Erosion Hazard Study

For

Skunk Tank Wash

Prepared for:

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009
(602) 506-1501

October 2000

Prepared by:

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

5235 S. Kyrene Road, Suite 205
Tempe, Arizona 85283
480-752-2124
www.jefuller.com

Registered Professional Engineer (Civil)
Certificate No. 26846
JONATHAN E. FULLER
Date Signed 10/31/00
ARIZONA, U.S.A.

Memorandum JE Fuller/ Hydrology & Geomorphology, Inc.

DATE: October 31, 2000

TO: Joe Tram, P.E./ FCDMC

FROM: Jon Fuller, P.E.

RE: FCD #2000CO13 – Assignment #1
Skunk Tank Wash Erosion Hazard Study

CC: Dave Johnson, P.E./ FCDMC

Introduction

This memorandum summarizes the procedures used to define the erosion hazard areas delineated for Skunk Tank Wash. Skunk Tank Wash, a tributary to Skunk Creek, is located in an unincorporated portion of northern Maricopa County (Figure 1).

Purpose

The Flood Control District of Maricopa County (District) has been implementing the State Standard 5-96 (SSA 5-96) Level 1 Methodology on various watercourses throughout Maricopa County to determine erosion setbacks. Based upon initial usage of SSA 5-96, concern has arisen that a more detailed assessment may be necessary for certain washes that are facing development pressure. The primary objective of the Skunk Tank Wash Erosion Hazard Study was to identify and delineate areas near Skunk Tank Wash that are subject to riverine erosion hazards. A secondary objective was to evaluate the SSA 5-96 erosion hazard setback methodology as applied to Skunk Tank Wash.

Channel Description

Skunk Tank Wash is an ephemeral drainage system which drains a relict alluvial fan surface located within the northern end of the Paradise Valley. The study reach extends from the confluence with Skunk Creek to Rockaway Hills Road near the headwaters. For the purposes of this study, the wash was divided into the following three subreaches:

- *Reach 1 – Upstream of Irvine Road.* Reach 1 has a tributary, single-channel drainage pattern. The single channel pattern is interrupted by short braided reaches that occur near channel obstructions (fallen trees, road crossing, fences), small avulsions, and tributary confluences. Channel widths and depths average about 15 feet and two feet, respectively, although bank heights where the active channel intersects geomorphically old surfaces may reach 10 feet. Channel banks are moderately well vegetated with small trees and brush, except where the floodplain has been altered by development. Bank failures by undercutting were observed at several places, including reaches where the bank materials included carbonate-cemented cobbles. Well-defined stream terraces which confine the natural floodplain occur throughout the reach.

- *Reach 2 – Irvine Road to 16th Avenue Alignment.* Reach 2 retains the tributary, single-channel drainage pattern of Reaches 1 and 3, but has several significant differences. First, the terraces and floodplain become much wider and less well defined than the adjacent reaches. Second, more evidence of overbank channel formation and incipient channel avulsions were observed, and the land area over which these features occurs is significantly wider than in Reaches 1 or 3. Third, the degree of disturbance of the main channel increases relative to other parts of Skunk Tank Wash, with numerous homes, fences, and other obstructions constructed along the channel and floodplain. Fourth, the channel capacity decreases markedly in Reach 2, increasing the probability of overbank flooding and erosion. Fifth, less evidence of bank failure was observed than in Reach 1. Channel banks are very well vegetated, except where disturbed by development.

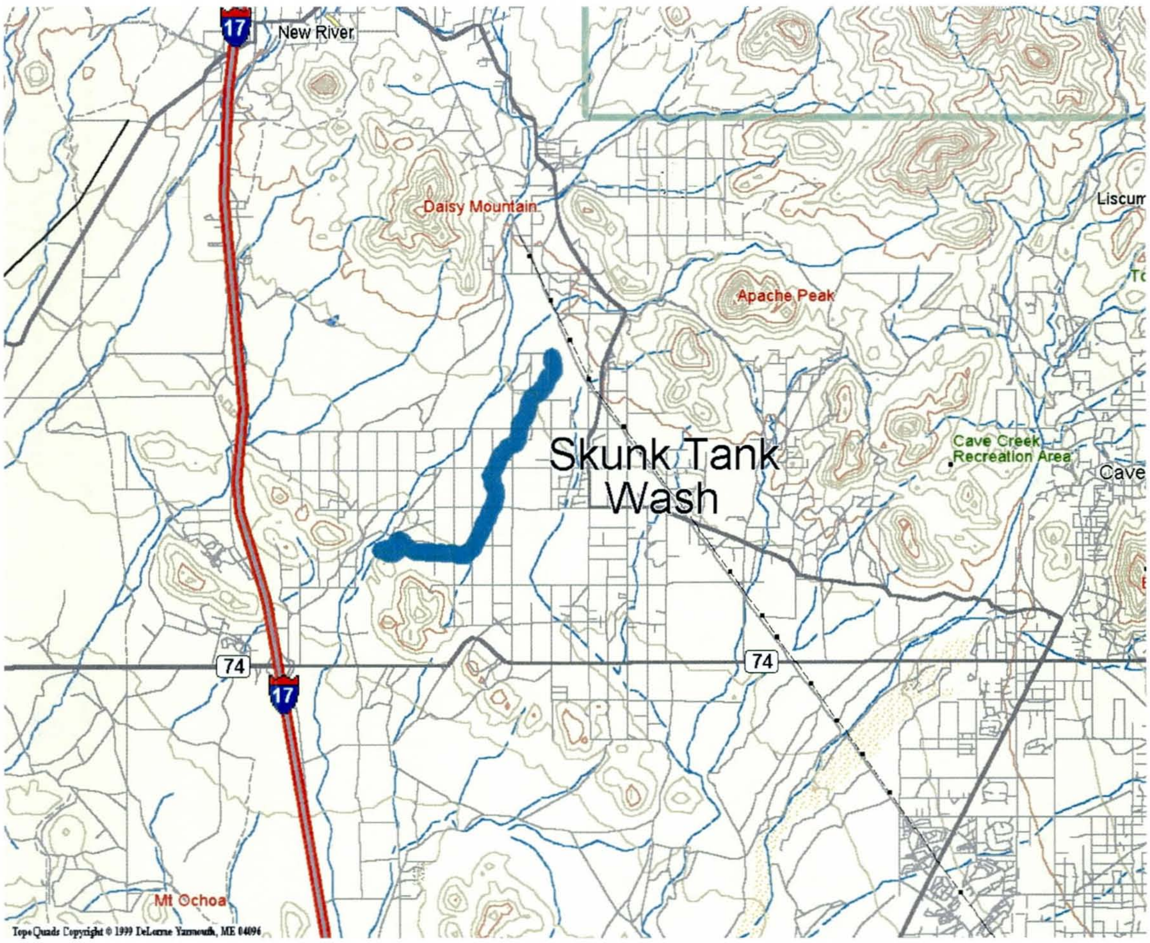


Figure 1. Skunk Tank Wash Location Map

- *Reach 3 – 16th Avenue Alignment to Skunk Tank.* Reach 3 has a tributary, single-channel drainage pattern. The bank height, channel width, and channel capacity are greater than in Reach 2, but evidence of moderately frequent overbank flooding was also observed. Well-defined terraces similar to those in Reach 1 were also observed in Reach 3. Channel banks are moderately well vegetated and do not appear to be subject to significant lateral erosion, except near development where the banks have been disturbed and the bank vegetation has been removed. The channel width and depth in Reach 3 averages about six feet and three feet, respectively. Within the Skunk Tank ponding limit, the channel again becomes less well defined than the reach upstream of the tank. Skunk Tank appears to have been breached by overtopping at some time in the recent past, although the dam still retains a small ponding area.

Limitations and Assumptions

Any technical analysis is limited by the data available, the contracted scope of services, and the assumptions of the methodologies used. For the Skunk Tank Wash erosion hazard assessment, the following general limitations apply:

- Hydrologic Data. No stream flow gauging data were available for the study reach. Estimates of the 100-year discharges were obtained from Floodplain Delineation Studies (FDS) performed by others, as described below. Gauged stream flow data for Skunk Tank Wash and its tributaries would improve the accuracy of the erosion hazard evaluation.
- Hydraulic Modeling. HEC-RAS models were prepared by others for the purpose of delineating the 100-year floodplain and floodway (EEC-MKE, 1997).[1] No additional modeling of more frequent flood events was part of this analysis.
- Geotechnical Data. No geotechnical data were available for the study area. More accurate predictions of existing lateral erosion hazards could be made if extensive geotechnical investigations were completed along the stream corridors.
- Level of Detail. The erosion hazard setbacks determined for this evaluation are based on observations made during field reconnaissance, interpretation of historical aerial photographs and topographic maps, consideration of data and mapping from previously published reports, and the SSA 5-96 Level 1 Methodology. It is possible that the recommended erosion hazard setbacks could be refined by applying more detailed methodologies, such as those used in the District's Watercourse Master Plan studies (JEF, 1999; 2000).[2,3] This study is roughly equivalent to the SSA5-96 Level 3 Analysis.
- Additional Erosion Hazards. Riverine erosion and flood hazards exist along the entire watercourses. In addition, erosion from slope processes will occur on steep slopes within the study area. This study is limited to evaluation of riverine erosion hazards on the main stem of Skunk Tank Wash.

---

[1] EEC-MKE Consulting Engineers, 1997, Technical Documentation Notebook and Workmaps for Skunk Tank Wash Floodplain Delineation Study, FCD #96-05.

[2] JE Fuller/ Hydrology & Geomorphology, Inc., 1999, Cave Creek/Apache Wash Watercourse Master Plan Report – Lateral Stability Analysis, Draft. Report to the Flood Control District of Maricopa County.

[3] JE Fuller/ Hydrology & Geomorphology, Inc., 1999, Skunk Creek Watercourse Master Plan Report – Lateral Stability Analysis, Draft. Report to the Flood Control District of Maricopa County.

Methodology

The following procedures and methodologies were used to define erosion hazards along Skunk Tank Wash:

- Field inspection
- Interpretation of aerial photographs
- Comparison of channel position on historical aerial photographs
- Interpretation of detailed soils maps
- Interpretation of surficial geology maps
- Interpretation of regional geology
- Analysis of longitudinal profile
- Application of allowable velocity criteria
- Application of State Standard SSA 5-96 Level 1 Methodology

Field Inspection. Field visits were conducted in the study reach on August 11th, August 31st, October 13th, and October 26th, 2000.[1] The objective of the field visits was to document existing channel and floodplain conditions. The types of field data collected included the following:

- Evidence of recent and historic channel erosion
- Location and extent of cut banks
- Location and extent of caliche or bedrock outcrops
- Location, height and boundaries of stream terraces
- Channel conditions at bridge, culvert, and road crossings
- Photographs of typical channel sections, erosion features and structures

Field data were marked and collated on 1:1200 scale aerial maps, and were later digitized in AutoCAD on a semi-rectified aerial photograph base map. Field photographs and photographs logs are provided in Appendix A. CAD data were provided digitally.

The following general conclusions are supported by the data collected during the field reconnaissance visits:

- Typical Cross Section. The typical cross section for Skunk Tank Wash varies significantly within the study reach, as illustrated in Figures 2 to 4. Channel width and depth in Reach 1 (Figure 2) generally increase in the downstream direction, but average about 15 feet and two feet, respectively. In Reach 2 (Figure 3), the channel becomes shallower and narrower in the downstream direction, and is less well defined. In Reach 3 (Figure 4), the channel width again increases in

[1] The October 26, 2000 field visit occurred after the October 22nd flood on Skunk Tank Wash.

the downstream direction, with an average width of about six feet, and a depth of about 3 feet

Figure 2. Reach 1, looking upstream.

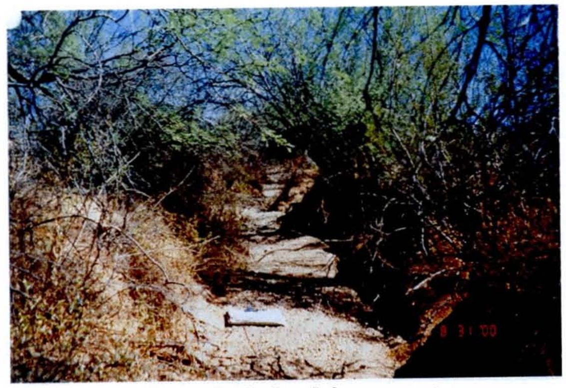


Figure 3. Reach 2, looking upstream.

Figure 4. Reach 3, looking downstream.

- Floodplain Dimensions. A natural floodplain (Figure 5) is present adjacent to the main channel throughout the study area. The floodplain generally widens in the downstream direction, especially in Reach 2, where it takes the shape of an alluvial fan. The height of the floodplain relative to the main channel is lowest in Reach 2, and is most variable in Reach 1. As the height of this natural floodplain above the main channel increases, the frequency of flow on the floodplain decreases, and the erosion potential of the main channel bank increases due to the relatively higher flow depths and velocities along the main channel bank, as illustrated in Figure 6. Where field evidence suggests more frequent overbank flow on the floodplain, the potential for avulsive channel change increases.

Figure 5. Floodplain terrace in Reach 1.

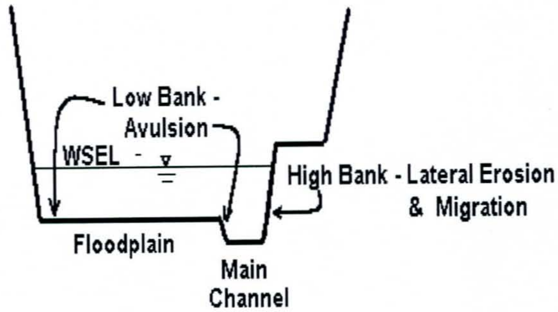


Figure 6. Sketch showing bank erosion type relative to bank height.

- Floodplain Soils. The soil materials underlying the natural floodplains adjacent to the main channels appear to be comprised of erosive, unconsolidated sand and gravel. A soil profile observed at a septic tank excavation is shown in Figure 7.

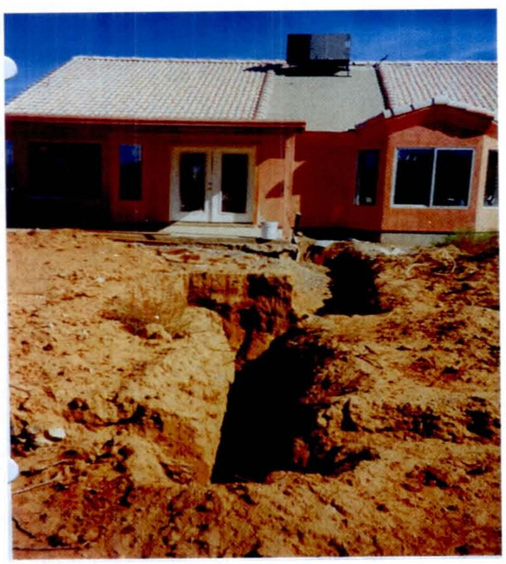


Figure 7. Soil profile for home in floodway of Skunk Tank Wash Reach 3.

- Caliche. Carbonate-rich soil layers (a.k.a. "caliche") were observed throughout Reach 1, and are exposed in cut banks where the main channel intersects the margins of older geomorphic surfaces (Figures 8 and 9; Table 3). While the caliche layers themselves are more resistant to erosion than the non carbonate-cemented soil layers, field data suggest that the carbonate layers have been eroded by recent stream flows. The carbonate layers erode primarily by undercutting the non-cemented underlying layers (cantilever failures), but also by direct shear and impact forces on the carbonate layers themselves (Figure 10). Locations of caliche outcrops observed in the field are shown on Exhibit 1.

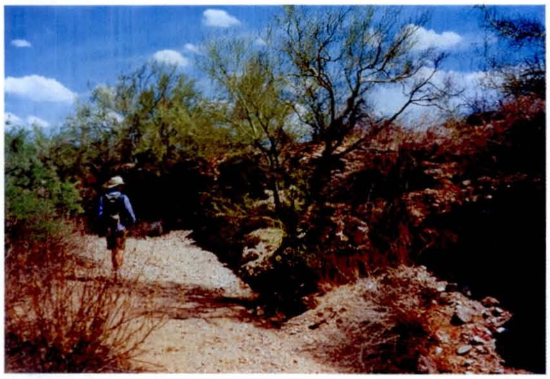


Figure 8. Caliche-cemented bank in Reach 1.

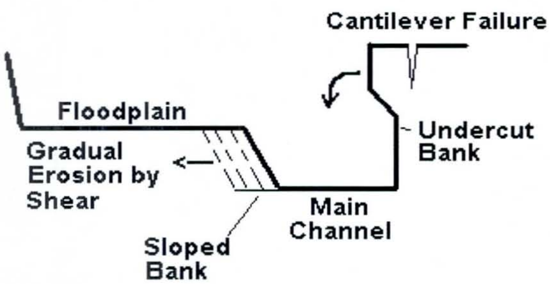


Figure 10. Illustration of cantilever failure and failure by shear.

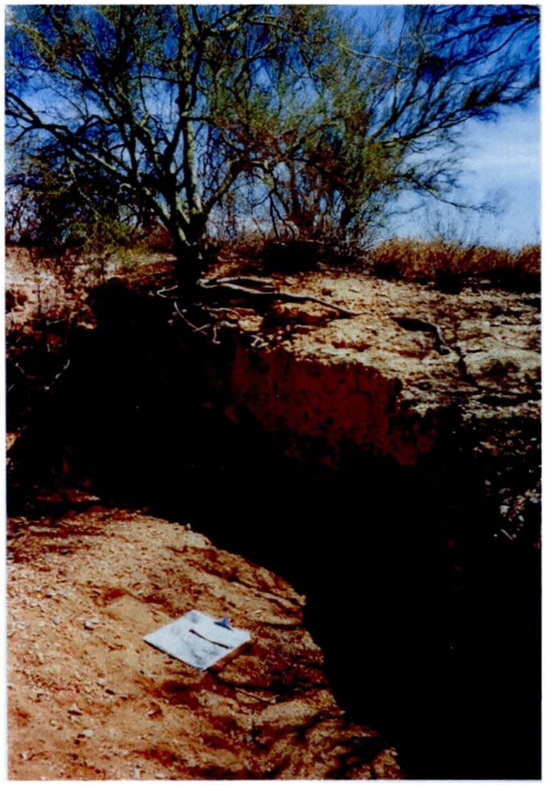


Figure 9. Undercut bank capped by carbonate layer.

- Bedrock. Lateral erosion is effectively prevented by bedrock. However, no bedrock outcrops were observed in the bed or on the banks of Skunk Tank Wash within the study reach or on any of the terraces adjacent to the wash, except on the hillslope adjacent to Skunk Tank. Therefore, there is no natural physical barrier that completely prevents lateral erosion of the wash.

- Long-term scour. No evidence of significant historical long-term degradation on Skunk Tank Wash was observed in the field. Field evidence of long-term scour typically includes undercut bank vegetation, leaning or fallen bank vegetation, high or multiple terraces, abundant cut banks, headcutting, armoring, perched channels, and excessive erosion at structures. The hypothesis of no significant long-term scour is supported by the comparison of longitudinal stream profiles from 1964 and 1997 discussed later in this memorandum (Figure 27).

- Local scour. Scour holes up to one foot deep were observed at some channel bends or where natural obstructions such as trees or boulders partially block the main channel. The relatively small size of the observed scour holes indicates a low potential for severe local scour and a balanced sediment budget for the stream, but also reflects the moderate flood velocities and peaks that occur in the wash.

- Structure impacts. Few structures for which structure impacts could be assessed exist within the study area. In general, the potential for lateral erosion increases near structures due to flow constriction, flow acceleration through the structure, and inability of the stream to adjust its boundaries within the structure in response to changing flow conditions. The impacts from structures observed in the field are summarized below.

    - Skunk Tank. Skunk Tank, the stock tank from which the wash derives its name, consists of an 8-foot high earthen dam located immediately upstream of the confluence with Skunk Creek. The dam is currently breached (Figure 11a), but continues to pond a small amount of water after flow events. No information on the construction date of the dam was readily available. The tank is visible on 1962 aerial photographs and does not appear to have been recently constructed at that time, so it must pre-date 1962. The ponding area of the tank has partially filled with fine-grained sediment. Sediment deposition in the ponding area appears to impact the morphology of the wash for a distance of about 0.4 miles upstream of the dam.

      After the photograph in Figure 11a was taken, a small flood occurred on Skunk Tank Wash on October 22, 2000. Figures 11b to 11d show the condition of the breach in the dam on October 26, 2000. Further degradation of the dam and subsequent floods will lead to headcutting through the tank impoundment area and increased lateral erosion in Skunk Creek downstream of the tank.

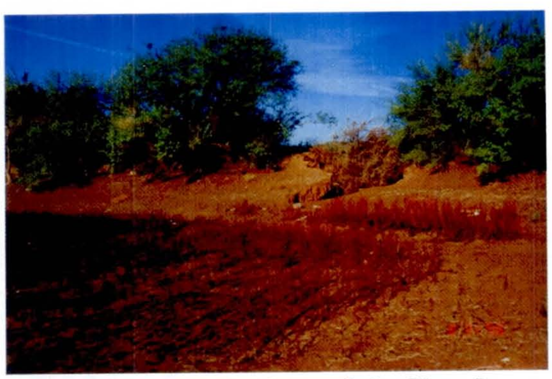


Figure 11a. Partial breach in Skunk Tank, looking downstream at dam on August 31, 2000.

Figure 11b. Full breach in Skunk Tank after October 22, 2000 flood.

Figure 11c. Looking upstream through breach after October 22, 2000 flood. Bottom of tank at eye level.

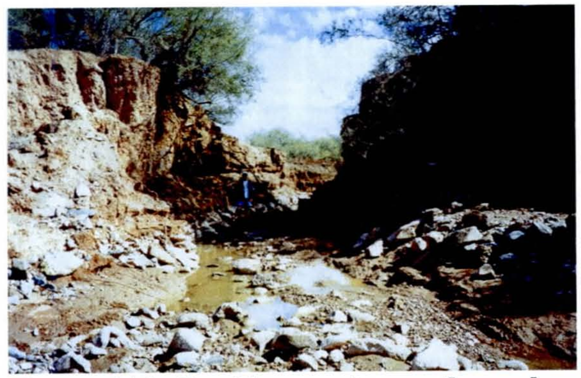


Figure 11d. Looking upstream through breach after October 22, 2000 flood.

- Road Dip Crossings. At-grade crossings of the few dirt roads that cross the streams in the study area have minimal impact on the streams, aside from trapping fine-grained sediment in the road section during flow events (Figure 12).

Figure 12. Dip crossing of Skunk Tank Wash at Irvine Road. Note evidence of recent sediment deposition.

- Culverts. Culverts have been constructed at Desert Hills Drive (2-5ft. CMP; Figure 13), 7th Avenue (3-4 ft. CMP; Figure 14), and Joy Ranch Road (3-4 ft. CMP). The culverts at Desert Hills Drive and 7th Avenue are in good condition with no obvious sedimentation impacts on the main channel. The Joy Ranch Road culverts are about ½ filled with sediment, probably because they were installed below the natural grade of the main channel. Because these culverts are undersized with respect to the 100-year flood, they will be overtopped. Overtopping flows may cause erosion of road grades or may direct flows away from the main channel and cause avulsive erosion of the floodplain.

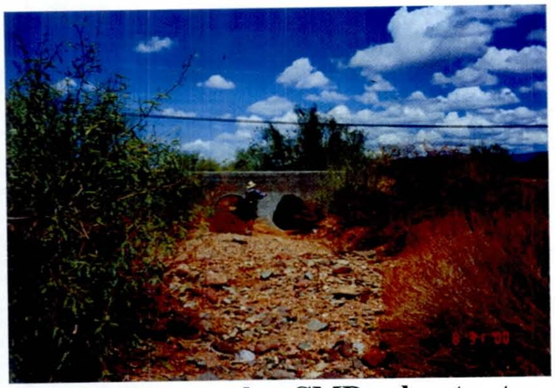


Figure 13. Irregular CMP culverts at Desert Hills Drive.

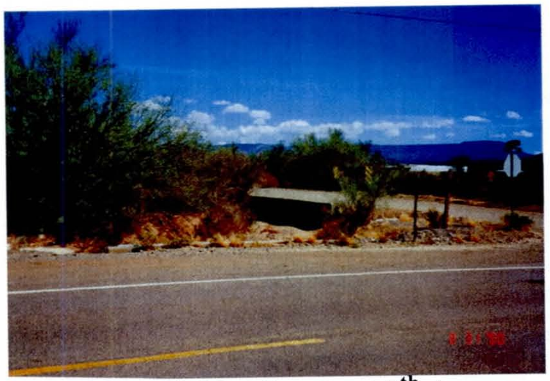


Figure 14. CMP culverts at 7th Avenue.

- Fences. Several homeowners have built fences over the main channel of Skunk Tank Wash (Figure 15). These fences will tend to trap sediment and debris, increasing local scour immediately surrounding the fence, and ultimately causing failure of the fence. More importantly, the fences will trap flood debris and divert water from the main channel into the floodplain, increasing the likelihood of avulsions or scour in the floodplain.

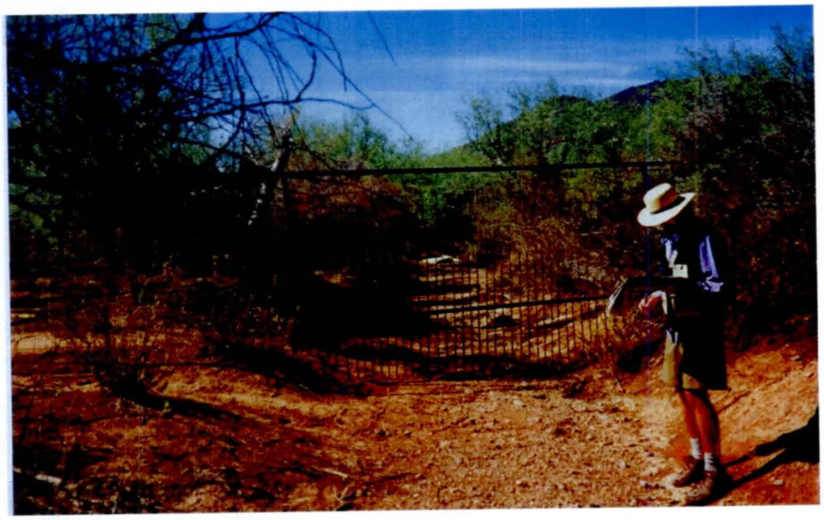


Figure 15. Chain link and iron grate fence over Skunk Tank Wash.

- Bridges. A number of homeowners have constructed small one-lane bridges over the main channel (Figure 16). These bridges tend to be undersized with non-standard construction materials. The bridges will tend to block flow and divert flow onto the floodplain, increasing the chance of avulsions and scour in the floodplain. Where bank vegetation was removed near the bridge abutments, the channel banks will be more erodible.

Figure 16. Small driveway bridge over Skunk Tank Wash.

- o Homes. Several homes and barns have been built in the floodway of Skunk Tank Wash within several feet of the main channel banks, and are at risk of erosion and flood damage (Figure 17). In a few cases improvements associated with new home construction have obliterated the natural channel by grading, and blocked the floodplain with chain link fences (Figure 18). Excessive erosion of the floodplain should be expected where the natural channel no longer exists.

Figure 17. Horse barn on fill encroaching in the floodway.

Figure 18. Homes with grading obscuring natural wash and blocking floodplain.

- Cut banks. The locations of cut banks observed in the field are plotted on Exhibit 1. The presence of cut banks indicates that active lateral erosion can occur within the stream systems in the study area regardless of bank vegetation, soil lithology, and soil composition (Figure 19).

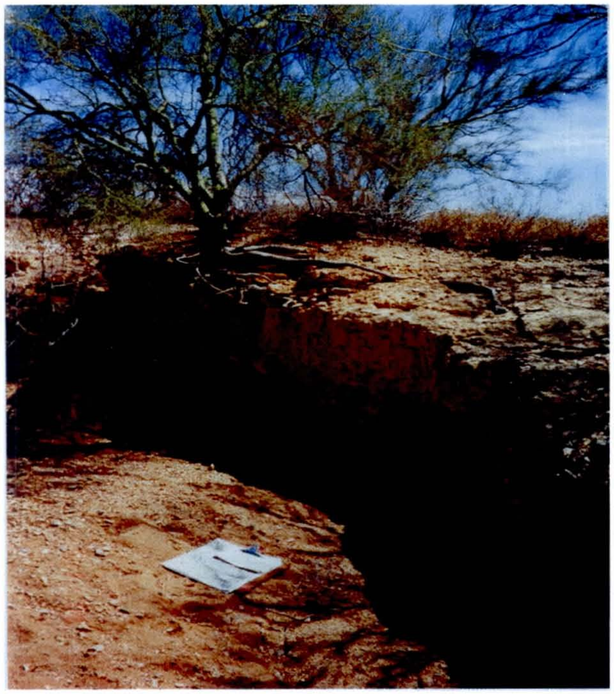


Figure 19. Cut bank in caliche cemented bank.

The incidence of cut banks observed in the field decreased in the downstream direction, despite the increase in discharge and degree of urbanization and a decrease in carbonate (caliche) content of the bank materials, as shown in Table 1. Furthermore, the cut bank features in Reaches 2 and 3 tended to be smaller and less active than those in Reach 1. Interestingly, the presence of caliche in the banks is correlated with an increase in the occurrence of cut banks, probably because caliche material cannot be rapidly colonized by bank vegetation.

Table 1. Skunk Tank Wash Erosion Hazard Analysis
Percent Caliche, Bedrock, & Cut Banks by Reach

Feature	Reach 1 (Upstream of Irvine)	Reach 2 (Irvine to 16th)	Reach 3 (16th to Tank)
Bedrock	0.0%	0.0%	0.0%
Caliche	5.8%	0.0%	0.0%
Cut Banks	24.0%	10.5%	5.5%

- Bank vegetation. In most locations, the banks are well vegetated with mesquite, palo verde, and dense brush (Figure 20). The bank vegetation generally covers the entire bank slope from toe to top, and includes deep rooting riparian species which enhance bank stability.[1] The following two aspects of the bank vegetation enhance bank stability: (1) roots which holds soil material in place, and (2) branches, leaves, and debris trapped in the vegetation which lower the velocities

[1] Bank vegetation enhances the stability of the bank materials, but does not preclude the possibility of bank erosion, as indicated by the presence of cut banks throughout the study area.

at the bank line and prevent high-velocity floodwaters from flowing directly on the soils that comprise the bank. The presence of mature bank vegetation throughout much of the study area indicates that the average rate of lateral erosion has been slow in the past 50 years. That is, the average rate of lateral erosion is less than the average growth rate of the vegetation on the banks.

Figure 20. Dense bank vegetation.

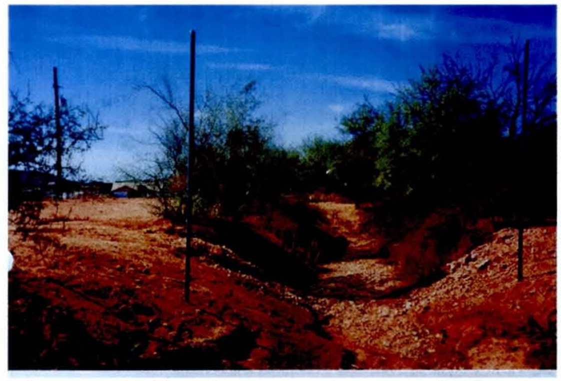


Figure 21. Bank vegetation partially removed by homeowner.

In some cases, bank vegetation has been removed on developed lots. Loss of the bank vegetation will accelerate the risk and rate of lateral erosion (Figure 20).

- Sediment Transport. The channel beds consist primarily of sand and gravel sized sediment, with some cobbles and small boulders (Figure 22). The floodplain soils typically consist of finer sand and gravel deposits. The difference in composition between the floodplain and channel indicates that fine sediment is transported through the main channels without being deposited. The main channel sediments are moderately well sorted, indicating that they have been transported by recent flows, and are not primarily derived from slope processes acting on the banks and canyon slopes. Fine-grained sediment deposited in Skunk Tank confirms that the streams transport fine-grained material, but that it is normally conveyed through the system without deposition in the main channels.

Figure 22. Coarse bed material in small riffle.

- Channel Pattern. The dominant channel pattern of the streams in the study area is a straight, single channel pattern. Where channel widening occurs, the channels become more braided or a significant volume of flow is diverted onto the floodplain. Change in channel pattern due to sediment deposition is one of the mechanisms of lateral instability and bank erosion in the study area.

- Avulsions. Where the main channel becomes small, the potential for high volumes of flow in the floodplain is high. That is, if the elevation of the overbank floodplain is low relative to the main channel, the floodplain will convey frequent flows of sufficient volume and peak to cause new channels to form (Figures 23 and 24). With time, these floodplain channels can capture the main channel and cause an avulsive shift of the main channel into the floodplain channel, resulting in a sudden relocation of the active channel from one side of the floodplain to the other. Remnants of past avulsions or incipient avulsive channels were observed on the wider floodplains in Reach 2. Small avulsions are found at a number of points in Reaches 1 and 2.

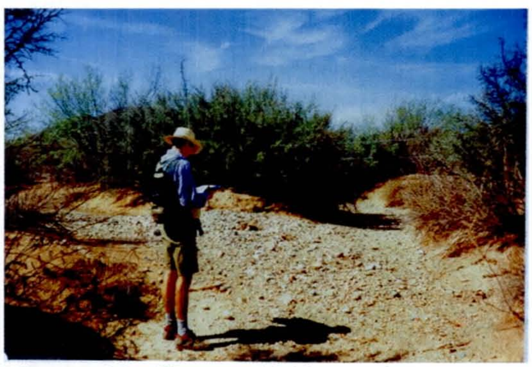


Figure 23. Channel bifurcation.

Figure 24. Channel split around mid-channel tree and debris.

- Flood High Water Marks. Flotsam observed along the banks of the main channels indicates that at least one flood has recently filled the channels and inundated portions of the floodplain.

- Human Impacts. Impacts associated with human occupation of the study area are limited, but include the following:
  - Fences (Figure 15)
  - Removal of bank vegetation (Figure 21)
  - Filling of the main channel (Figure 18)
  - Undersized culverts and bridges (Figures 13, 14, and 16)
  - Construction of homes in floodplain and floodway (Figures 7, 17 and 18)

  In general, human activities such as removing bank vegetation, causing flow obstructions, and changing natural runoff characteristics have decreased bank stability.

Interpretation of aerial photographs. The erosion hazard along Skunk Tank Wash was also evaluated by interpreting surficial characteristics visible on aerial photographs. The age of stream terraces adjacent to the main channels provides information on past stream bed elevations and positions that can be used to forecast where the stream may be located in the future. Geomorphic surface characteristics were used to compare terraces within the study limits to surfaces in the local area previously evaluated by the Arizona Geological Survey (Leighty and Holloway, 1998). Those characteristics included the following:

- Soil development
- Surface color
- Desert pavement
- Desert varnish
- Topographic relief
- Vegetative characteristics

Individually, these age-indicating characteristics provide a relatively low degree of confidence in age estimates. Considered together, the characteristics provide a higher degree of confidence. The physical characteristics of a surface give clues as to its depositional history, stability, and flood potential.

If a land surface ceases to receive new deposits, it will begin to age. As it ages, the surface begins to develop distinctive physical and chemical characteristics indicative of its age. As the soil develops, its structure, color and content change. Soils become redder with increased age due to oxidation of iron, a process called rubification. Clay and carbonate also accumulate as a soil ages, causing the soil to develop structure (clay), and become whiter (carbonate) and more cemented (carbonate). Soils with high clay and carbonate content are generally more resistant to erosion. As they age, surfaces may also develop gravel lag coverings known as desert pavement. The large clasts on the surface, if they contain sufficient ferromagnesian minerals, will develop a dark black patina called desert varnish on their tops and an orange coating underneath. Surfaces free from new deposition will also begin to erode and develop new tributary channel networks, creating a greater degree of relief between the channel bottoms and the ridges which separate them.

Because many of these characteristics take thousands of years to develop, it can be concluded that surfaces that exhibit well-developed soils, red color, significant carbonate development, desert pavements composed of strongly varnished gravels, and tributary drainage networks have been relatively free from flooding and erosion for thousands of years. Therefore, without external disturbance, it can be assumed that the flood and erosion hazard potential in the future will remain low.

Digital black and white aerial photographs provided by the District were used in conjunction with field observations to distinguish older, more stable surfaces from younger, more active surfaces near the stream channels using the principles described in the preceding paragraphs. These data were used to estimate the potential for future lateral erosion; i.e. the youngest surfaces were considered most prone to erosion.

Comparison of channel position on historical aerial photographs. The position of the main channel thalweg of Skunk Tank Wash was digitized from readily available historical aerial photographs and from the 7.5 minute USGS topographic quadrangles for the study area. A list of the historical aerial photographs used is shown in Table 2. The historical aerial photographs were scanned to create digital images which were then semi-rectified using AutoCAD 2000 software and the digital USGS quadrangles as the map base. A plot of the historical channel position in 1962 and 1999 is shown in Figure 25. In general, the channel position has not significantly changed during the 50 year period of record, although at least four avulsive-type braids were removed by development, and lateral channel movement up to 100 feet is recorded near Irvine Road.

Table 2. Skunk Tank Wash Erosion Hazard Evaluation
Historical Photographs and Maps

Year	Description	Scale	Source
1962	Black & white aerial photo (9-15-62)	1:24,000	USGS
1971	Black & white aerial photo (7-23-71)	1:40,000	Landis
1988	Black & white aerial photo (12-12-88)	1:40,000	Landis
1992	Black & white aerial photo (9-6-92)	1:40,000	NAPP
1995	Black & white aerial photo (12-1-95)	1:9,600	Kenney/FCDMC
1999	Color aerial photo (7-31-99)	1:20,000	AMC/FCDMC

A side-by-side plot of the 1962 and 1999 aerial photographs is provided in Figure 26 to illustrate the degree of urbanization of the floodplain.

Interpretation of detailed soils maps. Detailed soils mapping of the study area is available from the Soil Conservation Service (SCS).[1] Brief descriptions of the mapped soil units near Skunk Tank Wash are provided in Tables 3 to 5. Engineering characteristics of the soils are listed in Table 5. Note that all of the soil units in the study area were designated as fan terraces, and none were considered representative of drainageways or floodplains. In addition, as shown in Table 4, the soil classes for the units near Skunk Tank Wash are typically associated with surfaces of early Holocene age (7-11 ka[2]). The relationship of surface age with soil class is supported by the presence of clay and caliche in the soil profiles as noted in Table 4. The portion of the SCS soils map near Skunk Tank Wash is reproduced in Figure 27.

Designation of the soils in the study area as fan terraces appears to indicate that the erosion hazard outside the main channel is slight. However, the designation of fan terrace for these surfaces is probably more of a reflection of the macro-scale of the SCS mapping and unit descriptions than a precise interpretation of the existing surficial processes. Field evidence and the District's 100-year floodplain mapping clearly indicate potential

[1] Camp, P.D., 1986, Soil Survey of Aguila-Carefree Area, Parts of Maricopa and Pinal Counties, Arizona.

[2] ka = thousand years

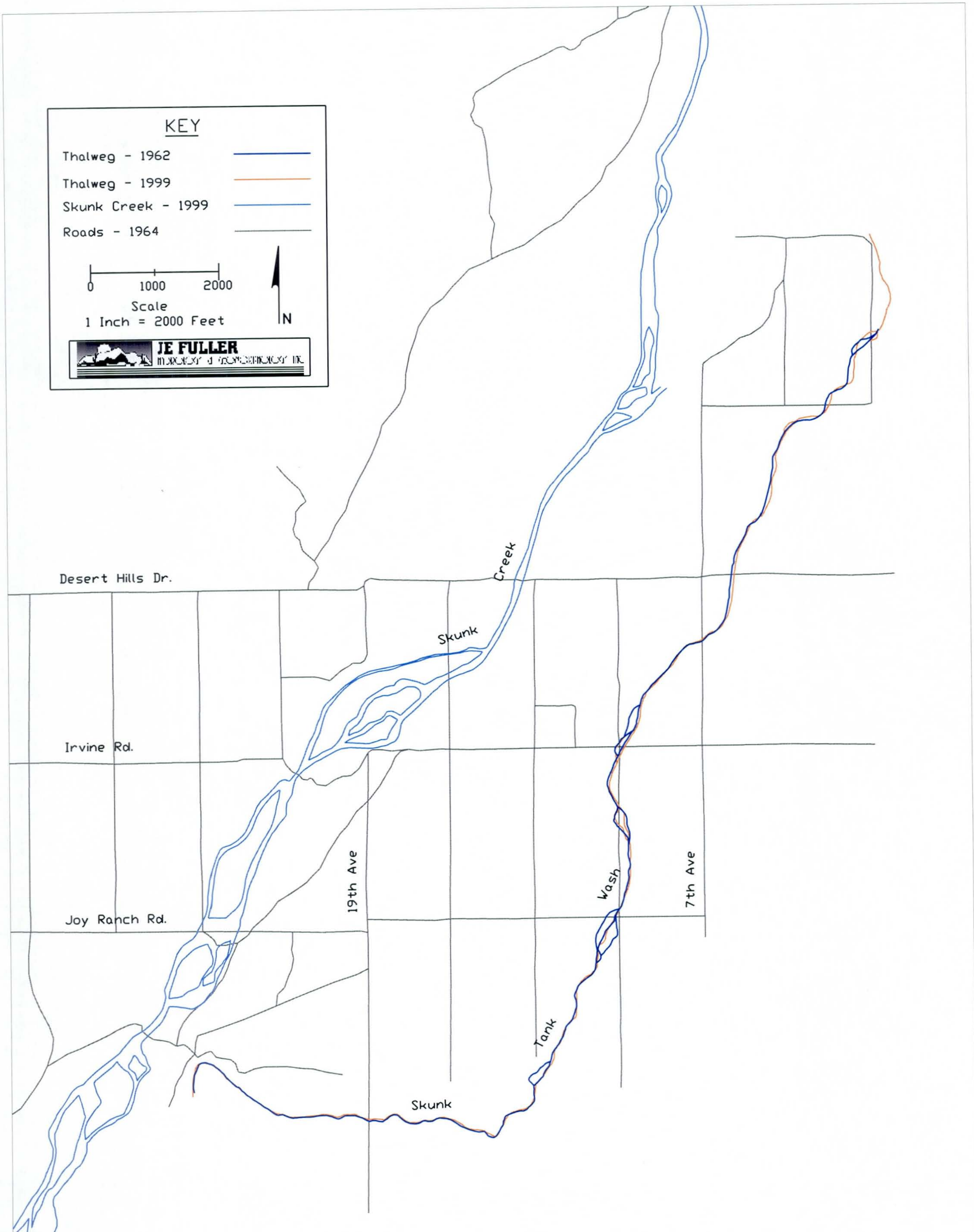
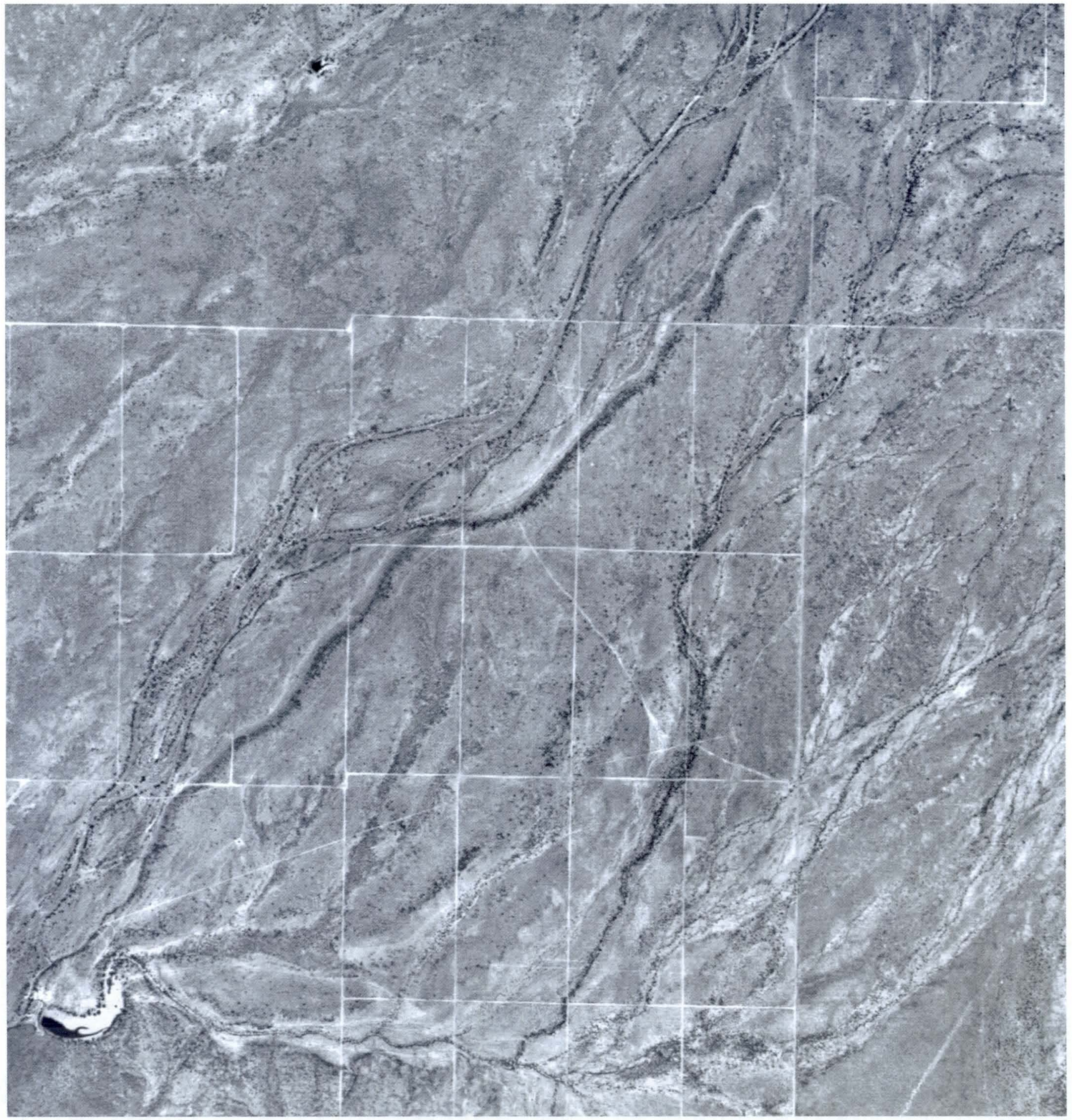
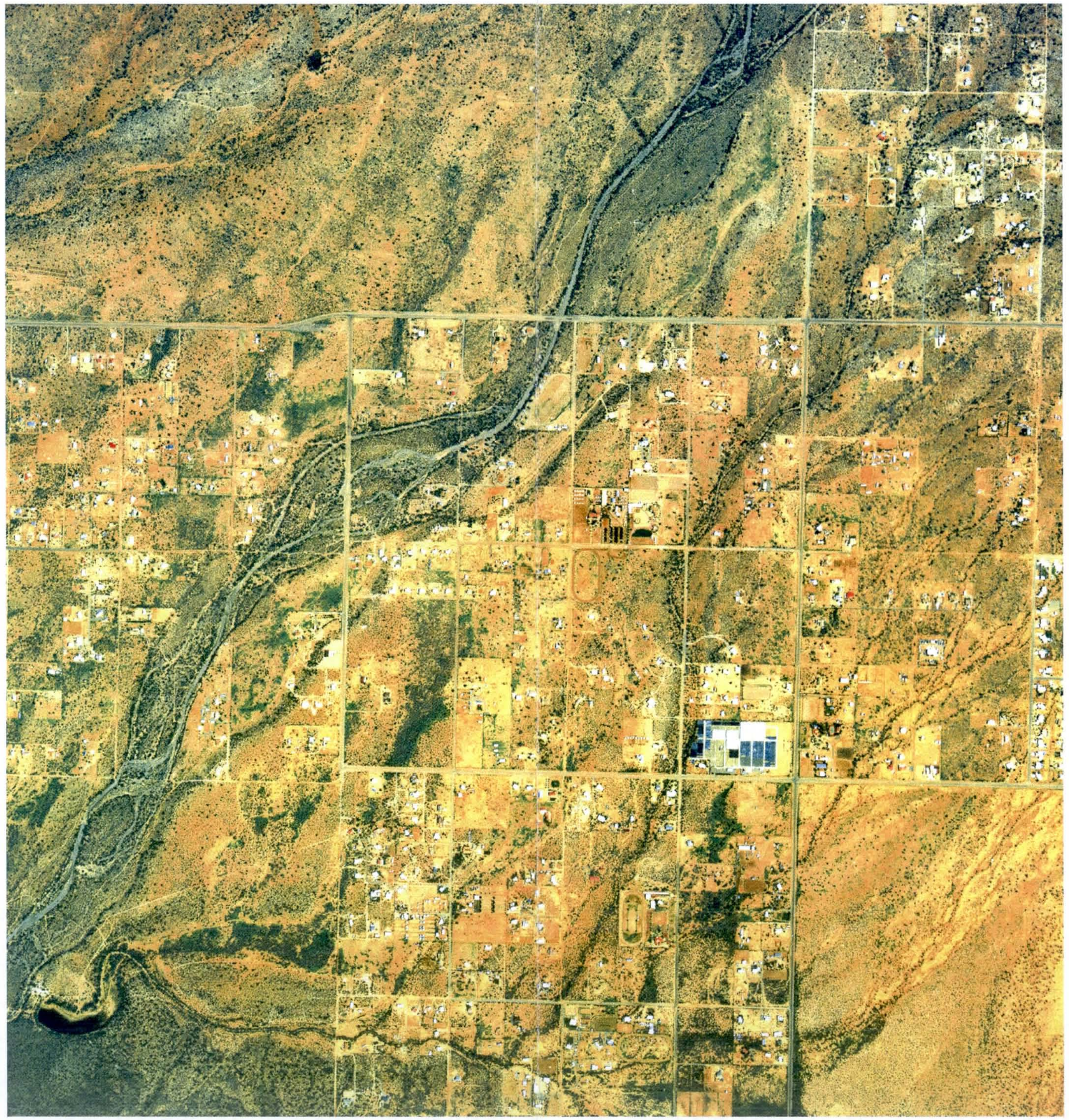


Figure 25. Skunk Tank Wash Thalweg Position, 1962 - 1999.

Figure 26. Skunk Tank Wash Photo Comparison



September 15, 1962



July 31, 1999

1 in = app. 1700 ft

Table 3. Skunk Tank Erosion Hazard Assessment
SCS Soils Information: Description, Classification, & Geomorphic Setting

SCS Map Unit	Component Soil Series	Position/Landform	Key Characteristics	Subgroup/Order
Carefree Cobbly Clay Loam (12)	Carefree - 80%	On fan terraces	Calcareous pink surface layer, reddish-brown calcareous subsurface layer Main limitation for development is shrink swell potential	Vertic haplargid Typic durargid
Carefree-Beardsley Complex (13)	Carefree – 50% Beardsley – 40%	On fan terraces	Carefree: Pink cobbly clay surface layer, reddish-brown calcareous clay subsurface layer Beardsley: reddish brown cobbly clay loam surface layer, reddish brown clay subsurface layer with silica cemented hardpan Main limitations to development are shrink swell potential and shallow cemented hardpan	Vertic haplargid Typic durargid
Contine Clay Loam (22)	Contine – 80%	On fan terraces	Brown calcareous clay loam surface layer, reddish brown calcareous clay loam and clay subsurface layer Some areas subject to rare flooding Main limitation for development is shrink swell potential	Typic haplargids
Ebon very Gravelly Loam (44)	Ebon – 80%	On fan terrace	Brown very gravelly loam surface layer, yellowish red very gravelly clay and calcareous very gravelly sandy clay subsurface layer, with white calcareous gravelly loamy sand substratum Few limitations for development, except slow percolation rate	Typic haplargids
Gachado Lomitas Rock Outcrop Complex (52)	Gachado – 45% Lomitas – 20% Rock – 20%	On mountain and hill slopes	Gachado: light brown very gravelly loam surface layer, brown very gravelly clay loam subsurface layer. Bedrock at depth of 7 inches Lomitas: brown very gravelly sandy loam , strong brown very gravelly sandy loam. Bedrock at depth of 10 inches Rock: andesite, rhyolite, & tuff Main limitation to development is shallow bedrock and slope	Lithic haplargid Lithic camborthid
Pinamt-Tremant Complex (98)	Pinamt – 45% Tremant – 35%	On fan terraces	Pinamt: brown calcareous very gravelly sandy clay loam surface layer, brown calcareous very gravelly loam subsurface layer Tremant: reddish yellow gravelly loam surface layer, reddish yellow and yellowish red calcareous sandy clay loam and gravelly clay loam subsurface layer Main limitation for development of Tremant is shrink swell potential. Few limitations for Pinamt	Typic haplargids
Suncity Cipriano Complex (110)	Suncity – 55% Cipriano – 30%	On fan terraces	Suncity: brown gravelly loam surface layer, reddish brown calcareous gravely clay loam subsurface layer. Hardpan at depth of 9 inches Cipriano: brown calcareous very gravelly loam surface layer, brown calcareous very gravelly loam subsurface layer over hardpan Main limitation for development is shallow hardpan	Typic duragid Typic durorthid
Tremant Gravelly Sandy Loam (112)	Tremant – 65%	On fan terraces	Reddish brown gravelly sandy loam surface layer, reddish brown gravelly sandy clay loam subsurface layer Main limitation for development is shrink swell potential	Typic haplargids
Tremant Gravelly Loam (113)	Tremant - 80%	On fan terraces	Reddish brown gravelly loam surface layer, reddish brown gravelly loam over reddish brown gravelly clay loam subsurface layer Main limitation for development is shrink swell potential	Typic haplargids

Table 4. Skunk Tank Erosion Hazard Assessment
General Soil Age & Relation of SCS and AZGS Map Units

SCS Map Unit	Subgroup/Order	Order	Minimum General Age Of Soil Order	AZGS Map Unit
Carefree Cobbly Clay Loam (12)	Vertic haplargid Typic durargid	Aridisols	Early Holocene (7-11 ka)	Q_m – Middle Pleistocene Alluvium (250-750ka)
Carefree-Beardsley Complex (13)	Vertic haplargid Typic durargid	Aridisols	Early Holocene (7-11 ka)	Q_m – Middle Pleistocene Alluvium (250-750ka)
Contine Clay Loam (22)	Typic haplargids	Aridisols	Early Holocene (7-11 ka)	Q_y – Holocene Alluvium (< 10ka)
Ebon very Gravelly Loam (44)	Typic haplargids	Aridisols	Early Holocene (7-11 ka)	Q_m – Middle Pleistocene Alluvium (250-750ka)
Gachado Lomitas Rock Outcrop Complex (52)	Lithic haplargid Lithic camborthid	Aridisols	Early Holocene (7-11 ka)	Q_{ct} – Quaternary Basalt (< 2 ma)
Pinamt-Tremant Complex (98)	Typic haplargids	Aridisols	Early Holocene (7-11 ka)	Q_y – Holocene Alluvium (< 10ka)
Suncity Cipriano Complex (110)	Typic duragid Typic durorthid	Aridisols		Q_m – Middle Pleistocene Alluvium (250-750ka) T_{sy} – Late Miocene to Pliocene Conglomerate & Sandstone (> 2ma)
Tremant Gravelly Sandy Loam (112)	Typic haplargids	Aridisols	Early Holocene (7-11 ka)	Q_m – Middle Pleistocene Alluvium (250-750ka)
Tremant Gravelly Loam (113)	Typic haplargids	Aridisols	Early Holocene (7-11 ka)	Q_m – Middle Pleistocene Alluvium (250-750ka)

Table 5. Skunk Tank Erosion Hazard Assessment SCS Soil Unit Hazards							
SCS Map Unit	**Building Site Development Restrictions (Table 9)**				**Sanitary Facility Hazards (Table 10)**	**Flooding Hazard (Table 15)**	**Depth to Bedrock**
	Shallow Excavation	**Dwellings without basements**	**Local Roads**	**Lawns & Landscaping**			
Carefree Cobbly Clay Loam (12)	Severe - Cemented pan	Severe – Shrink swell	Severe – Low strength, shrink swell	Severe – large stones	Clay; slope, percs slow, large stones	None	> 60 in
Carefree-Beardsley Complex (13)	Severe - Cemented pan	Severe – Shrink swell	Severe – Low strength, shrink swell	Severe – large stones; too clayey	Clay, cemented pan, percs slow, large stones	None	> 60 in
Contine Clay Loam (22)	Moderate – too clayey	Severe – Shrink swell	Severe – Low strength, shrink swell	Slight	Percs slow	None	> 60 in
Ebon very Gravelly Loam (44)	Severe – cut banks cave in	Moderate – shrink swell	Moderate – shrink swell	Severe – small stones	Percs slow, small stones	None	> 60 in
Gachado Lomitas Rock Outcrop Complex (52)	Severe – depth to rock; slope	Severe – depth to rock; slope	Severe – depth to rock; slope	Severe – small stones; slope; thin soil layer	Shallow rock, slope	None	4-20 in
Pinamt-Tremant Complex (98)	Slight	Slight to moderate – shrink swell	Slight to moderate – low strength; shrink swell	Moderate to severe – small stones	Percs slow, small stones	None	> 60 in
Suncity Cipriano Complex (110)	Severe – cemented pan	Severe – cemented pan	Severe – cemented pan	Severe – small stones, thin soil layer	Cemented pan, small stones	None	> 60 in
Tremant Gravelly Sandy Loam (112)	Slight	Moderate – shrink swell	Moderate – low strength; shrink swell	Moderate – small stones	Percs slow, small stones	None	> 60 in
Tremant Gravelly Loam (113)	Slight	Moderate – shrink swell	Moderate – low strength; shrink swell	Moderate – small stones	Percs slow, small stones	None	> 60 in

Fig. 28. Surficial Geology of Skunk Tank Wash, AZ

- Qm.........Mid Pleistocene alluvium
- Qm1.........Mid Pleistocene alluvium (older member)
- Tbl.........Chalk Canyon fm. basaltic rocks
- Qo.........Early Pliestocene alluvial fan deposits
- Qmr.......Mid Pliestocene river terrace deposits
- Qct.......Colluvium & talus, undivided
- Qlr.........Late Pliestocene river terrace deposits
- Qy..........Holocene alluvium
- Tsy......"Basin fill" conglomerate & sandstone
- Xf..........Early Proterozoic volcanics
- Qyr.......Holocene river terrace deposits
- Ql..........Late Pliestocene alluvium
- Qycr...Active channel deposits
- Tb.........Early-Mid Miocene Basaltic rocks, undivided
- Xvad...Early Proterozoic metavolcanics
- Approximate "Top of Bank"

Scale

0 1500 3000

1 in = 1500 ft

N

Fig. 27. Soil Distribution Along Skunk Tank Wash, AZ

N

Scale

0 1500

1 in = 1500 ft

- 3.....Antho-Carrizo-Maripo complex
- 12...Carefree cobbly clay loam
- 13...Carefree-Beardsley complex
- 22...Contine clay loam
- 44...Ebon very gravelly loam
- 50....Estrella loams
- 52...Gachado-Lomitas-Rock outcrop complex
- 55...Gilman loams
- 68....Gunsight-Cipriano complex
- 72....Lehmans-Rock outcrop complex
- 98....Pinamt-Tremant complex
- 109..Schenco-Rock outcrop complex
- 110...Suncity Cipriano complex
- 112..Tremant gravelly sandy loams
- 113..Tremant gravelly loams
- Approximate "Top of Bank"

inundation of a much broader surface than is designated by the SCS map units. The degree of soil development recorded by the SCS (Tables 3 to 5) does indicate that erosion of the areas outside the main channel corridor has been relatively rare during the past 7,000 years, and has generally been confined within the floodplain for the past 250,000 years.

SCS soil unit boundaries are provided in digital format with the AutoCAD deliverable for this study. The SCS soil unit boundaries are generally similar to the surficial geology maps prepared by the Arizona Geological Survey. Differences between the two maps are probably due to the scale of mapping used by each agency, rather than to different interpretation of the surfaces.

Interpretation of surficial geology maps. The surficial geology of the Skunk Tank Wash watershed was mapped previously by the Arizona Geological Survey (AZGS).[1] A portion of the AZGS surficial mapping near Skunk Tank Wash is provided in Figure 28. The AZGS mapping distinguishes the following three geomorphic surfaces in the vicinity of Skunk Tank Wash.

- Holocene alluvium (Q_y). The Q_y unit consists of river deposits younger than about 10,000 years, and is generally found in small active channels and on low terraces. The unit is characterized by unconsolidated, stratified, poorly to moderately sorted sand, gravel, cobble and boulder deposits along the drainageways. Alluvial surfaces exhibit bar and swale topography, with the ridges typically being slightly more vegetated. Q_y surfaces typically lack desert varnish or pavement, and have a sandy loam mantle. Surface colors are usually light brown to yellowish brown, with slight reddening due to iron oxidation. Q_y surfaces are considered subject to flooding and erosion.

- Late Pleistocene alluvium (Q_l). The Q_l unit consists of alluvial fan surfaces and terraces that are 10,000 to 250,000 years old. The unit may be moderately incised by stream channels, but has some constructional, relatively flat interfluvial surfaces with a subdued bar and swale topography. The surfaces have no to moderately developed desert pavement and varnish, with slightly more red color than Q_y surfaces. Soil profiles have weak to moderate argillic horizons and stage II-III carbonate development. Q_l surfaces are generally not flood prone, except where they are immediately adjacent to active washes.

- Middle Pleistocene alluvium (Q_m). The Q_m unit consists of relict alluvial fan and river terraces greater than 250,000 years old. The unit is characterized by tan, sandy to loamy materials with sand- to boulder-sized clasts. Q_m surfaces have generally been eroded into shallow valleys and ridges due to development of an internal drainage pattern. The surfaces typically have moderate to strongly

---

[1] Leighty, R.S., and Holloway, S.D., 1998, Geologic Map of the New River SE 7.5' Quadrangle, Maricopa County, Arizona. AZGS Open-File Report 98-21.

developed desert pavement and varnish, except where surface erosion has removed them, and are brown to reddish brown. The soils are strongly developed with reddened argillic horizons and stage II-IV calcic horizons. Q_m surfaces are generally not flood prone.

AZGS map unit boundaries are provided in digital format with the AutoCAD deliverable for this study. Correlation of AZGS map units and SCS soils map units were discussed above. For the purposes of this study, the Q_y and portions of the Q_l surfaces were considered to be subject to some risk of lateral erosion, channel avulsion, or erosion by concentration of overbank flooding.

Interpretation of regional geology. Surficial geology mapping (Leighty & Holloway, 1998) and field observations were used to make the following preliminary interpretation of the geologic history of the study area. Skunk Tank Wash flows across a relict alluvial fan[1] that was formed during middle Pleistocene time (250–750 ka) by deposition of sediments derived from the Skunk Creek watershed. During the late Pleistocene (10–250 ka), Skunk Creek became incised, which caused the fan apex to shift to a point downstream below the study area, ended the period of deposition on the fan, and initiated a period of gradual erosion of the fan surface. Since the late Pleistocene, erosion of the relict fan resulted in development of on-fan drainage systems. Skunk Tank Wash is one of the more prominent on-fan drainage systems that developed since the onset of late Pleistocene.

During the late Pleistocene and Holocene (0–10 ka), Skunk Tank Wash developed its own alluvial fan inset within the relict middle Pleistocene fan. The boundaries of the inset Skunk Tank Wash alluvial fan are defined by the Q_m/Q_l boundary, and are generally located in the reach between Joy Ranch Road and 19th Avenue, although some potential for alluvial fan-like avulsions may also exist near Irvine Road. Typical alluvial fan features such as remnants of abandoned flow paths, islands of older surfaces within the Q_l surface, decreasing channel capacity, low relief interfluves, and a fan-shaped geomorphic surface are visible on aerial photographs and surficial maps of the study area, lending support to the theory that a portion of Skunk Tank Wash may be a geologically-recent active alluvial fan, and subject to some degree of alluvial fan processes of erosion and deposition.

The degree of channel incision, as defined by the bank height and channel capacity, also provides some clues as to the geologic history of Skunk Tank Wash. Despite an increase in discharge in the downstream direction, the bank height, channel width, and capacity decrease in the downstream direction below Desert Hills Drive. After the wash turns to the west at about the 16th Avenue alignment, the bank height and width begin to increase in the downstream direction. The increase in channel capacity west of the 16th Avenue alignment may be due to prehistoric incision initiated at Skunk Creek prior to

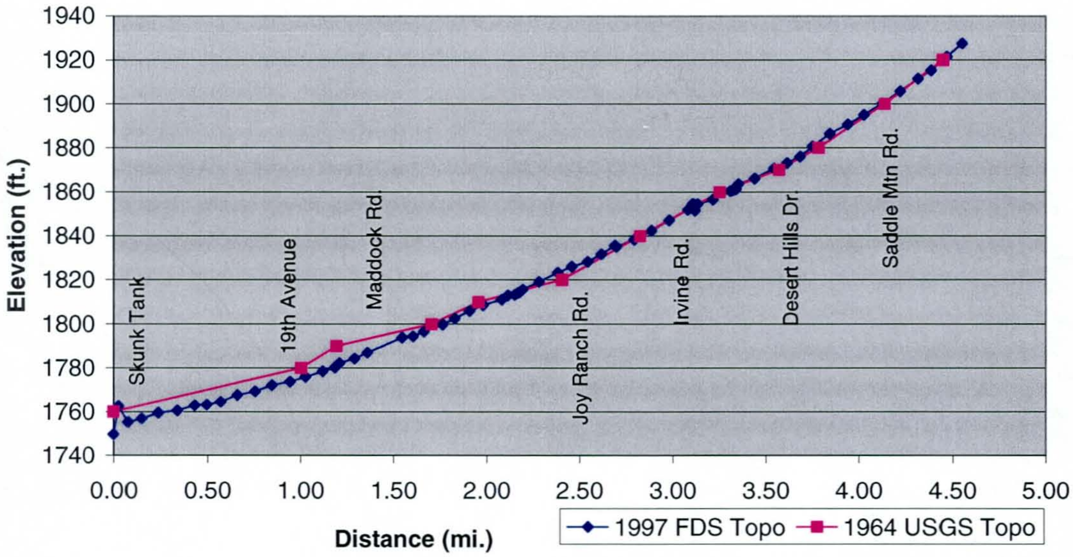
---

[1] The Q_m surface on the AZGS surficial geology maps represents the boundaries of the middle Pleistocene relict fan.

construction of Skunk Tank, or may simply be related to re-concentration of flow at the toe of an alluvial fan along the axial drainage system.

Analysis of longitudinal profile. The longitudinal profile is a plot of the channel elevation versus distance along the stream bed (Figure 29). Analysis of the longitudinal profile can be used to identify slope irregularities, over-steepened or over-flattened reaches, headcuts, and areas of natural grade control. The longitudinal profile also provides some information on expected lateral stability. Reaches with lower slopes than adjacent reaches will experience net deposition, and bank erosion associated with braiding and avulsions. Reaches with steep slopes typically experience high velocities and high rates of sediment transport associated with bank shear or degradation. Where longitudinal profiles from different time periods indicate channel incision has occurred, as in Figure 29, bank erosion due to undercutting and bank collapse may be expected. Bank erosion occurs after channel incision because the channel material that had previously provided lateral support to the banks is removed, or because the banks are extended below the elevation of the stabilizing rooting layer of the bank vegetation.

Figure 29. Skunk Tank Wash Longitudinal Profile



The following conclusions about lateral stability and erosion hazards can be drawn from the longitudinal profiles of Skunk Tank Wash shown in Figure 29:

- Shape. The Skunk Tank Wash longitudinal profile has concave up shape, which is the typical profile for an alluvial river. Active alluvial fans commonly have a concave down shape due to net aggradation of sediment below the fan apex. The 1997 Skunk Tank Wash profile indicates that the fan-like portions of the piedmont have not been actively aggrading in recent geologic time, although the 1964 profile has a classic concave down shape in the reach between Joy Ranch

Road and 19th Avenue. The discrepancy between the 1964 and 1997 profiles is discussed below.

- Profile comparison. Despite the difference in contour interval and map scale, the 1964 and 1997 profiles are almost identical, except in the reach between Maddock Road and 19th Avenue. It is not likely that the concave down profile of the 1964 topography is due only to differences map accuracy, since the discrepancy in bed elevations is greater than the vertical accuracy of the USGS mapping (±10 ft.), and because the trend of elevation differences is consistent over a considerable reach. However, no physical evidence of significant long-term degradation in this reach was observed in the field. At this time, no completely satisfactory explanation of the elevation differences for the longitudinal profiles of the reach between Joy Ranch Road and 19th Avenue exists. Throughout the rest of the study area, the two longitudinal profiles indicate that no significant long-term scour has occurred, a conclusion supported by field observations.

- Perturbations. Other than the concave down segment of the 1964 profile, there are no significant breaks in the 1997 or 1964 longitudinal profile of Skunk Tank Wash. The minor irregularities in the 1997 profile are the result of local scour, culverts and road crossings, and the low contour interval of the mapping.

Application of Allowable Velocity Guidelines. Allowable velocity criteria have long been used in channel design to estimate the velocity at which channel bed and bank sediments will begin to erode. A variety of allowable velocity data have been published by the Corps of Engineers (1970, 1990, 1995) and the Soil Conservation Service (1977), as well as by many other agencies.

The Corps of Engineers (1970; 1995) has established suggested maximum velocities for design of non-scouring flood control channels of various bank materials, as shown in Table 6. In general, the banks of the streams in the study area are composed of silty fine sand and are covered with brush and woody vegetation, except where local residents have removed the vegetation. Grass cover was not observed in the field. The average floodway velocities derived from the EEC-MKE (1997) HEC-RAS modeling indicate that the erosive threshold for the bank material will be exceeded during the 100-year event, as shown in Table 7. In some cases, even the erosive threshold for weak sedimentary rock will be exceeded. No information on expected velocities for the 2-, 10- or other recurrence intervals was readily available, but should be included if more detailed erosion hazard evaluations are conducted. Bed sediments observed in the field indicated that up to cobble-sized material is transported during bankfull events.

Table 6. Skunk Tank Wash Erosion Hazard Evaluation Suggested Maximum Permissible Mean Channel Velocities (USACOE, 1995)	
Channel Material	**Mean Velocity (ft/sec)**
Fine Sand	2.0
Fine Gravel	6.0
Grass-Lined Banks (< 5% Slope, Sandy Silt, Bermuda Grass)	8.0
Poor Rock (Sedimentary)	10.0

Table 7. Skunk Tank Wash Erosion Hazard Analysis FDS 100-Year Floodway Velocities		
Stream Segment	**Average Velocity (ft/s)**	**Maximum Velocity (ft/s)**
Upstream limit to Desert Hills Dr.	6.4	8.9
Desert Hills Dr. to Joy Ranch Rd.	5.6	8.3
Joy Ranch Rd. to 17th Avenue	5.1	6.9
17th Avenue to Skunk Tank Ponding Limit	7.4	10.6
Skunk Tank	3.6	6.7

The allowable velocity information summarized above indicates that bank erosion should be expected during the 100-year event, particularly where the stabilizing bank vegetation is removed.

Application of State Standard SSA 5-96. State Standards for floodplain management have been adopted by the Arizona Department of Water Resources (ADWR) as the minimum required regulatory policy in the State of Arizona under the authority of Arizona Revised Statutes 45-3605(a). SSA 5-96 (ADWR, 1996), adopted in 1996, describes a methodology for estimating an erosion setback to account for the lateral instability of Arizona streams. The SSA 5-96 Level 1 Methodology is based on the following two equations:

$$SB = 1.0*(Q_{100})^{0.5} \qquad \text{Eq'n \#1}$$
$$SB = 2.5*(Q_{100})^{0.5} \qquad \text{Eq'n \#2}$$

Where SB = Erosion hazard setback distance (ft.)
Q_{100} = 100-year peak discharge (cfs)

According to SSA 5-96, equation #1 is intended for stream segments that are straight or have "minor curvature." Equation #2 is intended for stream segments with "obvious curvature." Obvious curvature is defined as a channel centerline with a radius of curvature less than five times the channel topwidth. Other guidelines and limitations for the SSA 5-96 Level 1 Methodology are summarized in Table 1. In general, the SSA 5-96 methodology is applicable to the streams in the study area.

Table 8. Skunk Tank Erosion Hazard Evaluation SSA 5-96 Setback Guidelines and Limitation Study Area Condition	
SSA 5-96 Assumption	**Skunk Tank Wash**
Drainage area < 30 mi.^{2} ?	Yes. Drainage area = 4.8 mi^2
Significant channel filling?	No. Profile appears stable in recent history.
Local mining?	No. No significant in-stream mining.
Channel modifications?	Some. Culverts, removal of bank vegetation, fences, Skunk Tank dam.
Massive channel shifting?	Photos indicate minor recent shifting, but signif. within past 10,000 years.
Channelization?	No. Mostly natural channel except at road crossings & at Skunk Tank.

For the study area, channel curvature was measured on plots of digital aerial photographs provided by the District. 100-year discharge estimates were obtained from the Montgomery Watson Floodplain Delineation Study for Skunk Creek(1997). The results of the SSA 5-96 Level 1 Methodology for Skunk Tank Wash are shown in Table 9. The SSA 5-96 Level 1 setbacks were applied from the channel bank or the floodway, whichever was further from the channel centerline, as per the SSA 5-96 Level 1 Methodology. SSA 5-96 Level 1 setbacks for each of the six stream segments are shown on Exhibit 2.

Table 9. Skunk Tank Wash Erosion Hazard Evaluation SSA 5-96 Setbacks			
Reach Limits for Q100 Value	**Q100[1]**	**Erosion Setback Distance (ft)**	
(HEC-2 Cross Section # on FDS Work Map)	**(cfs)**	**Straight Chl**	**Curved Chl**
0.000 – 0.340 – Skunk Tank area	5260	73	145
0.432 – 0.573	5210	72	144
0.662	4830	69	139
0.759 – 0.848 – 19th Avenue alignment	4590	68	135
1.027 – 1.120	4340	66	132
1.184 – 1.211 – 17th Avenue alignment	4240	65	130
1.291	4190	65	129
1.360	4070	64	128
1.548	2490	50	100
1.606 – 1.830 – Maddock (Quartz) Road	2440	49	99
1.910 – 2.460 – Joy Ranch Road	2110	46	92
2.544 – 2.982 – Irvine Road	1880	43	87
3.122 – 3.217 – Desert Hills Drive	1570	40	79
3.310 – 3.684	1420	38	75
3.751 – 4.390 – Ridgecrest Road alignment	860	29	59
4.470 – 4.552 – Upstream study limit	300	20*	50*
Notes: 1. Source of discharge estimates - FDS work maps (EEC-MKE, 1997) 2. * indicates minimum SSA 5-96 setback used (20 ft., 50 ft., respectively) 3. The recommended setback is shown on Exhibit 2			

The applicability and reasonableness of the recommended setbacks obtained from the SSA 5-96 Level 1 Methodology relative to the recommended erosion hazards delineated using geomorphic analysis will be discussed in a separate deliverable for this project.

Summary

Based on the types of analyses described above, the following two types of erosion hazards were delineated for Skunk Tank Wash:

- Lateral migration hazard
- Long-term erosion hazard

The highest risk of erosion occurs within the lateral-migration erosion hazard zone. It is recommended that no development occur within the lateral migration erosion hazard zone without engineered bank protection, or without a detailed engineering and geomorphic analysis of the potential impacts of bank protection on adjacent reaches. Within the long-term erosion hazard zone, developers and residents should be warned of the potential for erosion caused by overbank flow concentration, diversion of overbank flows, and impact by shallow flooding. Structures and improvements that concentrate, divert or obstruct flow should be discouraged within the long-term erosion hazard zone.

Lateral migration hazard zone. Lateral migration erosion hazard occurs by failure of the main channel banks (Figure 10), and is caused primarily by the force of flood water flowing against the bank. Historical and field evidence suggests that lateral migration hazards have been moderate along Skunk Tank Wash during the past 40 years. Therefore, the lateral migration erosion hazard zone (LMEHZ), shown in red on Exhibit 2, was delineated using the following principles:

- Corridor width. The LMEHZ encompasses a width defined by the width of the main channel, including the width of the short braided reaches and small confined avulsive reaches that occur within the single channel reaches. That is, the LMEH allows a sufficient width for future braiding and small confined avulsions along the main channel.
- Bank vegetation. The LMEHZ was delineated along the outside of the canopy of the vegetation lining the main channel banks. *If bank vegetation is removed, the LMEHZ should be widened to account for increased bank erosion.*
- Channel bends. The LMEHZ is wider on the outside of channel bends than in straight reaches.
- Road crossings. The LMEHZ is wider at road crossing where undersized culverts increase the potential for erosion outside the main channel.
- Tributaries. The LMEHZ does not include erosion hazards of the tributaries that join Skunk Tank Wash.
- Fences. The LMEHZ is widened to reflect the likely effect of fences that block or divert the main channel.
- Field judgment. The LMEHZ reflects the judgment of the project geomorphologist's interpretation of the field conditions with respect to future erosion potential.

Long-term erosion hazard zone. The long-term erosion hazard zone includes erosion caused by obstructions in the floodplain and potential channel avulsions. Channel avulsions will occur along Skunk Tank Wash where significant overbank flooding occurs with sufficient depth and duration to scour overbank channels. Overbank channels which grow and intercept the main channel can lead to sudden relocation of the main channel to a new position in the former floodplain. The long-term erosion hazard zone (LTEHZ), shown in yellow on Exhibit 2, was delineated using the following principles:

- 100-year floodplain. The LTEHZ is at least as wide as the 100-year floodplain, except where the 100-year floodplain consists only of backwater areas.
- Shallow floodplain. The LTEHZ hazards are greatest where the floodplain terrace elevation is close to the channel bed elevation, and the risk of flood inundation is highest.
- Geomorphic surfaces. The LTEHZ generally includes the youngest geomorphic surfaces (Q_y and Q_l) and excludes the older geomorphic surfaces (Q_m), except where the main channel abuts an older surface and a cut bank is present. In the latter case, a buffer distance is included within the LTEHZ.
- Stream capture. The LTEHZ includes areas where the risk of overflow into adjacent drainages is indicated by the 100-year floodplain limits.
- Development. The LTEHZ attempts to include the impact of development in the floodplain. Floodplain development may concentrate or redirect overbank flooding and cause excessive scour.
- Field judgment. The LTEHZ reflects the judgment of the project geomorphologist's interpretation of the field conditions with respect to future erosion potential.

Plots of the LMEHZ and LTEHZ are provided on Exhibit 2.

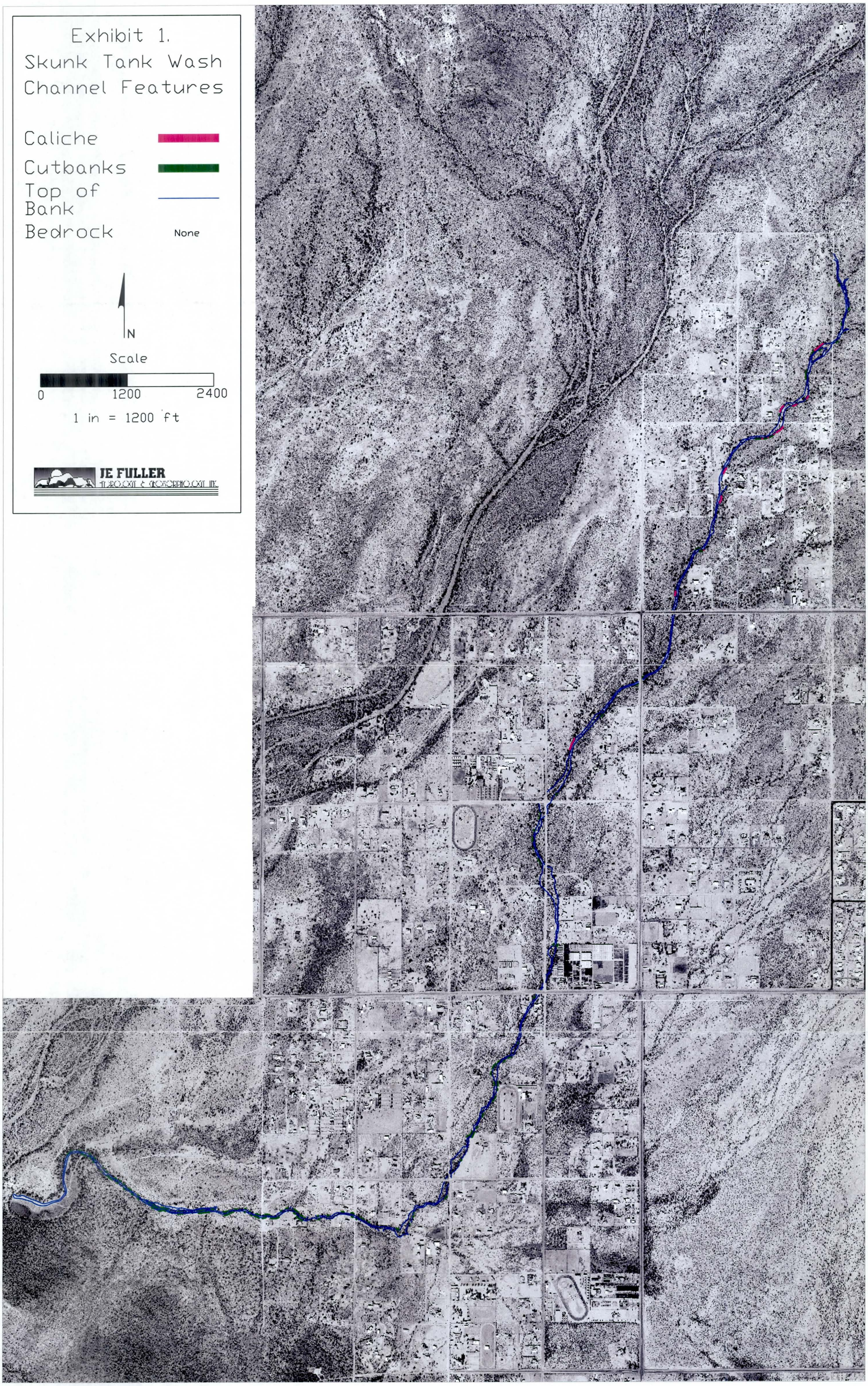
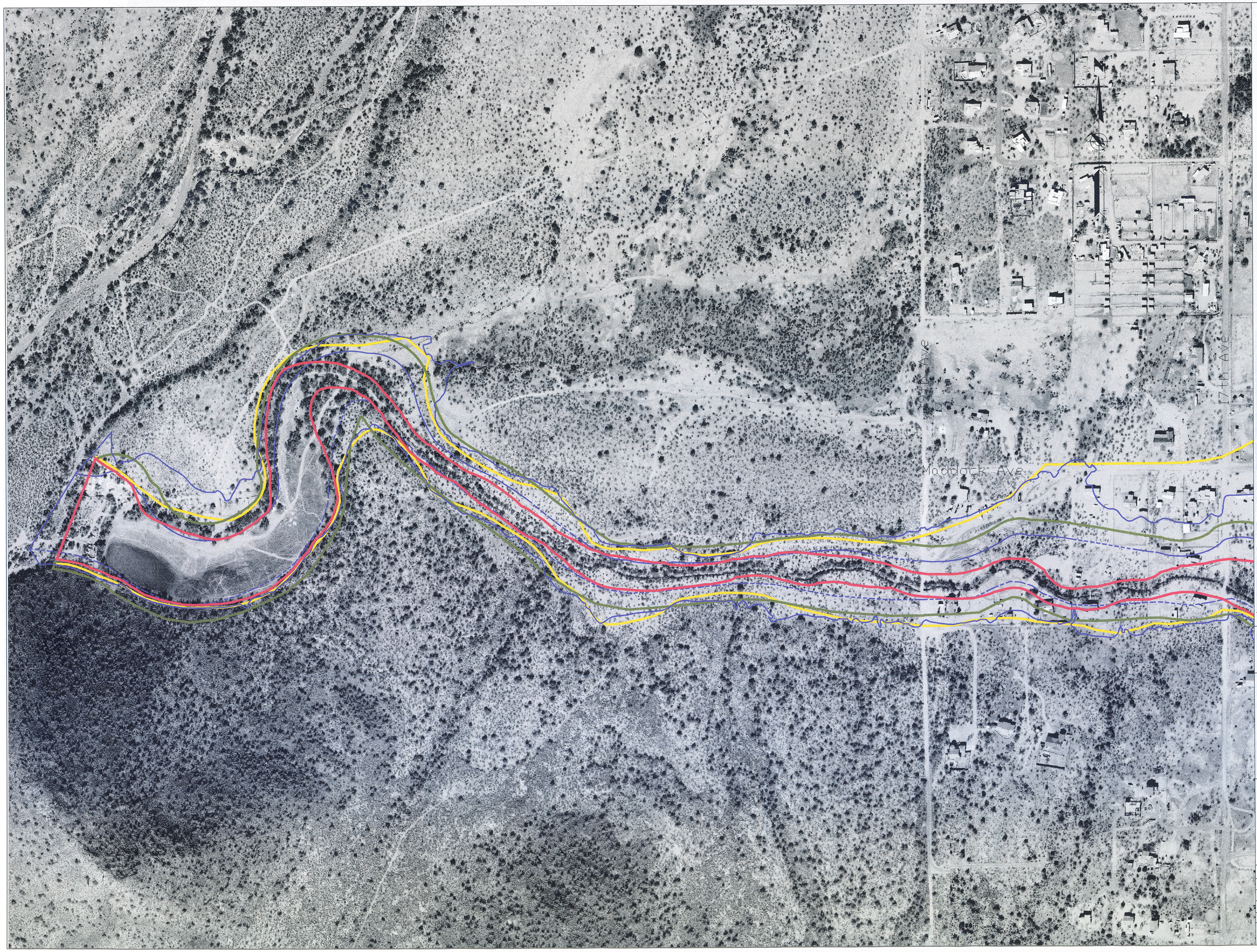


Exhibit 1.
Skunk Tank Wash
Channel Features
Caliche
Cutbanks
Top of Bank
Bedrock
None
N
Scale
0
1200
2400
1 in = 1200 ft
JE FULLER



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

EROSION HAZARD ASSESSMENT OF SKUNK TANK WASH
FCD 2000C013

OCTOBER, 2000

LEGEND

- 100-YEAR FLOODPLAIN
- 100-YEAR FLOODWAY
- LONG TERM EROSION HAZARD SETBACK
- SEVERE EROSION HAZARD SETBACK ☆ – Use this line for regulatory purposes
- SSA 5-96 SETBACK

NOTES

1. HORIZONTAL PROJECTION IS ARIZONA CENTRAL STATEPLANE, NORTH AMERICAN DATUM OF 1983
2. ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

INDEX MAP

200 0' 200 400

SCALE: 1 INCH = 200 FEET

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

	BY	DATE
DESIGN	JEF	10/2000
DESIGN CHK.	–	10/2000
PLANS	–	10/2000
PLANS CHK.	–	10/2000

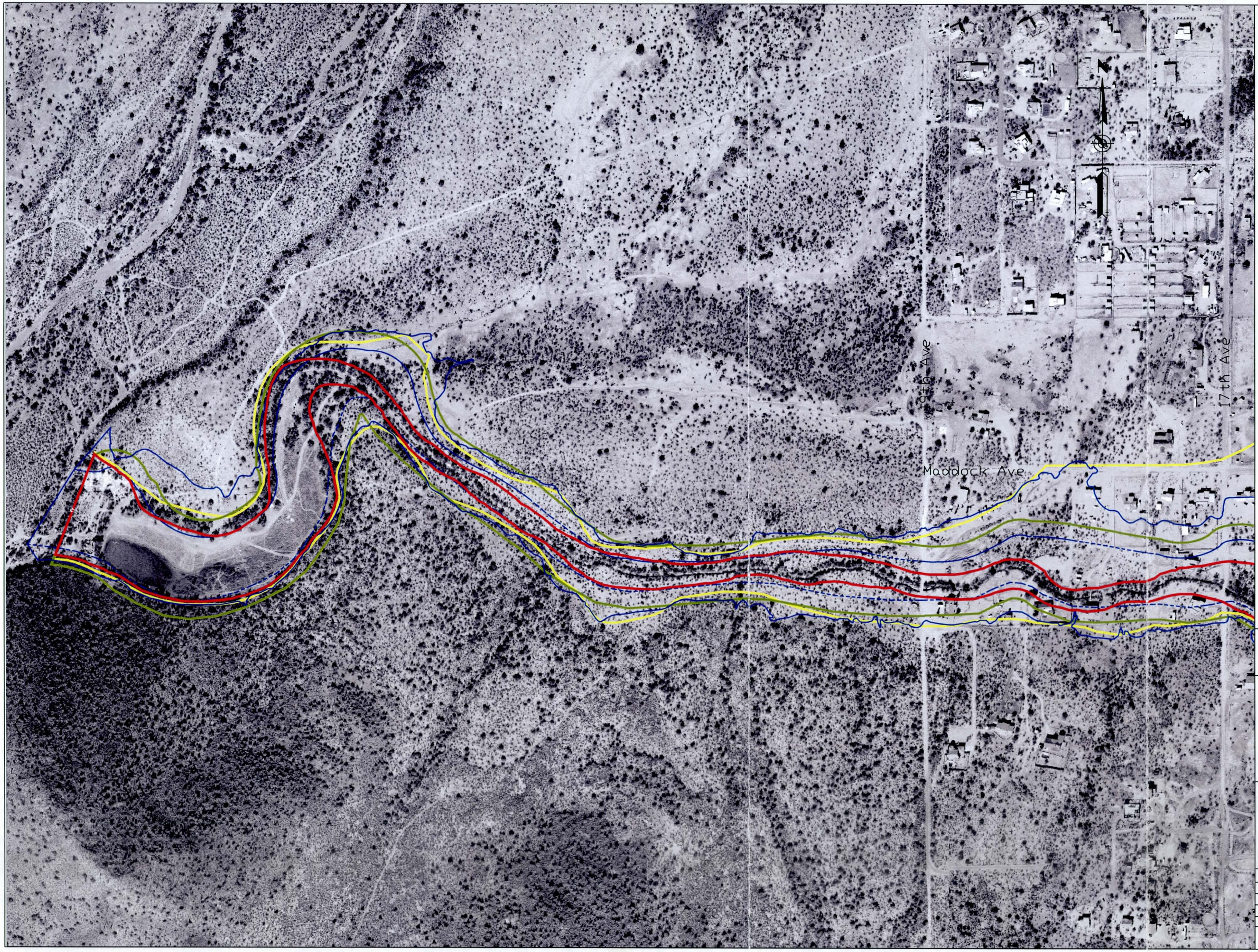
EXHIBIT 2

SHEET 1 OF 4

Erosion Hazard Assessment Skunk Tank Wash

See: A268.901 For Final Maps

Maps Are Scanned



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

EROSION HAZARD ASSESSMENT OF SKUNK TANK WASH FCD 2000C013

OCTOBER, 2000

LEGEND

- 100-YEAR FLOODPLAIN
- 100-YEAR FLOODWAY
- LONG TERM EROSION HAZARD SETBACK
- SEVERE EROSION HAZARD SETBACK
- SSA 5-96 SETBACK

NOTES

1. HORIZONTAL PROJECTION IS ARIZONA CENTRAL STATEPLANE, NORTH AMERICAN DATUM OF 1983
2. ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

INDEX MAP

200 0' 200 400

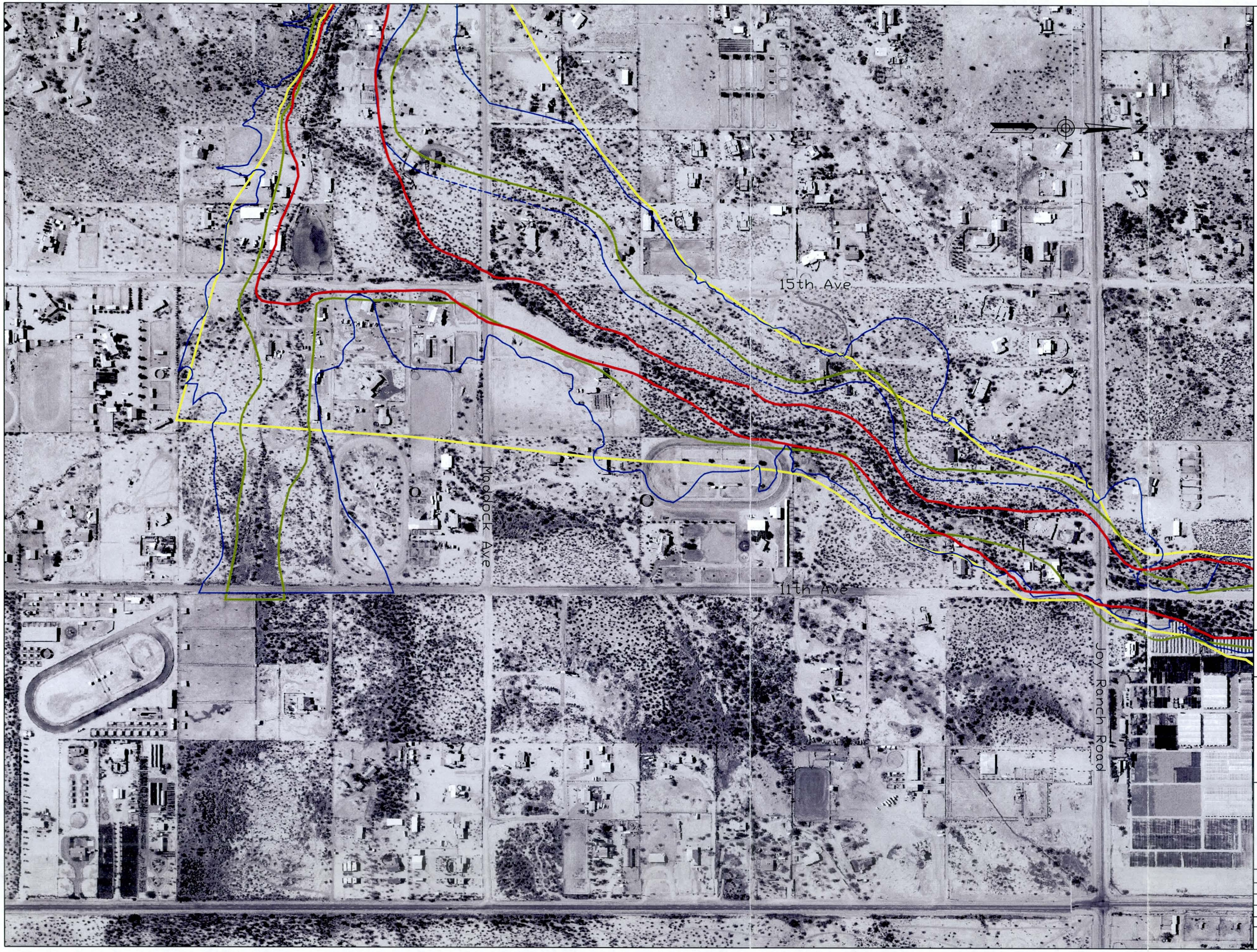
SCALE: 1 INCH = 400 FEET

JE FULLER

	BY	DATE
DESIGN	JEF	10/2000
DESIGN CHK.	–	10/2000
PLANS	–	10/2000
PLANS CHK.	–	10/2000

EXHIBIT 2

SHEET 1 OF 4



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

EROSION HAZARD ASSESSMENT OF SKUNK TANK WASH
FCD 2000C013

OCTOBER, 2000

LEGEND

- 100-YEAR FLOODPLAIN
- 100-YEAR FLOODWAY
- LONG TERM EROSION HAZARD SETBACK
- SEVERE EROSION HAZARD SETBACK
- SSA 5-96 SETBACK

NOTES

1. HORIZONTAL PROJECTION IS ARIZONA CENTRAL STATEPLANE, NORTH AMERICAN DATUM OF 1983
2. ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

INDEX MAP

200 0' 200 400

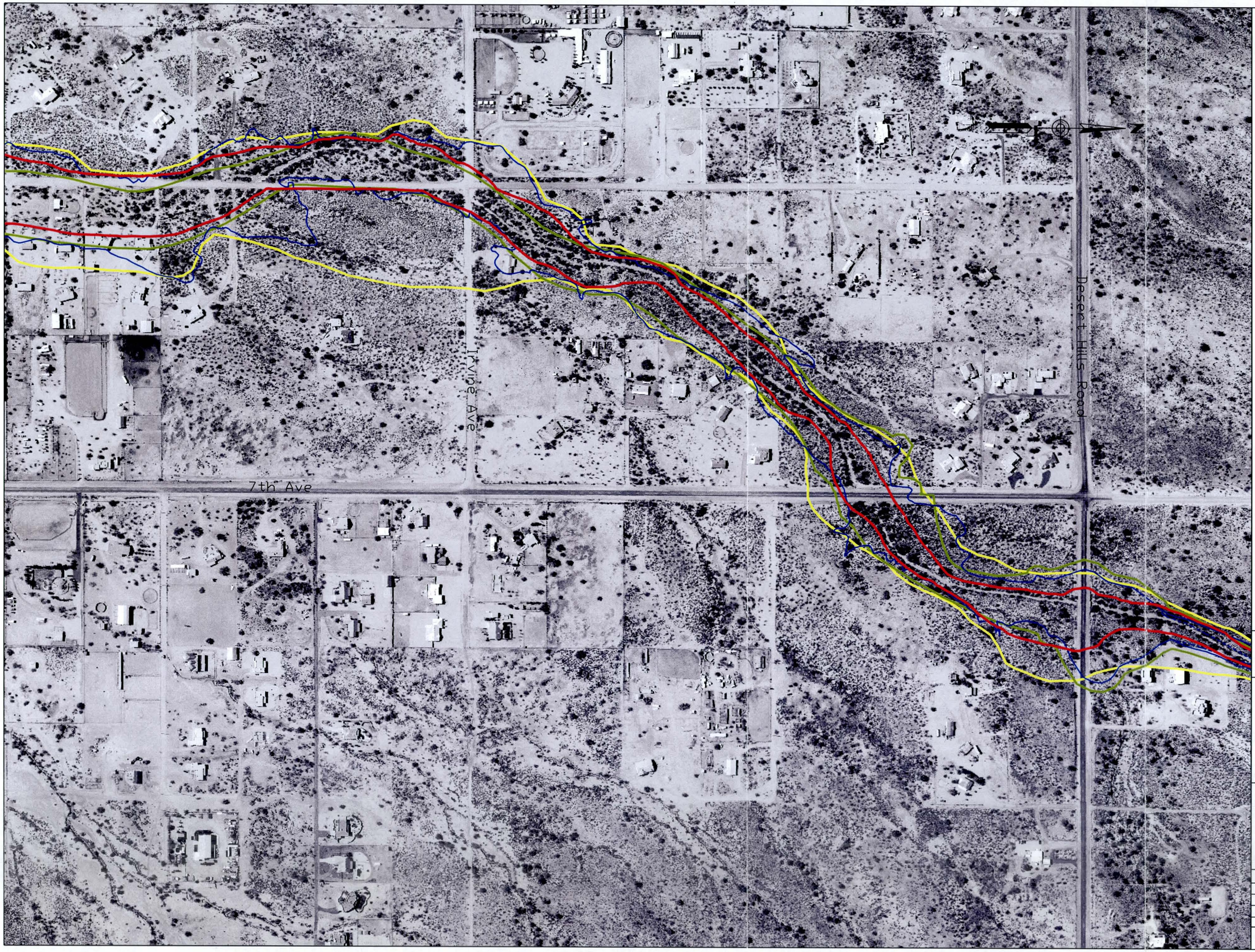
SCALE: 1 INCH = 400 FEET

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.

	BY	DATE
DESIGN	JEF	10/2000
DESIGN CHK.	–	10/2000
PLANS	–	10/2000
PLANS CHK.	–	10/2000

EXHIBIT 2

SHEET 2 OF 4



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

EROSION HAZARD ASSESSMENT OF SKUNK TANK WASH
FCD 2000C013

OCTOBER, 2000

LEGEND

- 100-YEAR FLOODPLAIN
- 100-YEAR FLOODWAY
- LONG TERM EROSION HAZARD SETBACK
- SEVERE EROSION HAZARD SETBACK
- SSA 5-96 SETBACK

NOTES

1. HORIZONTAL PROJECTION IS ARIZONA CENTRAL STATEPLANE, NORTH AMERICAN DATUM OF 1983
2. ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

INDEX MAP

200 0' 200 400

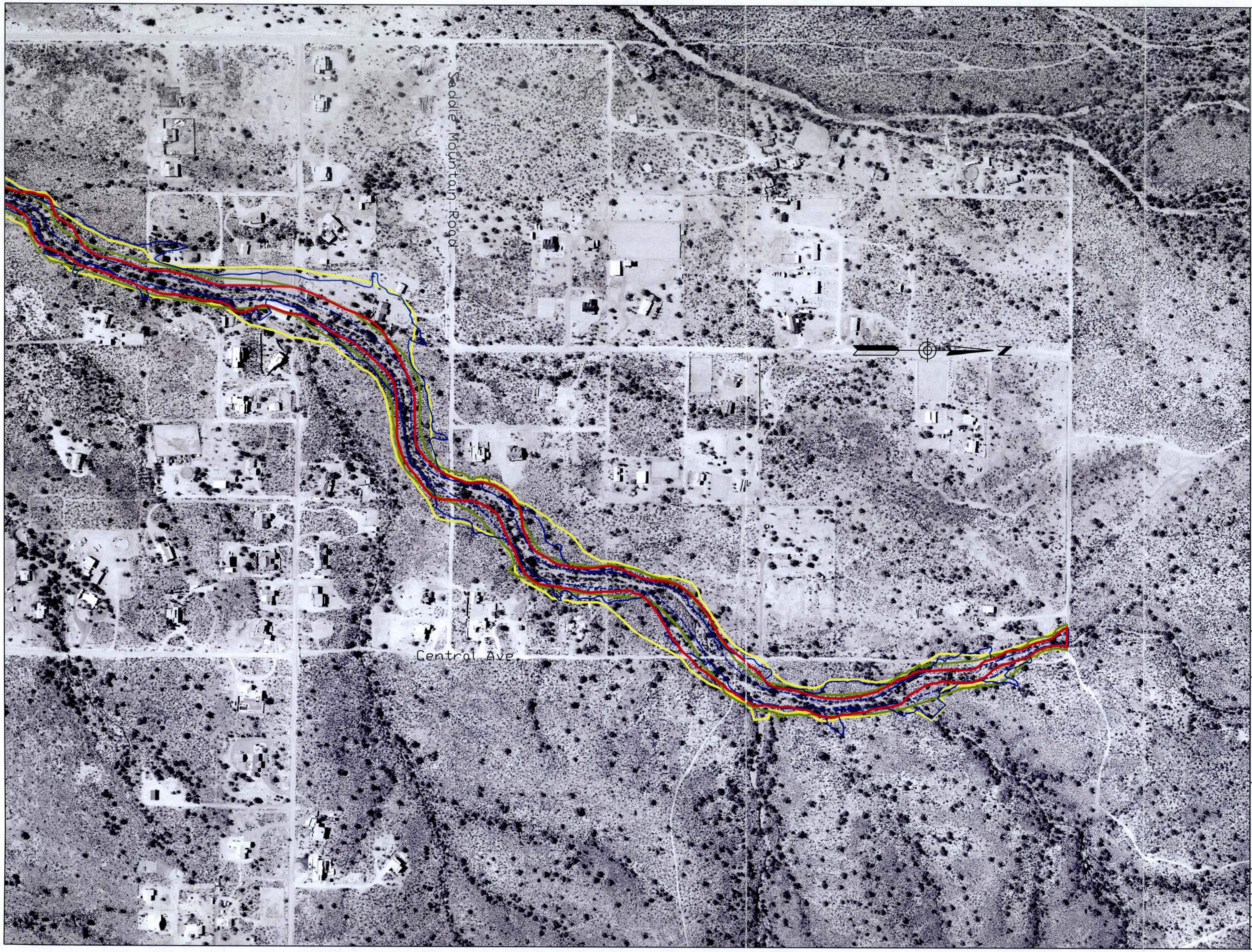
SCALE: 1 INCH = 400 FEET

JE FULLER

	BY	DATE
DESIGN	JEF	10/2000
DESIGN CHK.	–	10/2000
PLANS	–	10/2000
PLANS CHK.	–	10/2000

EXHIBIT 2

SHEET 3 OF 4



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

EROSION HAZARD ASSESSMENT OF SKUNK TANK WASH FCD 2000C013

OCTOBER, 2000

LEGEND

- 100-YEAR FLOODPLAIN
- 100-YEAR FLOODWAY
- LONG TERM EROSION HAZARD SETBACK
- SEVERE EROSION HAZARD SETBACK
- SSA 5-96 SETBACK

NOTES

1. HORIZONTAL PROJECTION IS ARIZONA CENTRAL STATEPLANE, NORTH AMERICAN DATUM OF 1983
2. ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

INDEX MAP

200 0' 200 400

SCALE: 1 INCH = 400 FEET

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC

	BY	DATE
DESIGN	JEF	10/2000
DESIGN CHK.	–	10/2000
PLANS	–	10/2000
PLANS CHK.	–	10/2000

EXHIBIT 2

SHEET 4 OF 4

Appendix A – Field Photographs

FIELD CHECK LIST – CHANNEL CHARACTERISTICS

STREAM NAME: SKUNK TANK	DATE: 8/31	FIELD CREW: JF + ZW
DESCRIPTION OF SECTION LOCATION: Sheet 1		☐ GPS LOCATION

1. PHOTO-DOCUMENTATION (RECORD PHOTO # & TIME)

NOTES: 1. INCLUDE SCALE IN PHOTOGRAPHS 2. PLOT PHOTO LOCATION & ASPECT ON AERIAL

PHOTO #	DESCRIPTION	PHOTO #	DESCRIPTION
Roll 1 - 1	breach @ tank	11	look d/s deep ch
2.	Look u/s in tank	12	look d/s from 19th Ave
3	overbank look N below tank @ Skunk Ck	13	u/s " 19th
4	look d/s @ W @ u/s end tank	14	look u/s @ LB cut - veg' removed
5	look d/s LB erosion around tree ~1 ft west	15	abut protection on footbridge
6	look d/s @ chl	16	Look u/s by corrals
7	Look d/s ~1' incision; narrow chl		
8	Look d/s narrow chl		
9	look d/s in chl ~1' incision		
10	" " @ overflow chl in ROB		

2. INFORMATION TO PLOT ON AERIALS

☐ POOL/RIFFLE BOUNDARY	☐ MISC. CHANNEL CHARACTERISTICS
☐ CUTBANKS	☐ HEADCUTS/ SLOPE BREAKS
☐ BEDROCK OUTCROP	☐ CALICHE/ CARBONATE OUTCROP
☐ HUMAN IMPACTS	☐ STRUCTURES
☐ ACTIVE FLOODPLAIN LIMIT	☐ TERRACE BOUNDARIES
☐ TRIBUTARIES	☐ OVERBANK CHANNELS

3. CHANNEL STABILITY INFORMATION 19th Ave to Tank

PRIMARY Banks	~~LEFT~~ Reach 1	RIGHT
☐ BANK HEIGHT	Varies 1' - 5'	
☐ BANK MATERIAL	S.FS, depositions; minor cobbles	
☐ BANK VEGETATION	Mod to good, PV, Mq, grass	
☐ BANKS ERODIBLE?	Prob - alternating small cuts	
☐ RECENT EROSION ?	Minor - more overflow than widening	
☐ FAILURE MECHANISM	shear; may be future undercutting	
☐ SCOUR OR DEPOSITION?	vertical scour ~1', deposition & braids in OB	

ADDITIONAL BANKS (NOTE RELATIVE LOCATION)	General Impression	
☐ BANK HEIGHT	Chl stable; undisturbed, straight	
☐ BANK MATERIAL	Some minor trimming of banks.	
☐ BANK VEGETATION	Good veg'n protection. Owls	
☐ BANKS ERODIBLE?	Some dumping OB flows may	
☐ RECENT EROSION ?	develop to chl - ~~some~~ one ~100'	
☐ FAILURE MECHANISM	double chl reach - incipient splays	
☐ SCOUR OR DEPOSITION?		

ADDITIONAL BANKS (NOTE RELATIVE LOCATION)		
☐ BANK HEIGHT		
☐ BANK MATERIAL		
☐ BANK VEGETATION		
☐ BANKS ERODIBLE?		
☐ RECENT EROSION ?		
☐ FAILURE MECHANISM		
☐ SCOUR OR DEPOSITION?		

☐ BED MATERIAL	D10________	D50________	D90________	(BY EYE)
	UPSTREAM LAMINATION		ARMORING?	VEGETATION

1/1

FIELD CHECK LIST – CHANNEL CHARACTERISTICS

STREAM NAME: Skunk Tank	DATE: 8/31	FIELD CREW: JF ZW
DESCRIPTION OF SECTION LOCATION: Sheet 2		☐ GPS LOCATION

1. PHOTO-DOCUMENTATION (RECORD PHOTO # & TIME)

NOTES: 1. INCLUDE SCALE IN PHOTOGRAPHS 2. PLOT PHOTO LOCATION & ASPECT ON AERIAL

PHOTO #	DESCRIPTION	PHOTO #	DESCRIPTION
17	look u/s @ 17th Ave box	2. 2	look u/s @ split rtn
18	house 6' sfs in RBB (septic dig)	3	look d/s along LOB chl
19	look u/s @ split rth - no K in chl	4	look d/s @ split @ fence forms
20	look u/s @ fence over wash	5	look d/s @ scour hole in main chl
21	look d/s @ fence	6	look u/s @ chl @ PL
22	look u/s small chl	7	look d/s from Joy Ranch Rd
23	look d/s from Maddock Rd	8	" u/s " " " "
24	u/s "		
25	look d/s @ graded ch area		
1	look u/s exposed roots		

2. INFORMATION TO PLOT ON AERIALS

☐ POOL/RIFFLE BOUNDARY	☐ MISC. CHANNEL CHARACTERISTICS
☐ CUTBANKS	☐ HEADCUTS/ SLOPE BREAKS
☐ BEDROCK OUTCROP	☐ CALICHE/ CARBONATE OUTCROP
☐ HUMAN IMPACTS	☐ STRUCTURES
☐ ACTIVE FLOODPLAIN LIMIT	☐ TERRACE BOUNDARIES
☐ TRIBUTARIES	☐ OVERBANK CHANNELS

3. CHANNEL STABILITY INFORMATION

PRIMARY Banks	~~LEFT~~ 19th Ave to Old Man's Orchard N of Maddock @ 15th	~~RIGHT~~ Orchard to Joy Ranch
☐ BANK HEIGHT	1'-3' shorter than d/s or u/s	3-4'
☐ BANK MATERIAL	SFS - some gravel unit @ base	SFS - basal gravel in places
☐ BANK VEGETATION	good, Mg PV, brush - some blocks chl	Good
☐ BANKS ERODIBLE?	yes but generally stable. ~~Roots~~	yes but generally stable
☐ RECENT EROSION ?	No, v. local v. minor	Some sloughs, minor bank, 1' incision
☐ FAILURE MECHANISM	Shear & undercutting; some avulsion ~~potential~~	Avulsion - saw 2
☐ SCOUR OR DEPOSITION?	Dep'n	Scour in chl ↓, Dep'n - f/p

ADDITIONAL BANKS (NOTE RELATIVE LOCATION)		
☐ BANK HEIGHT	Did this used to be sheet flow & then	Minor terraces visible @ Joy Ranch
☐ BANK MATERIAL	entrenched - explains lack of terraces.	Rd alignment.
☐ BANK VEGETATION	Prob. ½-1' of long-term scour has	
☐ BANKS ERODIBLE?	deepened chl	
☐ RECENT EROSION ?		
☐ FAILURE MECHANISM		
☐ SCOUR OR DEPOSITION?		

ADDITIONAL BANKS (NOTE RELATIVE LOCATION)		
☐ BANK HEIGHT	Generally low lateral movement	historically - Prob. incision of
☐ BANK MATERIAL	alluvial plain. No bedrock	or caliche in chl
☐ BANK VEGETATION		
☐ BANKS ERODIBLE?		
☐ RECENT EROSION ?		
☐ FAILURE MECHANISM		
☐ SCOUR OR DEPOSITION?		

☐ BED MATERIAL	D10_______ D50_______ D90_______ (BY EYE)
	UPSTREAM LAMINATION ARMORING? VEGETATION

FIELD CHECK LIST – CHANNEL CHARACTERISTICS

STREAM NAME: SKUNK TANK	DATE: 8-31-00	FIELD CREW: JF · ZW
DESCRIPTION OF SECTION LOCATION: SHEET 2 & 3		☐ GPS LOCATION

1. PHOTO-DOCUMENTATION (RECORD PHOTO # & TIME)

NOTES: 1. INCLUDE SCALE IN PHOTOGRAPHS 2. PLOT PHOTO LOCATION & ASPECT ON AERIAL

PHOTO #	DESCRIPTION	PHOTO #	DESCRIPTION
2- 9	look d/s by green houses	19	look u/s @ 7th Ave 2.5' cmp w/ HW
10	look u/s from dirt Rd	20	look d/s @ 7th Ave
11	look @ fence blocking wash	21	look u/s @ chl
12	look d/s from 11th Ave	22	look d/s (s) x f/p to 15' terrace
13	look u/s from 11th Ave	23	look u/s @ DH Drive 2 5' cmp - most
14	look u/s @ wide chl - gravel	24	look u/s from DH Drive
15	look u/s @ ~~Irvine~~ 11th Rd xing	25	look d/s from " "
16	look u/s x Irvine w/ stop sign		
17	look u/s @ chl		
18	look u/s @ chl stable banks		

2. INFORMATION TO PLOT ON AERIALS

☐ POOL/RIFFLE BOUNDARY	☐ MISC. CHANNEL CHARACTERISTICS
☐ CUTBANKS	☐ HEADCUTS/ SLOPE BREAKS
☐ BEDROCK OUTCROP	☐ CALICHE/ CARBONATE OUTCROP
☐ HUMAN IMPACTS	☐ STRUCTURES
☐ ACTIVE FLOODPLAIN LIMIT	☐ TERRACE BOUNDARIES
☐ TRIBUTARIES	☐ OVERBANK CHANNELS

3. CHANNEL STABILITY INFORMATION Joy Ranch to D. Hills Dr.

PRIMARY Banks	~~LEFT~~	RIGHT
☐ BANK HEIGHT	1-2' width = 10-20'	
☐ BANK MATERIAL	gravelly sand	
☐ BANK VEGETATION	sparser - PV, Fe, Mq, brush	
☐ BANKS ERODIBLE?	Yes, but generally stable	
☐ RECENT EROSION ?	slight to scour,	
☐ FAILURE MECHANISM	splays, shear	
☐ SCOUR OR DEPOSITION?	f/p deposition, some avulsion	

ADDITIONAL BANKS (NOTE RELATIVE LOCATION)		
☐ BANK HEIGHT	Chl is wider & better defined, some	
☐ BANK MATERIAL	splays & OB flow. Mostly depositional	
☐ BANK VEGETATION	in f/p though. Now terraces define	
☐ BANKS ERODIBLE?	f/p - up to 15' high, some CaCO3 IV	
☐ RECENT EROSION ?	at top of tallest banks. Overflow @	
☐ FAILURE MECHANISM	7th Ave xing due to clogging &	
☐ SCOUR OR DEPOSITION?	pipe alignment	

ADDITIONAL BANKS (NOTE RELATIVE LOCATION)		
☐ BANK HEIGHT		
☐ BANK MATERIAL		
☐ BANK VEGETATION		
☐ BANKS ERODIBLE?		
☐ RECENT EROSION ?		
☐ FAILURE MECHANISM		
☐ SCOUR OR DEPOSITION?		

☐ BED MATERIAL	D10______ D50______ D90______ (BY EYE)
	UPSTREAM LAMINATION ARMORING? VEGETATION

FIELD CHECK LIST – CHANNEL CHARACTERISTICS

STREAM NAME: SKUNK TANK	DATE: 8.31.00	FIELD CREW: JF / ZW
DESCRIPTION OF SECTION LOCATION: Sheet 4		☐ GPS LOCATION

1. PHOTO-DOCUMENTATION (RECORD PHOTO # & TIME)

NOTES: 1. INCLUDE SCALE IN PHOTOGRAPHS 2. PLOT PHOTO LOCATION & ASPECT ON AERIAL

PHOTO #	DESCRIPTION	PHOTO #	DESCRIPTION
Roll 3 - 1	look d/s @ chl	12	look d/s from J.M. rd @ splay
2	u/s	13	look d/s @ Fe in chl
3	look u/s @ $CaCO_3$ on LB	14	look u/s @ chl
4	cut bank & tree on LB	15	look u/s from Dirt Rd
5	look d/s @ chl by horses	16	look u/s @ tree & headcut? 17-18 - [illegible]
6	look u/s @ shed on fill in chl	19	look u/s from Corral
7	look d/s @ corral in COB	20, 21	look u/s @ chl & ROB
(8)	look u/s @ chl	22	look d/s @ tree in chl
10	look @ LB roots	23	look u/s @ chl end
11	look @ LB cut		

9-20 [illegible]

2. INFORMATION TO PLOT ON AERIALS

☐ POOL/RIFFLE BOUNDARY	☐ MISC. CHANNEL CHARACTERISTICS
☐ CUTBANKS	☐ HEADCUTS/ SLOPE BREAKS
☐ BEDROCK OUTCROP	☐ CALICHE/ CARBONATE OUTCROP
☐ HUMAN IMPACTS	☐ STRUCTURES
☐ ACTIVE FLOODPLAIN LIMIT	☐ TERRACE BOUNDARIES
☐ TRIBUTARIES	☐ OVERBANK CHANNELS

3. CHANNEL STABILITY INFORMATION

PRIMARY Banks	LEFT	RIGHT
☐ BANK HEIGHT	Varies w/ surface intersected 3'	f/p 8-15' 3rd terrace
☐ BANK MATERIAL	S & G	
☐ BANK VEGETATION	Mq, Fc, PV sparse	
☐ BANKS ERODIBLE?	yes, but generally not cut	
☐ RECENT EROSION ?	Some, mostly no	
☐ FAILURE MECHANISM	undercut - splays	
☐ SCOUR OR DEPOSITION?	Scour	

ADDITIONAL BANKS (NOTE RELATIVE LOCATION)

	LEFT	RIGHT
☐ BANK HEIGHT	Terrace boundary defines f/p	
☐ BANK MATERIAL	chl defined - veg makes splays	
☐ BANK VEGETATION	also to overbank, coarse bed	
☐ BANKS ERODIBLE?	material - no recent Q - no mud	
☐ RECENT EROSION ?	cobbles	
☐ FAILURE MECHANISM	Generally stable, low Q	
☐ SCOUR OR DEPOSITION?		

ADDITIONAL BANKS (NOTE RELATIVE LOCATION)

	LEFT	RIGHT
☐ BANK HEIGHT		
☐ BANK MATERIAL		
☐ BANK VEGETATION		
☐ BANKS ERODIBLE?		
☐ RECENT EROSION ?		
☐ FAILURE MECHANISM		
☐ SCOUR OR DEPOSITION?		

☐ BED MATERIAL	D10______ D50______ D90______ (BY EYE)
	UPSTREAM LAMINATION ARMORING? VEGETATION

10-26-00 Skunk Tank

Photo 1-4 – View U/S thru breach in Stock Tank at mouth

1-5 View of headcut thru breach ≈ 15' from toe of dam ≈ 5' deep
≈ 3' of sediment over layer of cobbles → sed yield!

1-6 look d/s @ cut

1-7 look N @ debris in huguin fence by Italian orchard – Maddock & 15th NE corner

1-8 look E along Joy Ranch from culvert. overflows to E & goes around E of 2nd house from corner

1-9 look d/s @ CMP under Joy Ranch 8" diam

1-10 View at U/S face of clogged culverts on Desert Hills

1-11 View D/S in chl D/S of Desert Hills Culvert. Note widening of bank on RB → possible model for severe erosion hazard. width of widened area ≈ 2 X TW of original chl.

1-12 cutting RV limbs on RB @ Central Ave (d/s side)

Valley Towing –

Skunk Tank
8/31/00

Roll 1

(1)

(2)

Roll 1


3


4

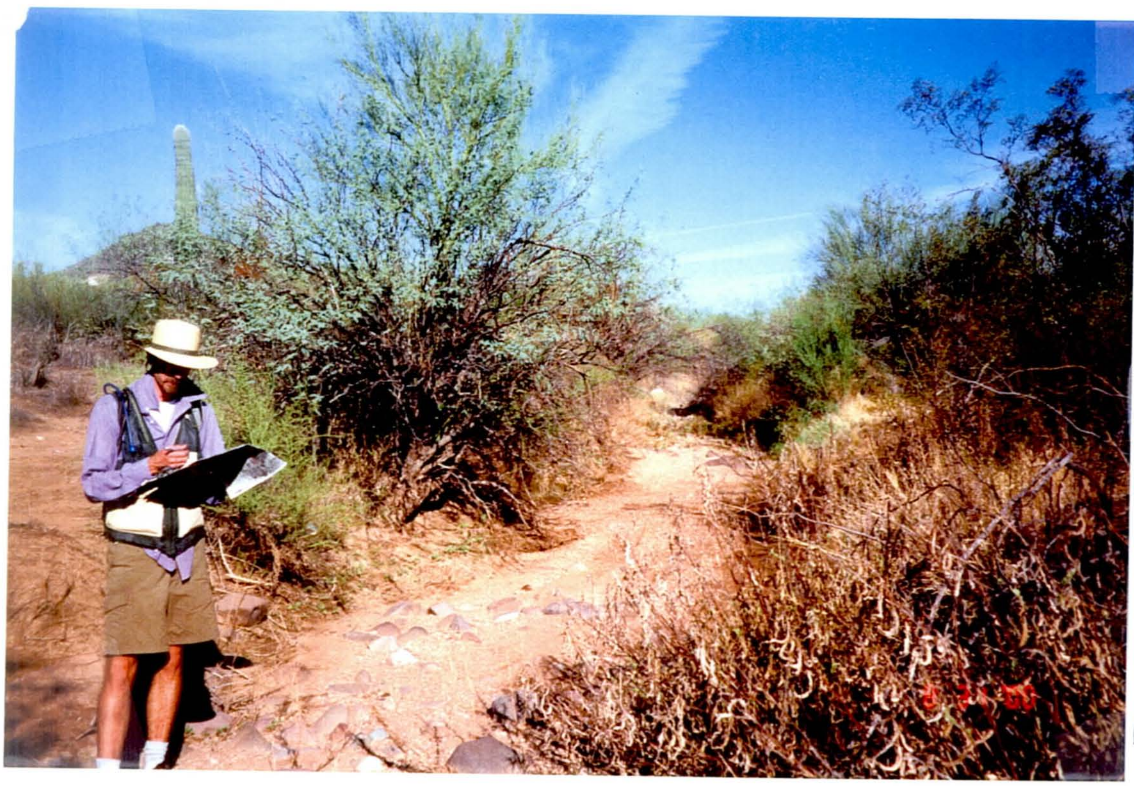
Roll 7

(5)

(6)

Roll 1

⑦



⑧

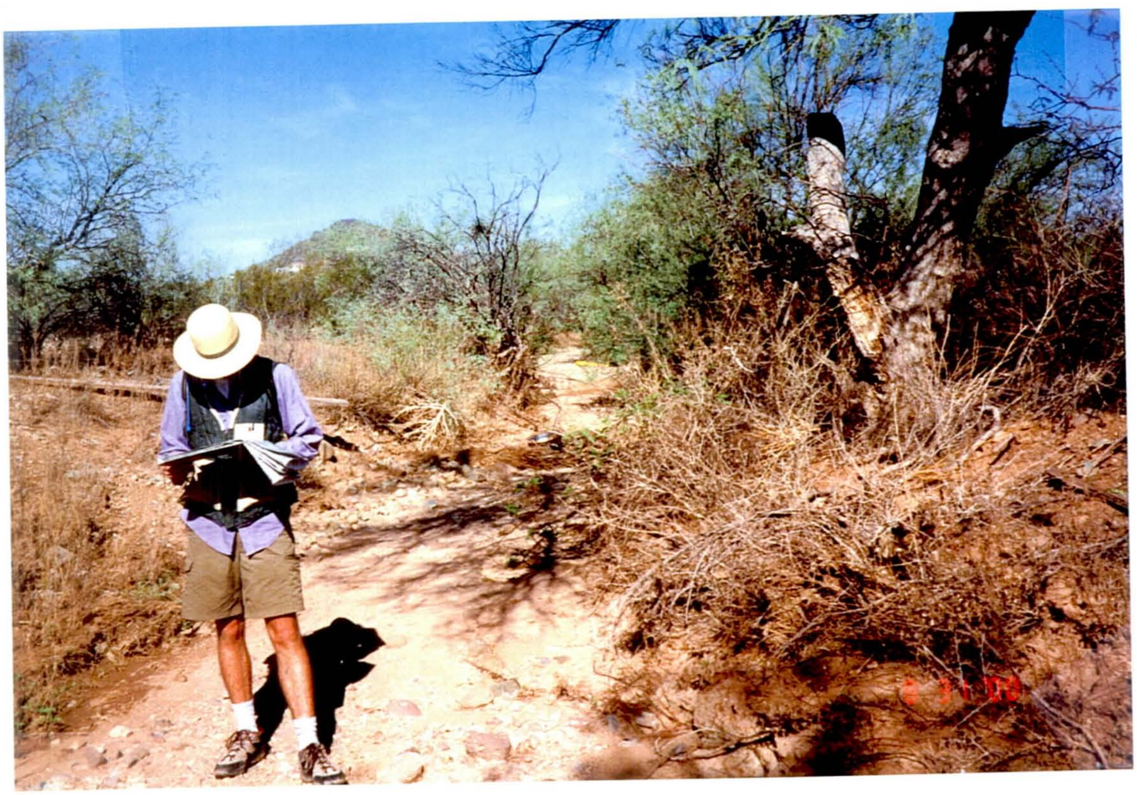
Roll I

(9)

(10)

Roll 1

11



12

Roll I

13

14

Roll 1

15

16

Roll 1

17

18

Roll I

19

20

Roll I

21

22

Roll 1

23

24

Roll 1

2-5

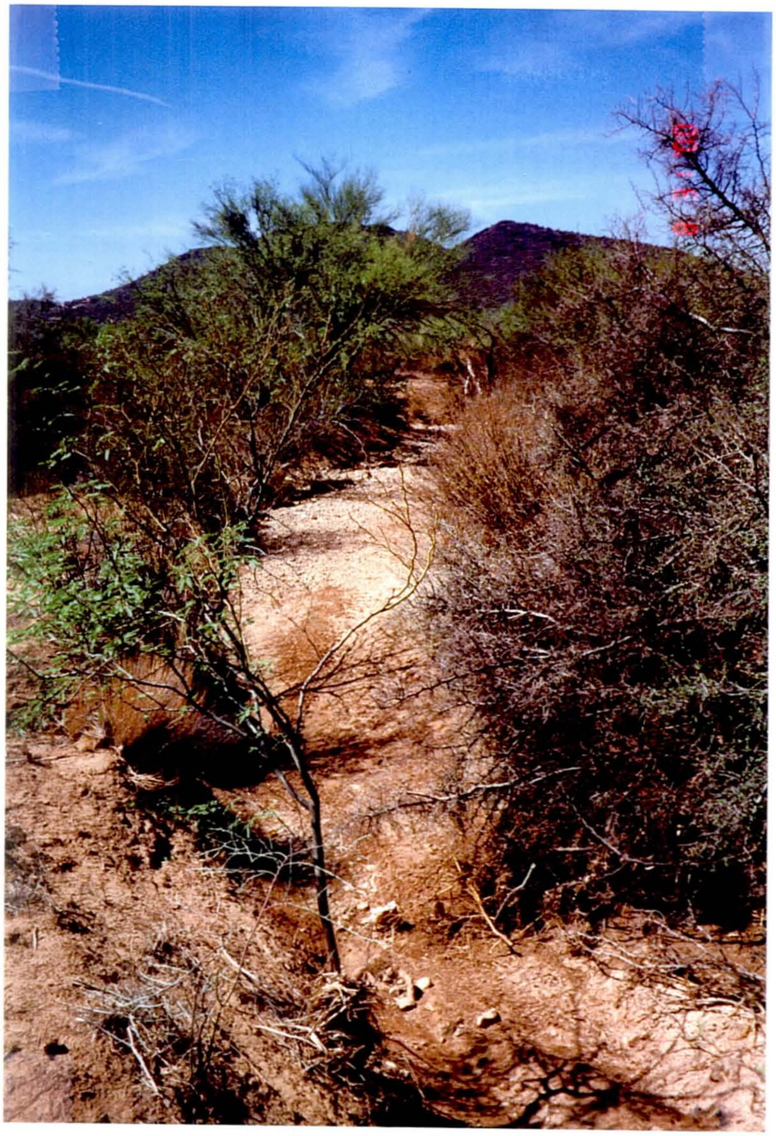
Roll 2

2-1

2-2

2-3

2·4



2-5

2-6

2-7

2-8

2 - 9

2 - 10

2-11

2-12

2-13

-14

2-15

2-16

2-17

2-18

2-19

2-20

2-21

2-22

2-23

2-24

2-25

Roll 3

3-1

3-2

3-3

3-4

3-5

3-6

3 7

3-8

3-9


3-10

3-11

3-12

3-13

3 14

3-15

3-16

3-17

3-18

3-19

3-20

3-21

3-22

10/28/00

after 10/22 flood

1

2

3

4

5

6

7

8

9