identify flood prone structures based on FFEs from survey.
- Identify and evaluate alternative mitigation measures, including their impact on the floodplain. Perform scour analyses as needed, including long-term degradation, to provide preliminary design parameters for the mitigation measures (e.g., floodwalls, bank protection, cut-off walls, etc.).

## II. HYDROLOGY

Valley View Wash

In 1984, it was standard engineering practice to conduct hydrologic analyses under the assumption that the upstream drainage area would be fully developed in accordance with the zoning conditions that were in place at the time of the study (i.e., future-conditions hydrology). The 1984 hydrology study performed by SLA was based on future conditions. It included a drainage basin map that outlined the zoning boundaries that were used in the study. Although the majority of the upstream watershed was developed at the time of the study, the most recent (2005) aerial photographs of the watershed were reviewed to determine if these boundaries were still valid.

Based on the results of that review, it was noted that three small areas in the watershed were developed at a greater density than previously assumed. An exhibit showing the location of these areas relative to the key concentration points is provided in Appendix A5. To determine the impact of these higher-density developments, the original hydrologic data sheets were revised accordingly. A comparison between the original values and the updated values is shown in Table 2.1. The revised hydrologic data sheets are provided in Appendix B. The three concentration points (CP) included in the comparison were CP 18, 11.1, and 13. CP 18 is located immediately downstream of the area containing the higher density developments. CP 11.1 is located at Sunrise Drive and CP 13 is located at the northern boundary of the Ranch Estates #1 subdivision.

Table 2.1 Pre- and Post-Development Hydrology (100-year)

| Conc. Pt. | Area (ac) | nb | I (%) | Cw | Tc (min.) | $Q_{100}$ (cfs) | change (%) |
|---|---|---|---|---|---|---|---|
| 11.1 (1986) | 927 | 0.047 | 8 | 0.65 | 38 | 2263 | |
| 13 (1986) | 1239 | 0.045 | 12 | 0.65 | 49 | 2512 | |
| 18 (1986) | 610 | 0.055 | 3 | 0.68 | 22 | 2175 | |
| 11.1 (1986 updated) | 927 | 0.047 | 9 | 0.66 | 38 | 2279 | 0.69% |
| 13 (1986 updated) | 1239 | 0.045 | 12.8 | 0.65 | 49 | 2527 | 0.61% |
| 18 (1986 updated) | 610 | 0.055 | 4.5 | 0.68 | 22 | 2192 | 0.81% |

Description of hydrologic variables: nb (basin factor); I (Impervious Cover); Cw (weighted runoff coefficient); Tc (time of concentration); $Q_{100}$ (100-year or regulatory discharge).

The largest increase (0.81%) occurs immediately downstream of the area containing the higher-density developments. Since the drainage area increases in the downstream direction, the relative impact decreases. The updated analysis clearly shows that the impact associated with the three higher-density developments is not significant. The impact in the immediate vicinity of Ranch Estates #9 is approximately 0.65%.

This comparative analysis was based on precipitation depths from Reference 3, which was used in Pima County in 1984. Today, the upper-bound of the 90% confidence interval values from Reference 5 are used in all hydrologic analyses. Therefore, a separate hydrologic analysis was conducted to define new discharge values at the key concentration points, which were used to remap the regulatory or 100-year floodplain.

The new regulatory discharge values are shown in Table 2.2. The associated hydrologic data sheets are provided in Appendix C.

Table 2.2 Updated Hydrology (100-year)

| Conc. Pt. | Area (ac) | nb | I (%) | Cw | Tc (min.) | $Q_{100}$ (cfs) |
|---|---|---|---|---|---|---|
| 11 | 908 | 0.047 | 9 | 0.70 | 35 | 2802 |
| 11.1 | 927 | 0.047 | 9 | 0.70 | 35 | 2861 |
| 11.3 | 1034 | 0.046 | 12 | 0.70 | 40 | 2916 |
| 11.3a | 1045 | 0.046 | 12 | 0.70 | 42 | 2855 |
| 11.3b | 1055 | 0.046 | 12 | 0.70 | 43 | 2804 |
| 11.4 | 1073 | 0.046 | 12 | 0.69 | 43 | 2844 |
| 11.4a | 1189 | 0.046 | 12 | 0.69 | 44 | 3119 |
| 13 | 1239 | 0.045 | 12.8 | 0.69 | 44 | 3219 |
| 13.1 | 1608 | 0.045 | 12.9 | 0.69 | 50 | 3797 |
| 18 | 610 | 0.055 | 4.5 | 0.73 | 19 | 2823 |

Description of hydrologic variables: nb (basin factor); I (Impervious Cover); Cw (weighted runoff coefficient); Tc (time of concentration); $Q_{100}$ (100-year or regulatory discharge).

SLA's 1989 study included runoff concentration points at both the northern and southern boundaries of the Ranch Estates #9 subdivision. These concentration points were CP 11.3 and 11.4, respectively. For the purpose of this study, three additional concentration points were defined. Two (CP 11.3a and 11.3b) are within the subdivision itself, and the third (CP 11.4a) is located immediately downstream of the confluence of the tributary wash that traverses the southern boundary of Lot 505. An exhibit showing the locations of the key concentration points listed in Table 2.2 is provided in Appendix A5. Based on the results of the updated hydrologic analysis, the regulatory discharge associated with CP 11.3 was selected for the floodplain analysis of the sub-reach that traverses the Ranch Estates #9, since the discharge at CP 11.3 exceeds the values associated with CP 11.3a, 11.3b, and 11.4. The downstream reach that traverses Ranch Estates #1 and #2 and Las Lomas de Catalina was analyzed using the discharges associated with CP 11.4, 13, and 13.1.

In addition, peak discharges for the more-frequent runoff events were determined at CP 11.3. These are summarized in Table 2.3. The associated hydrologic data sheets are also provided in Appendix C.

Table 2.3 Updated Hydrology (multi-frequency)

| Conc. Pt. | Return Interval (yr) | Tc (min.) | Cw | Q (cfs) |
|---|---|---|---|---|
| 11.3 | 2 | 104 | 0.31 | 268.00 |
| | 5 | 71 | 0.45 | 680.00 |
| | 10 | 59 | 0.53 | 1092.00 |
| | 25 | 49 | 0.61 | 1740.00 |

Description of hydrologic variables: Tc (time of concentration); Cw (weighted runoff coefficient); Q (peak discharge).

St. Thomas Church

As previously noted, the initial development of the St Thomas Apostle church occurred in 1987, with additional improvements in 1997. Copies of the two development plans are included in Appendix D. Since there was some concern that the overall development of the church had increased the magnitude of runoff impacting the subdivision, the pre- and post-developed conditions associated with the church site were evaluated. Based on the results of that evaluation, it was determined that the church has had no significant impact on the hydrology for the Valley View Wash. In addition, some of the improvements associated with the church have actually benefited potions of the subdivision.

When the church was initially developed in 1987, four detentions basins were constructed. Two of these basins regulate runoff that ultimately enters the Ranch Estates #9 subdivision. In 1984, approximately 1.6 acres of the church site contributed direct runoff to the subdivision. The associated 100-year peak discharge under Natural/Rural conditions was determined to be approximately 8.3 cfs. Under developed conditions (i.e., post-1997), the drainage area increased to approximately 3.0 acres with a current 100-year runoff potential of 23 cfs. However, approximately 2.2 acres of this area drains to the two detentions basins constructed in 1987. In order to limit the magnitude of runoff impacting the subdivision to 8.3 cfs, a conservative estimate of the required storage volume for these two basins is approximately 0.33 acre-feet. This estimate was made using the procedures outlined in Reference 6. Although it appears that only approximately one-half of the this volume was actually provided, the two basins should effectively reduce the 100-year peak discharge entering the subdivision to approximately 13.6 cfs, which is only 5.3 cfs above the pre-developed condition. Considering the magnitude of runoff associated with Valley View Wash during the 100-year event (2916 cfs), this increase in not significant.

It should be noted that the results just discussed are based on the rainfall depths associated with Reference 5. When the church was developed, they would have been permitted to use the values associated with Reference 3 to determine the required storage volume for each detention basin. Therefore, the results are not intended to suggest that they did not meet the requirements in effect at the time of development.

A comparison of the 2007 topography versus the 1984 topography was also conducted to determined if either site grading or other site improvements has had an adverse impact on the subdivision. The results indicate that site grading has actually benefited the subdivision by capturing and diverting a small quantity of overbank flow from the Valley View Wash, which slightly reduces the flood hazard associated with Lot 501. It was also noted that a grade-control structure placed just upstream of the northwest corner of Lot 500 and one placed just north of the southwest corner of Lot 498 have effectively stabilized the bed profile along the western boundary of Lots 498 and 499, in addition to protecting the pavement at Calle del Pantera.

## III. FLOODPLAIN ANALYSIS

Regulatory Flood Plain

Per Pima County's floodplain ordinance, the regulatory floodplain is defined as "that portion of the geologic floodplain associated with a watercourse….where the 100-year peak discharge is 100 cfs or greater, or those areas that are subject to sheet flooding." It is also important to note that the term 100-year flood or flood plain is a probability reference as opposed to a time period reference. The referenced year is divided into one (i.e., 1/100, or 1 divided by 100) to define the probability of occurrence in any given year. For example, the 100-year flood has a 1% chance of occurring in any given year. The 50-year flood has a 2% chance, the 5-year flood has a 20% chance, and so on.

The regulatory or 100-year flood plain within the study area was remapped using ground data from the 2007 topographic survey prepared by Cardinal Land Surveying, Inc. (CLS). A copy of the complete ground survey is provided in Appendix E. The floodplain analysis was performed using the HEC-RAS water-surface profile model (Reference 7). An exhibit showing the 2007 topography, including the 2007 aerial photograph for the study reach, is provided as Figure 3. The locations of the cross sections used in the HEC_RAS analysis are shown on Figure 4. The regulatory (100-year) floodplain boundary and floodprone area is also shown on Figure 4.

Sheet 1 of Figure 4 depicts three flood zones; whereas, Sheets 2 and 3 depict only one. This is due to the more-detailed floodplain analysis that was required to accurately map flooding conditions within Ranch Estates #9. The blue shaded area between the eastern and western-most 100-year or regulatory floodplain boundaries (on all sheets) is the approximate wetted portion or special flood hazard area as defined by the base flood elevations (e.g., WS= 2620.13) listed for each cross section. The base flood elevations relative to each cross section within the Ranch Estates #9 sub-reach are summarized in Tables 3.1a and 3.1b. The base flood elevations relative to each cross section within Ranch Estates #1 and #2 and Las Lomas de Catalina are summarized in Table 3.2. It should be noted that high ground or "islands" that may exist between the floodplain boundaries (i.e., locations where the ground is higher than the base flood elevations) were not identified or excluded from the floodprone area.

Table 3.1a Regulatory Discharges and Water-Surface Elevations for the Main Corridor of the Valley View Wash within Ranch Estates #9 (as shown on Sheet 1 of Figure 4)

| Reach | River Station (or Cross Section) | Q Total (cfs) | W.S. Elevation (ft) |
|---|---|---|---|
| Main Corridor | 1 | 3119 | 2608.88 |
| Main Corridor | 2 | 3119 | 2612.30 |
| Main Corridor | 3 | 1978 | 2613.85 |
| Main Corridor | 4 | 1775 | 2616.12 |
| Main Corridor | 5 | 1775 | 2620.59 |
| Main Corridor | 5.5 | Lateral Weir | |
| Main Corridor | 6 | 1816 | 2624.07 |
| Main Corridor | 6.5 | Lateral Weir | |
| Main Corridor | 7 | 2106 | 2627.85 |
| Main Corridor | 7.5 | Lateral Weir | |
| Main Corridor | 8 | 2366 | 2631.21 |
| Main Corridor | 8.5 | Lateral Weir | |
| Main Corridor | 9 | 2458 | 2634.48 |
| Main Corridor | 9.5 | Lateral Weir | |
| Main Corridor | 10 | 2551 | 2637.65 |
| Main Corridor | 10.5 | Lateral Weir | |
| Main Corridor | 11 | 2885 | 2641.20 |
| Main Corridor | 11.5 | Lateral Weir | |
| Main Corridor | 12 | 2916 | 2644.31 |
| Main Corridor | 13 | 2916 | 2646.94 |
| Main Corridor | 14 | 2916 | 2650.01 |
| Main Corridor | 15 | 2916 | 2652.79 |
| Main Corridor | 16 | 2916 | 2654.67 |
| Main Corridor | 17 | 2916 | 2656.90 |
| Main Corridor | 18 | 2916 | 2658.44 |
| Main Corridor | 19 | 2916 | 2660.90 |
| Main Corridor | 20 | 2916 | 2662.81 |

Table 3.1b Regulatory Discharges and Water-Surface Elevations for the West Channel of the Valley View Wash within Ranch Estates #9 (as shown on Sheet 1 of Figure 4)

| Reach | River Station (or Cross Section) | Q Total (cfs) | W.S. Elevation (ft) |
|---|---|---|---|
| West Overflow | 1 | 3119 | 2608.88 |
| West Overflow | 2 | 3119 | 2612.30 |
| West Overflow | 3 | 1140 | 2615.27 |
| West Overflow | 4 | 1140 | 2618.00 |
| West Overflow | 5 | 1140 | 2620.13 |
| West Overflow | 6 | 1099 | 2622.94 |
| West Overflow | 7 | 807 | 2625.59 |
| West Overflow | 8 | 551 | 2629.85 |
| West Overflow | 9 | 460 | 2633.54 |
| West Overflow | 10 | 367 | 2637.10 |
| West Overflow | 11 | 31 | 2640.67 |

Table 3.2 Requlatory Discharges and Water-Surface Elevations for the Valley View Wash Downstream of Ranch Estates #9 (as shown on Sheet 2 and 3 of Figure 4)

| Reach | River Station (or Cross Section) | Q Total (cfs) | W.S. Elevation (ft) |
|---|---|---|---|
| Main Channel | 0.01 | 3797 | 2530.72 |
| Main Channel | 0.02 | 3797 | 2533.42 |
| Main Channel | 0.03 | 3797 | 2536.97 |
| Main Channel | 0.04 | 3797 | 2541.83 |
| Main Channel | 0.05 | 3797 | 2543.86 |
| Main Channel | 0.06 | 3797 | 2545.92 |
| Main Channel | 0.07 | 3797 | 2549.46 |
| Main Channel | 0.08 | 3797 | 2551.01 |
| Main Channel | 0.09 | 3797 | 2553.56 |
| Main Channel | 0.10 | 3797 | 2557.19 |
| Main Channel | 0.11 | 3219 | 2561.73 |
| Main Channel | 0.12 | 3219 | 2565.60 |
| Main Channel | 0.13 | 3219 | 2569.43 |
| Main Channel | 0.14 | 3219 | 2574.09 |
| Main Channel | 0.15 | 3219 | 2578.48 |
| Main Channel | 0.16 | 3219 | 2582.23 |
| Main Channel | 0.17 | 3219 | 2585.84 |
| Main Channel | 0.18 | 3219 | 2589.53 |
| Main Channel | 0.19 | 3219 | 2592.94 |
| Main Channel | 0.20 | 3219 | 2596.39 |
| Main Channel | 0.21 | 3219 | 2599.43 |
| Main Channel | 0.22 | 3119 | 2601.46 |
| Main Channel | 0.23 | 3119 | 2605.49 |
| Main Channel | 0.24 | 3119 | 2608.88 |

Two water-surface profiles are represented by Tables 3.1a and 3.1b. Table 3.1a applies to the "main corridor" of the Valley View Wash within Ranch Estates #9, and Table 3.1b applies to the "west overflow" channel, which conveys flows that break out of the main corridor between Sections 5 and 12. The location of the drainage divide or "lateral weir" crest is shown on Sheet 1 of Figure 4 as a black-dashed line that extends south from the church's access drive to the house constructed on Lot 503. Breakout flows from the "main corridor" were used to map the flood plain associated with the "west overflow" channel. A section by section breakdown of the discharge associated with each overflow or "lateral weir" section is presented in Table 3.3. Since the average depth of flow over the weir between Section 6 and 10 was approximately one foot, a second flood zone characterized by shallow flooding with average depths equal to one foot was delineated between the weir crest and the eastern boundary of the "west overflow" flood plain.

The third delineated flood zone is characterized by shallow flooding with average depths less than one foot. This area is centered along Calle del Pantera in the vicinity of the Cerco del Corazon intersection.

Table 3.3 Lateral Weir Quantities and Hydraulic Properties

| Reach | River Station | Q Leaving (cfs) | Lateral Weir Max Depth (ft) | Lateral Weir Avg Depth (ft) | Lateral Weir Min El (ft) | W.S. Elevation u/s (ft) | W.S. Elevation d/s (ft) |
|---|---|---|---|---|---|---|---|
| Main Corridor | 5.5 | 42 | 0.87 | 0.45 | 2622.00 | 2624.07 | 2620.59 |
| Main Corridor | 6.5 | 292 | 1.38 | 1.14 | 2623.20 | 2627.85 | 2624.07 |
| Main Corridor | 7.5 | 256 | 1.24 | 1.11 | 2627.00 | 2631.21 | 2627.85 |
| Main Corridor | 8.5 | 91 | 1.16 | 0.67 | 2631.00 | 2634.48 | 2631.21 |
| Main Corridor | 9.5 | 93 | 1.65 | 1.10 | 2635.00 | 2637.65 | 2634.48 |
| Main Corridor | 10.5 | 337 | 1.42 | 1.17 | 2637.00 | 2641.20 | 2637.65 |
| Main Corridor | 11.5 | 31 | 0.69 | 0.42 | 2640.50 | 2643.63 | 2641.20 |

It should be noted that the water-surface elevations presented in Tables 3.1 and 3.2 are based on a critical flow regime, as opposed to a subcritical or supercritical flow regime. When the subcritical floodplain analysis defaulted to critical depth, a supercritical profile was evaluated. The results confirmed that critical flow dominates. This is significant in that the computed water-surface elevations are not subject to either upstream or downstream controls. For example, removing the culvert beneath the access drive to Lot 503 (Section 7) will not significantly change the water-surface elevation at either Section 6 or Section 8.

In addition to analyzing the 100-year or regulatory flood plain within Ranch Estates #9, a separate model was prepared to evaluate the capacity of the primary low-flow channel, which is currently the western-most watercourse, as opposed to the Calle del Pantera street section. The results indicate that the capacity falls between the 2-year and 5-year peak discharge, which is consistent with the results of the 1989 study. The bifurcation in the main channel located immediately upstream of Calle del Pantera was also evaluated to determine the approximate distribution of flow between the two flow paths. The results indicate that approximately half the flow will be conveyed along both watercourses, especially during high-flow events. During low-flow events, the current tendency is for most of the flow to be conveyed along the western watercourse. However, given the dynamic nature of this alluvial channel, this tendency can change, and there is no way to predict the actual flow path from one flow event to another (i.e., the relative distribution of flow can fluctuate from one event to another).

Flood Prone Structures

In addition to providing updated topographic information that could be used to remap the Valley View Wash flood plain, Cardinal Land Surveying obtained the finish-floor elevations (FFEs) of all homes within Ranch Estates #9 which were thought to be within the 100-year or regulatory flood plain per the 1989 study. Table 3.4 summarizes the results of their survey, in addition to providing a comparison between the regulatory water-surface elevation and the existing ground elevation (grade) on the upstream side of the structure.

The negative sign associated with the values in the "FFE versus $WS_{structure}$" column denotes that the regulatory water surface is above the finish-floor elevation. The values in the

"$WS_{structure}$ versus Grade" column denotes the approximate depth of flow adjacent the to upstream side of the structure during a regulatory event.

Per Pima County's floodplain ordinance, new homes constructed in or near a flood prone area must have their lowest finish floor elevated a minimum of one foot above the regulatory water-surface elevation on the upstream side of the structure. Only two structures in or near the remapped regulatory flood plain within Ranch Estates #9 meet this requirement – the main structure on Lot 493 and the garage on Lot 504. Although the finish-floor elevation for the structure on Lot 499 is above the computed water-surface elevation, the difference is only 0.45 feet.

Table 3.4 Comparison of FFE to W.S. Elevation and Existing Grade within Ranch Estates #9

| Lot No. | Description | FFE (ft) | W.S. Elev at Structure (ft) | FFE versus $WS_{structure}$ (ft) | Existing Grade at Structure (ft) | $WS_{structure}$ versus Grade (ft) |
|---|---|---|---|---|---|---|
| 498 | main structure | 2651.46 | 2652.79 | -1.33 | 2651.30 | 1.49 |
| 493 | main structure | 2648.78 | 2644.85 | 3.93 | 2649.00 | -4.15 |
| 499 | main structure | 2643.30 | 2642.85 | 0.45 | 2642.50 | 0.35 |
| 496 | main structure | 2635.54 | 2635.66 | -0.12 | 2634.50 | 1.16 |
| | sunken living | 2635.16 | 2635.66 | -0.50 | n/a | n/a |
| 495 | main structure | 2632.26 | 2632.31 | -0.05 | 2631.80 | 0.51 |
| 497 | main structure | 2630.73 | 2631.21 | -0.48 | 2630.30 | 0.91 |
| | bedroom addition | 2629.55 | 2629.83 | -0.28 | 2629.00 | 0.83 |
| 504 | garage | 2622.98 | 2620.17 | 2.81 | 2623.00 | -2.83 |
| 503 | main structure | 2621.78 | 2622.45 | -0.67 | 2621.50 | 0.95 |
| | carport | 2617.90 | 2618.43 | -0.53 | 2618.60 | -0.17 |
| 502 | main structure | 2630.75 | 2631.78 | -1.03 | 2630.30 | 1.48 |
| 501 | main structure | 2636.19 | 2636.59 | -0.40 | 2635.00 | 1.59 |
| 500 | main structure | 2639.71 | 2640.95 | -1.24 | 2639.40 | 1.55 |

Since all of the habitable structures within Ranch Estates #1 and #2 and Las Lomas de Catalina, which were thought to be flood prone in 1986, turned out to have FFEs from the 1989 survey that were above the previously defined base flood elevations, new FFEs were not obtained by Cardinal Land Surveying for these structures. Instead, FFEs for the previously-identified structures were estimated using the 1989 FFE plus a datum conversion constant. FFEs for any newly identified structures were estimated using the 2007 topographic survey as a guide. Table 3.5 summarizes the results of a comparison between the adjusted and/or estimated FFEs and the new regulatory (100-year) water-surface elevations.

Table 3.5 Comparison of FFE to W.S. Elevation and Existing Grade within Ranch Estates #1 and #2 and Las Lomas de Catalina

| Lot No.[1] | Description | Finish Floor Elevation (FFE)[2] | | W.S. Elev at Structure | FFE versus $WS_{structure}$ |
|---|---|---|---|---|---|
| | | OLD (ft) | NEW (ft) | (ft) | (ft) |
| 55 | secondary structure | 2598.70 | 2600.95 | 2602.04 | -1.09 |
| 12 | main structure | -- | 2591.50 | 2591.52 | -0.02 |
| 13 | main structure | -- | 2589.90 | 2588.28 | 1.62 |
| 14 | guest house | -- | 2585.90 | 2584.96 | 0.94 |
| 16 | east half of lot (split) | -- | 2578.25 | 2576.96 | 1.29 |
| 43 | main structure | 2557.70 | 2559.95[3] | 2558.90 | 1.05 |
| 44 | main structure | 2563.60 | 2565.85 | 2566.10 | -0.25 |
| 45 | main structure | 2553.80 | 2556.05 | 2554.31 | 1.74 |
| 46 | main structure | 2549.60 | 2551.85 | 2547.78 | 4.07 |
| 47 | main structure | -- | 2546.50 | 2544.00 | 2.50 |
| 48 | main structure | 2538.80 | 2541.05 | 2539.70 | 1.35 |
| 49 | main structure | -- | 2536.00 | 2534.36 | 1.64 |

Note: [1]Lot 55 is in Flecha Caida Ranch Estates No. 2, Bk 12 Pg 69. Lots 12 and 13 are in Las Lomas de Catalina, Bk 29, Pg 79. The remaining lots are in Flecha Caida Ranch Estates, Bk 11, Pg 74.

[2]If applicable, the "Old" FFE (NGVD 29) is from the 1989 SLA report. The "New" FFE (NAVD 88) was computed by adding 2.25 feet to the "Old" FFE. For all lots lacking an "Old" FFE, the "New" FFE was estimated using the topographic survey as a guide.

[3]The adjusted FFE for Lot 43 is significantly higher than the topographic mapping suggests

As previously noted, structures located in or near the 100-year flood plain are generally considered protected from flooding when their lowest finish floor is elevated a minimum of one foot above the 100-year water-surface elevation on the upstream side of the structure. Only one structure in Ranch Estates #1 (FC1), one in Ranch Estates #2 (FC2), and two in Las Lomas de Catalina (LLdC) do not meet this requirement – the secondary structure on Lot 55 of FC1, the main structure on Lot 55 of FC2, and the main structure on Lot 12 and guest structure on Lot 14 of LLdC. However, the guest structure on Lot 14 of LLdC is close with a difference of 0.94 feet. To verify the potential floodprone status or risk of flooding for these structures, it recommended that the owners have their FFEs surveyed for comparison with the water-surface elevations provided in Table 3.4. In addition, since the FFE for Lot 43 is questionable (see footnote 3 in Table 3.5), it is recommended that the owner contact a land surveyor and arrange to have the FFE determined, such that it can be compared to the elevations provided in Table 3.4. Also, if the owners of any of the remaining lots listed in Table 3.5 are concerned about the potential for flooding, it is recommended that they have their FFEs surveyed to more accurately identify their flood risk.

Erosion and Sedimentation

In addition to flooding problems, the subdivisions, to a varying degree, are also prone to erosion and sedimentation problems. Long-term degradation, which is the gradual lowing of the channel bed in response to a reduction in the upstream sediment supply, was the primary focus of the 1989 study, since it stood out as the most significant erosion problem. That study identified five problems areas within the Ranch Estates #9 subdivision and discussed the extent of the problem associated with each. The location of these problem areas are shown on a excerpt of the 1989 exhibit, which is provided in Appendix A1 (page 18). The full exhibit is provided in Appendix A4 (page 63). Using the same site numbers referenced in the 1989 study, the five sites are described as follows: Site 3 is located along the west branch immediately downstream of Calle del Pantera; Site 4 is located immediately downstream of the access drive for Lot 501; Site 5 is located just downstream of Cerco de Corazon, near the northwest corner of Lot 497; Site 6 is located immediately downstream of the access drive for Lot 503; and, Site 7 is located within the boundary of Lot 504 immediately downstream of Cerco del Corazon.

During the field investigation associated with this 2007 study, it was noted that erosion and/or sedimentation problems still exist at all five locations, with the possible exception of Site 3. As previously noted, two grade-control structures constructed adjacent to Lots 498 and 499 have temporarily checked long-term degradation at Site 3. However, some local erosion near the access drive to Lot 498 was noted. In addition, the installation of a grade-control structure just downstream of the access drive to Lot 502, and the paved access drive itself, which was not considered during the 1989 study, has temporarily mitigated the long-term degradation problem at Site 4. To show the short-term effect both of these structures have had on the streambed profile, Figure 5 was prepared. It compares the 1998 streambed profile along the western watercourse to the 2007 profile. The approximate locations of the three referenced grade-control structures are Stations 5+15, 10+35, and 12+23.

It should be noted that the magnitude of degradation in the vicinity of the access drive for Lot 501 is misleading. The difference between the two profiles at this location was due to bank erosion as opposed to channel bed degradation. During the 2007 summer monsoon season, the area experienced a 2-year to 5-year flow event. During this event, the west bank in the vicinity of the access drive eroded between 20 and 30 feet in a southwesterly direction. Bank erosion extended approximately 50 to 60 feet in upstream direction and ceased just downstream of the access drive. As a result, most of the rock riprap bank protection along the upstream reach was lost, and the majority of the sediment removed from the bank was deposited in the area between the wash and the north elevation of the home on Lot 502. Bank erosion was also noted along the east bank in the vicinity of the home on Lot 500. Currently, this structure is located less than ten feet from the top of the eastern bank. However, it does not appear that bank protection in the form of rock riprap has ever been provided along this bank.

With the exception of the additional erosion and sedimentation problems noted in the vicinity of Site 4 and the stabilizing effect of the church's grade-control structure relative to Site 3, long-term degradation is still the most significant erosion problem at the remaining sites. The existing slope of the bed along the western channel ranges between 2.15% and 2.45%. The slope of the bed along the eastern channel segment located within the boundary of Lot 497 is approximately 1.4%. The 1989 study estimated an equilibrium bed slope of approximately 1%. However, assuming a conservative sediment reduction factor of 40% relative to the upstream watershed, the equilibrium bed slope was estimated to be approximately 1.5% using the relationship provided in Chapter 6 of Reference 8.

The computed equilibrium slope of 1.5% was plotted on Figure 5 at several locations based on appropriate downstream pivot points. Typically, the pivot points around which a channel bed will adjust its grade are channel confluences, grade-control structures, and at-grade roadway crossings. For Sites 6 and 7, the downstream pivot point was the confluence with the eastern tributary channel that traverses the southern boundary of Lot 505. The estimated long-term degradation depth at Sites 6 and 7 were determined to be approximately 5.2 feet and 4.8 feet respectively. This is in addition to the drop height that currently exists, which is 1.0 feet and 2.0 feet, respectively. For the grade-control structure located just downstream of the access drive to Lot 502, the additional degradation depth was determined to be approximately 1.5 feet, with an existing drop of approximately 1.8 feet. Assuming this existing grade-control remains effective (i.e., does not fail), the approximate long-term degradation depth downstream of the access drive to Lot 502 is less than one foot, which is also applicable to the access drive for Lot 501, since the channel bed downstream of the access drive for Lot 501 pivots around the access drive for Lot 502. With respect to the existing grade-control structures at Station 10+35 and 12+23 and the downstream edge of pavement for Calle del Pantera, the long-term degradation depths were determined to be approximately 1.3 feet, 1.0 feet, and 2.5 feet, respectively. Again, these depths are in addition to the drop height that currently exists, which is approximately 2.0 feet, 1.0 feet, and 0.5 feet, respectively. Since the existing slope for the eastern channel is slightly less than the computed equilibrium slope, it is reasonable to assume that this channel is at or near its equilibrium slope; therefore, the existing drop height at Site 5, which is approximately four feet, is not expected to increase significantly.

An exhibit similar to Figure 5 was also prepared for the main branch of the Valley View Wash with Ranch Estates 31 and #2 and Las Lomas de Catalina. This exhibit is included in Appendix A5. Since the 2007 profile is very similar to the 1998 profile, long-term degradation does not appear to be a problem along this portion of the study reach. However, given the dynamic nature of alluvial channels, especially when man's activities are factored into the equation, the critical balance between the upstream sediment supply and the downstream sediment transport capacity could be upset at any time. The existing slope along this reach is approximately 2.3%, which is consistent with the existing slope of the west branch channel within Ranch Estates #9. Therefore, the estimated equilibrium bed slope for that reach (1.5%) is also applicable to this reach. Consequently, the long-term degradation depth for this reach is approximately one foot per 125 feet of channel relative to the downstream pivot.

In addition to estimating the long-term bed profile for the western channel within Ranch Estates #9, a single-event scour analysis was conducted in accordance with the procedure outlined in Chapter 6 of Reference 8. The associated computation sheets are provided in Appendix F. Based on the results of the scour analysis, the minimum design scour depth is three feet. A similar analysis was conducted for the main channel of the Valley View Wash within Ranch Estates #1 and #2 and Las Lomas de Catalina. Based on the results of that analysis the minim design scour depth is 3.5 feet within Ranch Estates #1 and #2 and 3.3 feet within Las Lomas de Catalina. The associated computation sheets are also provided in Appendix F.

Typically, when bank protection is proposed, the minimum scour depth is combined with the long-term depth to determine the design toe-down depth. When protection is proposed in the vicinity of a channel drop and bed protection is not provided, then the design toe-down depth must be increased to account for the depth of local scour on the downstream side of the drop, which is a function of the ultimate drop height. Under existing conditions, the maximum drop height is expected to occur at Site 6 within Ranch Estates #1. Based on an ultimate drop height of 6.2 feet, the maximum local scour depth was determined to be approximately 9.9 feet. Assuming a minimum drop height of three feet (e.g., Site 3), the local scour depth would be approximately 7.3 feet. These depths emphasize the importance of bed protection when excessive drop heights are anticipated or the importance of adequately spaced grade-control structures to stabilize the bed profile.

An erosion-hazard setback analysis was also performed in conjunction with the single-event scour analysis using the procedure outlined in Chapter 7 of Reference 8. Based on the results of that analysis, the average building setback distance was determined to be approximately 73 feet. This value is consistent with the minimum distance (75 feet) specified in Pima County's current floodplain and erosion hazard management ordinance for unprotected banks along natural channels. Currently, the homes on Lots 498, 500, and 501 are within the erosion-hazard area for the western channel. The existing setback distances for these homes are approximately 60 feet, 10 feet, and 20 feet, respectively. Since the home on Lot 498 is located on the inside of the channel bend and approach flows are more dispersed, the existing setback distance (60 feet) may be adequate. However, the potential for bank erosion and/or lateral migration of the channel bank should be a major concern for the owners of Lots 500 and 501. The 75-foot setback specified in Pima County's current floodplain and erosion hazard management ordinance is also applicable to the structures within Ranch Estates #1 and #2 and Las Lomas de Catalina. Currently, the homes on Lots 16B and 43 through 51 (Ranch Estates #1), Lot 55 (Ranch Estates #2), and Lots 11 through 16 (Las Lomas de Catalina) are within the erosion-hazard area for either the main channel or one of the secondary channels. However, the actual potential for bank erosion and/or lateral migration was not evaluated as part of this study. Within the majority of these lots, mitigating factors such as soils, channel-specific discharges, armoring, etc., may result in a reduced potential for bank erosion and/or lateral migrations.

## IV. FLOOD HAZARD MITIGATION

For the most part, the results of this 2007 study are consistent with the results of the 1989 study (see the floodplain comparison exhibit in Appendix A5). The floodplain boundaries are similar, as are the identified erosion hazards, with the possible exception of Site 4 within Ranch Estates #9. The 1989 study addressed the feasibility of regional solutions, including upstream detention and channelization of flows within the subdivision itself and determined that neither was cost-effective. To reduce the economic impact of flooding, flood insurance was recommended. To address long-term degradation, both short-term and long-term solutions in the form of gabion cut-off walls and grade-control structures were recommended. Although cut-off walls and grade-control structures have been provided within Ranch Estates #9, they were not designed in accordance with the recommendations of the study (i.e., concrete cutoff walls, concrete grade-control structures, and grouted rock aprons were installed instead). At the time, bank erosion in the vicinity of Lots 500 and 501 was not discussed, since rock riprap protected berms had already been provided upstream of these lots. However, the loss of this protection must now be addressed and floodproofing options should also be considered, in addition to the purchase of flood insurance. Although long-term degradation continues to be a problem within Ranch Estates #9, particularly at Site 6, the recommendations of the 1989 study are still valid. Since the Valley View Wash along the study reach is a natural watercourse that is subject to periodic flooding and the natural dynamic forces of sedimentation and erosion, mitigation measures will be needed to protect flood/erosion prone structures. However, mitigation measures must be addressed by individual property owners, since the wash is privately owned.

## Flood Prone Structures

As previously recommended, flood insurance should be purchased to reduce the economic impact of any flooding that may occur in the future. At a minimum, flood insurance should be purchased by the owners of all lots identified in Table 3.4 and 3.5, with the possible exception of Lots 493 and 504 (Ranch Estates #1), Lots 45-47 and Lot 49 (Ranch Estates #1), and Lot 13 (Las Lomas de Catalina). However, any lot owner concerned about the potential for flood damage should consider purchasing flood insurance. Since the subdivisions are not shown to be in a special flood hazard area on the effective FIRMs, Zone X insurance (the least expensive) can be purchased. Zone X premiums are significantly lower than Zone AE, Zone A01, or Shaded Zone X premiums. In addition, as along as the policy remains effective, owners who purchase insurance now will continue to qualify for this rate zone, even if the maps are revised to include the subdivision.

In addition, the owners should consider flood proofing their homes to minimize damage to the contents and to the structure itself. Floodproofing measures typically fall into to categories – wet and dry floodproofing. However, since wet floodproofing, which allows water to enter the structure, is typically limited to uninhabited parts of a residence, these measures would only apply to a garage or detached storage shed. Dry floodproofing involves sealing the home to prevent water from entering the structure. Typical dry floodproofing measures that are applicable to the flooding conditions that exist within the subdivision include:

- Adding a waterproof veneer (approx. two to three feet) along exterior walls
- Raising electrical system components approximately 1.5 feet
- Raising or waterproofing HVAC equipment approximately 1.5 feet
- Installing sewer backflow values

See Appendix G for more detailed information.

Although elevating, relocating, or demolishing (then rebuilding) the structure are other retrofitting measures, they would not be as cost-effective as simple floodproofing. Berms or low-profile levees and floodwalls are also effective retrofitting measures since they can effectively divert flows around and/or away from structures; however, engineering studies that document the impact of these structures would have to be prepared by each property owner and submitted to the Regional Flood Control District for approval before floodplain-use permits could be issued. These types of structures typically increase the water-surface elevation and/or divert flows onto adjacent properties. Consequently, the Flood Control District needs to be assured that implementation of these types of mitigation measures will not adversely impact adjacent properties. Although some floodproofing measures would still require a floodplain-use permit, they are more likely to be approved without the requirement for a detailed floodplain study, since the impact of encroachment into the flood plain would be minimal.

Erosion and Sedimentation

The long-term degradation problem associated with Site 4 within Ranch Estates #9 appears to have been addressed, at least for now, by the combined effect of the grade-control structure installed downstream of the access drive to Lot 502 and the access drive itself. However, the loss of the rock riprap bank protection along the west bank should be addressed by the installation of new bank protection. If loss rock riprap protection is provided on a 3:1 (horizontal to vertical) side slope, the D50 diameter of the rock should be one foot, and the thickness of the rock layer should be a minimum of two feet. In addition, filter fabric should be installed under the rock and the toe of the protection should extend below channel bed a minimum of three feet plus the long-term degradation depth (Figure 5).

The loss rock riprap bank protection along the east bank adjacent to Lot 500 should also address by the installation of new protection. However, since the existing home is located within 10 feet of the bank, vertical gabion baskets (i.e., wire-tied baskets filled with rock), which can be placed vertically along the bank, would minimize disturbance of the soil in the vicinity of the homes foundation. Loose rock on a 3:1 slope would require 12-15 feet to install.

The sedimentation problem associated with Lot 502 appears to be directly related to the recent bank erosion associated with Lot 501. If a portion of the west bank adjacent to Lot 501 is reconstructed and adequately protected, the sediment transport capacity along the reach will be increased and low-flow will be redirected to its pre-Summer 2007 flow path. If desired, the bank between Sections 8 and 10 could be elevated to contain all or a portion of the 100-year discharge that currently breaks out of the western channel in the vicinity of Lots 501 and 502. A separate HEC-RAS model demonstrated that eliminating breakout in this area would not have an adverse impact on either the adjacent or downstream property owners. However, eliminating breakout upstream of Lot 501 could have an adverse impact of Lots 500 and 501. In addition, eliminating breakout downstream of Lot 502 could increase the flood hazard associated with Lot 503. Although elevating the bank in the vicinity of Lots 501 and 502 would eliminate breakout in this area and reduce low-flow hazards, it will not eliminate the high-flow hazards and vehicular access over the berm would have to be addressed.

Access during times of flooding is also a problem for the owners of Lots 501 and 502. However, installation of culvert crossing similar to the one installed for Lot 503 would increase the long-term degradation potential for Lot 500 and could undermine the existing grade-control structure installed on the church property. Consequently, crossings should not be provided, unless detailed engineering plans are prepared for review and approval. The plans should include the installation of bank and bed protection and additional grade-control structures upstream of the crossings. It appears that the grade-control structure installed upstream of the access drive for Lot 503 was constructed to minimize the impact on the access drive for Lot 502, since some lowering the streambed would have been required to facilitate the crossing. However, it does not appear that plans were prepared for this crossing; therefore, the long-term stability of the structure is questionable.

The long-term degradation problem at Sites 6 and 7 can be addressed in the manner identified in the 1989 study (i.e., the installation of gabion grade-controls structures. Grade-control structures could also be constructed along the downstream reach to minimize the long-term degradation potential at these sites.

Since the slope of the eastern branch of the Valley View Wash within the boundary of Lot 497 appears to have reached equilibrium, long-term degradation should no longer be a problem for this reach, including Site 5. Therefore, the existing grouted rock bank protection along the east bank should continue to protect the home on Lot 497, which is within 30 feet of the bank. However, the addition of a loose rock riprap apron downstream of the existing grouted rock apron would provide some protection from local scour.

Since erosion and sedimentation problem areas were not previously identified in Ranch Estates #1 and #2 and Las Lomas de Catalina, no site specific evaluations or recommendations were prepared as part of this study.

## V. REFERENCES


1. Pima County Department of Transportation and Flood Control District, *Preliminary Assessment of Flooding Problems along Valley View Was in the Vicinity of the Flecha Caida Subdivision*, July 26, 1984.

2. Pima County Department of Transportation and Flood Control District, *Flecha Caida Flood Improvement Study – Phase I, 100-year Peak Discharge Magnitudes and Floodplain Mapping*, January 28, 1986.

3. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, *Precipitation – Frequency Atlas of the Western United States, Volume VIII, Arizona*, NOAA Atlas 2, 1973.

4. Pima County Department of Transportation and Flood Control District, *Valley View Wash, Flood and Erosion Control Study for the Calle Del Pantera Area (Phase II, Flecha Caida Flood Improvement Study)*, February 15, 1989.

5. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, *Precipitation – Frequency Atlas of the United States*, NOAA Atlas 14, Volume I, Version 4, 2004, revised 2006.

6. Pima County Department of Transportation and Flood Control District/City of Tucson, Department of Transportation, *Stormwater Detention/Retention Manual*, July, 1987.

7. U.S. Army Corps of Engineers, Hydraulic Engineering Center, *HEC-RAS River Analysis System, Version 4 Beta*, November 2006.

8. City of Tucson, Department of Transportation, Engineering Division, *Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona*, prepared by Simons, Li and Associates, Inc., December 1989, last revision, July 1998.

**Appendix A**

A1-Subdivision Plat/Historic Study Excerpts
A2-1984 SLA-Flooding Problems Report
A3-1986 SLA Phase 1-Hydrology and Mapping Report
A4- 1989 SLA Flood and Erosion Assessment/Mitigation Report
A5- Revised Drainage Basin/Floodplain Comparison Exhibits

## Appendix B

NOAA Atlas 2, Volume VIII (1973) Hydrologic Data Sheets

**Appendix C**

NOAA Atlas 14, Volume I (2006) Hydrologic Data Sheets

## Appendix D

Development Plans for St. Thomas Church

# Appendix E

2007 Topographic Survey Sheets (Cardinal Land Surveying, Inc.)

# Appendix F

Scour Computation Sheets

# Appendix G

Guides to Retrofitting Flood Prone Structures

**Appendix A through G**
(digital copies on compact disk)