Northern Parkway/ Tonopah Parkway Corridor Feasibility Study

Contract 2010-004
Project TT005

FINAL

Technical Memorandum 3
Conceptual Drainage Report

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1. INTRODUCTION

Technical Memorandum 3 (TM 3), entitled *Conceptual Drainage Report*, identifies and summarizes the existing drainage conditions, features, and hydrologic characteristics for the *Northern Parkway: Tonopah Parkway to Turner Parkway and Tonopah Parkway: Northern Parkway to Interstate 10 Corridor Feasibility Study* (hereafter referred to as the *Northern Parkway/Tonopah Parkway CFS*, or "the project"). Offsite concentration points and flow magnitudes prepared in previous studies and reports within the project study area for the 100-year storm event were compiled and are presented in this report. TM 3 is based on a review of available existing information including previous drainage master plans and studies, floodplain delineation studies, roadway drainage reports, discussions with select stakeholders, and field observations. Additional detailed information about the project is included in the following companion documents: *Existing and Future Corridor Features* (TM 1), *Environmental Overview* (TM 2), *Development and Evaluation of Candidate Alternative Alignments* (TM 4), and *Detailed Preferred Alignment* (TM 5).

1.1 Background and Study Need

In July 2008, the Maricopa Association of Governments (MAG) completed the *Interstate 10/Hassayampa Valley Transportation Framework Study* (known as the *Hassayampa Framework Study*), that recommended a comprehensive roadway network to meet the future traffic demands that result when the area west of the White Tank Mountains is completely developed (hereafter referred to as buildout travel demand). This long-range regional transportation network includes the "Arizona Parkway" as a new facility type to supplement more traditional roadway classifications in meeting projected travel demand.

The Arizona Parkway utilizes a distinct intersection treatment that prohibits left turns at major cross-street intersections and controls intersection traffic movements with two-phased traffic signal control. Left-turn movements are made indirectly using directional left-turn crossovers in the median immediately downstream of cross-street intersections.

The *Hassayampa Framework Study* demonstrated the need for both Northern Parkway and Tonopah Parkway. Although today's land development and travel demands in the project study area do not warrant major new high capacity roadways in the near-term future, the buildout forecast for future land development and travel demands does warrant major new high capacity roadways in the long-term future. Plans are already underway to convert some of the vacant lands within the project study area to land uses that will generate future traffic.

To preserve sufficient public right-of-way for the future Northern Parkway and Tonopah Parkway, the planning process needs to identify right-of-way requirements for buildout conditions. This study is the first step in the roadway development process and is meant to aid the governing bodies in defining and protecting a continuous future roadway corridor that can accommodate buildout traffic demands in the project study area.

The project scope of work for this study includes the tasks necessary to prepare a corridor feasibility report that will provide the Maricopa County Department of Transportation (MCDOT), the Town of Buckeye, area property owners, developers, and other stakeholders with a planning tool for future growth and development that will lead to the preservation of a 200-foot wide right-of-way corridor to accommodate the typical Arizona Parkway design. This will require significant coordination with various governing bodies, other public agencies, development interests, and the general public.

1.2 Project Study Area

The project study area includes the planned Northern Parkway, an east-west corridor centered on the Northern Avenue section line, from the planned Tonopah Parkway (411th Avenue alignment) to the planned Turner Parkway (267th Avenue alignment). The Northern Parkway corridor within the project study area is approximately 18 miles long and two miles wide. This section of Northern Parkway is referred to as the Northern Parkway Hassayampa section to distinguish it from other planned Northern Parkway sections east of the White Tank Mountains.

The project study area also includes the planned Tonopah Parkway, a north-south corridor centered on the 411th Avenue section line, from Interstate 10 (I-10) to the planned Northern Parkway. The Tonopah Parkway corridor within the project study area is approximately 3.75 miles long and two miles wide.

The project study area boundaries are shown in **Figure 1**.

1.3 Document Purpose and Scope

The purpose of the *Conceptual Drainage Report* is to describe the existing drainage conditions in the project study area. The drainage study was limited to the collection and review of existing drainage reports and studies, existing geologic and groundwater mapping, limited discussion with stakeholders, and field observations of existing drainage patterns and structures included in and adjacent to the project study area. Hydrologic information from previous drainage and floodplain studies was compiled to present watershed subbasins and previously determined peak flow rates draining to the project study area. This information provides an overview of the physical features of the project study area pertaining to drainage and will be used in the development of feasible alignment alternatives.

1.4 Design Drainage Criteria

Drainage design for the proposed parkway will follow criteria outlined in the *Drainage Policies and Standards for Maricopa County, Arizona* (Maricopa County, 2007) and Chapter 4.7 of the *Roadway Design Manual* (MCDOT, 2004). A draft version of an update to the *Drainage Policies and Standards for Maricopa County* was distributed by MCDOT for public review and comment in July 2010.

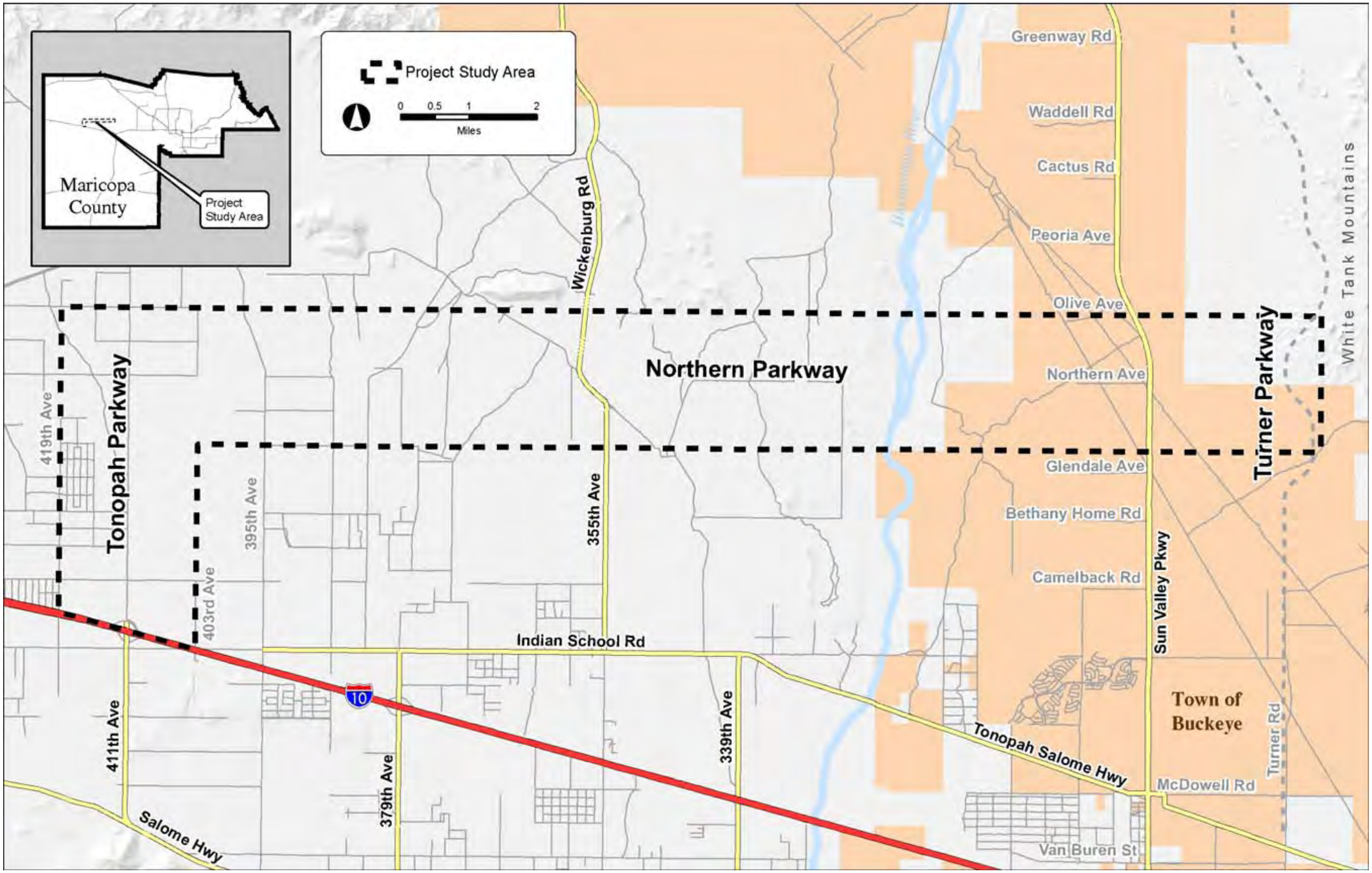

Figure 1 – Project Study Area

2. EXISTING STUDIES AND OTHER DATA SOURCES

Numerous drainage, geologic, and groundwater studies and other drainage-related documents have been prepared within or adjacent to the project study area. A complete list of the existing documents reviewed is included in **Appendix TM3-01**. Summaries of the most relevant documents are provided in the following sections. The general order of presentation and discussion is from west to east.

2.1 Summary of Drainage Studies

A map depicting the drainage studies that are in the general vicinity of the project study area is provided as **Figure 2** at the end of this section. The drainage studies shown in **Figure 2** that have direct relevance to the project are briefly discussed below. These drainage studies were reviewed for descriptions of existing hydrology, drainage features, and existing drainage patterns. Most of these drainage studies were completed for the Flood Control District of Maricopa County (FCDMC).

2.1.1 Palo Verde Watershed Zone A Floodplain Delineation Study Technical Data Notebook (2003)

This FCDMC study developed 100-year hydrology and delineated 400 linear miles of approximate Zone A floodplain. The Palo Verde Watershed extends from the Big Horn Mountains to just east of Wickenburg Road. Four of the studied washes cross the Tonopah Parkway corridor and seven studied washes cross the Northern Parkway corridor.

2.1.2 Hydrologic Study Report for Luke Wash Zone AE Floodplain Delineation Study (2008)

The purpose of this FCDMC study was to develop detailed 100-year hydrologic models to delineate 85 linear miles of Zone AE floodplains and floodways. The analysis focused on Luke Wash and nearby tributaries of the Hassayampa and Gila Rivers, with five washes that cross the Northern Parkway corridor: T2N-R6W-S36, Phillips Wash, T3N-R5W-S32E, T2N-R5W-S33E, and T2N-R5W-S05W.

2.1.3 Jackrabbit Wash Floodplain Delineation Study Technical Data Notebook Hydrology (1991)

This FCDMC study developed 100-year hydrology and delineated detailed floodplains for Jackrabbit Wash and tributaries. The Jackrabbit Wash Watershed within the project study area extends from 371st Avenue to the Hassayampa River. Three mapped washes, including Jackrabbit Wash, cross the Northern Parkway corridor.

2.1.4 Lower Hassayampa Watercourse Master Plan Phase 1 (FCDMC, 2006)

The FCDMC prepared this watercourse master to formulate technical guidance for managing flooding hazards, lateral migration of the watercourse, and cumulative impacts of existing and future development into the floodplain of the Hassayampa River. The Northern Parkway corridor crosses the river within River Reach 4, which extends from Jackrabbit Wash to Wagner/Daggs Wash. Phase 1 is complete and contains seven volumes; Phase 2 is currently under development and should be made available in the near future.

Volume 2 contains hydrologic documentation – an analysis of stream gage records, a simplified HEC-1 model, and multiple previous studies were compared to examine peak discharges for the river. Volume 5 contains river behavior analysis – compiled and presented historical and existing fluvial processes in the river.

2.1.5 Hydrologic Analysis of the Hassayampa River in Maricopa County, Arizona (1988)

This report was prepared for FEMA in order to estimate the 100-year discharges of the Hassayampa River for use in the corresponding FEMA Flood Insurance Re-Study. The study limits comprise approximately 53 stream miles from the Yavapai/Maricopa County line to the confluence with the Gila River. The Northern Parkway corridor crosses the Hassayampa River within this study reach.

2.1.6 Buckeye/Sun Valley Area Drainage Master Study (2006)

This FCDMC Area Drainage Master Study (ADMS) identified drainage, flooding, and erosion hazards within the Buckeye/Sun Valley area and developed preliminary guidelines for development to be used as a basis of stormwater management. The Buckeye/Sun Valley study limits extend from the Hassayampa River to the White Tank Mountains. This overall watershed was subdivided into four hydrologically distinct areas, with the Northern Parkway corridor falling within Area 3 (Buckeye Structures Area) and Area 4 (North Sun Valley Area). Hydrologic documentation was provided for the Buckeye Structures Area (Area 3).

2.1.7 Sun Valley Area Drainage Master Plan Step 3 Recommended Alternative Report (2006)

The Area Drainage Master Plan (ADMP) was prepared for the FCDMC as a follow-up to the ADMS process described above. It contained seven volumes that document the last step of a three step process to develop a regional flood control master plan, and presented specific recommended regional drainage improvements for each alluvial fan. The master plan watershed extends from the Hassayampa River to the White Tank Mountains. The Northern Parkway corridor crosses the Hassayampa sub-area (Volume 4 of the ADMP) and the White Tank Wash sub-area (Volume 5 of the ADMP).

2.1.8 Drainage Report Sun Valley Parkway Phase II and Phase III (1987)

These documents were two separate drainage reports prepared for the Adams Group. Both drainage reports were in support of roadway design for the proposed Sun Valley Parkway, which has since been constructed. Sun Valley Parkway intersects the Northern Parkway corridor near the eastern edge of the study area. Phase II was from Northern Avenue to approximately 255th Avenue, and Phase III was from I-10 to Northern Avenue. Both reports document the amount of runoff that crosses Sun Valley Parkway and sized the proposed culverts and channels.

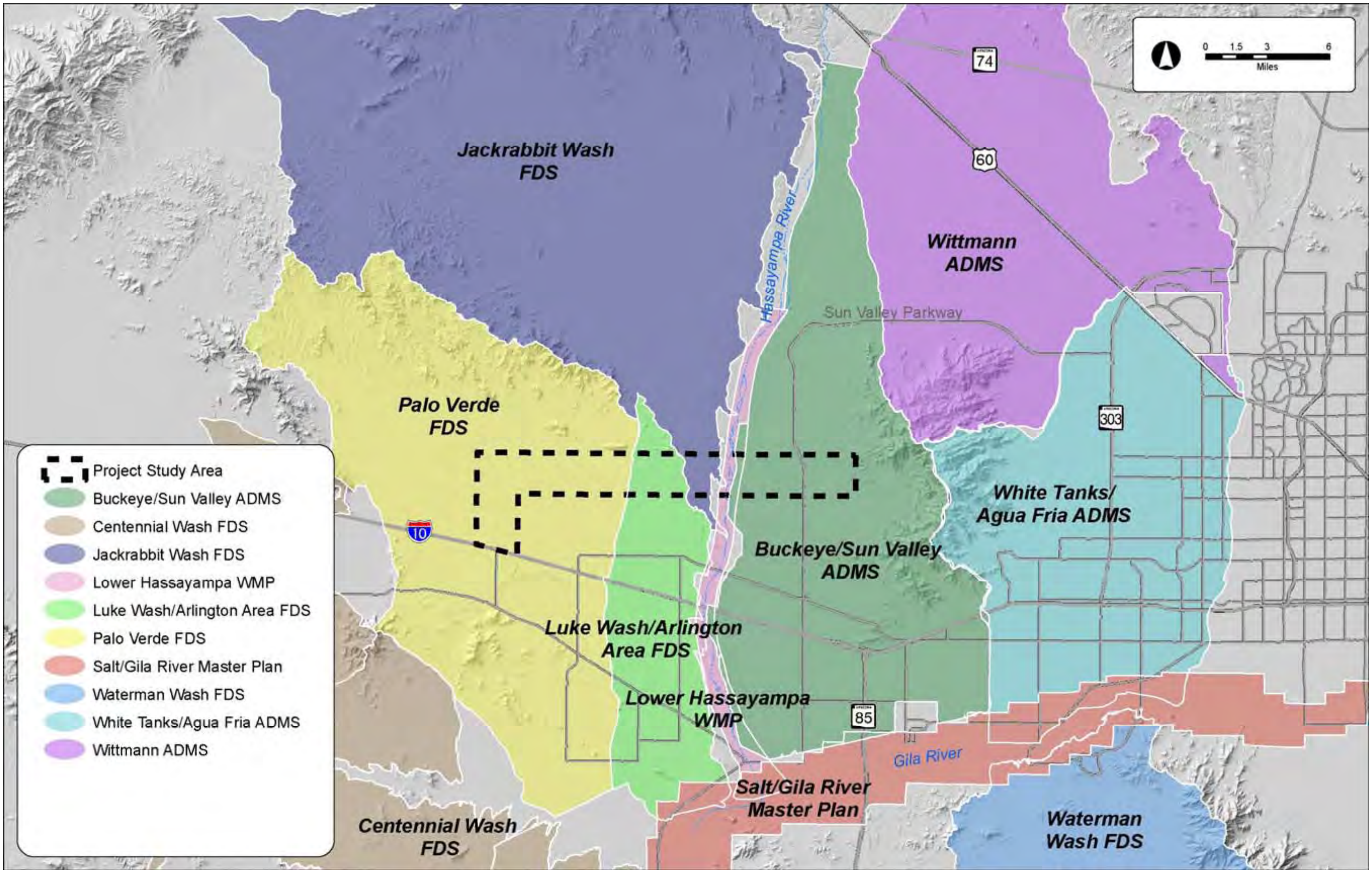

Figure 2 – Area Drainage Studies

2.2 Summary of Other Drainage Documents and Data

In addition to drainage studies, data sources such as geologic investigations, groundwater records, and irrigation canal plans were reviewed for information on other regional physical processes that could potentially impact the project study area. A summary of the most relevant data sources is provided below.

2.2.1 Geologic Mapping of Flood Hazards in Arizona: An Example From the White Tank Mountains Area, Maricopa County (1992)

The Arizona Geological Survey (AZGS) developed a method for identifying flood hazard zones from geologic mapping and field investigations. The resulting product, also known as Open-File Report 91-10, presented a practical exercise of this process using the White Tank Mountains Area as an example. This example area encompasses the Northern Parkway corridor east of the Hassayampa River.

2.2.2 Geologic Map of the Flatiron Mountain 7.5' Quadrangle, Maricopa County, Arizona (2006)

The AZGS produced digital geologic mapping and descriptions of the Flatiron Mountain 7.5' Quadrangle. This quadrangle encompasses the Northern Parkway corridor from 383rd Avenue to just west of the Hassayampa River. The descriptive map legend described the process of distinguishing young alluvial surfaces from older, more stable surfaces.

2.2.3 Geologic Map of the Wagner Wash Well 7.5' Quadrangle, Maricopa County, Arizona (2004)

The AZGS produced digital geologic mapping and descriptions of the Wagner Wash Well 7.5' Quadrangle. This quadrangle encompasses the Northern Parkway corridor from the Hassayampa River to the western slopes of the White Tank Mountains.

2.2.4 Earth Fissure Map of Maricopa County, Arizona (2009)

The AZGS produced a map summarizing the earth fissure mapping that had been completed in Maricopa County. It presented a graphical overview of the eight areas that had been found to have active earth fissures, none of which are within the project study area.

2.2.5 Main Canal and Laterals Tonopah Irrigation District, Arizona, Central Arizona Project Drawings (1985)

These construction drawings were prepared for the United States Department of the Interior Bureau of Reclamation (USBR) system of canals that carries water south from the Central Arizona Project (CAP) canal for agricultural usage. The main canal that branches off of the CAP canal is called the Tonopah canal. The Tonopah canal crosses the Northern Parkway corridor near 383rd Avenue. The Tonopah Irrigation District, which covers the irrigated lands that benefit from the Tonopah canal and associated lateral canals, extends from approximately 395th Avenue to 379th Avenue within the project study area.

2.2.6 Active Land Subsidence Areas in Arizona Based on ADWR InSAR Data (2009)

This working document shows active land subsidence areas monitored by the Arizona Department of Water Resources (ADWR). Interferometric synthetic aperture radar (InSAR) technology is used to measure temporal elevation changes in the Earth's surface. The map covers the entire state of Arizona.

2.2.7 Uplift in the Vicinity of the Tonopah Recharge Facility (2010)

This ADWR working document shows the extent of uplift, or elevation of the Earth's surface, caused by the Tonopah Desert Recharge Project. The recharge facility is located west of the project study area adjacent to the CAP Canal.

2.2.8 Groundwater Site Inventory (GWSI) (2010)

The GWSI is ADWR's primary repository for statewide groundwater data. It contains historical well levels and other background information for each well in the database, including the wells within the project study area. The GWSI is an online product that is continuously updated as new field data is collected.

3. WATERSHED FEATURES

3.1 Topography and Geology

The land west of the Hassayampa River gently slopes towards the south. The Belmont Mountains, Hot Rock Mountain, and Flatiron Mountain are located north of the project study area. A land form slope analysis map is provided in **Figure 3**. The map shows the land slopes mildly south of these mountains. According to the *Geologic Map of the Flatiron Mountain 7.5' Quadrangle, Maricopa County, Arizona* (AZGS, 2006), much of this area is composed of relict alluvial fans. Land surfaces are drained by broad swales and well-developed, moderately-to-deeply incised tributary channel networks. There is enough topographic confinement that there are no major distributary channel networks or active alluvial fans. Flood hazards are restricted to broad, nearly-flat valley bottoms in this western area. The Arizona Geological Survey (AZGS) maps pertaining to the study area have been included as **Appendix TM3-02**.

The region around the Hassayampa River contains more undulating terrain and steeper slopes. Jackrabbit Wash and the Hassayampa River both feature wide incised channels within older, higher banks. According to the *Geologic Map of the Wagner Wash Well 7.5' Quadrangle, Maricopa County, Arizona* (AZGS, 2004), this area features a moderately thick sequence of old Hassayampa River and alluvial fan deposits that have over time been dissected and eroded. The unit descriptions in this map suggest that the current Hassayampa River channel is 20 to 30 meters (66 to 98 feet) below the terraces formed by the maximum aggradation of the river.

The land east of the Hassayampa River slopes towards the west and the southwest. The White Tank Mountains lie on the eastern edge of the project study area. There are steep slopes associated with the mountains, but the land between the White Tanks Mountains and the Hassayampa River is predominantly mildly sloped. The intersection of Northern Avenue with Sun Valley Parkway occurs on young deposits associated with recently active alluvial fans and terraces, and active and inactive alluvial fans are present throughout the piedmont. Many of the larger tributaries that drain to the Hassayampa River have become deeply incised. However, in the southern part of the quadrangle where piedmont drainages turn to the southwest before joining the Hassayampa River, many have major expansion reaches with distributary channel networks. These areas are of particular concern because of the potential for widespread inundation and changes in channel positions during floods.

3.1.1 Land Subsidence and Earth Fissures

Based on a review of *Active Land Subsidence Areas in Arizona Based on ADWR InSAR Data* (ADWR, 2009) there are no active subsidence areas within the project study area. However, ADWR is monitoring an active uplift area caused by the Tonopah Desert Recharge Project. The recharge facility is located adjacent to the CAP canal approximately 9,000 feet west of the project study area. The facility's groundwater plume and associated ground uplift have extended southeast to approximately 355th Avenue. ADWR provided an exhibit called *Uplift in the Vicinity of the Tonopah Recharge Facility* (ADWR, 2010) that is included in **Appendix TM3-03**. This map shows that zero to three centimeters (zero to 1.2 inches) of uplift occurred within the project study area between 2006 and 2010. Well logs from the *Groundwater Site Inventory (GWSI)* (ADWR, 2010) were reviewed to confirm the groundwater plume. The historical hydrograph for well site #333146112560801, located at 411th Avenue and Glendale Avenue, has also been included in **Appendix TM3-03**. This hydrograph shows that the groundwater level has dramatically risen by approximately 70 feet in recent years. The recharge project will probably not impact the selection of a Northern Parkway or Tonopah Parkway alternative, but uplift or subsidence in this area should be monitored in future design phases, especially if the Tonopah Desert Recharge Project modifies or stops the groundwater recharge.

Based on a review of the *Earth Fissure Map of Maricopa County, Arizona* (AZGS, 2009), there are no earth fissures mapped within the project study area. No surface evidence of fissures has been found, but this conclusion does not guarantee that hidden or future earth fissures are not present.

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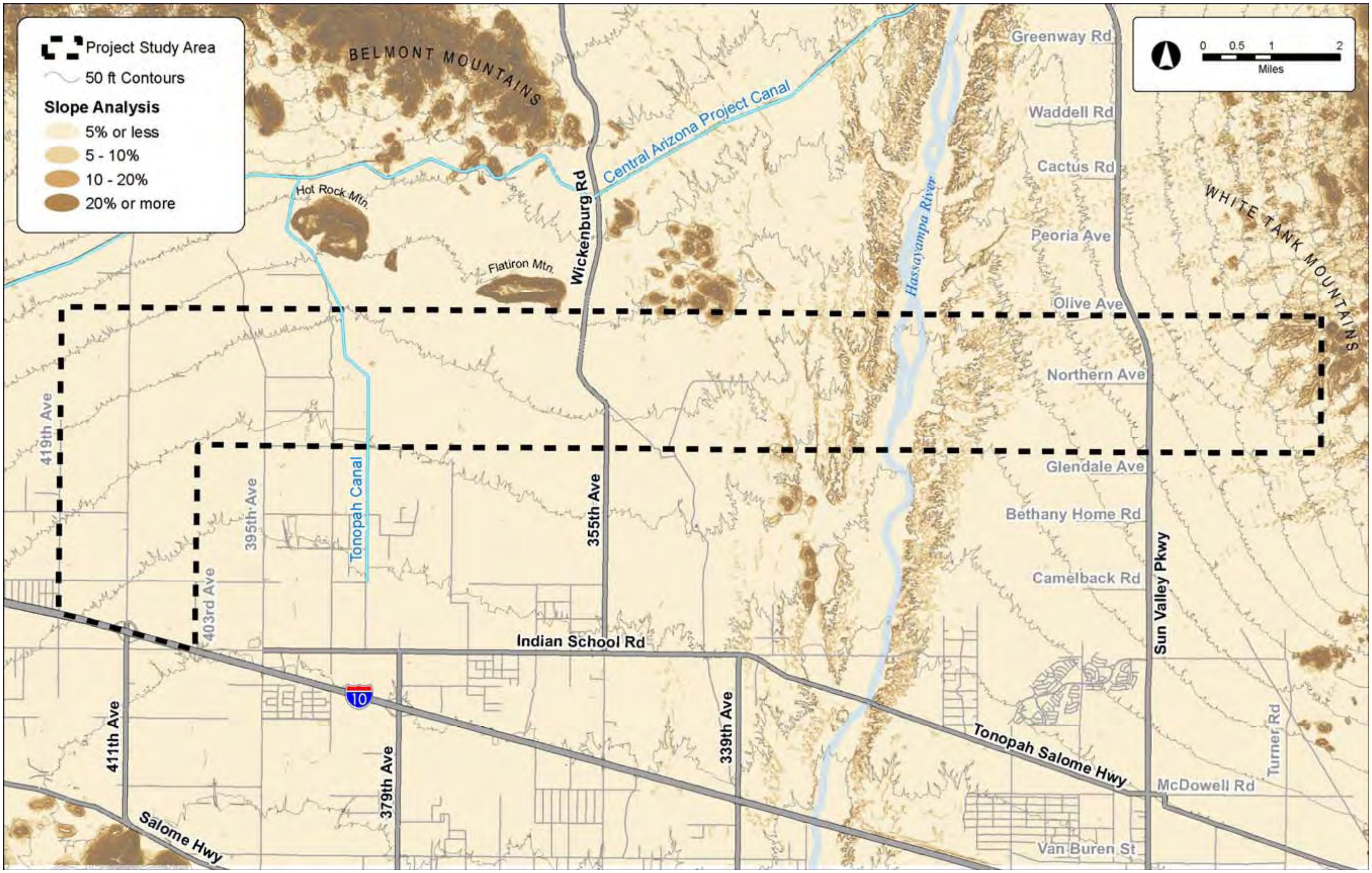

Figure 3 – Topography

3.2 Soils

The National Resources Conservation Service (NRCS) assigns soil map unit components to hydrologic soil groups to broadly indicate soils groups that have similar runoff characteristics. These hydrologic soil groups are shown in **Figure 4**. Most of the project study area falls within Group A or Group B: soils that have low or moderately low runoff potential when thoroughly wet. These areas typically have a large proportion of sands and allow unimpeded transmission of water through the soil. As shown in **Figure 4**, there are limited regions that fall within Hydrologic Group C: soils with moderately high runoff potential. The most significant Group C regions are the area between Fourmile Wash and Phillips Wash and the area surrounding the Hassayampa River (but not including the active floodplain portion of the river). Soils in Group C typically have between 20 to 40 percent clay and less than 50 percent sands. Water movement through the soil is expected to be somewhat restricted.

The area north of the Northern Avenue alignment and east of Sun Valley Parkway falls within Hydrologic Group D: soils with high runoff potential when thoroughly wet. Water movement in these soils is restricted or very restricted. Soils in Group D typically have greater than 40 percent clay or the depth to a water impermeable layer (such as rock) is less than 20 inches. Descriptions of the hydrologic soil groups were taken from Chapter 7 of the NRCS *National Engineering Handbook Part 630 Hydrology* (2007). Contributing watersheds that contain Hydrologic Group D soils should be carefully analyzed when designing downstream structures or roadways since precipitation events may result in very quick runoff responses.

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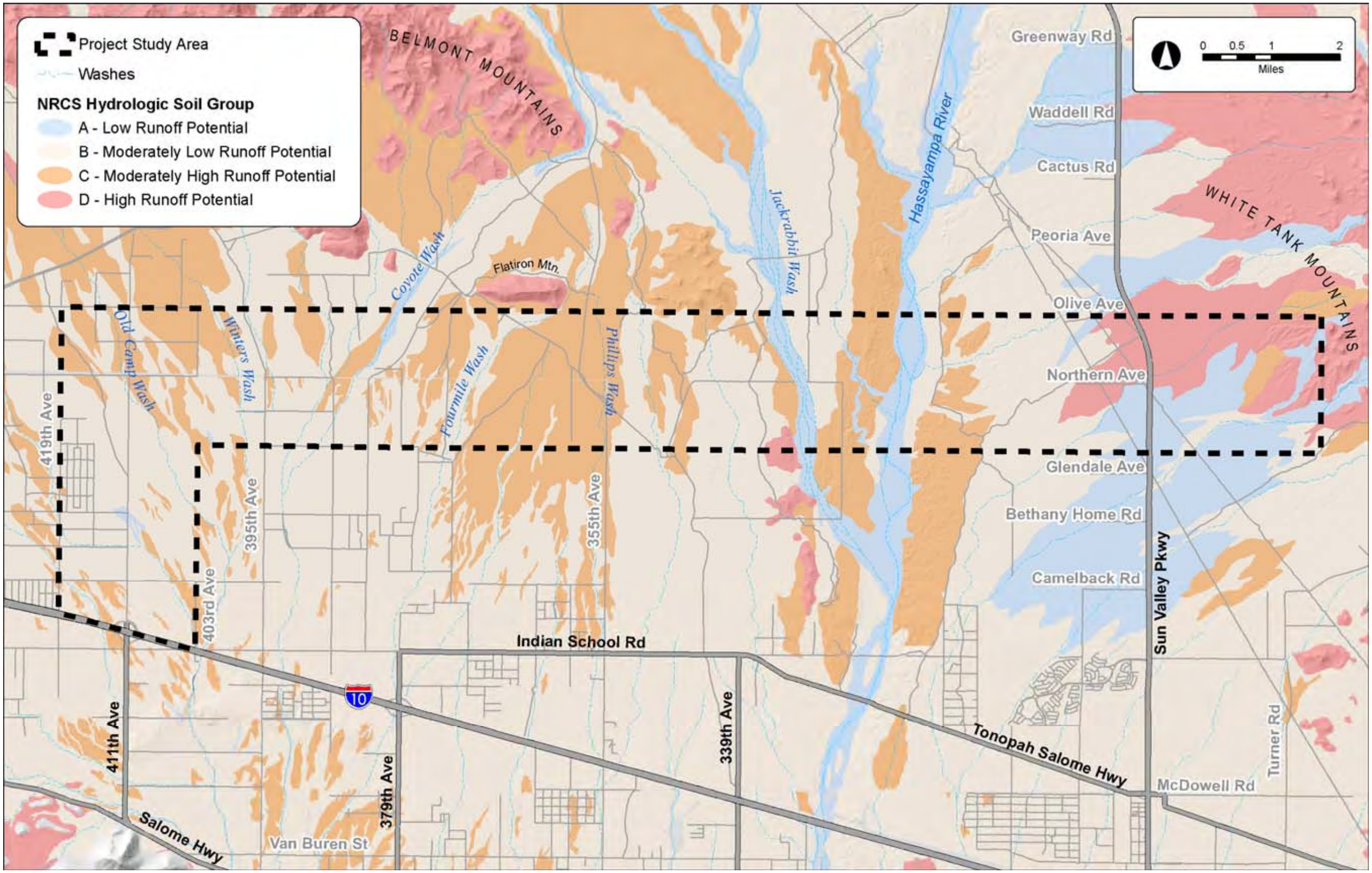

Figure 4 – Soil Hydrologic Groups

3.3 Existing Land Use

Technical Memorandum 1 (TM 1) presents a discussion of land ownership, zoning, existing land use, future land use, existing and planned developments, and existing and future transportation networks can be found in TM 1. The land use descriptions below are abbreviated versions of the TM 1 descriptions that pertain to drainage design.

3.3.1 Existing Land Use

The predominant existing land use within the project study area is vacant land. **Appendix TM3-04** provides photographs taken during field reviews of the project study area land uses and major drainage features. Photos 334 and 580 in particular show undeveloped desert landscape that is typical of the project study area. A few clusters of residential and agriculture use are located between 379th Avenue and 419th Avenue as well as a limited network of two-lane paved roadways and unpaved roadways that corresponds to the same area. Wickenburg Road and Sun Valley Parkway are the only other existing transportation features of note. These paved roadways cross the project study area but the land around these roadways is not developed.

3.3.2 Future Land Use

According to Maricopa Association of Governments (MAG) general plan GIS data provided by Public Works of Maricopa County (May 2009), existing vacant land within the study area is anticipated to be converted to primarily residential land use at buildout. Most of the study area land west of 371st Avenue is planned to be single family low density residential use, while the land to the east of 371st Avenue is planned to have higher density residential uses. There are also large areas of retail, office, and industrial land uses at major intersections throughout the study area east of 371st Avenue. These future land use patterns follow the land use plans for the large master planned communities in this region.

3.4 Flooding Hazards

3.4.1 Regulatory Floodplains

Floodplain and floodway delineations were based on the *Flood Insurance Study, Maricopa County, Arizona and Incorporated Areas, FIS No. 04013CV001A* (Federal Emergency Management Agency, 2005). Numerous FEMA floodplains drain through the project study area. The watercourses in the west half of the study area drain south to ultimately discharge to the Gila River. Watercourses in the east half of the study area drain west and southwest to the Hassayampa River, which ultimately drains south to the Gila River. **Figure 5** provides a map of the 100-year floodplain areas and also displays the Flood Insurance Rate Map (FIRM) panels containing the effective floodplain mapping. Both FEMA effective and FCDMC (typically pending FEMA approval) floodplain limits are shown on this exhibit.

The project study area contains 22 regulatory floodplains. Floodplain encroachment is a consideration for the parkway alternatives, especially when crossing wide floodplains such as the Hassayampa River and Jackrabbit Wash. The Hassayampa River 100-year floodplain is approximately 3,100 feet wide and the Jackrabbit Wash 100-year floodplain is approximately 1,100 feet wide at the Northern Avenue alignment. Crossing these wide floodplains while minimizing adverse impacts to the surrounding properties will be a challenge. Detailed hydraulic studies will be necessary.

The crossings near Coyote Wash also deserve further attention when developing alignment alternatives because two tributaries join Coyote Wash near the Northern Avenue and 387th Avenue intersection. All three washes have regulatory floodplains delineated. Upstream of the confluence at the Northern Avenue alignment, the individual 100-year floodplains are approximately 400 feet, 500 feet, and 600 feet wide. The combined floodplain width is approximately 2,300 feet at the confluence. Significant coordination with FCDMC and FEMA may be required at this location and wherever floodplain encroachments occur.

3.4.2 Geologic Flood Hazards

Five flood hazard zones were defined for the area east of the Hassayampa River in *Geologic Mapping of Flood Hazards in Arizona: An Example From the White Tank Mountains Area, Maricopa County* (1992). Excerpts of the mapping have been reproduced with regulatory floodplains and project boundaries overlaid on the AZGS flood hazard zones in **Appendix TM3-05**. Most areas within the project study area are classified as the lowest hazard zone, L1, which occur in areas that have not been flooded for at least 10,000 years with entrenched streams.

The highest hazard zone, H1, occurs in extensive young deposits with a distributary channel system. Within the project study area, H1 zones typically correspond with the approximate areas delineated by effective floodplains. However, in two cases, the following discrepancies were observed:

- White Tank Wash was mapped as an H1 hazard zone upstream of the Sun Valley Parkway alignment but an L1 hazard area downstream of the Sun Valley Parkway alignment (until the confluence with a tributary);
- The small tributary that joins the Hassayampa River from the east at the Northern Avenue alignment was mapped as an H1 zone even though it is not a regulatory floodplain.

Proposed roadway alignments should avoid H1 flood hazard zones when possible. This designation indicates either an entrenched major drainage or a distributary flow area with potentially high flow velocities. Mitigation measures that include structural improvements built in these areas would likely need to be sized for large capacities and have increased maintenance needs.

3.4.3 Alluvial Fans

Active and inactive alluvial fan systems are prevalent in the study area east of the Hassayampa River. These alluvial fans are sloping, fan-shaped landforms created over long periods of time by the deposition of sediment as flows from the White Tank Mountains spread out. The alluvial fans in this area have been studied in detail as part of the *Sun Valley Area Drainage Master Plan* (*SVADMP*). The information presented in this section has been taken from the *SVADMP Step 3 Recommended Alternative Report*, the *Hassayampa Sub-Area (Volume 4)*, and the *White Tank Wash Sub-Area (Volume 5)* (FCDMC, 2006). Known problems associated with alluvial fan flooding include spatial uncertainty of the flow distribution, lack of containment within the relatively flat topographic relief laterally across the fan, avulsive movement of defined flow paths, distributary flow, sheet flooding, scour, and landform aggradation. Relatively steep channel slopes between the base of the White Tank Mountains and the incised Hassayampa River can result in high flow velocities with the energy to move significant volumes of sediment and debris during floods.

The *SVADMP* analyzed several alternatives for mitigating the flood hazards of the alluvial fans including structural and non-structural strategies. The result of the alternatives evaluation process was to recommend large in-line detention basins at the apex of each alluvial fan together with downstream corridors protected by levees. The detention basins were designed to outlet 10 percent of the 100-year inflow volume from each alluvial fan. The corridors were designed to act as regional flood control trunk systems and were sized to include local drainage as well as sediment from adjacent watershed areas. Numerous drop structures would be constructed as part of the wash corridors. A conceptual cross-section of the leveed corridor and the location of the recommended flood control improvements are included in **Appendix TM3-06**.

The Northern Parkway alignment will almost certainly cross the drainage corridor associated with alluvial fan #6, also known as White Tank Wash. The location of the apex of each studied alluvial fan is shown in **Appendix TM3-06.** *Volume 5* of the *SVADMP* stated that the recommended detention basin at the apex of this alluvial fan would have a top area of 17 acres and a volume of 72 acre-feet. The apex of alluvial fan #6 was located approximately 6,700 feet upstream of the Sun Valley Parkway crossing. The wash corridor for approximately one mile downstream of Sun Valley Parkway was designated as natural containment, suggesting that the location of the existing wash in this area may be more stable than in other reaches. This conclusion matches the lower flood hazard noted in the discussion of geologic flood hazard mapping in Section 3.4.2.

The recommended drainage corridors associated with alluvial fans #4 and #5 are also within the project study area. As shown in **Appendix TM3-06**, these corridors enter the study area near the Hassayampa River and can likely be avoided by locating the Northern Parkway alignment near the Northern Avenue alignment or configured with an offsite channel for Northern Parkway.

3.4.4 Scour and Sedimentation

Degradation of the Hassayampa River channel bed was not expected to be limited by the development of an armored layer of larger materials according to the *Lower Hassayampa Watercourse Master Plan Phase I* (FCDMC, 2006). Total scour (not including local scour) was estimated to be 8-10 feet for the 10-year event and greater than 10 feet for the 100-year event. Despite the large amount of sediment that moves through the Hassayampa River system, historical channel slopes have been relatively constant, suggesting that the system is near sediment balance equilibrium. This equilibrium could readily change in the future if sand and gravel mining in the river or other disturbances to the sediment balance occur. Increased pressure to mine the Hassayampa River channel for sand and gravel will increase as development occurs in the area.

Sediment issues are expected to be a critical maintenance concern for any Northern Parkway culvert constructed east of Jackrabbit Wash. Very high sediment loads have been associated with Jackrabbit Wash, the Hassayampa River, and the alluvial fans between the river and the White Tank Mountains. Photo 579 in **Appendix TM3-04** shows the typical debris that was found in the Hassayampa River during the field visit. The FCDMC also provided photos of a significant flood event that occurred in January of 2010. One of these photos showing sediment deposition of the Hassayampa River near the Tonopah-Salome Highway has been included in **Appendix TM3-07**. Water can be seen flowing through the main channel in the background of the photo, and the foreground shows the overbank where slowing flows have deposited approximately six feet of sediment.

Alluvial fans are built up from sediment that drops out of flood waters when flows start to spread out at the base of mountains. Therefore, excessive sedimentation can be expected in active alluvial fan areas such as the study area east of the Hassayampa River. The *Buckeye/Sun Valley Area Drainage Master Study Volume V-A1: Area 3 Hydrology Report* (FCDMC, 2006) noted that the existing culverts under Sun Valley Parkway had reduced capacities due to sedimentation. The culverts were designed for the 100-year event but current conditions indicated that overtopping of Sun Valley Parkway occurred during the 100-year event. Photo 609 in **Appendix TM3-04** shows one set of these culverts with a small amount of sediment on the culvert bottoms.

3.4.5 Lateral Erosion

Bank erosion from flood events is another critical concern for potential Northern Parkway and Tonopah Parkway infrastructure. Most of the soils in the project study area are composed of sands and non-cohesive materials that water can easily erode. Avulsions can readily occur where some change in the terrain, manmade or natural, causes water to abandon a previously established channel in favor of a new drainage path. Excerpts from the *Lower Hassayampa Watercourse Master Plan River Behavior Report* (FCDMC, 2006) pertaining to erosion in the Hassayampa River and tributaries have been included in **Appendix TM3-08**. One of the exhibits in this appendix, titled "Major tributary avulsion locations," shows the current Jackrabbit Wash channel compared with the previous channel overlaid on an aerial photograph. The current channel is approximately 5,000 feet away from the historical channel. An example of an existing avulsion within the project area is shown in Photos 280 and 281 in **Appendix TM3-04**: Photo 280 looks downstream at the historical flow path of Old Camp Wash, and Photo 281 looks downstream at the new flow path along the east side of 411th Avenue. Avulsions like this could lead to downstream developed areas or infrastructure receiving unexpected increases in flood flows. Northern Parkway and Tonopah Parkway should minimize changes to existing flow paths as much as possible, and provide adequate structural protection of the roadway at all wash crossing locations.

Photos 331 and 341 in **Appendix TM3-04** show wash banks in the project area that have been recently eroded into near vertical cut banks. These banks are unstable and may continue to erode during successive flood events until a more resistant soil layer is encountered.

Appendix TM3-07 presents photos and a map exhibit showing the extent of bank erosion of the Hassayampa River during the recent January 2010 flood event. As shown in the map exhibit, the three SRP transmission line towers along the Indian School Road alignment were originally built above the banks of the Hassayampa River. The banks of the river eroded approximately 265 feet during this single storm event, exposing the tower footings as shown in the photos. While this location of the river is downstream of the project study area, it provides a good indication of the extremely erosive nature of the Hassayampa River.

The *Lower Hassayampa Watercourse Master Plan* classified the river as having a naturally braided pattern. The river is subject to extreme rates of lateral erosion during small and large flood events. The active flow channel moves laterally on a frequent basis, except at confluences with major tributaries. The maximum reported change in channel position during a single storm event was 1,300 feet. The *Watercourse Master Plan* included the delineation of Jackrabbit Wash and Hassayampa River erosion hazard zones to safeguard future development from river bank movement. Existing erosion hazard maps and historical channel locations are shown in **Appendix TM3-08**.

The *Buckeye/Sun Valley Area Drainage Master Study* (FCDMC, 2006) recommended that grade controls or other erosion protection be considered at outlets of future retention basins. The study also cautioned that smaller, more frequent flow events should be analyzed in addition to the 100-year event to adequately protect downstream washes. This was recommended because future land use changes may have a proportionally greater impact on the runoff response of a smaller, more frequent storm event. Erosion hazard setbacks were also determined for watercourses with existing floodplain delineations. These erosion hazard zones are shown in the "Interim Guidelines for Development Flooding and Erosion Areas" exhibit included at the end of **Appendix TM3-08**.

Wherever possible, care must be taken to locate foundations and structures outside of the erosion hazard zones that have been delineated for the Hassayampa River, Jackrabbit Wash, and the alluvial fan areas. These drainage systems are highly dynamic and have a history of rapidly changing channels.

3.5 Potentially Impacted Existing Drainage Structures

3.5.1 CAP and Tonopah Canals

The Central Arizona Project (CAP) canal is located upstream of the project study area. Many of the contributing watershed hydrographs are modified by the CAP due to significant storage along the upstream dikes protecting the canal. Drainages cross the canal at select locations via culverts, overchutes, or siphons. The Northern Parkway and Tonopah Parkway corridors are expected to have no impact on the CAP canal.

An existing concrete irrigation canal known as the Tonopah canal extends south from the CAP through the project area along 383rd Avenue. The location of this canal and the CAP canal are shown on **Figure 3**. The Tonopah canal is owned by the Bureau of Reclamation (USBR) and operated by the Tonopah Irrigation District (TID). The TID boundary is generally located along Northern Avenue to the north, 379th Avenue to the east, Tonopah-Salome Highway to the south, and 435th Avenue to the west. Within this district boundary, the TID uses the canal to distribute CAP water to farms. A figure showing the boundary of the TID can be found in the companion document, *Existing and Future Corridor Features* (TM 1). The existing canal is a five-foot deep, concrete-lined trapezoidal ditch with six-inch berms on both sides of the canal. The main canal typically runs approximately parallel to drainage flow paths, but inverted siphons exist where crossing major drainages such as Coyote Wash. The TID staff suggested that Northern Parkway may be able to minimize impacts to the canal by utilizing one of the two existing siphon crossings located north of the Northern Avenue alignment. Both of these existing siphons are located at washes with regulatory floodplains delineated. Alternately, new canal siphons or a bridge crossing could also be used for Northern Parkway to cross the Tonopah canal.

3.5.2 Sun Valley Parkway

The *Drainage Report Sun Valley Parkway Phase II* (The Adams Group, 1987) and the *Drainage Report Sun Valley Parkway Phase III* (The Adams Group, 1987) quantified the amount of runoff that would cross the roadway and sized proposed culverts and channels for Sun Valley Parkway. Erosion protection for box culvert outlets consists of grouted riprap aprons with minimum four-foot cutoff walls. The pavement and median drainage was designed for the 10-year storm. Cross drainage structures were designed for the 100-year, 1-hour event. Nine cross culverts in *Phase II* and eight culverts within *Phase III* fall within the project study area. These culverts are highlighted in the 'Runoff and Culvert Summary' excerpts included in **Appendix TM3-09-01**. As the intent of drainage design for Northern Parkway will be to maintain existing flow patterns to the extent feasible, it is not expected that Northern Parkway will have adverse impacts on the Sun Valley Parkway culverts. However, the Northern Avenue alignment intersects with Sun Valley Parkway within a regulatory floodplain for White Tank Wash. As a result, there may be interaction between the culverts of each project or even opportunities for combined drainage crossings that serve both roadways.

3.5.3 Buckeye Flood Retarding Structure #1

The easternmost watersheds of the project study area drain southwest to the Buckeye Flood Retarding Structure (FRS) #1 located immediately upstream of I-10. This earthen embankment was constructed in 1974 to provide flood protection for the Interstate and downstream properties. The embankment is approximately seven miles long and outlets west into the Hassayampa River. Additional information on the FRS, the hydrology model used to design it, and a map showing the structure and contributing watersheds, are included in **Appendix TM3-09-2**. Note that the documents in **Appendix TM3-09-02** were from the original design of the FRS. The FCDMC is currently completing the final design for rehabilitation of Buckeye FRS #1 and may be developing updated hydrology for the contributing area. The updated design documents should be reviewed when they are made available. However, the intent of drainage design for Northern Parkway will be to maintain existing flow patterns to the extent feasible, therefore Northern Parkway is not expected to have adverse impacts on the Buckeye FRS #1.

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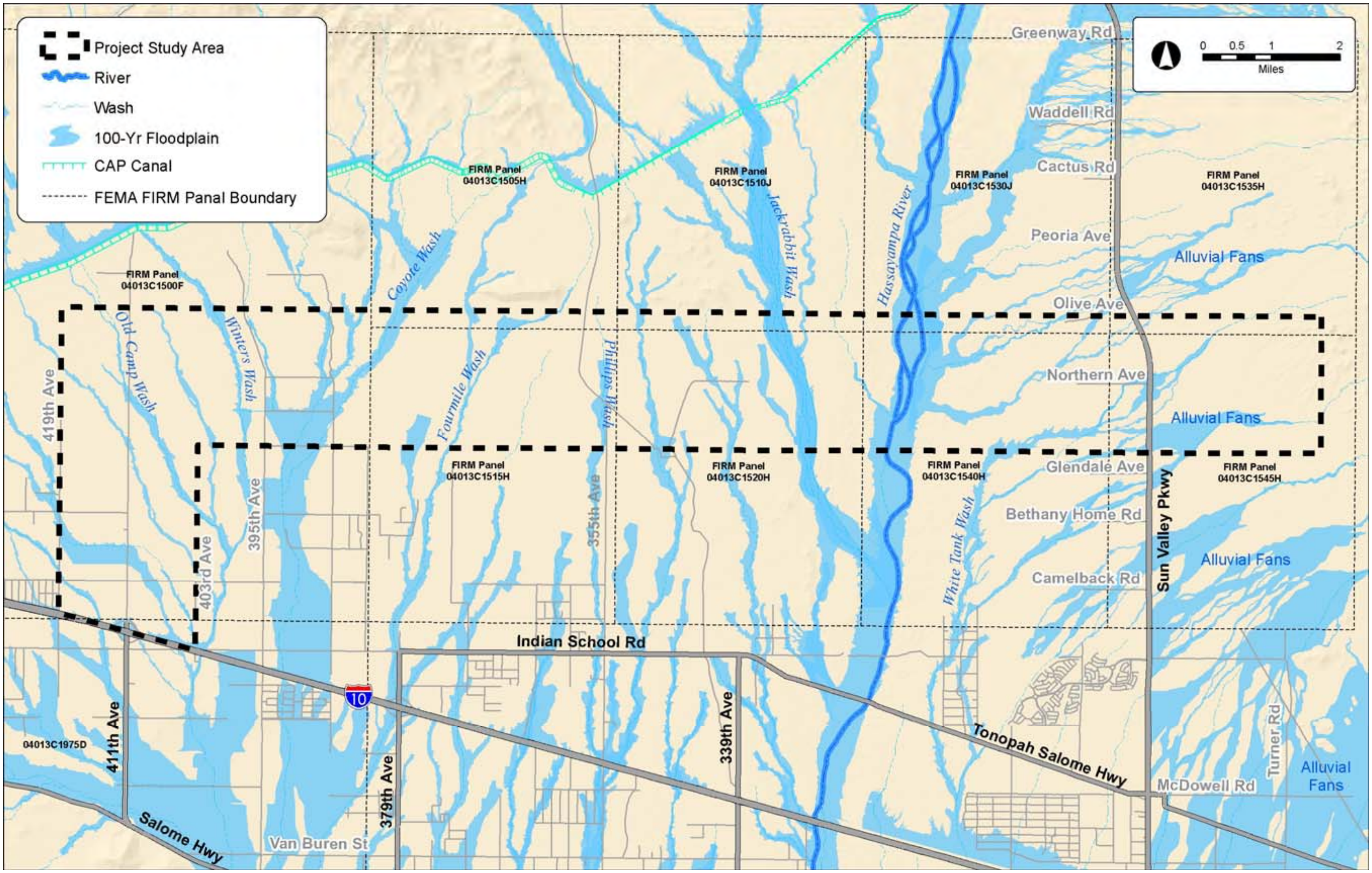

Figure 5 – Regulatory Floodplains

4. EXISTING HYDROLOGY

Various hydrologic studies have been completed that together encompass the entire study area. These existing studies were not necessarily performed to the same level of detail. Some studies, typically those intended for planning purposes, focused on broad drainage trends, featuring large subbasins and a limited number of concentration points. On the other hand, studies intended for floodplain delineation purposes typically used small subbasins and a large number of concentration points. To present a consistent level of hydrologic analysis throughout this study, offsite flows were reported at each location where a regulatory 100-year floodplain or a United States Geological Survey (USGS) "blue line" stream crossed the project study corridor centerline. Regulatory floodplains can be FEMA effective floodplains or 100-year floodplains that have been recognized by FCDMC. USGS "blue lines" refer to intermittent and perennial streams that are shown (in blue) on the commonly referenced USGS primary series quadrangle maps. **Table 1** presents an overview of the offsite hydrology concentration points examined for this report.

The location of each offsite drainage crossing is provided in **Figure 6** at the end of this section. Drainage crossings 1-4 are located approximately on the Tonopah Parkway portion of the alignment and crossings 5-23 are located approximately on the Northern Parkway portion of the alignment. Eight named washes exist in the project study area.

4.1 Summary of Hydrology Methods

Existing hydrology data for the project study area was extracted for each of the 23 offsite concentration points from the following five studies:

- Palo Verde Watershed Zone A Floodplain Delineation Study Technical Data Notebook (FCDMC, 2003);
- Hydrologic Study Report for Luke Wash Zone AE Floodplain Delineation Study (FCDMC, 2008);
- Jackrabbit Wash Floodplain Delineation Study Technical Data Notebook Hydrology (FCDMC, 1991);
- Hydrologic Analysis of the Hassayampa River in Maricopa County, Arizona (FEMA, 1988); and
- Buckeye/Sun Valley Area Drainage Master Study Volume V-A1: Area 3 Hydrology Report (FCDMC, 2006).

Figure 6 shows the subbasins within each of these watersheds grouped by color. Concentration points in existing studies were used directly if located near the center of the project corridor. If a crossing was not near a published concentration point, the peak flow was calculated as the contributing area weighted portion of the next downstream published value. The methodology used in each existing study is summarized below. The watersheds are discussed from a west to east direction.

Table 1 – Significant Offsite Drainage Crossings

Crossing ID	Watercourse Name	Nearest Cross Street	Regulatory Floodplain	USGS "Blue Line"
1	Unnamed Tributary to Winters Wash	I-10	Yes	No
2	Unnamed Tributary to Winters Wash	Missouri Ave	Yes	Yes
3	Unnamed Tributary to Winters Wash	Glendale Ave	Yes	No
4	Old Camp Wash	Northern Ave	Yes	Yes
5	Unnamed Tributary to Old Camp Wash	403rd Ave	Yes	No
6	Winters Wash	395th Ave	Yes	Yes
7	Unnamed Tributary to Coyote Wash	395th Ave	Yes	Yes
8	Unnamed Tributary to Coyote Wash	387th Ave	Yes	Yes
9	Coyote Wash	383rd Ave	Yes	Yes
10	Fourmile Wash	373rd Ave	Yes	Yes
11	Unnamed Tributary to Fourmile Wash	363rd Ave	No	Yes
12	Phillips Wash	355th Ave	Yes	Yes
13	Phillips Wash North	Wickenburg Rd	Yes	Yes
14	T2N-R5W-S05E	Aguila Rd	Yes	No
15	T3N-R5W-S32E	Aguila Rd	Yes	Yes
16	T2N-R5W-S05W	Aguila Rd	Yes	No
17	TWN-R5W-S04	unnamed	Yes	No
18	Jackrabbit Wash	unnamed	Yes	Yes
19	T2N-R5W-S2	unnamed	Yes	Yes
20	Hassayampa River	unnamed	Yes	Yes
21	Unnamed Tributary to Hassayampa River	unnamed	Yes	No
22	White Tank Wash	Sun Valley Parkway	Yes	Yes
23	Unnamed Tributary to White Tank Wash	Sun Valley Parkway	Yes	No

4.1.1 *Palo Verde Watershed*

An area/runoff relationship was developed for the Floodplain Delineation Study to calculate 100-year peak flows for the Palo Verde watershed. Results from two general HEC-1 models were used to generate local regression equations (flow as a function of area) for mountain and valley terrain types. The first model included the entire watershed and was used to develop the mountain area/runoff relationships. The second model included only the valley basins and was used to develop the valley area/runoff relationships. The project study area only comprises what the Palo Verde study considers valley area, so the following equations are applicable:

- For basins < 26 mi^2, Q_{100} (cubic feet per second (cfs)) = 510 * Area (mi^2); and
- For basins > 26 mi^2, Q_{100} (cfs) = 8,060 * Area (mi^2).

National Oceanic and Atmospheric Administration (NOAA) Atlas rainfall data was used to estimate the design rainfall depth for this study. The Clark Unit Hydrograph method was used for the computation of peak discharges in the preliminary HEC-1 models. These HEC-1 models were not detailed enough to accurately reflect flow splits, so flow splits were estimated manually by comparing downstream channel capacities of the flow paths at each split using normal depth of weir flow equations.

Storage was ignored when creating the original HEC-1 models used to develop the area/runoff relationships. To account for storage at the CAP canal, a separate HEC-1 model was developed that included level pool storage routing at the CAP structures. Stage/discharge and stage/storage parameters were estimated from topography and Federal Highway Administration (FHWA) inlet control nomographs.

4.1.2 *Luke Wash Watershed*

The 100-year, 6-hour and 24-hour storm events were modeled for the Luke Wash watershed using HEC-1 software, in conjunction with methods and procedures described by FCDMC. Watershed Modeling System (WMS) software was used to develop the preliminary subbasin boundary delineations. Drainage Design Management System for Windows (DDMSW) software was utilized to prepare the input parameters for the HEC-1 models. ArcGIS was applied to transfer databases available from FCDMC to prepare parameters for modeling purposes.

NOAA 14 rainfall data was used to estimate the design rainfall depth for this study. FCDMC 6-hour local storm distributions for the 6-hour model and the SCS Type II precipitation distribution for the 24-hour model were used for HEC-1 rainfall distributions. The Green and Ampt Method was utilized for the estimation of rainfall losses. The S-Graph method was used for the development of unit hydrographs.

Normal depth channel routing methodology was utilized in the hydrologic model to route surface runoff through subbasins. An eight-point composite channel cross-section was developed to represent typical wash cross-section conveyance using 2-foot contour mapping. The longitudinal slopes were estimated based on general existing wash slopes, and Manning’s “n” values were based on field reconnaissance estimates.

Surface runoff from the subbasins has the potential to concentrate at more than one point. It was assumed that the concentration point was located at the hydrologic low point of the subbasin. A potential split flow from Jackrabbit Wash was identified on one of the study washes. A rating curve was developed using the HEC-RAS models for Jackrabbit Wash to determine the diverted flow. This diverted flow hydrograph was coded into the 100-year, 24-hour HEC-1 model. There was no split flow for the 100-year, 6-hour storm model (FCDMC, 2008).

4.1.3 Jackrabbit Wash Watershed

HEC-1 version 4.0 software as implemented by Dodson & Associates was used to calculate runoff for the 100-year, 6-hour and 100-year, 24-hour events. Rainfall distributions for the 6-hour storm were taken from the FCDMC Hydrology Manual. SCS Type II rainfall distribution was used for the 24-hour storm.

Subbasin boundaries were delineated to use an average subbasin size of five square miles upstream of the CAP canal and an average subbasin size of three square miles downstream of the CAP. Boundaries were also added to allow the computation of peak discharges at major county road crossings and confluences of major washes. Rainfall losses were estimated using the Green & Ampt infiltration equation. The S-Graph method was found to be the most appropriate method developing unit hydrographs.

Hydrograph routing was performed with normal depth channel routing. Actual cross-sections were measured in the field for approximately 50 percent of the routing reaches, and were used to develop typical sections for the remaining reaches. A split flow estimate for Coyote Wash was calculated by modeling both downstream branches with HEC-2 software to generate stage-discharge curves. Where water ponds against the CAP canal, reservoir routing was performed using the Modified Puls Method. Stage versus discharge curves for CAP structures were calculated by using the Hydraulics of Culvert Waterways computer software.

4.1.4 Hassayampa River

Peak discharges at three existing stream gage locations were calculated using a Log-Pearson Type III statistical analysis of each site's gage records. Northern Parkway is upstream of gage station 95170 (Arlington) and downstream of gage station 95165 (Morristown), which had 22 and 30 years of recorded data, respectively. The study recommended using a 100-year peak discharge of 74,100 cfs at the Arlington gage station and 61,600 cfs at the Morristown gage station.

The magnitude of the 100-year flood peak of Jackrabbit Wash at the confluence with the Hassayampa River was estimated from a HEC-1 analysis. This model used a 24-hour storm duration with SCS Type II rainfall distribution, SCS dimensionless unit hydrograph, and SCS curve number method. The HEC-1 analysis produced a 100-year peak discharge of 28,338 cfs for Jackrabbit Wash at the Hassayampa River. This peak discharge was used in a simplified triangular hydrograph for the Jackrabbit Wash hydrograph. Field investigations were utilized to determine typical channel reaches for Jackrabbit Wash and the Hassayampa River, and Manning's equation was used to calculate travel times for the respective hydrographs. When the hydrographs were combined, the estimated point contribution of Jackrabbit Wash to the 100-year Hassayampa River peak was 15,600 cfs.

The original published discharge (FEMA, 1988) nearest the project study area was the Hassayampa River upstream of Jackrabbit Wash with a 100-year peak of 59,400 cfs. Flow rates for locations between the reference stations described previously were calculated by separately calculating the Jackrabbit Wash point contribution and uniformly attenuating the flow.

4.1.5 Buckeye/Sun Valley Watershed

This watershed was subdivided into multiple general areas with similar characteristics. Area 3 comprised the area that drained south to the Buckeye Flood Retarding Structures near I-10. Detailed hydrology was developed with a modified HEC-1 computer program embedded in WMS software for nine existing conditions storm events ranging from the 10-year, 6-hour storm to the 100-year, 10-day storm. NOAA 2 rainfall data was used to estimate the design rainfall depth for this study. Rainfall distributions for the 6-hour storm were taken from the FCDMC *Hydrology Manual*. SCS Type II precipitation distributions were used for 24-hour models. The Green and Ampt Method was utilized for the estimation of rainfall losses. The S-Graph method was used for the development of unit hydrographs.

Normal depth channel routing methodology was used to route runoff through subbasins. An eight-point composite channel cross-section was obtained from field surveys to represent typical wash cross-section conveyance. Some routing channels were expanded if they were incapable of conveying the 100-year peak discharge. Flow diversions due to Sun Valley Parkway were assumed to be negligible because the roadway was typically lower than subbasin boundaries.

Area 4 comprised the area that directly drained west to the Hassayampa River. The *Area Drainage Master Study* did not use detailed hydrologic or hydraulic methods for Area 4; instead a summary of existing evaluations was performed.

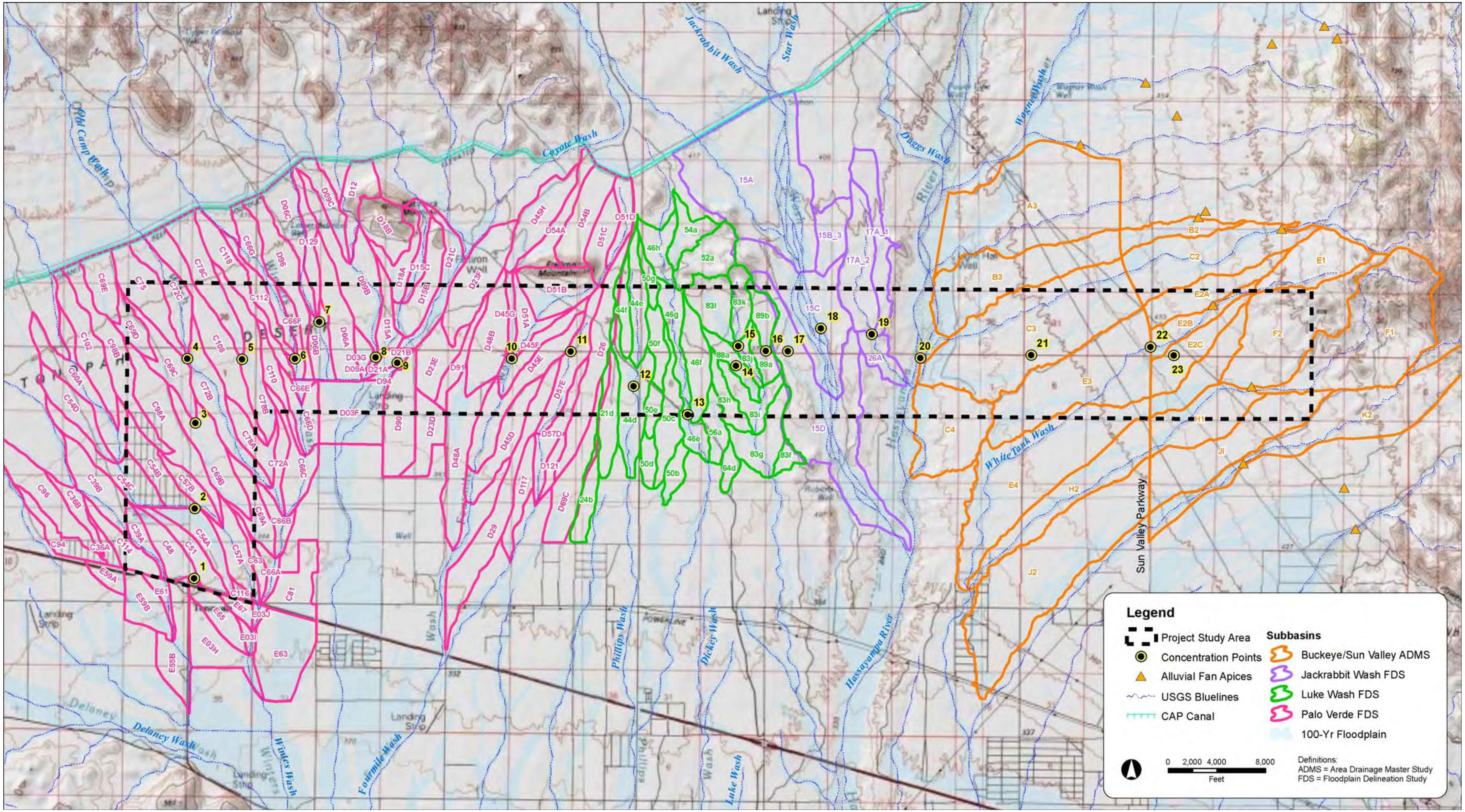

Figure 6 – Offsite Hydrology Workmap

4.2 Offsite Hydrology Results

Detailed hydrologic analysis was not performed as part of this study. The existing peak 100-year flows for each major wash crossing of the project study area are listed in **Table 2**. The wash information presented previously is also included to provide a comprehensive summary of the offsite hydrology at each crossing. **Table 2** indicates if the peak flow was taken directly from an existing study or if the discharge was calculated as a contributing area weighted portion of a published value. The concentration point or subbasin identification and storm duration used in each existing study are also presented. Excerpts from the original source documents of each respective hydrologic study are included in **Appendix TM3-10**.

The two largest watercourses within the study area are Jackrabbit Wash (Crossing 18) and the Hassayampa River (Crossing 20). The peak flows presented for these large crossings in **Table 2** reflect the effective FEMA discharges, but it should be noted that these values have been the subject of significant debate. A limited record of stream gage measurements were available when the peak flows were calculated for FEMA in 1988 and new statistical analyses continue to be performed as more gage data becomes available. An analysis completed for the FCDMC as part of the *Lower Hassayampa Watercourse Master Plan Hydrology Report* in 2005 presented peak discharges that were much lower than the effective peak discharges. For instance, the Hassayampa River 100-year flow immediately upstream of the Jackrabbit Wash confluence was calculated as 40,000 cfs. The 100-year flow presented in the original 1988 FEMA report was 59,400 cfs, and the most recent FEMA effective flow is 55,980 cfs at this location. The USGS is also conducting a statistical analysis of their Hassayampa River gage records and should present results later in 2010. However, despite the varying results it is unlikely that FCDMC and FEMA will adopt different regulatory flows for these reaches in the near future. The recommended design flows for Jackrabbit Wash and the Hassayampa are the FEMA effective flows shown in **Table 2**.

Table 2 – Offsite Hydrology Results

Crossing ID	Watercourse Name	Nearest Cross Street	Drainage Area (mi^2)	Regulatory Floodplain	USGS "Blue Line"	Calculation Method	Existing Study Name	Existing Study ID	Storm Duration	Peak 100-Year Flow (cfs)
1	Unnamed Tributary to Winters Wash	I-10	0.4	Yes	No	published value	Palo Verde FDS	C48-03	24-Hour	210
2	Unnamed Tributary to Winters Wash	Missouri Ave	5.2	Yes	Yes	published value	Palo Verde FDS	C54-09	24-Hour	2,650
3	Unnamed Tributary to Winters Wash	Glendale Ave	2.1	Yes	No	published value	Palo Verde FDS	C69-09	24-Hour	1,050
4	Old Camp Wash	Northern Ave	0.7	Yes	Yes	published value	Palo Verde FDS	C75-03	24-Hour	360
5	Unnamed Tributary to Old Camp Wash	403rd Ave	0.8	Yes	No	published value	Palo Verde FDS	C78-12	24-Hour	390
6	Winters Wash	395th Ave	1.6	Yes	Yes	published value	Palo Verde FDS	C66-33	24-Hour	810
7	Unnamed Tributary to Coyote Wash	395th Ave	1.0	Yes	Yes	published value	Palo Verde FDS	D06-09	24-Hour	490
8	Unnamed Tributary to Coyote Wash	387th Ave	6.0	Yes	Yes	published value	Palo Verde FDS	D09-06	24-Hour	3,040
9	Coyote Wash	383rd Ave	10.2	Yes	Yes	published value	Palo Verde FDS	D21-06	24-Hour	5,190
10	Fourmile Wash	373rd Ave	5.2	Yes	Yes	published value	Palo Verde FDS	D45-24	24-Hour	2,660
11	Unnamed Tributary to Fourmile Wash	363rd Ave	0.2	No	Yes	partial area pro-rate	Palo Verde FDS	D57E	24-Hour	103
12	Phillips Wash	355th Ave	0.7	Yes	Yes	published value	Luke Wash FDS	C44e	6-Hour	683
13	Phillips Wash North	Wickenburg Rd	3.0	Yes	Yes	published value	Luke Wash FDS	C46g	6-Hour	1,591
14	T2N-R5W-S05E	Aguila Rd	0.2	Yes	No	partial area pro-rate	Luke Wash FDS	88a	6-Hour	174
15	T3N-R5W-S32E	Aguila Rd	0.9	Yes	Yes	published value	Luke Wash FDS	C83k	6-Hour	1,031
16	T2N-R5W-S05W	Aguila Rd	0.3	Yes	No	published value	Luke Wash FDS	89b	6-Hour	389
17	TWN-R5W-S04	unnamed	0.4	Yes	No	partial area pro-rate	Jackrabbit Wash FDS	15D	24-Hour	181
18	Jackrabbit Wash	unnamed	367.4	Yes	Yes	published value	Flood Insurance Study 04013CV001A	Below Star Wash	24-Hour	33,409
19	T2N-R5W-S2	unnamed	2.2	Yes	Yes	published value	Jackrabbit Wash FDS	17A	24-Hour	1,570
20	Hassayampa River	unnamed	975.4	Yes	Yes	published value	Flood Insurance Study 04013CV001A	Just above confluence with Jackrabbit Wash	n/a	59,400
21	Unnamed Tributary to Hassayampa River	unnamed	8.3	Yes	No	partial area pro-rate	Buckeye/Sun Valley ADMS	C4R	24-Hour	3,073
22	White Tank Wash	Sun Valley Parkway	1.4	Yes	Yes	published value	Buckeye/Sun Valley ADMS	E3RB	6-Hour	1,053
23	Unnamed Tributary to White Tank Wash	Sun Valley Parkway	0.4	Yes	No	partial area pro-rate	Buckeye/Sun Valley ADMS	E2C	6-Hour	347

5. SUMMARY AND CONCLUSIONS

The purpose of TM 3 is to describe the existing drainage conditions and patterns, including peak flows, for the project study area. The findings of this memorandum can help determine the best alignment for the proposed Northern Parkway and Tonopah Parkway. Drainage structures and features in and around the project study area have been identified and should be considered during the design of the future parkways. Peak flows reported in this memorandum have been compiled for planning purposes only. Discharges should be evaluated based on FCDMC drainage criteria during final design of the parkways.

The impacts of crossing the numerous washes discussed in this memorandum should be considered when developing and evaluating potential parkway alignment alternatives. Alignment considerations will need to include the drainage structures, such as bridges and box culverts, that may be necessary to convey flood flows under the proposed parkways, particularly at the Hassayampa River and Jackrabbit Wash. While an effort can be made to align the proposed Northern Parkway to cross the Hassayampa River and Jackrabbit Wash at narrower floodplain locations, the selection of crossing locations should also take into account the dynamic nature of these watercourses and the significant potential for lateral migration of the channel. Floodplain impacts and the potential need for detailed floodway studies should also be considered.

The design of proposed drainage structures along the Northern Parkway alignment will need to take into account the active and inactive alluvial fan systems east of the Hassayampa River, especially the area designated as alluvial fan #6, also known as White Tank Wash. The uncertainty of flow distribution, distributary flow and potential for avulsions must be considered in future hydrologic analyses of these alluvial fans. Design of Northern Parkway should also consider the recommended FCDMC drainage corridors associated with alluvial fans # 4 and #5, which are in the project study area.

Sedimentation must be taken into account when designing the proposed drainage structures; this is a particular concern for structures between Jackrabbit Wash and the White Tank Mountains due to the very high sediment loads. Adequate erosion control as well as correct sizing and placement of structures to minimize sediment deposition will be necessary for the proposed drainage structures to convey flows properly throughout the service life of these structures. In addition, maintaining existing drainage patterns and sediment transport capacities will reduce maintenance costs and minimize the potential for causing erosion problems downstream of the project.

The proposed Northern Parkway and Tonopah Parkway may cause incremental increases in ponding and inundation in adjacent properties. The watershed is mostly undeveloped desert, but there are a few residential, industrial, and agricultural developments in the area. Increased inundation and ponding on developed land should be avoided where feasible, and coordination with FCDMC and FEMA may be required. Care should be taken not to adversely affect the functions of the Tonopah Canal and the existing culverts along Sun Valley Parkway during the drainage design for the parkways.

In summary, the most critical drainage issue to be considered during the alignment alternatives analysis is the location of crossings at the Hassayampa River and Jackrabbit Wash as well as at other major washes. The selection of these crossing locations will need to consider the cost of the structures, hydraulic impacts upstream and downstream, lateral migration, and scour. The impact of the existing alluvial fans and corresponding drainage corridors on the proposed alignment are another important consideration. The two overarching goals of drainage design for the Northern Parkway and Tonopah parkway are to minimize the impacts of proposed roadways on existing drainage patters, and minimize the impacts of drainage on parkway alignments.

APPENDIX TM3-01

DATA COLLECTION SUMMARY

Summary Table of Documents Reviewed - Kimley-Horn and Associates

AZGS = Arizona Geological Survey
ADOT = Arizona Department of Transportation
ADWR = Arizona Department of Water Resources
FCDMC = Flood Control District of Maricopa County
FEMA = Federal Emergency Management Agency
KHA = Kimley-Horn and Associates
MAG = Maricopa Associated Governments
MC - Maricopa County
MCDOT - Maricopa County Department of Transportation

Northern Parkway/Tonopah Parkway Corridor Feasibility Study Data Collection Summary

LIBRARY	ITEM				TRACKING			
KHA No.	Title	Description	Author	Date	Source	Format/ File Type	Collected By	Discipline
1	2010 Update - Regional Tranportation Plan	transportation improvement planning info	MAG	Jul 2010	MAG	pdf	BCP	Transportation
2	A Compilation of Geomorphic and Hydrologic Reports on the Jackrabiit Wash Flood, October 2000, Maricopa County, Arizona	3 reports: Landsat flood detection, geomorphic assessment, and flood reconstruction. Primarily looks at Jackrabbit Wash upstream of confluence with Star Wash (north of NP study area) so is not esp. pertinent.	AZGS	Jun 2002	FCDMC	pdf	BML	Drainage
3	Active Land Subsidence Areas in Arizona Based on ADWR InSAR Data	map showing active subsidence areas	ADWR	Jul 2009	ADWR	pdf	BML	Water
4	ADWR GIS Data CD-ROM	Shapefiles: recharge points, industry points, depth to water and water level elev (Phoenix AMA only), irrigation polygons, hardrock	ADWR	Mar 2009	ADWR	CD	BML	Water
5	Approximate Flood Hazard Assessment for White Tank Fans Alluvial Fan Site 37A (East of Sun Valley Parkway) Town of Buckeye, Arizona Technical Data Notebook	determines flood hazard delineation for alluvial fan. Fan 37 is just south of NP study area and ends at Sun Valley Pkwy	Coe & Van Loo Consultants	Oct 2006	FCDMC	pdf	BML	Drainage
6	Approximate Zone A Floodplain Delineation Study of Watershed "OO" Coyote Wash and Tributaries	2 volumes in TDN. North of NP study area so not esp. pertinent.	JE Fuller	May 2003	FCDMC	pdf	BML	Drainage
7	Approximate Zone A Floodplain Delineation Study of Watershed "OO" Hassayampa River Tributaries & Lower Jackrabbit Wash Tributaries	6 volumes in TDN, report in vol 1 and exhibits in vol 4-6. only 2 tributaries at southern end of this study impact the NP (Inset 46B and 46C in maps).	JE Fuller	Apr 2003	FCDMC	pdf	BML	Drainage
8	Approximate Zone A Floodplain Delineation Study of Watershed "OO" Upper Jackrabbit Wash and Tributaries	Zone A delineation study, not esp. pertinent to NP because is upstream of study area	JE Fuller	Dec 2003	FCDMC	pdf	BML	Drainage
9	Arizona Parkway Intersection/Interchange Operational Analysis and Design Concepts Study	AZ parkway intersection ROW information	Wilson & Company	Aug 2009	MCDOT	PDF	MLG	Transportation
10	Arizona Parkway Intersection/Interchange Operational Analysis and Design Concepts Study	report with R/W requirements, traffic volumes, intersection layouts	Wilson & Company	Aug 2009	MCDOT	pdf	MLG	Transportation
11	Arizona Parkway Projected Travel Volumes and Laneage/Interchange Needs	Projected build-out traffic volumes for Hassayampa and Hidden Valley Framework areas with laneage and interchange needs on parkways; GIS shapefiles	Wilson & Company	Jun 2009	MAG	pdf/GIS on CD	MLG	Transportation
12	As-Built Report Buckeye Site 1 Drain Maricopa County, Arizona	as-built inspection report for 4.5 miles of 17.5' deep embankment drain trench for Buckeye FRS #1, includes plans at end of document	ERTEC, Inc.	Mar 1981	FCDMC	pdf	BML	Drainage

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Northern Parkway/Tonopah Parkway Corridor Feasibility Study Data Collection Summary

LIBRARY	ITEM				TRACKING			
KHA No.	Title	Description	Author	Date	Source	Format/ File Type	Collected By	Discipline
13	Buckeye Area Drainage Master Plan Recommended Design Report	describes various plan components to manage runoff. Study area is south of I-10 so not esp. pertinent to NP.	Dibble Engineering	Jun 2009	FCDMC	pdf	BML	Drainage
14	Buckeye Area Flood Delineation Study Hydrology Report	FEMA report to estimate 100-yr peak flows for floodplain delineation. Study area is south of I-10 so not esp. pertinent to NP.	McLaughlin Kmetty Engineers	Jul 1992	FCDMC	pdf	BML	Drainage
15	Buckeye/Sun Valley Area Drainage Master Study Volume I: Master Document Summary	overview of the project and the four areas included. References the other eight volumes	PBS&J	Jun 2006	FCDMC	pdf	AOM	Drainage
16	Buckeye/Sun Valley Area Drainage Master Study Volume V-A1: Area 3 Hydrology Report	description of hydrologic methods and results for Area 3	PBS&J	Jan 2006	FCDMC	pdf	AOM	Drainage
17	D.W.R. Hydrologic Map Series Report No. 10	maps showing groundwater conditions in the Hassayampa Sub-basin of the Phoenix Active Management Area	ADWR	1982	ADWR	pdf	BML	Water
18	D.W.R. Hydrologic Map Series Report No. 27	maps showing groundwater conditions in the Phoenix Active Management Area	ADWR	1992	ADWR	pdf	BML	Water
19	D.W.R. Hydrologic Map Series Report No. 35	maps showing groundwater conditions in the Phoenix Active Management Area	ADWR	Nov 2002-Feb 2003	ADWR	pdf	BML	Water
20	Design Guideline Recommendations for the Arizona Parkway	AZ parkway ROW requirements, intersection layout	DMJM Harris; AECOM	Aug 2008	MCDOT	PDF	MLG	Transportation
21	DGM-37	Geologic Map of the Buckeye NW 7.5' Quadrangle, Maricopa County, Arizona	AZGS	Nov 2004	AZGS	CD	BML	Geology
22	DGM-47	Geologic Map of the Wintersburg 7.5' Quadrangle, Maricopa County, Arizona	AZGS	Mar 2006	AZGS	CD	BML	Geology
23	DI-05: Geologic Data for the Phoenix South 30' x 60' Quadrangle	1:100,000 digital map of OFR93-18, in jpg and shp formats	AZGS	Mar 2006	AZGS	CD	BML	Geology
24	Draft Environmental Impact Statement Allocation of Water Supply and Long-Term Contract Execution Central Arizona Project Appendix L	brief history of Tonopah Irrigation District and its CAP water allocation	USBR	Jun 2000	USBR	pdf	BML	Water
25	Drainage Design Report for Sun Valley Parkway Drainage Enhancement	documentation for interceptor channel collector ditch, wagner wash outlet protection, detention basin ditch/inlets, and baffle block design. Not esp. pertinent since all of these drainage improvements are north of the NP study area.	Collar, Williams & White Engineering	Dec 1988	FCDMC	pdf	BML	Drainage
26	Drainage Enhancements for Sun Valley Parkway	written in response to damage from August 1988 storm event: discusses storm frequency analysis, design approach, channel bank protection, Wagner Wash outlet protection, drop structure damage, roadside channel enhancements, interceptor channel damage.	Collar, Williams & White Engineering	Oct 1988	FCDMC	pdf	BML	Drainage

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Northern Parkway/Tonopah Parkway Corridor Feasibility Study Data Collection Summary

LIBRARY	ITEM				TRACKING			
KHA No.	Title	Description	Author	Date	Source	Format/ File Type	Collected By	Discipline
27	Drainage Report Sun Valley Parkway Phase II (Station 410+00 - 1023+95)	quantifies runoff that crosses roadway and sizes culverts/channels. Phase II starts at Northern Ave alignment and extends north/east to Phase I. Drainage area map at end of document.	Collar, Williams & White Engineering	Apr 1987	FCDMC	pdf	BML	Drainage
28	Drainage Report Sun Valley Parkway Phase III (291st Avenue from I-10 to Northern Avenue)	quantifies runoff that crosses roadway and sizes culverts/channels. Pdf is missing drainage area map.	Collar, Williams & White Engineering	Apr 1987	FCDMC	pdf	BML	Drainage
29	Earth Fissure Map of Maricopa County, Arizona	mapping of earth fissures	AZGS	Dec 2009	AZGS	pdf	BML	Geology
30	Enhanced Parkway Study Final Report	AZ parkway intersection ROW information	Morrison Maierle	Aug 2007	MCDOT	PDF	MLG	Transportation
31	Executive Summary Existing Flood Control Facilities Landscape Aesthetics and Multiple-Use Opportunities Assessment	preliminary assessment for retrofitting Buckeye FRS 1,2,3 (and other projects outside NP study area) for enhanced recreational/aesthetic opportunities	Carter Burgess	Feb 2001	FCDMC	pdf	BML	Drainage
32	Flood Insurance Study Maricopa County, Arizona and Incorporated Area	FIS No. 04013CV001A: description of general flooding issues in county, effective discharges, and flood profiles	FEMA	Sep 2005	KHA	pdf	BML	Drainage
33	FY 2011-2015 Transportation Improvement Program	programmed transportation improvements	MAG	Jul 2010	MAG	pdf	BCP	Transportation
34	Geologic Map of the Flatiron Mountain 7.5' Quadrangle, Maricopa County, Arizona	DGM-46. mapped surface and bedrock units with descriptions	AZGS	Mar 2006	AZGS	pdf	BML	Geology
35	Geologic Map of the Wagner Wash Well 7.5' Quadrangle, Maricopa County, Arizona	DGM-38. mapped surface and bedrock units, also includes separate report document with descriptions	AZGS	Nov 2004	AZGS	pdf	BML	Geology
36	Geologic Mapping of Flood Hazards in Arizona: An Example From the White Tank Mountains Area, Maricopa County	OFR 91-10: outlines methods used to map alluvial surfaces of different ages, then converted to five flood-hazards zones. Includes four 24"x36" plates.	AZGS	Mar 1992	AZGS	hardcopy	BML	Geology
37	GIS and Volume Data	GIS Data, buildout traffic volumes	Wilson & Company	Jun 2009	MAG	CD	BCP	Transportation
38	GIS shapefiles from FCDMC	drainage, floodplain, railroad, wilderness, jurisdictions, community features, subdivisions, road features, 10-ft contours, aerials	FCDMC	May 2009	FCDMC	GIS on CD	ES	ALL
39	GWSI Database CD-ROM	Access database of Groundwater Site Inventory: well ownership, historic water levels, construction data, etc.	ADWR	Jul 2009	ADWR	CD	BML	Water
40	GWSI Hydrograph Site ID 333146112560801	historical groundwater levels at 411th Ave and Bethany Home Rd	ADWR	Dec 2009	ADWR	pdf	BML	Water
41	Hassayampa Basin Gravity Survey	shows points for depth to bedrock study	ADWR	unknown	ADWR	pdf	BML	Water

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Northern Parkway/Tonopah Parkway Corridor Feasibility Study Data Collection Summary

LIBRARY	ITEM				TRACKING			
KHA No.	Title	Description	Author	Date	Source	Format/ File Type	Collected By	Discipline
42	Hassayampa River Planning and Design Analysis Report	investigation of bank erosion next to CAP (and concept designs) -- not esp. pertinent to NP study	CH2MHill	Aug 1997	FCDMC	pdf	BML	Drainage
43	Hydrologic Analysis of the Hassayampa River in Maricopa County, Arizona	FEMA report to estimate 100-yr peak flows for floodplain delineation (reach is Wickenburg to Gila River)	Cella Barr Associates	May 1988	FCDMC	pdf	BML	Drainage
44	Hydrologic Study Report for Luke Wash Zone AE Floodplain Delineation Study	Contains only the hydrology documentation (Section 4) of a larger study	Wood, Patel & Associates	Sep 2008	KHA	pdf	BML	Drainage
45	Hydrologic/Hydraulic Design Analysis of Proposed Sun Valley Parkway Crossing of the Buckeye Watershed Structure	summary of the analysis of the proposed improved interchange on the Buckeye FRS #1. south of the NP study area so not esp. pertinent.	Collar, Williams & White Engineering	Aug 1987	FCDMC	pdf	BML	Drainage
46	Interstate 10/Hassayampa Valley Transportation Framework Study Final Report and Executive Summary	overview, existing and future conditions, evaluation framework, travel demand forecasting, alternatives, implementation, funding; GIS shapefiles	DMJM Harris; AECOM	Jul 2008	bqaz.org/ MAG	pdf/GIS on CD	MLG	Transportation
47	Jackrabbit Wash Floodplain Delineation Study Contract Amendment Number One: Hydrologic Model Sensitivity Analysis	supplement to FDS analyzing accuracy/sensitivity of HEC-1 parameters. Also includes FCDMC comments.	Burgess & Niple	Jul 1991	FCDMC	pdf	BML	Drainage
48	Jackrabbit Wash Floodplain Delineation Study Technical Data Notebook Hydrology	2 books. FEMA report to estimate 100-yr peak flows for floodplain delineation	Burgess & Niple	May 1991	FCDMC	pdf	BML	Drainage
49	Lower Hassayampa Watercourse Master Plan Phase I	seven technical reports intended to develop guidance for managing the river floodplain	FCDMC	Apr 2006	FCDMC	pdf	AOM	Drainage
50	Luke Wash Watershed FDS	map of Floodplain Delineation Study boundary	FCDMC	unknown	FCDMC	jpg	BML	Drainage
51	Luke Wash Watershed Zone AE Floodplain Delineation Study Technical Data Notebook	4 volumes. Report, survey field notes, supporting documentation, and exhibits.	Wood, Patel & Associates	Mar 2009	FCDMC	pdf	BML	Drainage
52	Maricopa County Drainage Policies and Standards	drainage guidelines	MC	Jan 2007	KHA	pdf	BML	Drainage
53	Maricopa County Major Streets and Routes Plan Street Classification Atlas	road classifications	MC	Sep 2004	MC	pdf	BCP	Transportation
54	Maricopa County Regional Trail System Plan	description of plans for regional trail facilities	MC	Aug 2004	MC	pdf	BCP	Planning
55	Maricopa County Transportation System Plan	road conditions, road planning info	MC	Feb 2007	MC	pdf	BCP	Transportation
56	Maricopa County Zoning Ordinance	zoning ordinance	MC	Jun 2010	MC	pdf	BCP	Planning
57	Maricopa County Zoning Ordinance	zoning ordinance descriptions and codes	Maricopa County	Jul 2009	MC	pdf	MLG	Planning
58	National Engineering Handbook Part 630 Hydrology	Chapter 7 Hydrologic Soil Groups	NRCS	May 2007	NRCS	pdf	BML	Drainage
59	Open-File Report 91-8	Surficial Geology Around the White Tank Mountains, Central Arizona	AZGS	Nov 1991	KHA	hardcopy	BML	Geology

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Northern Parkway/Tonopah Parkway Corridor Feasibility Study Data Collection Summary

LIBRARY	ITEM				TRACKING			
KHA No.	Title	Description	Author	Date	Source	Format/ File Type	Collected By	Discipline
60	Palo Verde Watershed Zone A Floodplain Delineation Study Technical Data Notebook	7 volumes. Hydrology, hydraulics, and floodplain delineation for approx. 400 miles of washes; Area C and Area D cover western portion of NP study area.	Entellus	May 2003	FCDMC	pdf	BML	Drainage
61	Phase I Report Project Calculations Hydrologic Analysis Buckeye Floodwater Retarding Structures #1, #2, and #3	precipitation calcs, PMP storm distributions, HEC-1 input parameters, capacity data and reservoir routing documentation	Dames & Moore	Jan 1990	FCDMC	pdf	BML	Drainage
62	Phoenix Active Management Area	maps shows major infrastructure and grandfathered water rights	ADWR	Sep 2003	ADWR	pdf	BML	Water
63	Preliminary Geologic Maps of the Eastern Big Horn and Belmont Mountains, West-Central Arizona	OFR 85-14. mapped surface and bedrock units with descriptions. Mapped area is north of NP project area.	AZGS	Nov 1985	AZGS	hardcopy	BML	Geology
64	Preliminary Investigation Report for Tonopah Watershed Maricopa County, Arizona	high level overview of various problems and proposed drainage projects, contains useful exhibits at end of documents	USDA SCS	Jul 1974	FCDMC	pdf	BML	Drainage
65	Preliminary Master Drainage Report for Sun Valley Maricopa County, Arizona	very preliminary (no specifics) drainage report for 28,000 ac master planned community north and west of White Tank Mtns, has useful exhibits at end of document	Collar, Williams & White Engineering	May 1986	FCDMC	pdf	BML	Drainage
66	Proposed Development: Belmont	proposed site map showing development boundaries and primary features, vicinity map showing other developments in area	Hadley Design Group	Nov 2007	MC	pdf	MLG	Planning
67	Proposed Development: Douglas Ranch	conceptual land use and framework plans	Greey Pickett	Jul 2008	MC	pdf	MLG	Planning
68	Proposed Development: Mirielle	conceptual land use plan	WRG Design	Oct 2007	Communities Southwest	pdf	BCP	Planning
69	Proposed Development: Montiere	proposed site map showing development boundaries and uses	David Evans	May 2006	MC	pdf	MLG	Planning
70	Proposed Development: Sun Valley South	conceptual land use plan with boundaries; KHA traffic impact analysis	CMX; KHA	May 2006	MC; KHA	pdf	MLG	Planning
71	Proposed Development: Sun Valley Villages III and IV	conceptual land use plan with boundaries	Carter Burgess	Jul 2008	MC	pdf	MLG	Planning
72	Roadway Design Manual	guidelines for standard roadway design	MCDOT	Apr 2004	KHA	pdf	BML	Transportation
73	Solicitation/Specifications Main Canal and Laterals Tonopah Irrigation District, Arizona Central Arizona Project	Vol 2 of 2 (DRAWINGS) -- contains construction plans and soil boring for major canal that runs along 383rd Ave alignment	Franzoy Corey Engineering	Feb 1985	FCDMC	pdf	BML	Drainage
74	Statewide Rail Framework Study	2050 Vision plan with maps	BQAZ	Aug 2009	BQAZ	pdf	MLG	Transportation

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Northern Parkway/Tonopah Parkway
Corridor Feasibility Study
Data Collection Summary

LIBRARY	ITEM				TRACKING			
KHA No.	Title	Description	Author	Date	Source	Format/ File Type	Collected By	Discipline
75	Sun Valley Area Drainage Master Plan Area 4 Hydrology Technical Data Notebook	provides updated hydrology for Area 4 of ADMS -- downstream end of this area impacts the NP study.	JE Fuller	Aug 2006	FCDMC	pdf	BML	Drainage
76	Sun Valley Area Drainage Master Plan Planning and Regulatory Coordination	describes federal, state, and local ordinances that guide development, also includes inventory of proposed developments	EDAW	Dec 2006	FCDMC	pdf	BML	Drainage
77	Sun Valley Area Drainage Master Plan Scenery Multiuse Data Collection and Analysis	assessed scenic/recreational resources and provides alternatives evaluation	Logan Simpson Design	Jan 2007	FCDMC	pdf	BML	Landscape Architecture
78	Sun Valley Area Drainage Master Plan Step 1 Alternatives Formulation and Preliminary Analysis	outlines preliminary alternatives for flood protection alternatives. Hassayampa and White Tank Wash sub-areas apply to NP study.	JE Fuller	Aug 2006	FCDMC	pdf	BML	Drainage
79	Sun Valley Area Drainage Master Plan Step 2 Proposed Alternatives Report	7 volumes. Vol 1 provides overview of ADMP process, and Volumes 4 and 5 contain the specific alternatives for the NP study area.	JE Fuller	Sep 2006	FCDMC	pdf	BML	Drainage
80	Sun Valley Area Drainage Master Plan Step 3 Recommended Alternative Report	7 volumes. Vol 1 provides overview of ADMP process, and Volumes 4 and 5 contain the specific alternatives for the NP study area.	JE Fuller	Dec 2006	FCDMC	pdf	BML	Drainage
81	Sun Valley Area Drainage Master Plan Technical Data Notebook Approximate Zone A Floodplain Delineation Study of White Tank Fan 6	delineates 100-year floodplain for alluvial fan near NP alignment. Also includes lengthy section on geomorphic methods.	JE Fuller	Nov 2006	FCDMC	pdf	BML	Drainage
82	Sun Valley Area Drainage Master Plan Technical Data Notebook Approximate Zone A Floodplain Delineation Study of White Tank Fans 4 & 5	delineates 100-year floodplain for alluvial fans between White Tank Mtns and Hassayampa River. Also includes lengthy section on geomorphic methods.	JE Fuller	Nov 2006	FCDMC	pdf	BML	Drainage
83	Sun Valley Area Drainage Master Plan Technical Data Notebook: Approximate Zone A Floodplain Delineation Study of White Tank Piedmont Appendix G	compilation of AZGS geologic reports/maps, NRCS soil surveys, and sediment yield analysis	JE Fuller	Sep 2006	FCDMC	pdf	BML	Geology
84	Sun Valley Parkway Access Control and Corridor Improvement Study	study for reference on right of way and utilities	Parsons	Dec 2006	MC	pdf	BCP	Transportation/ Planning
85	Sun Valley Parkway Correspondence	contains various documentation regarding the damage from the Aug 1988 storm, Greiner reviews of CWW drainage reports, variance from standard drainage design criteria -- valuable lessons on building a roadway in this alluvial fan area	FCDMC	unknown	FCDMC	pdf	BML	Drainage

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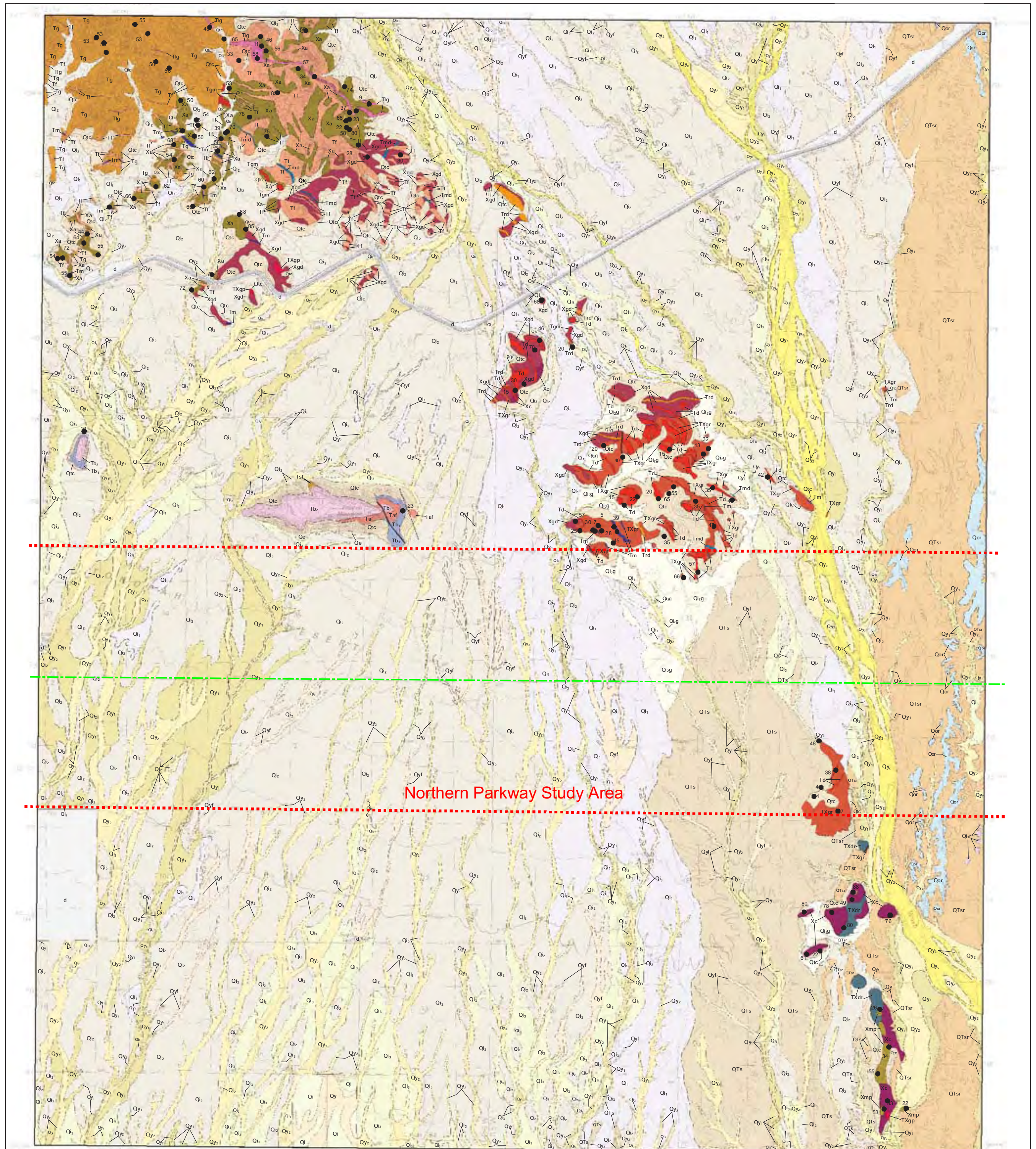
KHA No.	Title	Description	Author	Date	Source	Format/ File Type	Collected By	Discipline
86	Sun Valley Parkway North FIS Hydrology Report	hydrologic analysis to determine peak 100-yr flows to study area north of White Tank Mtns -- note that this is northeast of NP study area so will not be reviewed further	A-N West, Inc.	Mar 1991	FCDMC	pdf	BML	Drainage
87	SW Maricopa County Linkage Designs and Conservation Priorities	comment letter from AGFD, wildlife linkage designs, conservation priorities, environmental features and constraints	Arizona Game and Fish Department	Jul 2009	KHA	pdf/GIS in e-mail	MLG	Environmental
88	The Use of Multi-spectral Remote Sensing Imagery For Geomorphic Mapping and Determination of Flood Prone Areas on Piedmonts in Maricopa County, AZ: An Example From a Portion of the Jackrabbit Wash Watershed	report explores using LANDSAT imagery to determine floodprone areas -- not esp. pertinent to NP study, only uses NE portion of Jackrabbit Wash watershed as an illustrative example	JE Fuller	Feb 2002	FCDMC	pdf	BML	Drainage
89	Tonopah/Arlington Area Plan	land use, zoning, transportation classifications, environmental information	MC	Sep 2000	MC	pdf	MLG	Transportation/ Planning
90	Town of Buckeye Draft Transportation Master Plan	exhibits showing planned road, trail, and transit networks	Town of Buckeye	Dec 2009	Buckeye	pdf	BCP	Planning
91	Town of Buckeye General Plan Figures	land use, circulation, environmental conditions, growth area land use, floodway transitional areas, master planned communities	Partners for Strategic Action	May 2008	Buckeye	pdf	MLG	Planning
92	Town of Buckeye GIS Data	land use and zoning GIS data	Town of Buckeye	Aug 2010	Buckeye	GIS in email	BCP	Planning
93	Town of Buckeye Zoning and Annexation History Figures	zoning and annexation history	Town of Buckeye	May 2009	Buckeye	pdf	MLG	Planning
94	Uplift in the Vicinity of the Tonopah Recharge Facility	map showing ground uplift from 2006 to 2010 due to recharge plume	ADWR	Mar 2010	ADWR	pdf	BML	Water

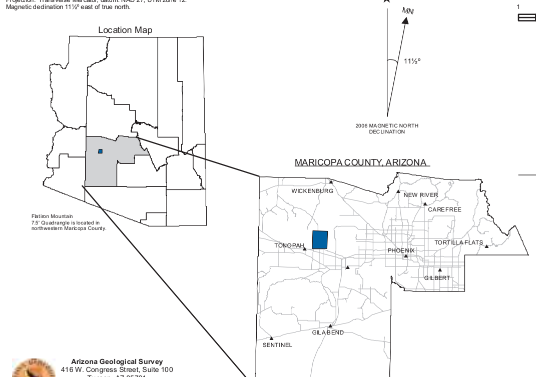
Kimley-Horn and Associates, Inc.

APPENDIX TM3-02

EXISTING GEOLOGIC MAPPING



Topographic base from USGS Flatiron Mountain 7.5' quadrangle.
Topography by photogrammetric methods from aerial photographs taken 1951 and 1960;
Field checked 1986; map edited 1990;
Projection: Transverse Mercator, datum: NAD 27, UTM zone 12.
Magnetic declination 11½° east of true north.



2006 MAGNETIC NORTH DECLINATION (MN, 11½°)

SCALE 1:24,000

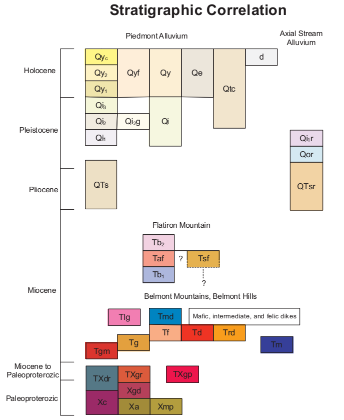
contour interval 20 feet

Map Symbols

- contact; accurately located, approximately located, concealed, arrow shows dip of contact
- fault; accurately located, concealed, arrow shows dip of fault
- inclined lithologic layering and parallel foliation in gneissic rocks
- inclined schistosity in foliated granite and amphibolite schist
- inclined joint
- inclined flow foliation in igneous rocks
- dip of contact
- trend and plunge of mineral lineation in amphibolite schist
- fault or vein orientation

Arizona Geological Survey
416 W. Congress Street, Suite 100
Tucson, AZ 85701
(520) 770-3500
www.azgs.az.gov

Stratigraphic Correlation



Surficial Units

Piedmont Alluvium

Quaternary and late Tertiary piedmont deposits from several mountain ranges to the north cover most of the Flatiron Mountain quadrangle. This alluvium was deposited primarily by larger tributary streams that head to the north of the quadrangle; these larger streams and local, smaller streams have eroded and reworked some of these deposits. Deposits range in age from modern to Pliocene. Abbreviations are ka, thousands of years before present, and Ma, millions of years before present.

Qy_c — **Modern channel deposits (<~100 yrs)** — Active channel deposits composed of very poorly-sorted sand, pebbles, and cobbles with some boulders to moderately-sorted sand and pebbles. Channels are generally incised 1 to 2 m below adjacent Holocene terraces and alluvial fans, but may be incised as much as 4 m below adjacent Pleistocene deposits. Channel morphologies generally consist of a single-thread high flow channel or multi-threaded low flow channels with gravel bars. Channels are extremely flood prone and are subject to deep, high velocity in moderate to large flow events, and severe lateral bank erosion.

Qy_2 — **Late Holocene alluvium (<~2 ka)** — Young deposits in low terraces and small channels that are part of the modern drainage system. Includes Qy_c where not mapped separately. Along the larger drainages, unit Qy_2 sediment is generally poorly to very poorly sorted sand, pebbles, cobbles, and boulders; terrace surfaces typically are mantled with pebbles, sand, and finer sediment. On lower piedmont areas and in smaller tributary washes young deposits consist of moderately sorted sand and silt, with some pebbles and cobbles in channels. Channels generally are incised less than 1 m below adjacent terraces, but locally incision may be as much as 2 m. Channels are flood prone and may be subject to deep, high velocity flows in large flow events. Potential lateral bank erosion is severe. Channel morphologies generally consist of a single-thread high flow channel or multi-threaded low flow channels with gravel bars adjacent to low flow channels. Flood flows may significantly change channel morphology and flow paths. Local relief varies from fairly smooth channel bottoms to undulating bar-and-swale topography that is characteristic of coarser deposits. Terraces have planar surfaces, but small channels are common. Qy_2 have no to weak soil development.

Qy_1 — **Holocene alluvium (<~10 ka)** — Older Holocene terrace deposits found at scattered locations along incised drainages throughout the study area. Qy_1 surfaces are higher and less subject to inundation than adjacent Qy_2 surfaces. Qy_1 terraces are generally planar but local surface relief may be up to 1 m where gravel bars are present. Qy_1 surfaces are <2 m above adjacent active channels. Surfaces typically are sandy but locally have unvarnished open fine gravel lags or pebble and cobble deposits. Qy_1 soils typically are weakly developed, with some soil structure but little clay and no to stage I calcium carbonate accumulation (see Machette, 1985, for description of stages of calcium carbonate accumulation in soils). Yellow brown (10 YR) soil color is similar to original fluvial deposits.

Qyf — **Fine-grained Holocene alluvium (<~10 ka)** — Thin, fine-grain Holocene alluvial deposits formed in swales on ridges of mid- to early Pleistocene fan deposits. Qyf deposits are very thin, typically less than 0.5 m thick, but locally may be up to 1 m thick. Sediment is mainly silt and sand, with occasional deposits of open, unvarnished, fine gravel lag. Soil development is minimal. Where it has developed soil is typically a reddened (7.5 YR) sandy loam with substantial disseminated carbonate but no visible carbonate accumulation.

Qy — **Holocene alluvial deposits, undifferentiated (<~10 ka)**

Qe — **Eolian deposits (<~10 ka)** — Thin, fine-grain Holocene eolian deposits formed in low ridges at the base of Flatiron Mountain. Sediment is mainly silt and fine sand. Soil development is minimal.

Qi_3 — **Late Pleistocene alluvium (~10 to 130 ka)** — Unit Qi_3 is composed of slightly to moderately dissected relict alluvial fans and terraces. Active channels are incised up to about 2 m below Qi_3 surfaces. Qi_3 fans and terraces are lower in elevation than adjacent older surfaces. Qi_3 deposits consist of pebbles, cobbles, and finer-grained sediment. Qi_3 surfaces commonly have bar and swale topography moderately preserved, loose to moderately packed pebble and cobble lags, and are moderately reddened. Surface clasts typically exhibit weak to moderate rock varnish but some surfaces in the northern and eastern areas of the quadrangle are mainly composed of volcanics and are darkly varnished. Qi_3 soils are moderately developed, with orange to reddish brown (7.5 YR) clay loam to light clay argillic horizons and stage II calcium carbonate accumulation.

Qi_2 — **Middle Pleistocene alluvium (~130 to 750 ka)** — Unit Qi_2 is composed of moderately to highly dissected relict alluvial fans with strong soil development found throughout the map area. Qi_2 surfaces are drained by broad swales and well-developed, moderately to deeply incised tributary channel networks; channels are typically several meters below adjacent Qi_2 surfaces. Well preserved, planar Qi_2 surfaces are smooth with scattered pebble and cobble lags; surface color is reddish brown; surface clasts are moderately to strongly varnished. More eroded, rounded Qi_2 surfaces are characterized by strongly varnished, scattered, cobble to cobble and pebble lags with broad ridge-like topography. Soils typically contain reddened (5 to 7.5 YR), modestly clay-rich argillic horizons, with clay skins and subangular blocky structure. Underlying soil carbonate development is typically stage III with areas to stage IV, and abundant carbonate through at least 1 m of the soil profile.

Qi_2g — **Locally derived late Pleistocene alluvium (~10 to 130 ka)** — Unit Qi_2g is composed of moderately dissected relict alluvial fans locally derived from bedrock units TXgr, Td, and Xgd. Active channels are incised up to about 2 to 3 m below Qi_2g surfaces, exposing underlying bedrock. Qi_2g deposits consist of angular to subangular pebbles, cobbles, boulders, and finer-grained sediment with loose to moderately packed pebble and cobble lags. Surface clasts of these lithologies exhibit no to strong rock varnish. Qi_2g soils are moderately developed, with orange to reddish brown (7.5 YR) clay loam to clay argillic horizons with strong stage III to IV carbonate accumulations.

Qi_1 — **Middle to Early Pleistocene alluvium (~500 ka to 1 Ma)** — Unit Qi_1 is composed of deeply dissected relict alluvial fans. Qi_1 surfaces form rounded ridges that are higher than adjacent Qi_2 surfaces. Drainage networks include broad swales on the ridge tops and tributary channels incised 3 to 4 m. Underlying eroded QTs deposits are occasionally exposed along some ridge slopes and wash banks. Well-preserved Qi_1 surfaces have moderately to tightly packed cobble, boulder, and pebble lag. Surface clasts are strongly to very strongly varnished and often have carbonate rinds up to 2 mm. More eroded, rounded Qi_1 surfaces are characterized by very strongly varnished, scattered, cobble and boulder lags with exposed laminar carbonate horizons. Where well preserved, Qi_1 soils are strongly developed with a dark red (5-2.5 YR), heavy clay argillic horizon and subangular blocky to prismatic structure. Carbonate accumulations are 1-2 m thick and range from stage IV-V. This unit approximately correlates to Field's and Pearthree's (1991) unit M1a.

Qi — **Pleistocene alluvium, undivided (~10 ka to 1 Ma)**

QTs — **Early Pleistocene to Pliocene alluvium (~1 to 5 Ma)** — Unit QTs is composed of dissected and highly eroded alluvial fan deposits. Locally these deposits are overlain by younger Quaternary units and are mainly exposed on eroded ridge slopes, in wash banks, and in channels as strath terraces. QTs deposits include carbonate cemented, tan, pebble to cobble conglomerates, poorly sorted, subangular to subrounded, pebbles and cobbles in layers or lenses, and moderately to well sorted, subangular to subrounded, moderately indurated, cross-bedded, red, pebbly sandy beds. In the southeast corner of the quadrangle unit QTs is preserved in high, rounded ridges with tributary drainages incised 3 to 4 m. These ridges have moderately packed, moderately to strongly varnished, pebble and cobble surface lag and stage IV carbonate accumulations. In aerial photographs the dark brown, coarse surface lag on ridge crests appears distinctly different from underlying, lighter, carbonate cemented sediments. The thickness of QTs deposits is not known.

Hassayampa River Alluvium

Qi_1r — **Middle Pleistocene river deposits (~130 to 750 ka)** — Deposits associated with a set of high terraces along the Hassayampa River. Terrace surfaces are of limited extent in this quadrangle. Terraces are fairly flat or slope gently toward the river, but terrace surfaces are dissected by tributary drainages. Deposits typically are quite gravelly at the surface but limited exposures indicate that they also contain sand and silt. Qi_1r terrace surfaces range from about 10 to 20 m above the active river channel.

Qor — **Early Pleistocene river deposits (~500 ka to 1 Ma)**

QTsr — **Pliocene to early Pleistocene river deposits (~1 to 5 Ma)**

Other Units

Bedrock Units

Geologic Map of the Flatiron Mountain 7.5' Quadrangle, Maricopa County, Arizona

by Jon E. Spencer, Ann Youberg, and Charles A. Ferguson

Arizona Geological Survey Digital Geologic Map 46 (DGM-46), version 1.0
March 2006

Citation for this map: Spencer, J.E., Youberg, A., Ferguson, C.A., 2006, Geological map of the Flatiron Mountain 7.5' Quadrangle, Maricopa County, Arizona: Tucson, Arizona Geological Survey Digital Geologic Map 46(DGM-46), version 1.0, 1 CD-ROM with 1 Adobe Acrobat file (1 sheet, layout scale 1:24,000).

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Acknowledgments

The Flood Control District of Maricopa County provided high -resolution digital orthophotos that were used to accurately locate surficial geologic unit boundaries. Stevan Gyetvai was the cartographer for version 1.0 of DGM-46.

Introduction

The Flatiron Mountain 7.5' Quadrangle is located approximately 70 km (40 miles) west of downtown Phoenix, and is just north of Interstate Highway 10. The map area includes the southeastern part of the Belmont Mountains and many isolated bedr ock hills south and southeast of the Belmont Mountains. Most of the quadrangle, however, is underlain by Quaternary surficial deposits. Jackrabbit and Coyote washes, heading in the proximal piedmonts of the Big Horn Mountain northwest of the study area, are the major drainages. Jackrabbit Wash is incised up to four meters into older Pleistocene deposits. Coyote Wash flows around the Belmont Mountains and diverges into multiple channels to the south. The channels and floodplains of Coyote Wash are less incised than Jackrabbit Wash. Smaller tributary washes on adjacent older Pleistocene deposits generally are not incised more than two meters. Older Hassayampa River deposits are found along the eastern side of the quadrangle.

The Quadrangle was mapped during the 2004-2005 field season. Jon Spencer and Charles Ferguson were responsible for mapping bedrock, and Ann Youberg was responsible for mapping Quaternary surficial deposits. Map compilation was done using ESRI ArcMap software, and the resultant GIS geodatabase will eventually be available to the public. Mapping was done as part of a multiyear mapping program directed at producing complete geologic map coverage for the Phoenix-Tucson metropolitan corridor. During this 2004-2005 field season and the previous 2003-2004 field season, a total of eight geologic maps, listed below, were produced for the Hassayampa Plain area. All these maps were prepared under the joint State-Federal STATEMAP program, as specified in the National Geologic Mapping Act of 1992. Also listed below are detailed maps of bedrock in adjacent areas.

Surficial Geology

Surficial mapping was conducted using natural-color (scale 1:24,000) stereo-pair aerial photographs from the Bureau of Land Management (BLM) taken in 1979, and false color, high resolution digital orthophotographs (2004) provided by Maricopa County Flood Control District. Preliminary unit designations were field checked throughout the map area and mapping was supplemented by observations and descriptions of soils and stratigraphy. This mapping was done in conjunction with geologic mapping of the Wintersburg quadrangle (Pearthree and Ferguson, 2005) to the south, and is one of eight 1:24,000 scale geologic maps covering much of the Hassayampa Plain area that have been produced in 2004 and 2005. Mapping was compiled in a GIS format and the final linework was generated from the digital data. Surficial deposits of the map area were then correlated with regional deposits to roughly estimate their ages.

Characteristics evident on aerial photographs and on the ground were used to differentiate and map various alluvial surfaces. The color of alluvial surfaces depicted on aerial photographs is primarily controlled by soil color, rock varnish and desert pavement development. Significant soil development begins on an alluvial surface after it becomes isolated from active flooding and depositional processes (Gile et al., 1981; Birkeland, 1999). Over thousands of years, distinct soil horizons develop. Two typical soil horizons in Pleistocene alluvial sediments of Arizona are reddish brown argillic horizons and white calcic horizons. As a result, on color aerial photographs older alluvial surfaces characteristically appear slightly redder or whiter (on more eroded surfaces) than younger surfaces. Older surfaces have a dark brown color where darkly varnished desert pavements are well preserved. Differences in the drainage patterns between surfaces provide clues to surface age and potential flood hazards. Young alluvial surfaces that are subject to flooding commonly display distributary (branching downstream) or braided channel patterns; young surfaces may have very little developed drainage if unconfined shallow flooding predominates. Dendritic tributary drainage patterns are characteristic of older surfaces that are not subject to extensive flooding. Topographic relief between adjacent alluvial surfaces and the depth of entrenchment of channels can be determined using stereo-paired aerial photographs and topographic maps. Young flood-prone surfaces appear nearly flat on aerial photographs and are less than 1 m above channel bottoms. Active channels are typically entrenched 1 to 5 m below older surfaces.

Variations in the distribution of surfaces of different ages and sources and concomitant variations in dissection across the quadrangle provide evidence regarding the recent geologic evolution of this area and the distribution of flood hazards. Generally, areas along the Hassayampa River are moderately dissected, whereas dissection on the piedmont to the west is modest. High terrace remnants of the Hassayampa River (unit Qor) record the river bed in the early to middle Quaternary. Qor terraces cap a substantial aggradational sequence that was deposited during late Tertiary to early Quaternary (unit QTsr). Deposits of the Hassayampa River have been exploited as aggregate resources at several locations. Adjacent piedmont areas were likely aggrading at this time as well (unit QTs). At that time the river was probably was depositing sediment across a fairly broad floodplain in the eastern part of the quadrangle, and alluvial fans on both sides of the river were interfingering with the river floodplain. Since then the Hassayampa River has downcut 10 to 15 m, with dissection increasing slightly to the north. The effects of this downcutting are expressed by incision of tributary drainages immediately west of the Hassayampa River. Along these tributary drainages, late Quaternary deposits are quite limited in extent and flood hazards are restricted to relatively narrow valley bottoms.

In the western half of the quadrangle, piedmont washes drain to the south before eventually joining the Gila River. Much of this piedmont is mantled by fairly old Pleistocene tributary deposits (units Qi_2 and Qi_1) that have been eroded into broadly rounded ridges. Incision along these tributary drainages is less than a few meters, but there is enough topographic confinement that late Pleistocene and Holocene deposits are inset below the ridges and there are no major distributary channel networks or active alluvial fans on the piedmont. Thus, flood hazards are restricted to broad, nearly flat valley bottoms in this area (units Qy_c, Qy_2, and locally Qy_1). Agricultural activity and recent residential development have modified the landscape to greater or lesser degrees. Areas are mapped as "disturbed" where the surficial deposits are profoundly altered (stock tanks, agricultural fields).

Bedrock Geology

The Belmont Mountains, which form a southeastern extension of the Big Horn Mountains, consist largely of a Middle Tertiary granite that contains sparse fluorite (Reynolds et al., 1985) as well as numerous northwest trending, compositionally diverse dikes. This granite was intruded during a several million year period of volcanic activity and extensional faulting that produced most of the rocks and structures in the Belmont and Big Horn Mountains(Capps et al, 1985; Stimac et al, 1994). Most of this activity occurred between about 16 and 21 Ma (Spencer et al., 1995).

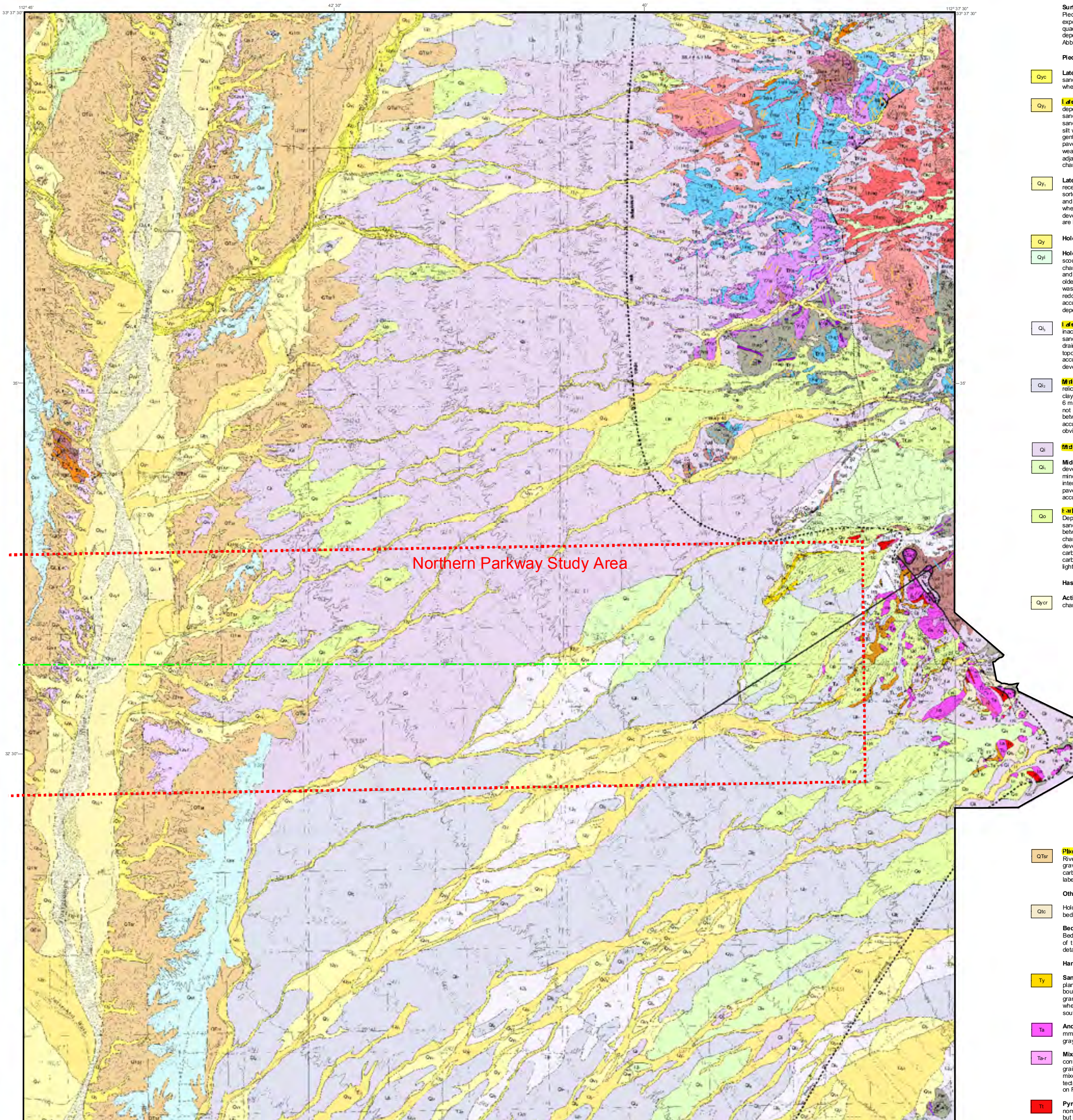
The southeastern tip of the Belmont Mountains is within the map area. In this area the middle Tertiary Belmont Granite grades southeastward into a zone of felsic dikes and irr egular hypabyssal intrusions emplaced within a crystalline complex of Proterozoic metamorphic rocks and granit ic rocks of uncertain age.

References

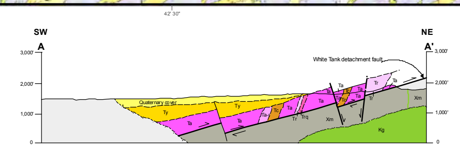
STATEMAP Geologic Maps, Hassayampa Plain Area, 2004-2005

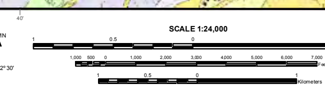
Tertiary to early Proterozoic intrusive and metamorphic rock units

Dikes shown on map with single colored line



Topographic base from USGS Wagner Wash Well 7.5' quadrangle, compiled from aerial photographs taken 1951 and 1960; field checked in 1962. Transverse Mercator projection, NAD 27 datum, UTM zone 12 meters. Reprojected to NAD 83, stateplane feet. Magnetic declination 12.5° east of true north. Contour interval 20 feet.





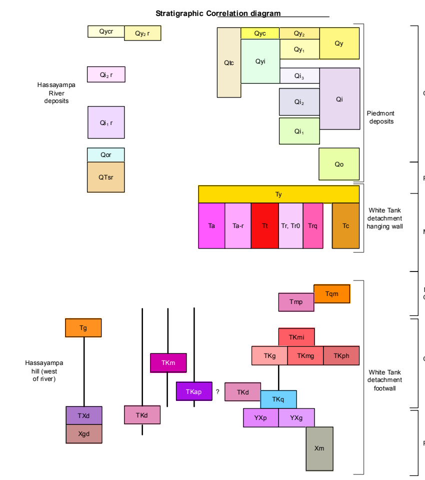
Map Legend

- Bedding, accurate
- Generic foliation
- Schistosity
- Inclined flow foliation
- Gneissic layering
- Vertical gneissic foliation
- Slickenside striae lineation
- Lineation in cumulate rocks
- Fault attitude
- Contact, accurate
- Contact, approximate
- Fault, accurate
- Fault, approximate
- Fault, concealed
- White Tank detachment fault, accurate (barbs on hanging wall)
- White Tank detachment fault, concealed (barbs on hanging wall)

Dikes

- Quartz monzonite porphyry dike (unit Tqm)
- Monzonite porphyry dike (unit Tmp)
- Basaltic dike (unit Tb)
- Mafic dike (unit TKm)
- Andesite porphyry dike (unit TKap)
- Fine-grained diorite stocks and dikes (unit TXd)
- Dacite porphyry dike (unit TKd)
- Rhyolite porphyry dike (unit TKq)

Stratigraphic Correlation diagram



Unit Descriptions

Surficial map units

Piedmont surficial deposits cover most of the Wagner Wash Well 7.5' quadrangle, with fairly extensive exposures of Quaternary to late Tertiary Hassayampa River deposits in the western part of the quadrangle. The lower margins of the piedmonts are defined by their intersection with relict river deposits. Approximate age estimates for the various units are given in parentheses after the unit name. Abbreviations are ka, thousands of years before present, and Ma, millions of years before present.

Piedmont Alluvium

Qyc — **Late Holocene active channel deposits of larger washes** – Poorly sorted to very poorly sorted sand, pebbles, and cobbles in channels of larger washes. Also includes minor bars and low terraces, where deposits are generally sand and silt with minor gravel.

Qy_2 — **Late Holocene deposits in active stream channels, low terraces, and alluvial fans** – Very young deposits associated with active or recently active fluvial systems. Channel deposits typically consist of sand and pebbles with some cobbles and small boulders in middle and upper piedmont areas, and sand and some pebbles lower on the piedmont. Terrace and fan deposits typically consist of sand and silt with some gravel lenses. Fan and terrace surfaces typically are planar where deposits are fine and gently undulating where deposits are coarser, with gravel bars and finer-grained swales. Desert pavement development is minimal and rock varnish is very light or nonexistent. Soil development is weak. Surface dissection is minimal and is associated with channels that are incised up to 1.5 m below adjacent fans or terraces. Channel patterns are variable, including anastamosing or distributary linked channels and separate small tributary channels feeding into larger channels.

Qy_1 — **Late to early Holocene deposits on alluvial fans and terraces** – Young deposits associated with recently active alluvial fans and terraces. In middle and upper piedmont areas, deposits are poorly sorted, consisting sand, silt, pebbles, and cobbles; in lower piedmont areas, deposits are typically sand and silt with minor gravel. Surface relief varies with particle size, with relict bar and swale topography where deposits are gravelly and relatively smooth surfaces where sand and silt predominate. Soil development is weak, with some soil structure and minor carbonate accumulation. Surfaces typically are brown to gray, with common gravel litter but minimal desert pavement or rock varnish.

Qy — **Holocene alluvial deposits, undifferentiated**

Qyi — **Holocene and late Pleistocene alluvial deposits** – Broadly rounded alluvial fans, and terraces and scoured benches along smaller tributary washes. Qyi surfaces are less than 1 m above active channels. They are primarily covered by a thin (< 1 m) veneer of Holocene fine-grained alluvium (Qy_2 and Qy_1) over reddened Pleistocene alluvium (Qi_2, Qi_1 or Qio) or eroded basin-fill deposits (QTs). The older units are exposed in scoured, eroded benches adjacent to active channels and in cut banks of washes. Holocene soils vary in development with color ranging from yellow brown (10YR) to slightly reddened (7.5YR) with no to weak subangular blocky structure and no to minor carbonate accumulation, although soils strongly effervesce due to source material. Coarse clasts within these deposits are typically reworked from older deposits and often exhibit carbonate coats or rinds.

Qi_3 — **Late Pleistocene alluvial fan and terrace deposits** – Younger intermediate deposits associated with inactive alluvial fans and terraces along washes. Deposits typically are poorly sorted mixtures of silt, sand, pebbles and cobbles with few small boulders. Surfaces are moderately dissected by tributary drainages that head on the surfaces and through-going distributary channels. Local surface topographic varies from about 1 to 2 m. Soil development is moderate, with minimal to some clay accumulation and soil reddening and weak to moderate calcic horizon development. Desert pavement development typically is moderate, and rock varnish varies from light to dark brown.

Qi_2 — **Middle Pleistocene alluvial fan deposits** – Older intermediate deposits associated with extensive relict alluvial fans. Deposits are poorly sorted, including sand, pebbles and cobbles, with minor silt and clay. Surfaces are moderately to deeply dissected, with local topographic relief varying from about 1 to 6 m. Original depositional topography typically is not preserved, and surfaces are quite smooth where not eroded. Qi_1 surfaces are drained by extensive tributary drainage networks. Interfluve areas between drainage vary from quite flat to broadly rounded. Soils have weak to moderate clay accumulation and slight reddening in the upper 30 cm beneath the surface, and calcic horizons show obvious visible carbonate accumulation.

Qi — **Middle and late Pleistocene alluvial fan and terrace deposits, undifferentiated**

Qi_1 — **Middle to early Pleistocene alluvial fan deposits** – Old relict alluvial fans with moderately strong soil development. Deposits are poorly sorted, including sand, pebbles, cobbles, and small boulders with minor silt and clay. Surfaces typically are moderately dissected with up to 6 m of local relief, but interfluve surfaces are quite smooth and have dark, strongly developed pebble-cobble desert pavements. Soils have moderate clay accumulation and obvious reddening and abundant carbonate accumulation resulting in weak cementation.

Qo — **Early Pleistocene to late Pliocene alluvial fan deposits** – High, very old relict alluvial fan deposits. Deposits typically are very poorly sorted, including angular to subangular cobbles and pebbles with sand and minor silt and clay. Surfaces are moderately to deeply dissected, with 2 to 10 m of relief between channels and ridgecrests. Original fan surfaces have been removed by erosion, so the characteristic topographic expression of these deposits are alternating ridges and valleys. Soil development is moderate to strong, depending on local preservation, but all soils are dominated by carbonate accumulation and clay-rich horizons were not observed. Surfaces typically are littered by carbonate fragments derived from eroded or perturbed petrocalcic horizons; this gives Qo surfaces a light appearance on aerial photographs.

Hassayampa River Alluvium

Qycr — **Active river channel deposits** – Moderately to poorly sorted sand, gravel and minor silt in active channels of the Hassayampa River. Gravel includes subangular to well-rounded clasts.

Qy_2r — **Late Holocene to modern floodplain deposits** – Sand, silt, and gravel deposits associated with slightly higher terraces along the Hassayampa River. Terrace surfaces are smooth and are less than 3 m above the active channel. Terrace surfaces are covered with fine-grained floodplain deposits, but relict gravel bars and lenses are common.

Qi_2r — **Middle to late Pleistocene river deposits** – Older terrace deposits of very limited extent found in a few places along the Hassayampa River. Deposits are gravelly with some sand, silt and clay. Soil development is moderate with some clay accumulation where terrace surfaces are well preserved. Terrace surfaces typically are less than 10 m above the active river channel.

Qi_1r — **Middle Pleistocene river deposits** – Deposits associated with a set of high terraces along the Hassayampa River. Terrace surfaces are of limited extent in this quadrangle. Terraces are fairly flat or slope gently toward the river, but terrace surfaces are dissected by tributary drainages. Deposits are quite gravelly at the surface but limited exposures indicate that they also contain sand and silt. Qi_1r terrace surfaces range from about 10 to 20 m above the active river channel.

Qor — **Early Pleistocene river deposits** – Deposits associated with the high terraces along the Hassayampa River that record the maximum aggradation of the river. Terrace surfaces are fairly flat or broadly rounded, but all terrace surfaces are moderately to deeply dissected by tributary drainages and the river and have been substantially modified by erosion. Exposures are poor, but well-rounded gravel is evident at the surface. Terrace surfaces are also covered with litter from underlying petrocalcic soil horizons. Qor terrace surfaces are more extensive than any of the younger Pleistocene terraces (Qi_2r). Terrace surfaces range from about 20 to 30 m above the active river channel, and rise to the north across the quadrangle.

QTsr — **Pliocene to early Pleistocene river deposits** – A moderately thick sequence of old Hassayampa River deposits that underlies the Qor terrace/fan deposits. These deposits consist of river sand, gravel and silt with a substantial component of tributary sand and gravel. Local zones of substantial carbonate accumulation may represent moderately to strongly developed buried soils. Queried unit labels (QTsr?) indicate areas where exposures are poor.

Other units

Qtc — Holocene and Pleistocene colluvium and talus – Very poorly sorted hillslope deposits mantling bedrock slopes.

Bedrock map units

Bedrock units are divided into three groups: 1) volcanic and sedimentary rocks in the hanging wall of the detachment fault, 2), plutonic and metamorphic rocks in the footwall of the White Tank detachment fault, and 3) plutonic rocks of the Belmont Mountains west of the Hassayampa River.

Hanging wall rock units, White Tank Mountains

Ty — **Sandstone and conglomerate (middle to late Tertiary)** – Thin- to medium-bedded, dominantly plane-bedded, gently dipping, pebbly sandstone, and rounded to sub-rounded, cobble-pebble, rare boulder, sandy conglomerate. In most areas, the unit is light-colored and clasts consist of >70% granodiorite, schist, and orthogneiss, and < 30% mafic volcanic rocks. Locally, mostly to the east, where volcanic clasts make up greater than 50%, the unit is reddish. Imbricated cobbles indicate southwest-directed paleocurrents.

Ta — **Andesite (middle Tertiary)** – Andesitic lava flows containing 1-25%, subhedral to euhedral, 0.5-4 mm plagioclase phenocrysts and minor <2 mm altered mafic phenocrysts. Matrix is typically dark gray to dark purple. Samples: CAF-2-7339, 7402, 7436, 7481, 7488.

Ta-r — **Mixed andesite and rhyolite (middle Tertiary)** – Rare flows of phenocryst-poor andesitic lava contain 5-50% irregular inclusions ranging in size from less than 1 m to greater than 50 m of fine-grained, phenocryst-poor rhyolite lava. The unit appears to be a distinctive flow characterized by mixed lava, but poor exposure makes it possible in some areas that the mixed nature of the unit is tectonic. The unit may correlate with a distinctive bimodal andesite-rhyolite mixed lava unit (Tax) on Flatiron Mountain in the southeastern Belmont Mountains.

Tt — **Pyroclastic rocks (middle Tertiary)** – Massive to thick-bedded, mostly matrix-supported, nonwelded felsic tuff with abundant lithic lapilli. Lithic clasts are dominantly andesite and rhyolite, but locally, granitic and metamorphic clasts are also abundant. Samples: CAF-27271, 7569.

Tr — **Phenocryst-poor rhyolite lava (middle Tertiary)** – Rhyolite lava containing 1-10% 1-3 mm feldspar phenocrysts. The lava is typically pink to lavender in color and preserves massive, flow-foliated and autobrecciated textures. Samples: CAF-2-7413, 7575

Trq — **Phenocryst-poor, quartz-phyric rhyolite lava (middle Tertiary)** – Rhyolite lava containing 1-10% 1-3 mm feldspar and quartz phenocrysts. The flows are typically pink to lavender in color and preserve massive flow-foliated and autobreccia textures. Samples: CAF-2-7476, 7564, 7565,

Tr0 — **Aphyric rhyolite lava (middle Tertiary)** – Rhyolite lava flows that are typically pink to lavendar in color and preserve massive flow-foliated and autobreccia textures.

Tc — **Conglomerate and breccia (middle Tertiary)** – A massive, rarely thick-bedded, dark reddish colored, clast-supported, sandy matrix, coarse-grained conglomerate and breccia unit dominated by granitic and metamorphic clasts, but also containing 0-30% andesite and rhyolite clasts. The clasts are typically cobble to boulder sized and sub-rounded to angular. The dominant clast types are (1) coarse-grained, potassium-feldspar porphyritic granite (similar to the YXg map unit of this map area), and (2) fine- to medium-grained biotite schist and amphibolite schist (similar to the Xp and Xa map units of the southerly adjacent Buckeye NW 7.5' quadrangle). The conglomerate and breccia unit is intimately interbedded (generally steeply-dipping) with the andesitic (Ta, Ta-r), and rhyolitic (Tr, Trq, Tr0) lava flows in the area. Sample CAF-2-7350.

Footwall rock units, White Tank Mountains

Age assignments for plutonic rocks in the northwestern White Tank Mountains are based primarily on their age relative to an early Tertiary to Late Cretaceous (56.2 ± 14 Ma) complex of medium-grained granite (TKg) and comagmatic heterogeneous mafic plutonic rocks (TKmg, TKmi, TKph). Hypabyssal rocks that are intruded by this complex are also assigned an early Tertiary to Late Cretaceous age (TKq, TKd), whereas those that intrude the complex are assigned a Tertiary age (Tqm, Tmp, Tb). Hypabyssal rocks with no known age relationship to the complex are assigned a Tertiary-Cretaceous age (TKap, TKm), and a mafic dike unit with a fine- to medium-grained phaneritic texture (TXd) is assigned a Tertiary-Early Proterozoic age. An undeformed coarse-grained granite (YXg), and associated pegmatite complex (YXp) is assigned a Middle to Early Proterozoic age, and tectonically foliated plutonic and metamorphic rocks are assigned to the Early Proteroic (Xgd, Xm).

Tqm — **Quartz monzonite porphyry (Tertiary)** – Fine-grained, typically dark greenish matrix porphyry containing 5-20% 0.5-30 mm subhedral to euhedral plagioclase, 1-10% 2-50 mm subhedral to euhedral potassium feldspar, and 1-10% 1-5 mm anhedral to subhedral, deeply embayed quartz phenocrysts, 1-5% 1-3 mm chloritic-altered biotite. The porphyry also contains sparse 0.2-1 mm clinopyroxene, and sparse opaque minerals. In some areas, the quartz monzonite porphyry has a light gray matrix and is very similar to the rhyolite porphyry (TKq). The quartz monzonite porphyry is distinguished from the rhyolite porphyry (TKq) and other quartz-phyric porphyry units based primarily on cross-cutting relationships. Along with the monzonite porphyry (Tmp), the quartz monzonite porphyry is one of the youngest intrusive units in the area. It consistently intrudes two important units; the medium-grained granite (TKg) and a swarm of basaltic dikes (Tb) that consistently intrude the rhyolite porphyry (TKq). The quartz monzonite porphyry correlates with Barrett's (1976) quartz monzonite porphyry. Samples: CAF-2-8222, 8228.

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GEOLOGIC MAP OF THE WAGNER WASH WELL 7.5' QUADRANGLE, MARICOPA COUNTY, ARIZONA

by Charles A. Ferguson, Jon E. Spencer, Philip A. Pearthree, Ann Youberg and John J. Field

Arizona Geological Survey Digital Geologic Map 38 (DGM-38), version 1.0

November, 2004

Citation for this map: Ferguson, C.A., Spencer, J.E., Pearthree, P.A., Youberg, Ann, and Field, John J., 2004, Geologic Map of the Wagner Wash Well 7.5' Quadrangle, Maricopa County, Arizona: Arizona Geological Survey Digital Geologic Map 38 (DGM-38), 7 p., 1 sheet, scale 1:24,000.

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Unit Descriptions continued…

Tmp — **Monzonite porphyry (Tertiary)** – Porphyritic dikes characterized by the absence of quartz phenocrysts visible in hand specimen. Phenocryst content varies from 10-50%. Subhedral to euhedral plagioclase (0.5-5 mm) is by far the most abundant phase. Potassium feldspar is virtually absent, but sparse, microscopic (<0.2 mm) subhedral to anhedral quartz is ubiquitous. Mafic phenocrysts are strongly chloritic-altered biotite (1-2% 0.4-1.5 mm), and 0.5-3% 0.5-1.5 mm glomeroporphyritic clinopyroxene. Traces of sphene (<0.3 mm) and opaques are associated with the biotite and clinopyroxene. Glomeroporphyritic clumps of clinopyroxene are commonly rimmed by euhedral plagioclase phenocrysts. The monzonite porphyry is generally coarser grained and has a more crystalline matrix than the andesite porphyry (TKap), but the two units which occur in different areas, the monzonite porphyry to the north and the andesite porphyry (TKap) to the south, may be correlative. The monzonite porphyry correlates with Barrett's (1976) monzonite porphyry and quartz latite porphyry units. Samples: CAF-2-8201, 8224, JES-12-9-03-2, 12-10-03-6.

Tb — **Basaltic dikes (Tertiary)** – Fine-grained, generally dark gray to purple, aphanitic-matrix basaltic dikes with sparse plagioclase (1-4 mm) and altered mafic (≤2 mm) phenocrysts. The basaltic dikes are similar to the generic mafic dikes (TKm) which tend to have fine-grained phaneritic matrix. The basaltic dikes represent a wide-ranging swarm of dikes that consistently intrude the medium-grained granite (TKg) and are mostly intruded by the quartz monzonite (Tqm) and monzonite porphyry (Tmp). In the north basaltic dikes are commonly intruded by parallel dikes of the quartz monzonite (Tqm) and monzonite porphyry (Tmp), and in some areas, overlapping relationships are present. The basaltic dikes correlate with Barrett's (1976) dacite porphyry dikes. Samples: JES-11-19-03-5, 12-10-03-2, 12-10-03-5.

TKm — **Mafic dikes (Tertiary – Cretaceous)** – Dark-colored, fine-grained to very fine-grained dioritic dikes with sparse 1-4 mm plagioclase and mafic phenocrysts. Samples: CAF-2-6959, 7077, JES-12-12-03-2, 12-12-03-3.

TKap — **Andesite porphyry (Tertiary – Cretaceous)** – Dark gray to purple matrix, andesite porphyry dikes with 10% 2-4 mm, euhedral plagioclase phenocrysts. The andesite porphyry appears to be restricted to the hanging wall of the Wagner fault. Samples: CAF-2-7124, 7137, 7323, 7324.

TXd — **Fine-grained diorite stocks and dikes (Tertiary – Early Proterozoic)** – Fine- to medium-grained, dark-green amphibolite to diorite, locally with felted mafic phenocrysts up to 10 mm. Samples: CAF-2-7978, 8135.

TKmg — **Heterogeneous mafic granitoid (early Tertiary – Late Cretaceous)** – A complex suite of granitoids ranging in composition from granodiorite to monzodiorite, quartz monzodiorite and diorite, and from very fine- to medium-grained (mixed together on scale of 10-100 cm), with highly variable mafic content (6-50% clinopyroxene, and hornblende, locally with some biotite), and up to 1% sphene. The granitioids form irregular stocks and dikes that both intrude and are intruded by the closely related TKg map unit. Some biotite granite in contact with dioritic granitoids is pegmatitic, with coarse interiors and vein-like form; in other places dioritic granitoids have chilled margins. The heterogeneous mafic granitoid unit correlates with Barrett's (1976) quartz diorite to the east of the Wagner fault, and possibly in part with the (TKgd) unit of Reynolds et al. (2002). Samples: CAF-2-6959, 7077, JES-11-17-03-2, 11-18-03-8, 12-11-03-3, 12-11-03-6.

TKmi — **Granitoids associated with heterogeneous mafic granitoids (early Tertiary – Late Cretaceous)** – Felsic to intermediate, sparsely quartz-phyric granitoids associated with mafic granitoids and probably comagmatic with them. This unit generally contains 3-8% mafic minerals (mostly pale green, alteration product or primary?, some vaguely micaceous) and 1-2% < 1mm sphene. Samples JES-11-18-03-1, 11-18-03-4, -11-18-03-7, 12-11-03-2, 12-11-03-5, 12-12-03-1.

TKph — **Pyroxene- and hornblende-rich mafic granitoids (early Tertiary – Late Cretaceous)** – An irregular shaped stock of very dark mafic granitoids. Sample JES-11-18-03-5 contains 25-35%, brownish green, 2-20 mm subhedral to euhedral hornblende phenocrysts within a fine- to medium-grained quartz monzonite matrix that contains 10-20% 0.5-1.0 mm, subhedral to euhedral clinopyroxene, and 5% 0.5-3.5 mm, subhedral to euhedral hornblende. Sample JES-11-18-03-6 is a hornblendite containing ~35% 1-4 mm, subhedral to euhedral hornblende in a quartz monzodiorite matrix with up to 2% sphene. The rocks display faint layering defined by variations in the abundance and grain size of pyroxene and hornblende.

TKg — **Medium-grained granite (early Tertiary – Late Cretaceous)** – Medium-grained to locally coarse-grained, equigranular to potassium-feldspar porphyritic granite with 3-15%, ≤ 3 mm subhedral to euhedral biotite, up to 1% hornblende, and sparse opaques associated with the biotite and hornblende. The granite typically weathers into tors and rounded grus-covered hills, and is present on both sides of the Wagner fault. To the west, the granite is leucocratic (< 7% biotite), homogeneous, and porphyritic with up to 20% very fine-grained crystalline matrix. On the east side of Wagner fault, the granite ranges from medium-grained, equigranular granite, monzogranite, and granodiorite to sparsely and abundantly potassium-feldspar-porphyritic granite with potassium-feldspar phenocrysts up to 30 mm, and biotite content that ranges from 5-15%. The middle portion of the eastern pluton includes several irregular stocks of heterogeneous mafic granitoids (TKmg) that show abundant evidence of comagmatic emplacement with the granite. Contacts between the two units range from sharp to gradational with conflicting cross-cutting relationships. The mafic granitoids (TKmg) range from granodiorite and monzodiorite to diorite and pyroxenite (TKph), and in areas where contact relationships with the medium-grained granitoids are vague, a change from biotite-dominated to hornblende-dominated mafics is used as the criteria for unit assignment. To the west of the Wagner fault, where a K-Ar hornblende date of 88.2 ± 3.1 Ma (Armstrong, 1975 as reported in Reynolds et al., 1986) was obtained from this unit, the medium-grained granite correlates with Barrett's (1976) granite porphyry. To the east of the Wagner fault, where a K-Ar biotite cooling age of 19.6 ± 0.5 Ma (Shafiqullah et al., 1980) was obtained, this granite correlates with the granodiorite (TKgd) unit of Reynolds et al. (2002). Another sample of this unit, from the White Tank Mountains NE 7.5' quadrangle, yielded a U-Pb zircon date of 56.2 ± 14 Ma (Spencer et al., 2003). Our Late Cretaceous to early Tertiary age assignment for this unit is based on the interpretation that both the U-Pb and hornblende K-Ar dates reflect a Late Cretaceous to early Tertiary crystallization age, and the biotite K-Ar age is related to cooling during later extensional exhumation. Samples: CAF-2-6948, 7941, 8208, JES-11-18-03-2, 11-19-03-2, 12-10-03-11, 12-11-03-1, 12-11-03-4a, b. 11-18-03-2, 11-19-03-2, 12-10-03-11, 12-11-03-1, 12-11-03-4a, b.

TKd — **Dacite porphyry (early Tertiary – Late Cretaceous)** – Aphanitic-matrix feldspar porphyry containing 20-35% 2-15 mm plagioclase and lesser potassium feldspar, plus 1-5% biotite. The dacite porphyry is intimately related to the rhyolite porphyry (TKq) with conflicting intrusive relationships observed in several areas. The dacite porphyry probably represents the mafic end-member of a continuum of felsic porphyries dominated by the rhyolite porphyry (TKq). Samples: CAF-2-7087, 7089.

TKq — **Rhyolite porphyry (early Tertiary – Late Cretaceous)** – A composite unit of quartz-phyric rhyolite porphyry dikes and stocks with highly variable phenocryst content. The main outcrop area of this unit includes up to 30% country rock, which consists mostly of the coarse-grained granite (YXg) unit, but also includes significant areas of the granodiorite (Xgd) unit to the north. The rhyolite porphyry is characterized by light gray, commonly flow-foliated aphanitic matrix and contains between 0.5% and 40% 1-10 mm quartz, potassium feldspar, and plagioclase phenocrysts with sparse biotite, hornblende, and other mafics. More than 60% of the unit is represented by porphyry containing 10-15% 1-4 mm phenocrysts, and most of the rest consists of an aphyric to phenocryst-poor (≤5%) variety. Lesser amounts of coarse-grained (2-10 mm), phenocryst-rich (25-40%) porphyry is also present. In general, grain size and the abundance of accessory mafic minerals increases with phenocryst content. Contacts between the different varieties are sharp, and many of the dikes are occupied by more than one variety. The rhyolite porphyry, and its constituent phenocryst-poor to phenocryst-rich varieties, along with the dacite porphyry (TKd), represent a continuum of essentially contemporaneous felsic to intermediate hypabyssal rocks. The rhyolite porphyry is distinguished from the quartz monzonite porphyry (Tqm) by its lighter colored matrix and because it is older than the medium-grained granite (TKg). The bulk of the rhyolite porphyry correlates with the older rhyolite and aplite porphyries of Barrett (1976) and the intrusive rocks (Ti) unit of Reynolds et al. (2002). Samples: CAF-2-6950, 6954, 7005, 7133, 7246, 7247, 7261, 8203, JES-11-19-03-6, 11-19-03-8, 12-10-03-4, 12-10-03-7, 11-19-03-1, 11-19-03-4, 11-19-03-7, 12-9-03-1, 12-10-03-1, 12-10-03-3, 12-10-03-8, 12-12-03-4, 12-12-03-5, 12-12-03-6.

YXg — **Coarse-grained granite (Middle or Early Proterozoic)** – Coarse-grained, potassium-feldspar porphyritic granite with 7-10% biotite. The coarse-grained granite correlates with Barrett's (1976) granite unit. Sample 11-19-03.

YXp — **Pegmatite and leucogranite complex (Middle and Early Proterozoic)** – Medium- to coarse-grained pegmatite and heterogenous texture, banded, muscovite leucogranite. The pegmatite and leucogranite complex occurs in small stocks that intrude the granodiorite (Xgd) and metamorphic complex (Xm) along the southern margin of the coarse-grained granite (YXg) pluton.

Xm — **Metamorphic complex (Early Proterozoic)** – A metamorphic and plutonic complex consisting of four main rock types intimately mixed on a scale that precludes mapping separately, although each is recognized and locally mapped separately in this map area or in the southerly adjacent Buckeye NW 7.5' quadrangle. The oldest, making up between 0-70% of the unit, is a fine- to medium-grained, mafic-rich, variably quartz veined, banded orthogneiss and amphibolite schist (Xa). The metamorphic rocks are intruded by foliated, medium-grained granodiorite (Xgd), which makes up between 0-70% of the unit, and lesser amounts (0-10%) of weakly foliated, fine- to medium-grained, 10-20% biotite granite or quartz monzonite (Xg) that appears to be younger than the granodiorite (Xgd). The entire complex is intruded by pegmatite dikes (YXp) that make up between 0-5% of the unit. The metamorphic complex is distinguished from the heterogeneous mafic granitoid (TKm) unit by its pervasive tectonic foliation and by its ubiquitous pegmatite dikes and quartz veins. The metamorphic complex correlates with the undifferentiated metamorphic rocks (Xm) and granitic rocks and pegmatite (Xgr) units of Reynolds et al. (2002).

Xgd — **Granodiorite (Early Proterozoic)** – Medium-grained, weakly to strongly foliated granitoid ranging from monzogranite to granodiorite and quartz monzodiorite, and containing 15-40% mafics. Mafic minerals in sample CAF-2-8237 are hornblende (5-8% 1-3 mm) and clinopyroxene (2% <0.5 mm). The granodiorite is closely associated with the metamorphic complex (Xm), and may include up to 30% of its constituents in its outcrop area. The granodiorite correlates with the hornblende diorite, quartz diorite and diorite units of Barrett (1976) to the west of the Wagner fault in the northeast corner of the map area. In the south, the granodiorite correlates with the undifferentiated metamorphic rocks (Xm), granitic rocks and pegmatite (Xgr), and tonalite (Xt) units of Reynolds et al. (2002).

Belmont Mountains (west of the Hassayampa River)

Tb — **Basaltic dikes (Tertiary)** – Fine-grained, generally dark gray to purple, aphanitic-matrix basaltic dikes with sparse plagioclase (1-4 mm) and altered mafic phenocrysts (≤2 mm). These dikes may correlate with the basaltic dikes of the White Tank Mountains.

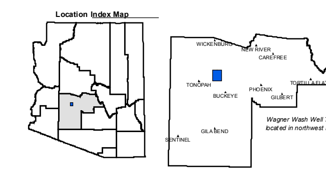
Tg — **Belmont Granite (Tertiary)** – Medium- to coarse-grained, 10% biotite, weakly potassium-feldspar porphyritic granite with ubiquitous 0.5-5.0 cm miarolitic cavities. The granite forms a series of southeast-striking, southwest-dipping dikes that intrude foliated granodiorite (Xgd) in a single hill along the west bank of the Hassayampa River. The margins of the dikes display contact zones up to 20 m wide that grade from flow-foliated, 5-10% 1-4 mm quartz-feldspar porphyry through 20-50% 2-4 mm, quartz-feldspar porphyry into the granitic interior of the dikes. These textural relationships, the host rock, and the orientation of the dikes are identical to what is observed in the southeast contact zone of the Belmont pluton in the southeast Belmont Mountains to the west. Samples from here and in the Belmont Mountains: CAF-2-7955, 7957, 7962, 7974, 7989, 8141.

TXd — **Fine-grained diorite stocks and dikes (Tertiary – Early Proterozoic)** – Fine- to medium-grained dark green amphibolite to diorite, locally with felted mafic phenocrysts up to 10 mm. Samples: CAF-2-7978, 8135.

Xgd — **Granodiorite (Early Proterozoic)** – Medium-grained, weakly to strongly foliated granodiorite to quartz monzodiorite containing between 15-40% mafics.

See accompanying 7-page text for more information.

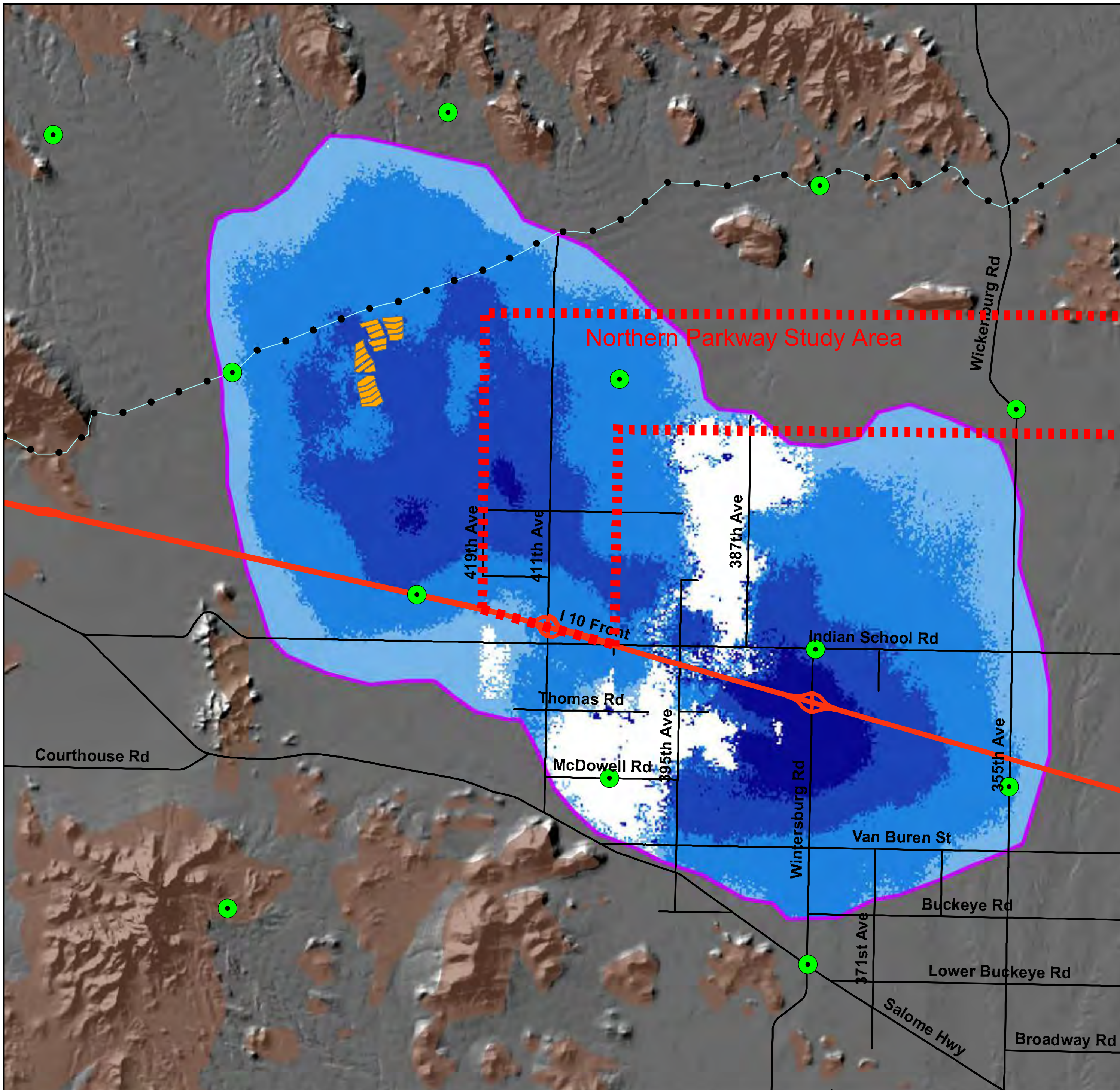
Location Index Map



Wagner Wash Well 7.5' quadrangle is located in northwest Maricopa County.

APPENDIX TM3-03

TONOPAH UPLIFT DOCUMENTATION



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Uplift in the Vicinity of the Tonpah Recharge Facility
Based on ADWR EnviSat Time-Series InSAR Data
Time Period of Analysis: 2.8 Years 03/13/2006 To 03/06/2010

MCDOT GDACS Monuments
CAP Canal
Hardrock
Highways and Interstates
Interstate
US
State
Roads
Railway

Tonopah Recharge Basins
Area of Uplift

03/13/2006 To 03/06/2010
Uplift
Decorrelation/No Data
0 To 1 cm
1 To 2 cm
2 To 3 cm
3 To 4 cm

1:136,676

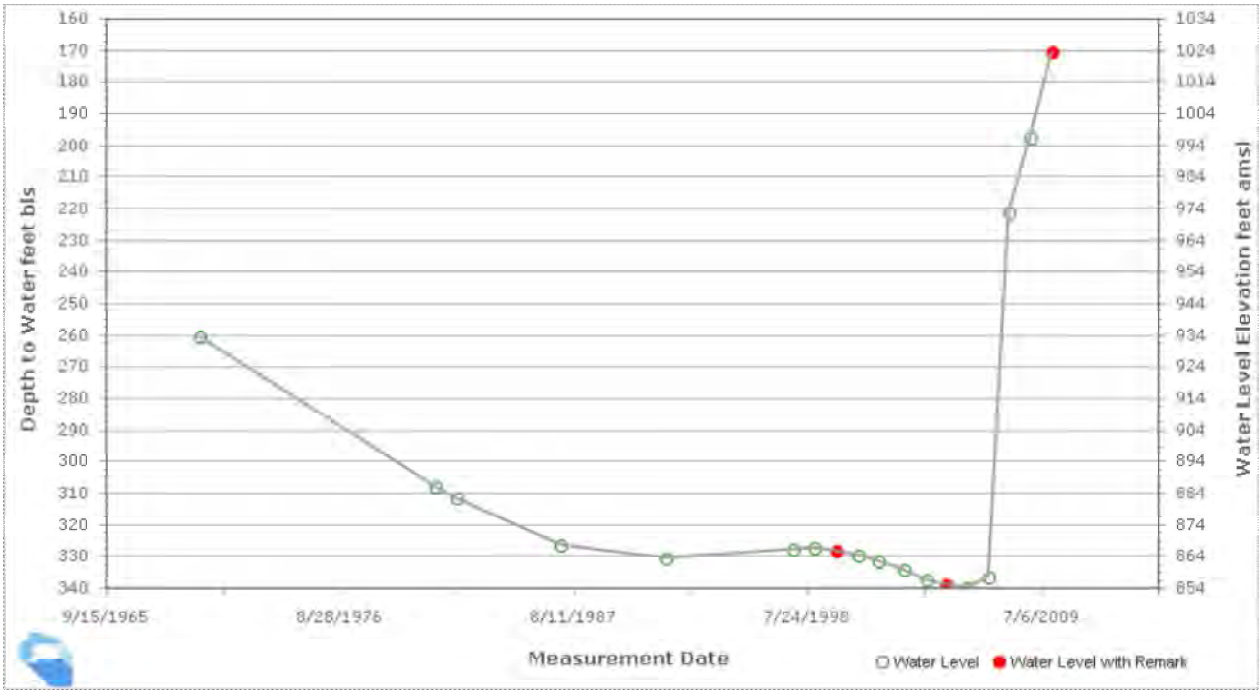
0 0.5 1 2 3 4 Miles

Decorrelation (white areas) are areas where the phase of the received satellite signal changed between satellite passes, causing the data to be unusable. This occurs in areas where the land surface has been disturbed (i.e. bodies of water, snow, agriculture areas, areas of development, etc).

ARIZONA DEPARTMENT OF WATER RESOURCES

Arizona GroundWater Monitoring Site Hydrograph

Local ID	Site ID	Registry ID	Latitude NAD27	Longitude NAD27	Alt. (ft amsl)	Water Use	Well Depth (ft)	Case Dia. (in)	Drill Date	Latest WL Date	DTW (ft)	WL Elv. (ft)
B-02-07 12CBB	333146112560801	802455	33° 31' 45.6"	112° 56' 8.8"	1194	DOMESTIC	600	12	11/30/1962	12/10/2008	197.2	996.8

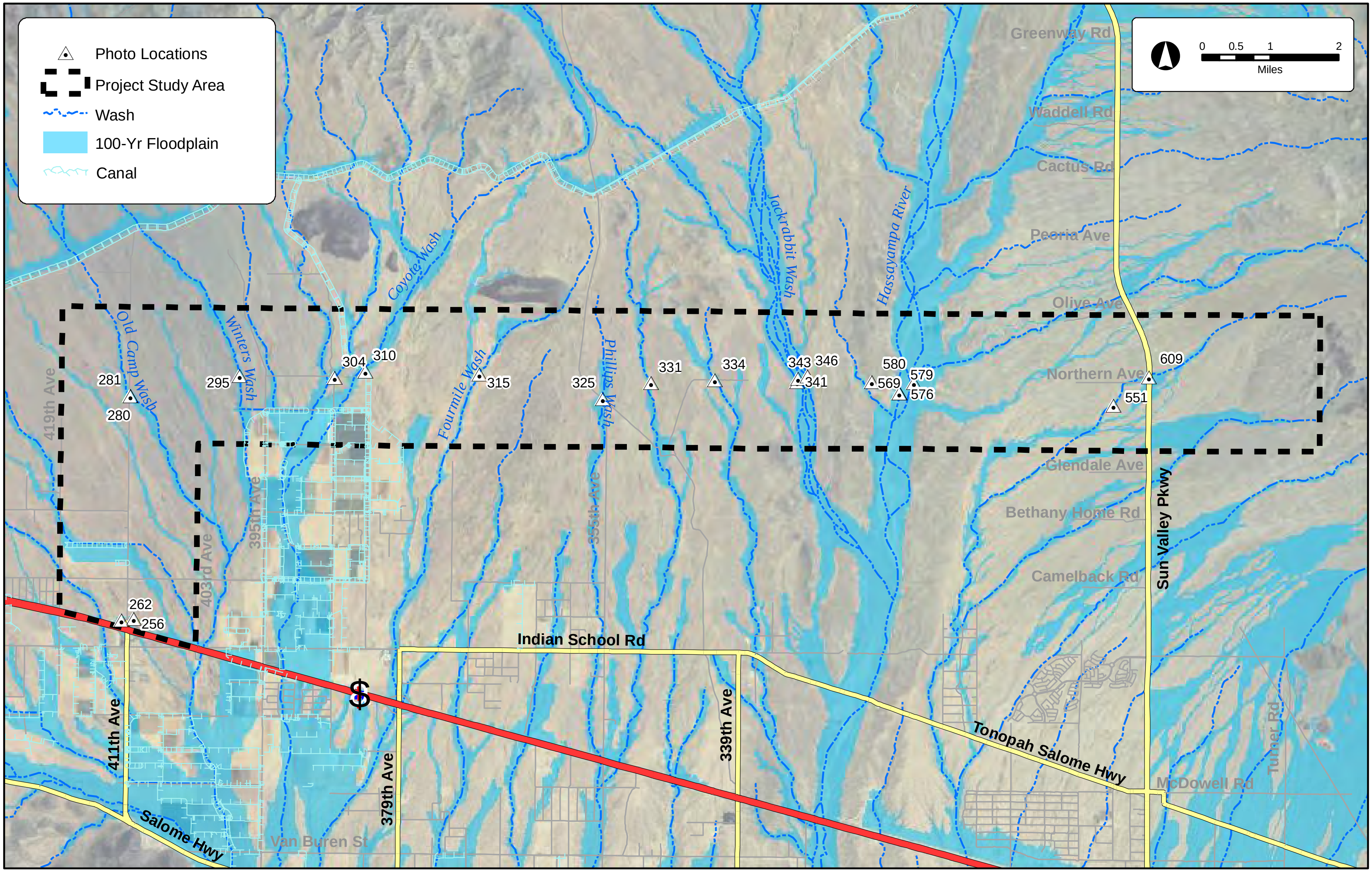


GWSI is ADWR's technical database of well locations, construction data, and water levels.

Created on 8/24/2010

APPENDIX TM3-04

DRAINAGE FIELD PHOTOS



Kimley-Horn and Associates, Inc.	Northern Parkway (Hassayampa Section) Corridor Feasibility Study – I-10 to Turner Parkway	Maricopa County, Arizona
	Appendix TM3-04. Drainage Field Photo Locations	

256: I-10 entrance ramp box culvert (near 411th Ave)

262: Area between I-10 and 411th Ave entrance ramp

280: Old Camp Wash natural path and avulsion

281: Old Camp Wash captured by 411th Ave

091337217

Kimley-Horn and Associates

295: Winters Wash

304: Culverts at 387th Ave

310: Tonopah Irrigation District Canal

315: Fourmile Wash

Photos Dates: July 14 and 28, 2010

Maricopa County Department of Transportation


325: Phillips Wash


331: Cut banks on unnamed wash near Aguila Rd


334: Typical land use


341: Cut banks in Jackrabbit Wash

091337217

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343: Sandy channel bed in Jackrabbit Wash

346: Upstream at Jackrabbit Wash

551: White Tank Wash

569: Sandy channel bed at Hassayampa River

Photos Dates: July 14 and 28, 2010

Maricopa County Department of Transportation

576: Wide channel bed at Hassayampa River

579: Debris in Hassayampa River

580: Hassayampa River valley overview

609: White Tank Wash box culverts at Sun Valley Parkway

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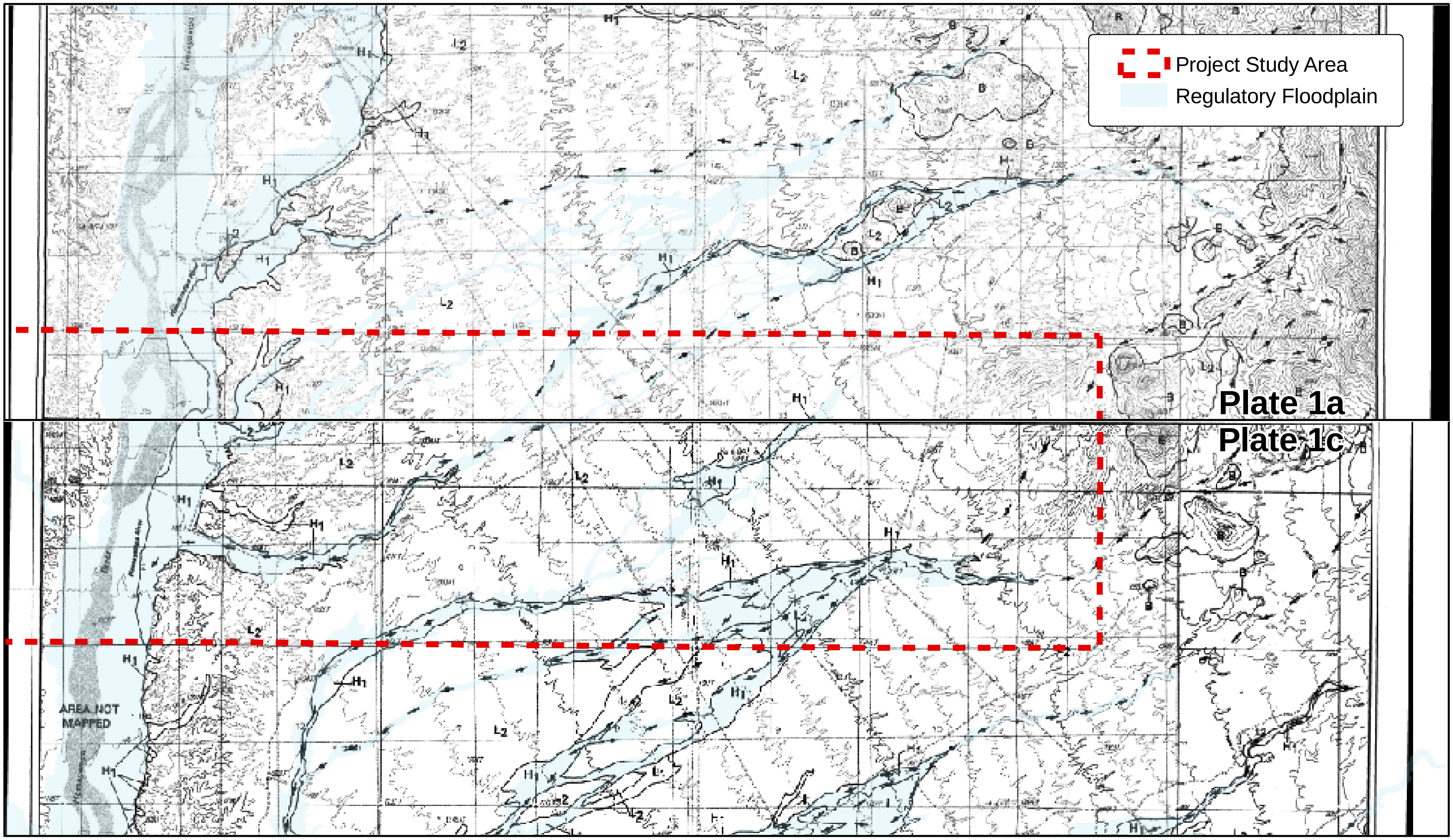
APPENDIX TM3-05

EXISTING GEOLOGIC FLOOD HAZARD MAPPING

WHITE TANK MOUNTAINS



Background images from: White Tanks Mountains Flood Hazard Map (Arizona Geological Survey Open File Report 91-10)

0 2,500 5,000 Feet

Kimley-Horn and Associates, Inc.

Northern Parkway (Hassayampa Section) Corridor Feasibility Study – I-10 to Turner Parkway	Maricopa County, Arizona
Appendix TM3-05. White Tanks Flood Hazard Map	

K:\PHX_Systems\091337127 - MCDOT Northern Parkway\CADD\GIS\Maps\Drainage\AppendixXX_WT_FldHaz.mxd

White Tank Mountains
Flood Hazard Map - SW Section

by
John J. Field and Philip A. Pearthree
1991

E X P L A N A T I O N

Map Unit Description

H_1 **Flood Hazard:** Highest; high-velocity channelized flow and sheetflow

Distribution: Entrenched reaches of major drainages and distributary flow areas on middle and upper piedmont

Soil Group*: Torrifluvents

Channel Pattern: Braided (anastomosing) or distributary

Surface Relief: Less than 2 ft; bar and swale topography

Surface Texture: Silt to very gravelly sand

Surface Color: Dull yellow-orange (10YR 6/4)

Desert Varnish: Unvarnished gravel

Vegetation:** Brittle bush, rabbit bush, bunch grass, creosote

Estimated Surface Age: Historical to late Holocene (0 to 2,000 yrs old)

H_2 **Flood Hazard:** Moderately high; dominantly sheetflow with minor channel flows

Distribution: Restricted to lower piedmont and small drainages heading on the piedmont

Soil Group: Torrifluvents

Channel Pattern: Distributary; incipient dendritic drainage in less active areas

Surface Relief: Less than 2 ft with uncommon, 4-ft arroyo cuts; smooth surface

Surface Texture: Sandy silt with 10% scattered gravel; less active areas have granule to pebble lag

Surface Color: Dull yellow-orange (10YR 6/4)

Desert Varnish: Unvarnished gravel

Vegetation: Creosote, brittle bush

Estimated Surface Age: Historical to late Holocene (0 to 2,000 yrs old)

I **Flood Hazard:** Intermediate; has not been subject to significant flooding for more than 1,000 yrs, but lack of topographic relief between these surfaces and active surfaces (H_1 and H_2) suggests that they could become flood prone with channel filling, avulsion, or human disturbance

Distribution: Adjacent to H_1 and H_2 in distributary flow areas and on lower piedmont

Soil Groups: Torrifluvents and Camborthids

Channel Pattern: Widely spaced, dendritic tributary drainages

Surface Relief: Less than 4 ft in distributary flow areas and less than 3 ft on lower piedmont; bar and swale topography well preserved in distributary flow areas

Surface Texture: Open desert pavement consisting of granules and small cobbles

Surface Color: Dull yellow-orange (10YR 6/4)

Desert Varnish: Unvarnished to weakly developed over 10% of the surface - brownish black (7.5YR 3/1) on top and orange (7.5YR 7/6) on undersides

Vegetation: Brittle bush, creosote, palo verde

Estimated Surface Age: Late Holocene to latest Pleistocene (1,000 to 15,000 yrs old)

L_1 **Flood Hazard:** Low; localized sheetflooding possible; flooding might occur if channels are altered by human disturbance because of low relief downslope from major distributary flow areas

Distribution: Downslope from and adjacent to distributary flow areas on middle and lower piedmont

Soil Groups: Camborthids and Haplargids

Channel Pattern: Moderately spaced, dendritic tributary drainages

Surface Relief: 1 to 10 ft; fairly smooth subdued bar and swale topography

Surface Texture: Open to closed desert pavement consisting of granules and cobbles

Surface Color: Bright brown (7.5YR 5/6) to orange (7.5YR 6/6)

Desert Varnish: Weakly to moderately developed over 50% of surface - brownish black (7.5YR 2/2) to grayish brown (7.5YR 4/2) on top and dull orange (5YR 6/4) to reddish brown (2.5YR 4/6) on undersides

Vegetation: Brittle bush, creosote, cane cholla

Estimated Surface Age: Latest Pleistocene to middle Pleistocene (15,000 to 250,000 yrs old)

L_2 **Flood Hazard:** Lowest; restricted to small channels and localized sheetflooding

Distribution: Upper and middle piedmont and adjacent to Hassayampa River

Soil Groups: Haplargids and Durorthids

Channel Pattern: Closely to widely spaced, dendritic tributary drainages; rounded interfluves in areas of highest relief

Surface Relief: 5 to 40 ft; fairly smooth surface; uncommon bar and swale topography

Surface Texture: Closed desert pavement consisting of cobbles and pebbles; uncommon salt-shattered cobbles; in places, surface is denuded and covered by petrocalcic fragments

Surface Color: Dull orange (7.5YR 6/4 to 5YR 6/3)

Desert Varnish: Well developed over 50 to 100% of undenuded surfaces - black (5YR 1.7/1) on top and dark red (10R 3/6) to dull orange (7.5YR 7/4) on undersides

Vegetation: Jumping cholla, brittle bush, creosote

Estimated Surface Age: Late Pleistocene to Pliocene (50,000 to 1,000,000+ yrs old)

M **Flood Hazard:** Mechanized disturbance; flood hazard unknown

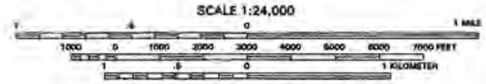
B **Flood Hazard:** Bedrock outcrops; flood hazard low, but localized slope wash and debris flows possible in steepest areas

* Soil groups are taken from the Soil Conservation Service survey of the Aguila-Carefree area

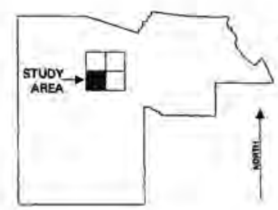
** Only dominant plant types are listed

Channel bottoms of larger drainages heading in the White Tank Mountains

SCALE 1:24,000



TOPOGRAPHIC CONTOUR INTERVAL 5, 10, 20, 40 FEET



INDEX MAP OF ARIZONA
Showing Location of Maricopa County

Legend image from: White Tanks Mountains Flood Hazard Map (Arizona Geological Survey Open File Report 91-10)

Kimley-Horn and Associates, Inc.	Northern Parkway (Hassayampa Section) Corridor Feasibility Study – I-10 to Turner Parkway	Maricopa County, Arizona
	Appendix TM3-05. White Tanks Flood Hazard Map Legend	

Kimley-Horn and Associates, Inc.

APPENDIX TM3-06

RECOMMENDED AREA DRAINAGE MASTER PLAN IMPROVEMENTS

ALLUVIAL FANS

- Obtain the maximum peak flow volume and peak stage from HEC-1 results.
- Compare results with the designed basin volume and basin depth (includes freeboard and sediment) to see if they are adequate. That is, the total basin depth should be less than 12 feet. The volume and depth are considered adequate if the combination of sediment, runoff, and freeboard fit within the basin.
- Modify basin dimensions and outlet structure parameters, and repeat the process until the basin volume and depth are adequate.

Calculations are provided in the appendix for each fan system.

5.10 Walled-Levee Corridors

5.10.1 Design Considerations

The walled-levee corridors were designed to act as a regional flood control trunk system and were sized to include local drainage as well as sediment from the adjacent watershed area. As part of the Step 3 design process, four discharge values are analyzed to ensure the applicability of the design to a range of flows. The four flows are simply ratios of the 100-year peak flows: 10%, 30%, 75% and 100%. The 10% flow can be expected to approximately represent the 2-year flow, 30% represent the 5 to 10-year flow, and 75% represent the 50-year flow. These ratios were selected based on guidance in the District's draft Hydrology Manual (2003). Figure 26 shows a plot of the ratios from the District Manual along with the 25-year and 50-year ratios selected for use in the ADMP. The discharge ratios were also used in the sediment yield analyses.

The walled-levee corridors were generally designed for subcritical flow with Froude numbers less than 0.86. Subcritical flows result in flows with lesser velocity and are favorable from public safety point of view. However, for some cross sections, the existing natural channel widths, slopes, and/or depths do not allow this criterion to be met.

Velocity within the walled-levee corridors was designed to be no greater than 6 ft/sec for the 100-year discharge and about 4 ft/sec for the 5 to 10-year discharge. Average flow depth in the corridors was restricted to 2 feet unless the velocity or Froude number requirement could not be met simultaneously. The minimum freeboard for the walled-levee corridors was set to meet the FEMA freeboard requirement of 3 feet for the concept designs.

Figure 27 shows a conceptual cross section of the walled-levee corridor. Figure 28 shows an oblique rendering of an example corridor reach.

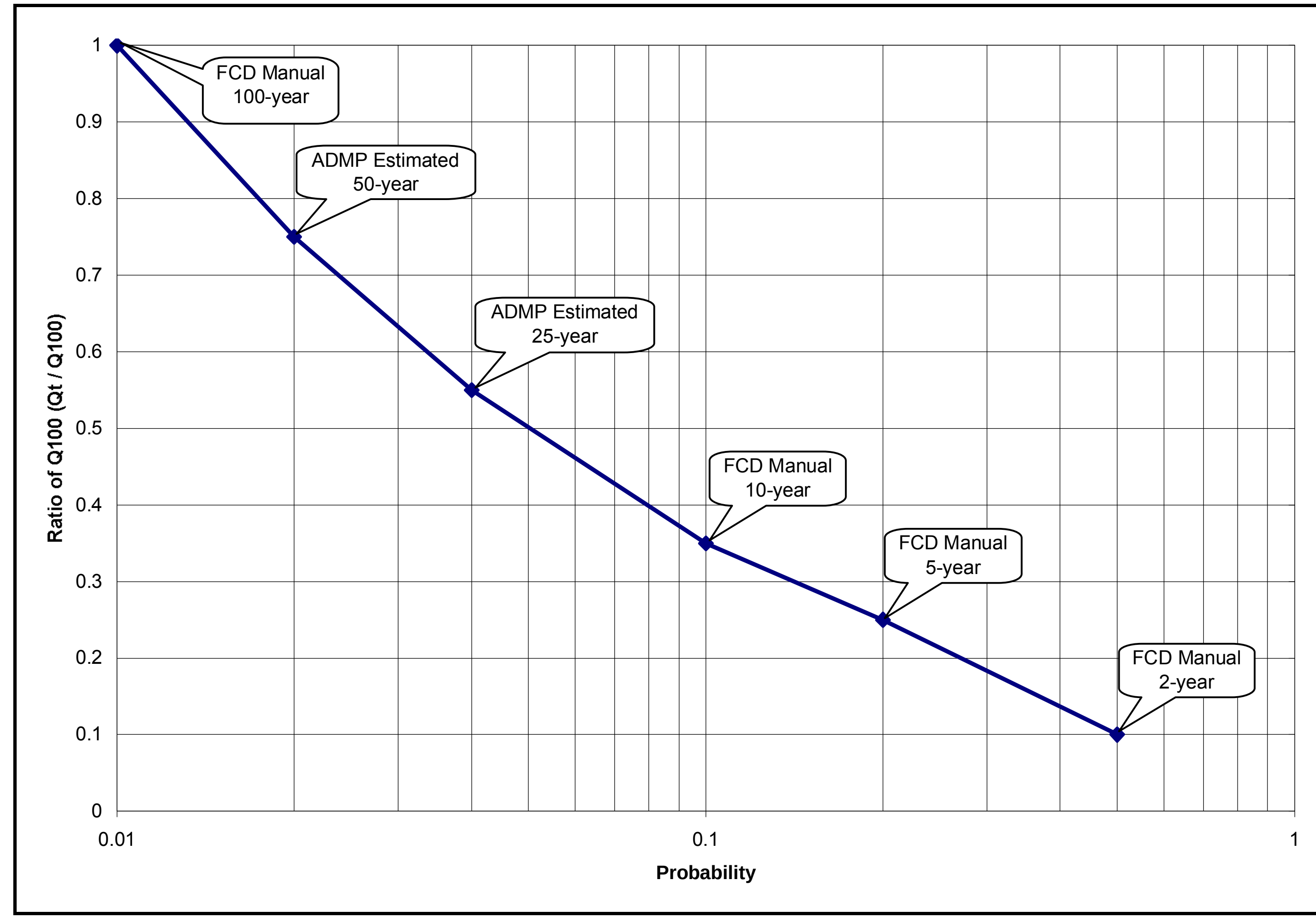


Figure 26 Development Of 25-Year & 50-Year Ratios For SVADMP

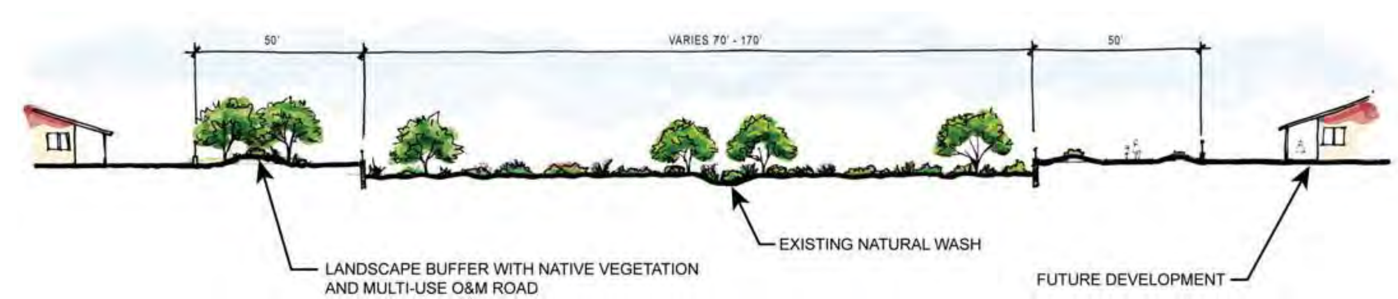


Figure 27 Concept Cross Section For Leveed Corridor With Walls & Aesthetic Treatments

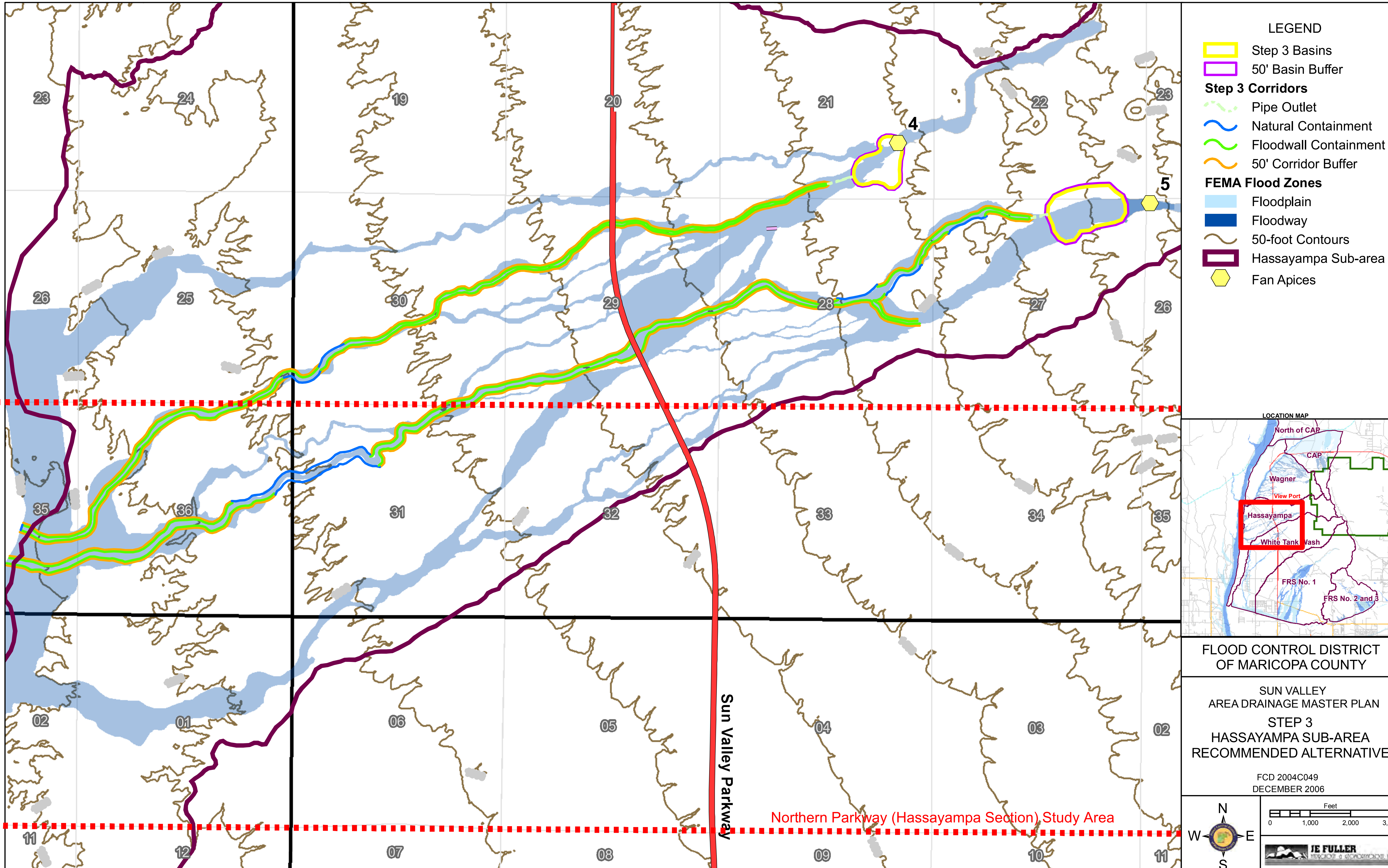


Figure 36 FEMA Floodplains, Recommended Alternative, and Benefited Area

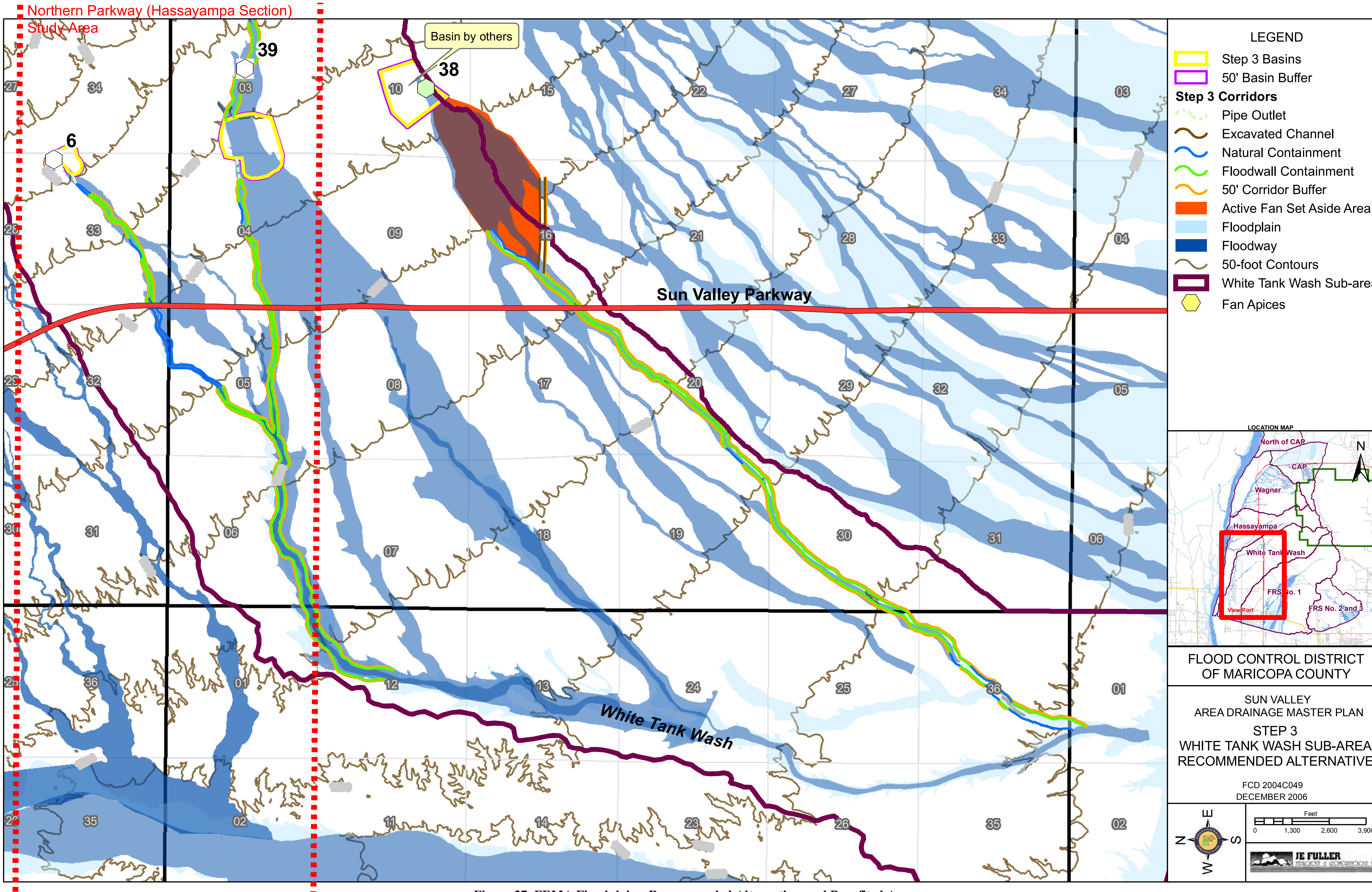


Figure 37 FEMA Floodplains, Recommended Alternative, and Benefited Area

Kimley-Horn and Associates, Inc.

APPENDIX TM3-07

RECENT EROSION AND SEDIMENTATION IN HASSAYAMPA RIVER

JANUARY 2010 STORM

Channel erosion at SRP poles

Overview of channel at SRP poles

Sediment deposition at Tonopah Salome Highway

Bank erosion at Tonopah Salome Highway


1978 embankment
BUCKEYE
2009 embankment
265'
PV-WW1 T144
PV-WW2 T144
PV-Rudd T28
Eroded 2010
(18,500 cfs flow 1/21/10)
Exhibit courtesy of WEST Consultants

APPENDIX TM3-08

EXISTING EROSION HAZARD MAPPING

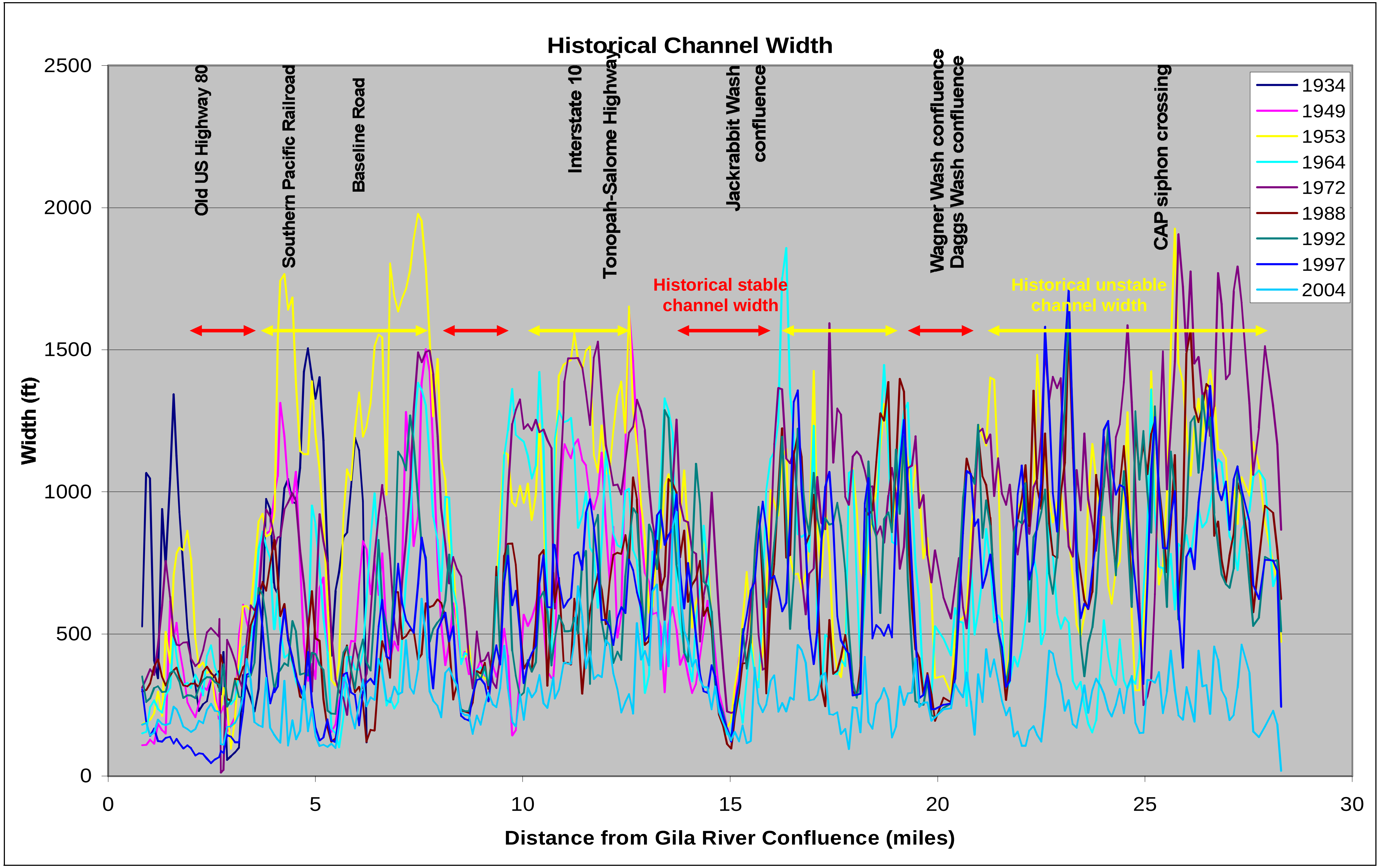


Figure 6-4. Width change analysis summary

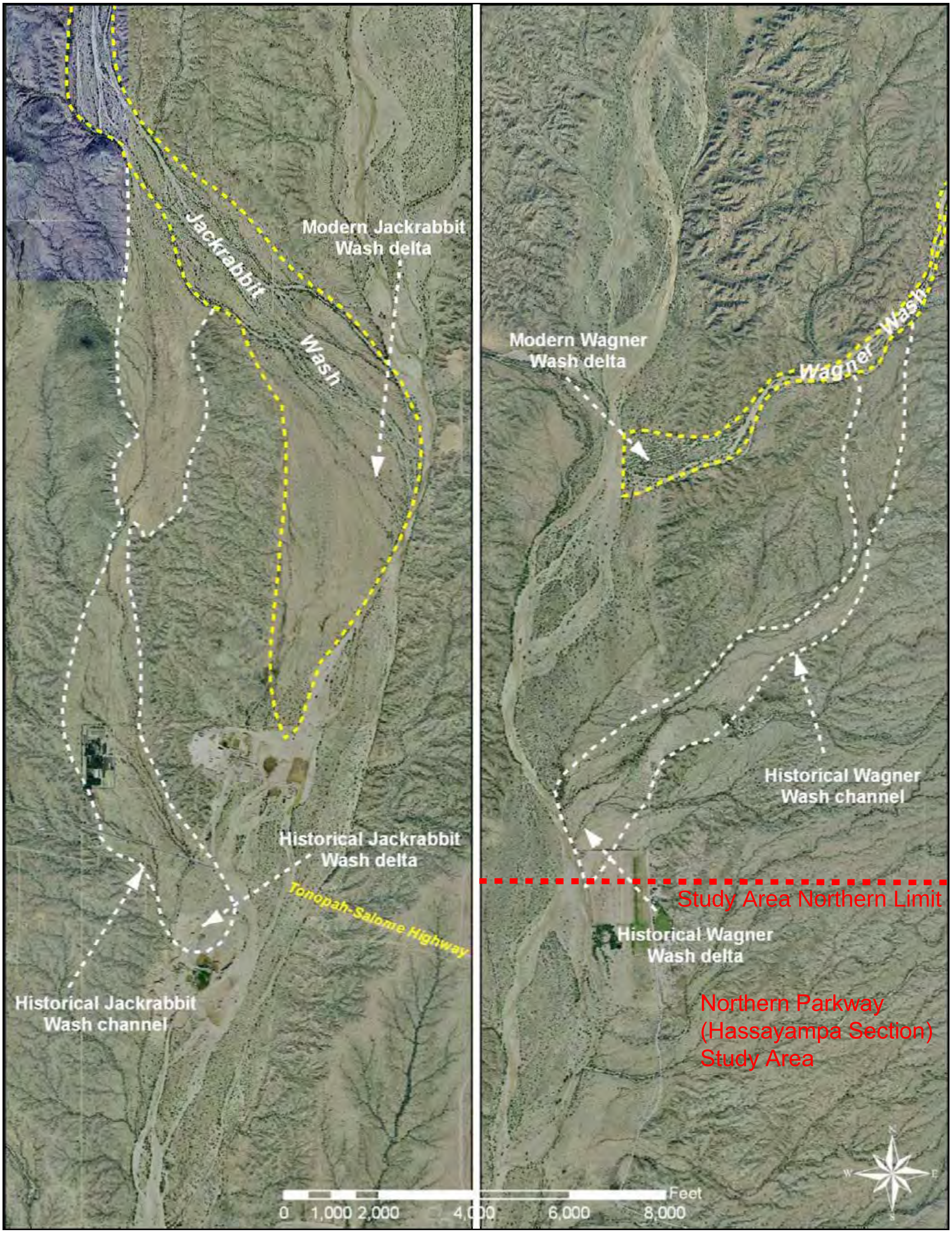


Figure 6-5. Major tributary avulsion locations

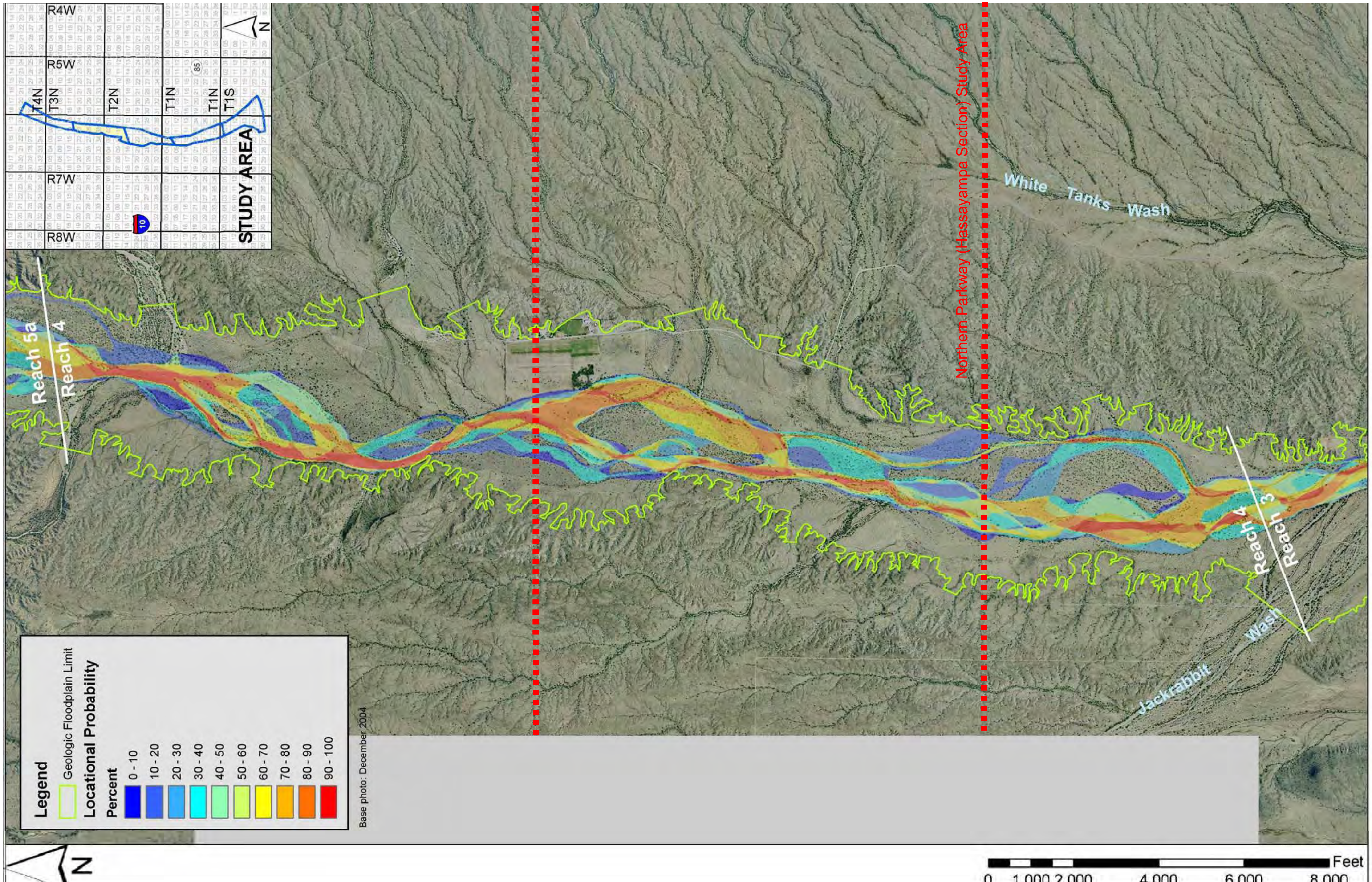


Figure 6-10. Locational Probability for Reach 4 (maximum potential number of years = 51 years)

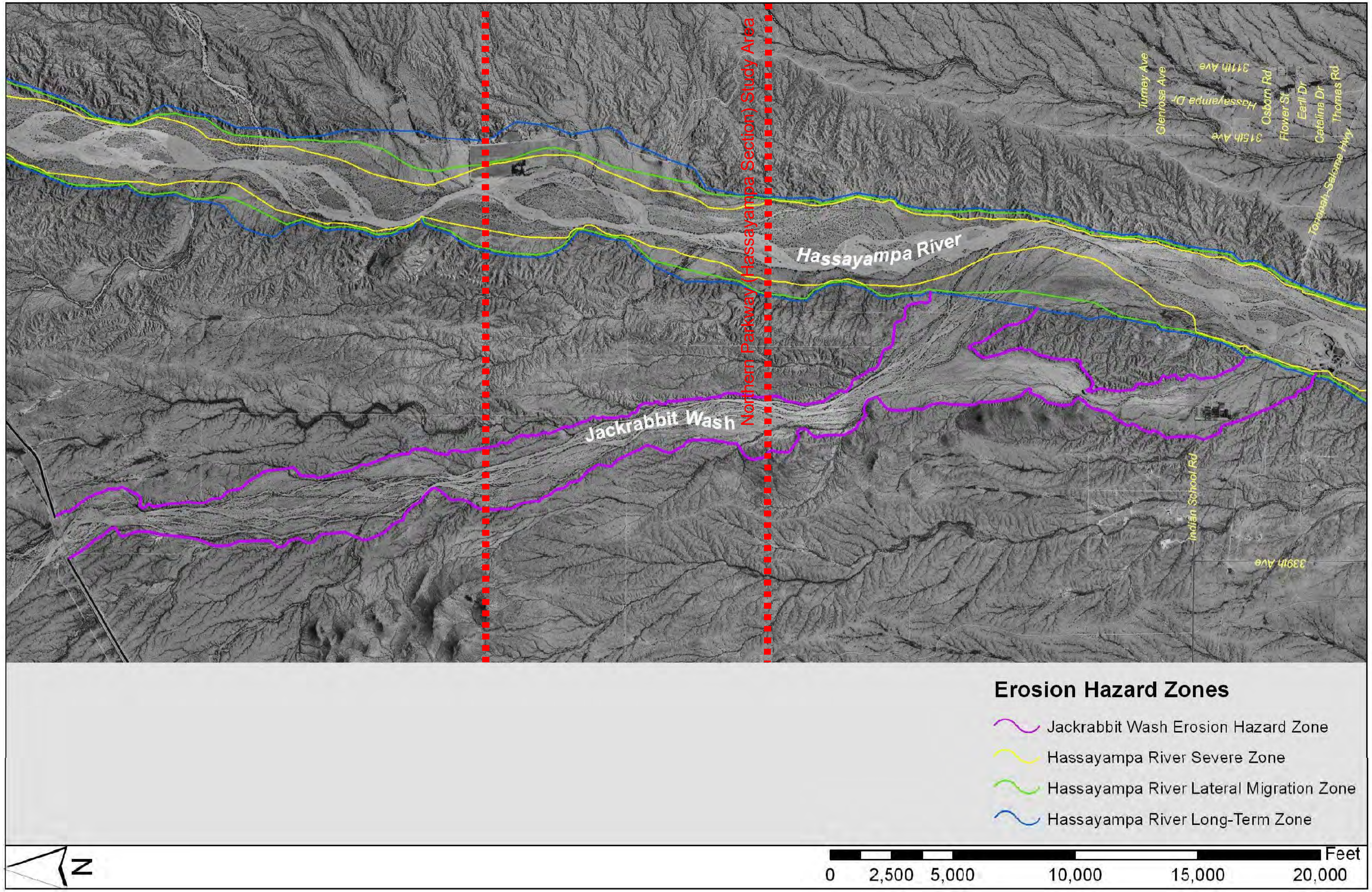
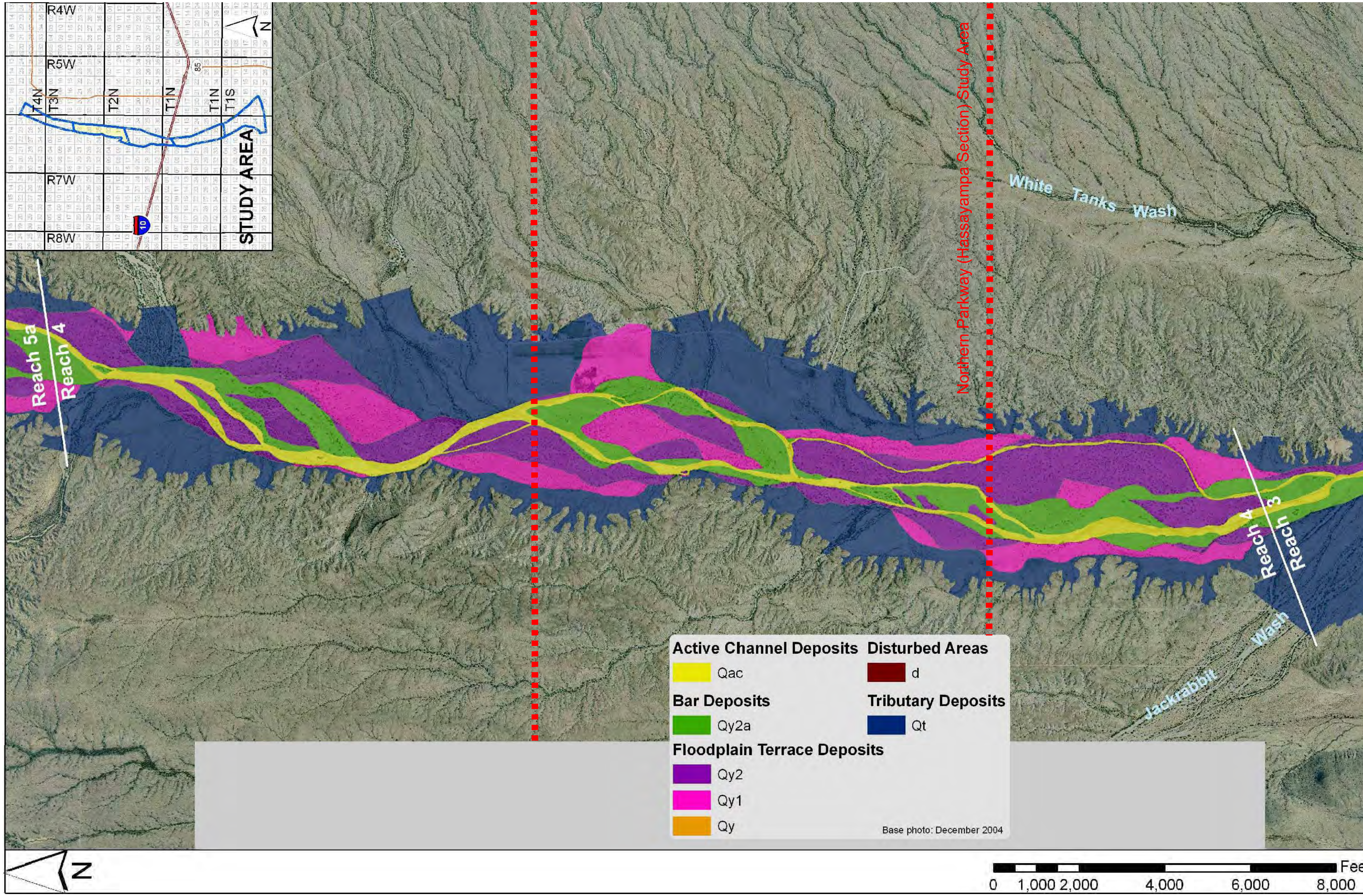
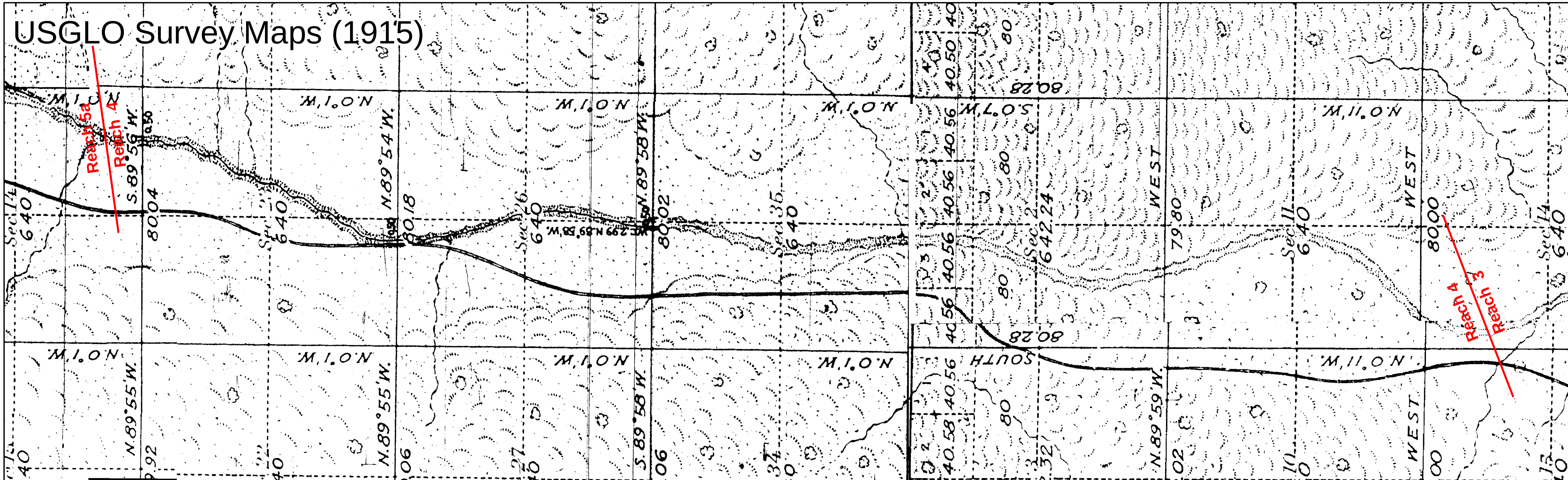
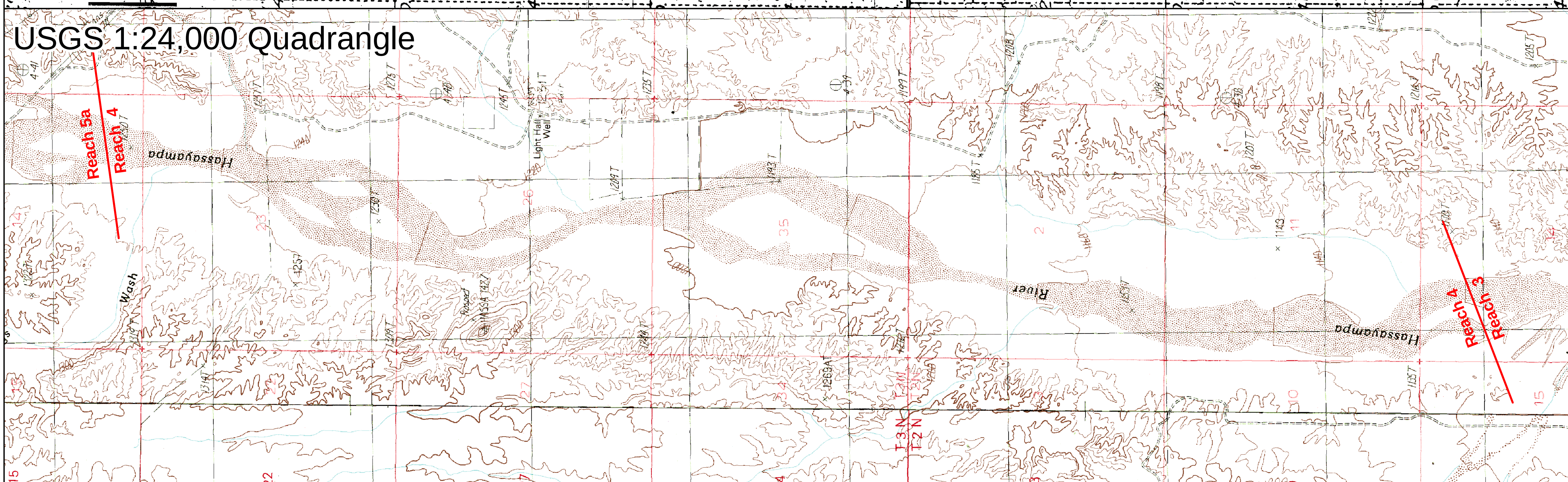


Figure 6-23. Jackrabbit Wash Erosion Hazard Zone

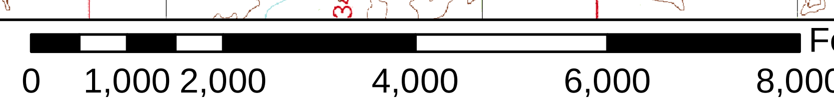


Reach 4 mapped geomorphology

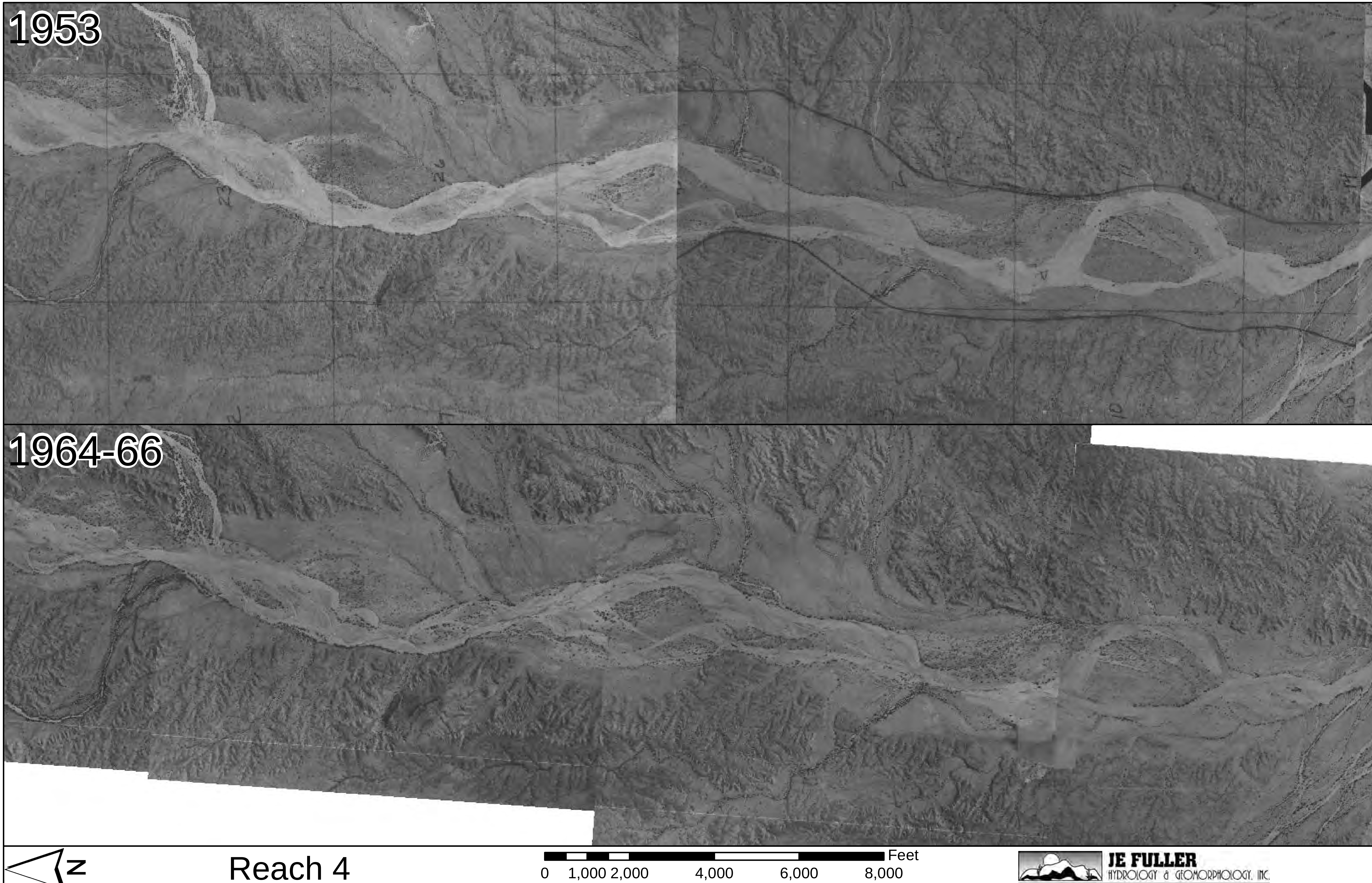


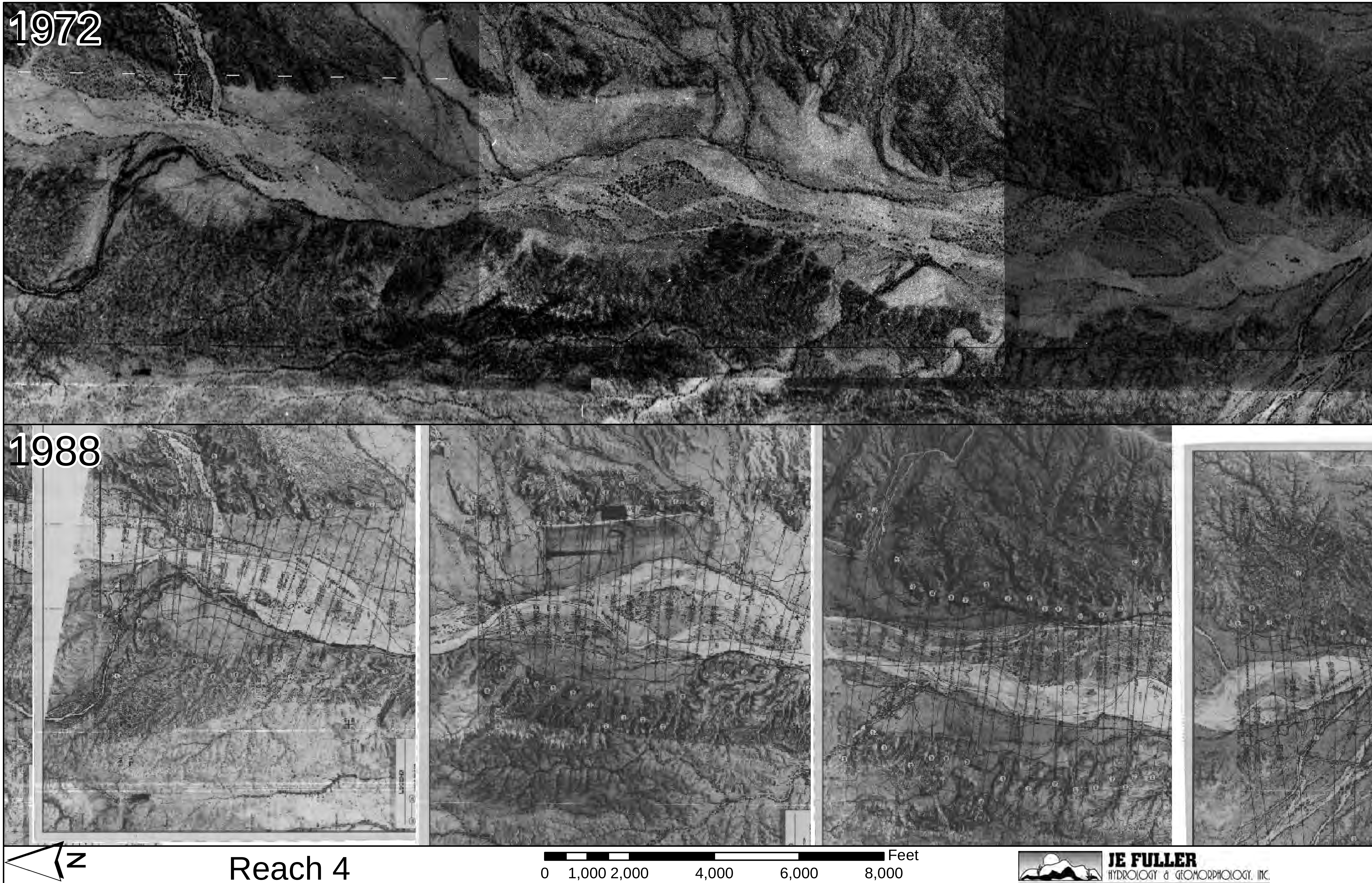


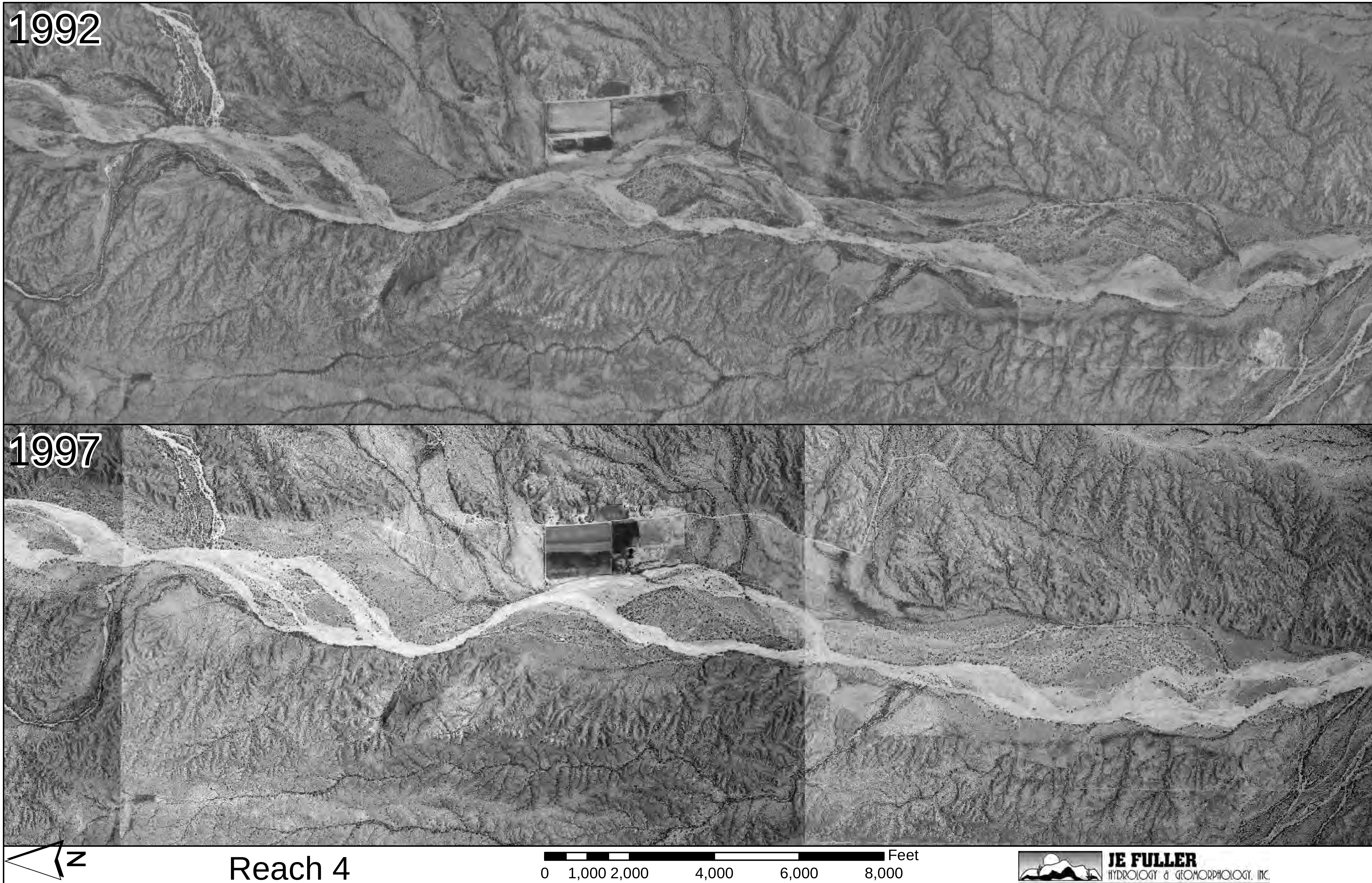
Reach 4



JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.

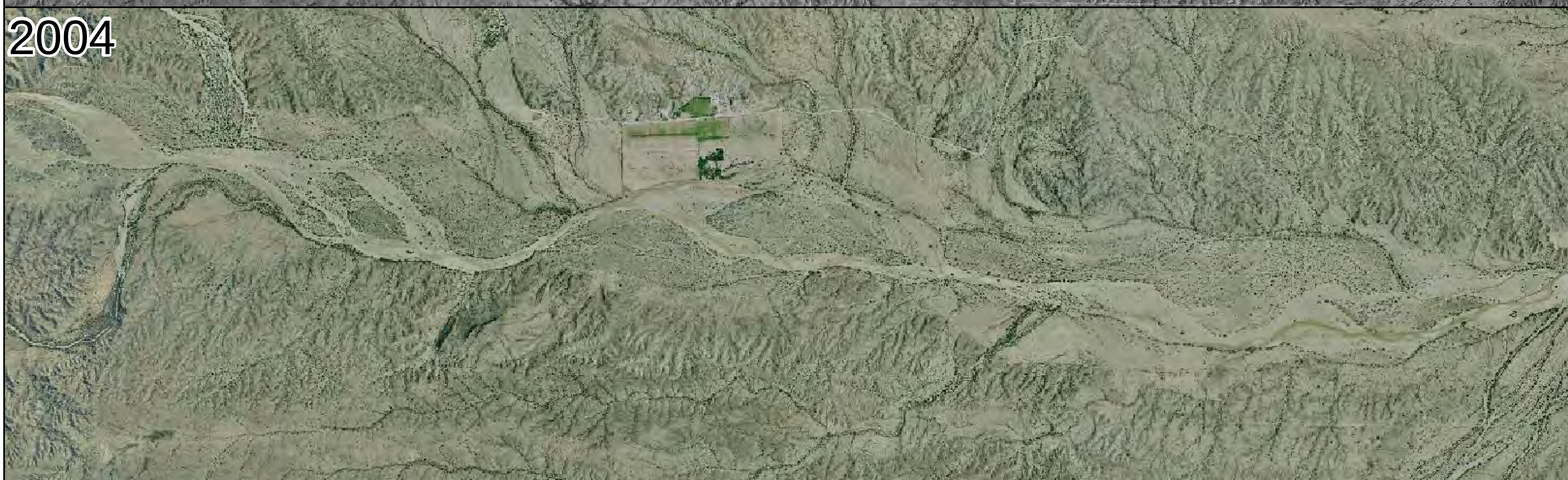

1953
1964-66
N
Reach 4
Feet
0
1,000
2,000
4,000
6,000
8,000
JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.


1972
1988
N
Reach 4
Feet
0
1,000
2,000
4,000
6,000
8,000
JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.



1992
1997
N
Feet
0
1,000
2,000
4,000
6,000
8,000
JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

Reach 4

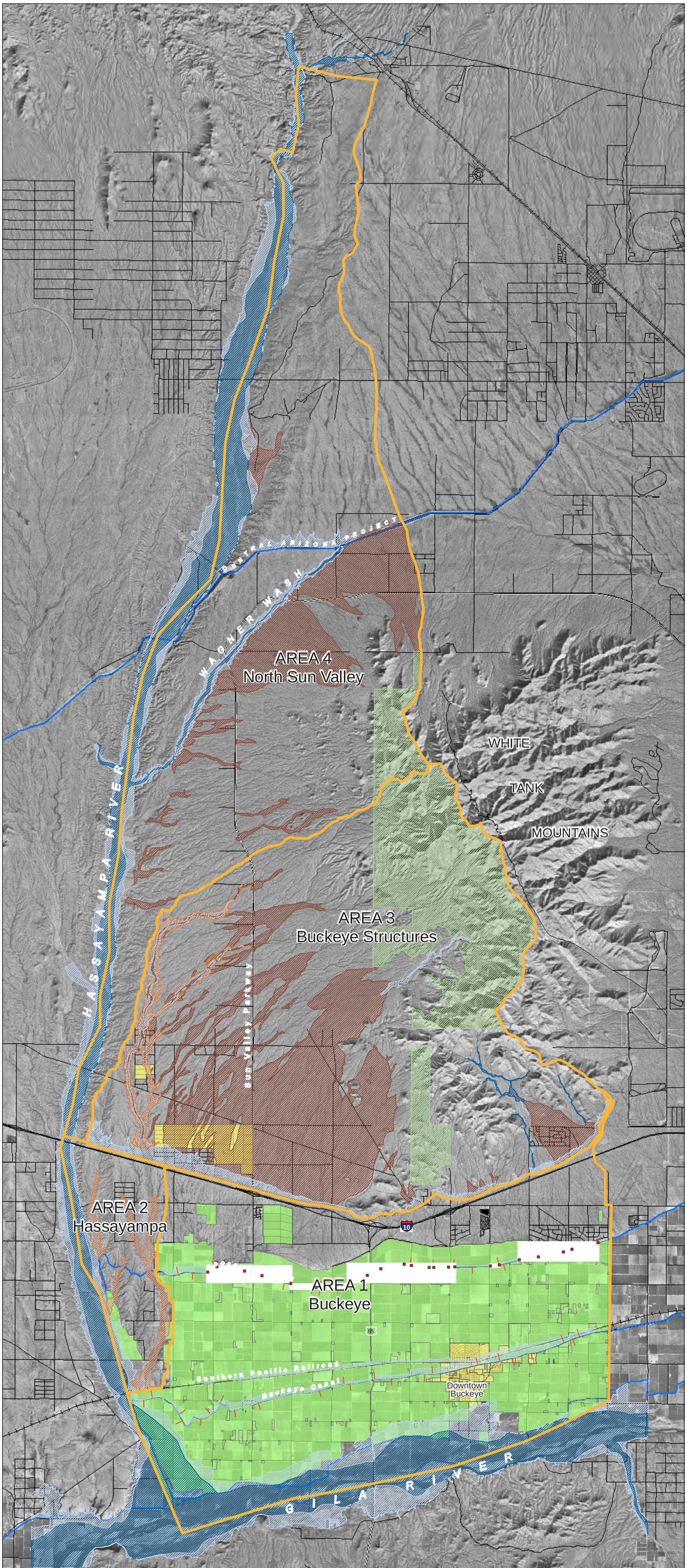


N

Reach 4

Feet
0 1,000 2,000 4,000 6,000 8,000

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.



Buckeye/Sun Valley Area Drainage Master Study

Interim Guidelines for Development Flooding and Erosion Areas

Legend

Areas of Unique Flooding and Erosion Considerations

AREA 1 - Buckeye
- Undeveloped Natural Sonoran Desert Areas
- Agricultural Lands/Fields
- Urbanized Areas

AREA 2 - Hassayampa
- Undeveloped Natural Sonoran Desert Areas
- Agricultural Lands/Fields

AREA 3 - Buckeye Structures
- Undeveloped Alluvial Fans
- Low Density Alluvial Development

AREA 4 - North Sun Valley
- Undeveloped Alluvial Fans

Potential Flood/Erosion Hazard Areas
- Floodway
- Areas of 100-year flood
- Areas of active alluvial fan flooding
- Areas of undetermined but possible flood hazards (not evaluated in this study)
- Erosion Hazard Zones
- Canal Overtopping Location

Note:
Not all hazards within the study area have been evaluated and identified including delineations of all floodplains, erosion hazards for the Hassayampa River, etc.

0 1 2 3 4
Miles

Figure 7

Kimley-Horn and Associates, Inc.

APPENDIX TM3-09-1

EXISTING DRAINAGE STRUCTURE DOCUMENTATION

SUN VALLEY PARKWAY CULVERTS

TABLE II

Sun Valley Parkway Phase II

Runoff and Culvert Summary

Drainage Basin	Watershed Area (acres)	Peak Discharge Q100 (cfs)	Culvert Inlet Location	Culvert Size & Type	Comments
1	941	1469	413+19	Triple 10'x3' RCBC	
1	"	"	416+36	Six 10'x3' RCBC	
2	12	40	425+35*	2- 35"x24" CSP	
3	350	530	430+82+	2- 8'x 4' RCBC	
4	27	67	437+19*	2- 35"x24" CSP	
5	145	232	443+84+	8'x4' RCBC	
6	80	150	446+24	8'x4' RCBC	
7	363	559	454+01	2- 8'x 4' RCBC	
8	81	98	460+45	6'x4' RCBC	Split
8		70	463+30	2- 35"x24" CSP	Split
9,10	72	164	473+45	8'x3' RCBC	
11	94	126	477+00	6'x3' RCBC	
12	2876	6753	480+11+	Six 10'x4' RCBC	Split
12	"	"	481+11+	Six 10'x4' RCBC	Split
12	"	"	482+66+	Six 10'x4' RCBC	Split
		24	489+72	35"x24" CSP	Req'd by ground config
13	182	279	492+78	10'x3' RCBC	
14	55	140	496+82*	24" CSP	Split
14	"	"	500+12*	42"x29" CSP	Split
14	"	"	505+04*	2- 42"x29" CSP	Split
15	563	1132	512+67	4- 10'x 4' RCBC	
16	1306	2449	518+75	6- 12'x 5' RCBC	
17	41	89	525+44*	57"x38" CSP	
18	23	65	530+05+*	57"x38" CSP	
19	168	256	539+44	10'x3' RCBC	
20	56	112	544+13*	57"x38" CSP	
21	70	150	549+16	6'x4' RCBC	
		28	550+67*	35"x24" CSP	Req'd by ground config
		11	552+75*	28"x20" CSP	
		12	555+08*	28"x20" CSP	Req'd by ground config
22	28	72	557+40*	49"x33" CSP	
23	53	120	561+95*	6'x3' RCBC	
24	14	46	568+23*	42"x29" CSP	
25	787	1123	577+13	3- 10'x 5' RCBC	
26	768	1538	580+67	4- 10'x 4' RCBC	
27	11	39	586+29*	42"x29" CSP	
28	20	66	590+82*	2- 42"x29" CSP	
29	9	11	595+12	28"x20" CSP	Split
29	"	29	598+34	42"x29" CSP	Split
30	58	124	602+10	2- 49"x33" CSP	
31	40	103	605+95	3- 42"x29" CSP	
32	18	46	611+51	2- 35"x24" CSP	Split
32	"	17	614+57	28"x20" CSP	Split
33	798	1565	618+19+	4- 10'x 4' RCBC	

TABLE II (CONT.)
Sun Valley Parkway Phase II
Runoff and Culvert Summary

Drainage Basin	Watershed Area (acres)	Peak Discharge Q100 (cfs)	Culvert Inlet Location	Culvert Size & Type	Comments
34	16	12	620+99	28"x20"CSP	
34	"	30	624+66	2- 28"x20" CSP	
35	18	50	628+00	2- 35"x24" CSP	
36	1026	1820	631+28	4- 10'x 3' RCBC	
36	"	"	632+12	4- 10'x 3' RCBC	
37	14	50	637+84	2- 35"x24" CSP	
38	99	158	645+73	10'x 3' RCBC	
39	7	32	652+10*	42"x29" CSP	
40	26	68	656+83*	2- 42"x29" CSP	
41	23	61	658+94*	2- 42"x29" CSP	
42	143	217	665+04	10'x3' RCBC	
43	7	26	670+28*	35"x24" CSP	
44	436	780	676+30	Triple 10'x3' RCBC	
45	569	1086	683+64	4-10'x3' RCBC	
46	23	65	690+29*	57"x38" CSP	
47		30	698+00*	Dble 28"x20" CSP	149 CFS rted to 716+43
48-49	10479	9679	716+43	Triple 10'x4' RCBC	
48-49	"	"	717+89	Triple 10'x4' RCBC	Wagner Wash South
A-Y	"	"	720+44	Triple 12'x6' RCBC	Collects areas:
"	"	"	721+10	Triple 12'x6' RCBC	A-Y, B1-K1, 47-49.
B1-K1	"	"	721+78	Triple 12'x6' RCBC	(See HEC-1)
"	"	"	724+09	Triple 10'x4' RCBC	
"	"	"	724+74	Triple 10'x4' RCBC	
		50	774+97	Dble 35"x24" CSP	Req'd by ground config
		28	781+52	Dble 28"x20" CSP	Req'd by ground config
Y	342	236	784+61	10'x4' RCBC	
U	314	384	824+91+	Dble 10'x3' RCBC	
T	315	423	839+23	Dble 10'x3' RCBC	
G-K, O-S	2776	2515	849+39+	Six 12'x4' RCBC	Wagner Wash North
K	66	111	1015+84	57"x38" CSP	

* Drainage Area Less than 64 acres.
\+ Culvert Outlet Velocity Less than 1.5 times the Natural Channel Velocity.

PHASE III

TABLE II

Runoff and Culvert Summary

Drainage Basin	Watershed Area (acres)	Peak Discharge Q100 (cfs)	Culvert Size & Type	Culvert Location
1	27	46	2- 35"x24"CSP	STA 404+55
2	38	31	1-30" RGRCP	STA 397+66
		31	1-30" CLCSP	STA 398+51
3	18.5	40**	Routed to Area #4	
4	275	330	10' x 4' RCBC	STA 386+05
5	48	83	42" CLCSP	STA 382+81
6	3850*	610	4-10'x3' RCBC	STA 374+64
7	30	61	42" CLCSP	STA 363+05
8D	3940*	1031	4-10'x4' RCBC	STA 360+44
		120	6'x3' RCBC	STA 356+13
9	29	52	36" RGRCP	STA 350+40
10	16	36**	Routed to Area #8E	
8E	4120*	250	10' x 4' RCBC	STA 337+14
		739	3-10'x4' RCBC	STA 333+84
11	4120*	300	2-10'x3' RCBC	STA 329+27
11		360	3-8' x 3' RCBC	STA 327+07
11B	16	36	30" CLCSP	STA 326+17
12	58	112	2 - 36" CLCSP	STA 316+73
13	102	168	6'x 3' RCBC	STA 312+17
14	26	52	2-30" RGRCP	STA 300+31
15	35	61	42" RGRCP	STA 292+09
16	864	115	10'x3' RCBC	STA 289+26
		688	4-10'x4' RCBC	STA 285+00
17	13	32**	Routed to Area 18	
18	2828	534	3-10'x3' RCBC	STA 271+21
		1575	6-10'x4' RCBC	STA 266+50
19	34	70	42" RGRCP	STA 253+94
20	81	136	10'x3' RCBC	STA 243+74
21	1205	280	2-10'x3' RCBC	STA 230+27
		200	2-10'x3' RCBC	STA 227+85
		450	3-10'x3' RCBC	STA 225+19

PHASE III

TABLE II (Continued)

Drainage Basin	Watershed Area (acres)	Runoff Q100 (cfs)	Culvert Size	Culvert Location
22	27	45	Route to Area 23	
23	4200*	756	4-10'x3' RCBC	STA 197+95
24	3630*	1820	6-10'x4' RCBC	STA 195+10
25	3630*	369	2-8'x3' RCBC	STA 172+93
26	10	23	30" RGRCP	STA 171+20
27	77	130	Routed to Area #28	
28	4135*	1067	6-10'x3' RCBC	STA 161+67
29	36	63	42" RGRCP	STA 142+48
30	3994*	284	3-10'x3' RCBC	STA 136+90
31	3917*	277	3-10'x3' RCBC	STA 129+55
32	27	51	Routed to Area 36	
33	163	284	2-8' x 3' RCBC	STA 92+80
34	98	177	Routed to Area 36	
35	40	73	Routed to Area 36	
36	1925*	658	3-10'x3' RCBC & Routed to Area 37	STA 38+82
37	2060*	881	Routed to Buckeye Watershed Project.	

*Portions of the runoff from this watershed have been diverted to other watersheds.

**Assumed R.O. peaked too soon to add to peak of area routed to.

APPENDIX TM3-09-2

EXISTING DRAINAGE STRUCTURE DOCUMENTATION

BUCKEYE FRS #1

Property of
Flood Control District of MC Library
Please Return to
2801 W. Durango
Phoenix, AZ 85009

PHASE I REPORT

HYDROLOGIC ANALYSIS
BUCKEYE FLOODWATER RETARDING
STRUCTURES #1, #2, AND #3
FOR
FLOOD CONTROL DISTRICT
OF
MARICOPA COUNTY
FCD PROJECT 88-63

DAMES & MOORE

D&M Job No. 15448-003-022
January 23, 1990

Table 1.1

SELECTED ENGINEERING DESIGN DATA FOR BUCKEYE FRS SYSTEM

	Units	FRS Identification Buckeye #1	Buckeye #2	Buckeye #3
Embankment				
Length	Miles	7.0	2.3	3.0
Maximum Height	Feet	48	26	34
Crest Elevation	Feet	1088.0[a]	1117.0	1170.0
Principal Spillway				
Conduit Diameter	Inches	60	48	30
Emergency Spillway				
Crest Width	Feet	800	350	400
Crest Elevation	Feet	1079.8	1111.2	1163.2
Reservoir				
Surface Area				
@ E. Spillway Crest	Acres	1137	150	180
@ Dam Crest	Acres	1952	235	335
Storage Volume				
@ E. Spillway Crest	Acre Feet	8200	780	920
@ Dam Crest	Acre Feet	19024	1920	2786

[a] Buckeye FRS #1 embankment crest includes a 5580-foot-long level section at elevation 1088.0 feet, a 31,500-foot-long level section at elevation 1089.5 feet and a 600-foot-long sloping transition section between the two level sections.

Ref: Arizona Water Commission 1979, a, b

SCHEMATIC OF FRS #1
HEC-1 COMPUTER MODEL

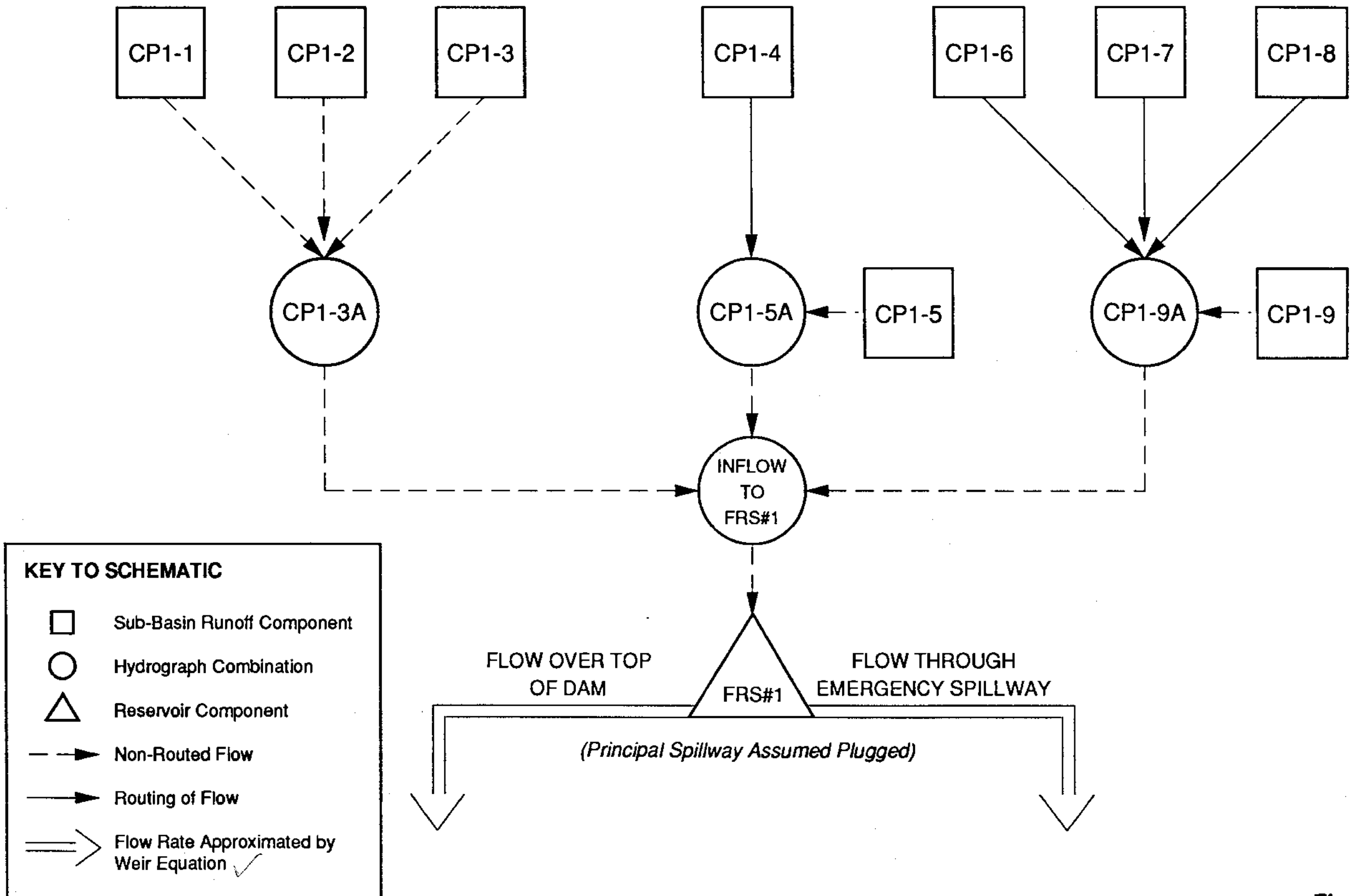
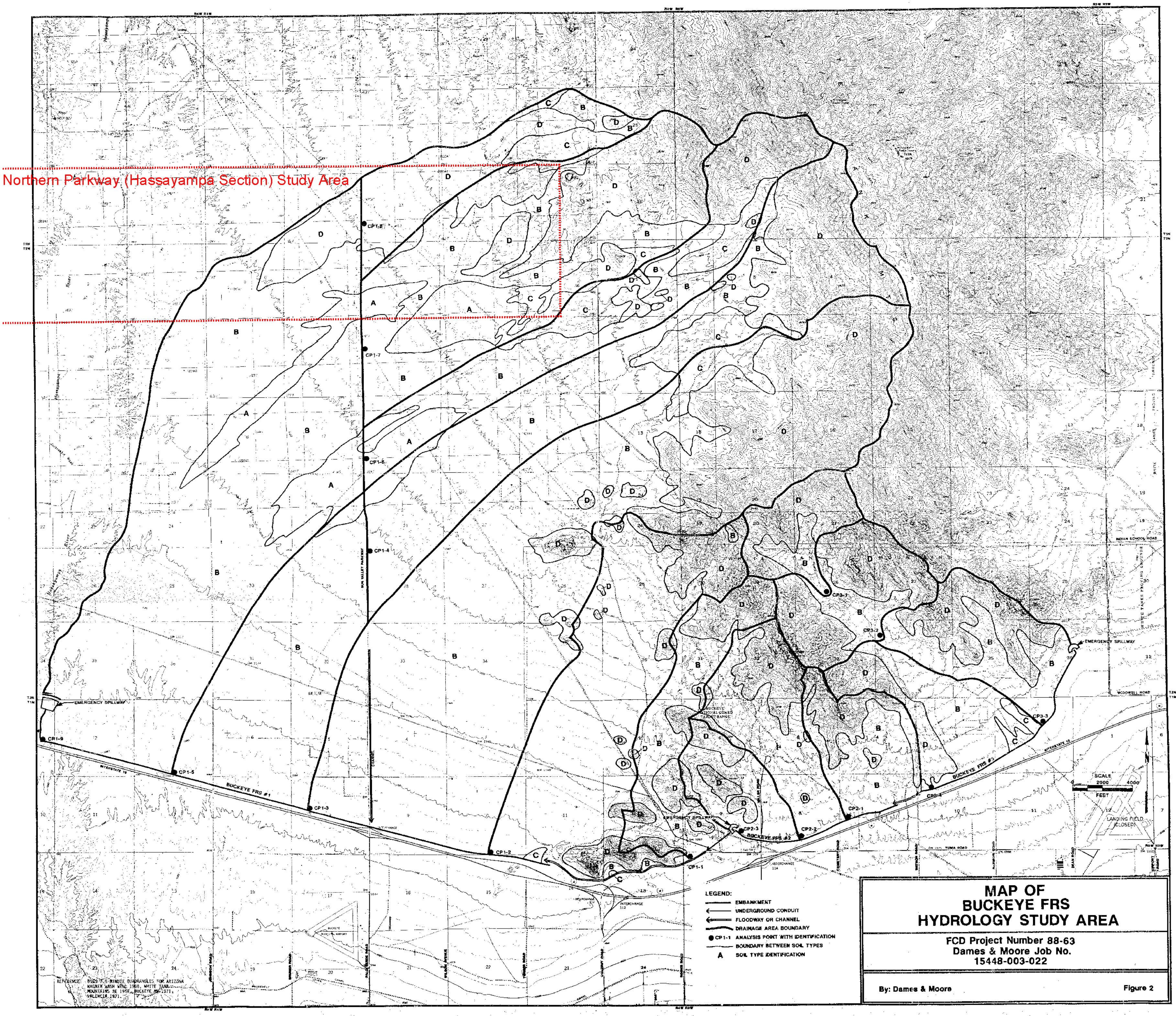


Figure 3



MAP OF BUCKEYE FRS HYDROLOGY STUDY AREA

FCD Project Number 88-63
Dames & Moore Job No.
15448-003-022

By: Dames & Moore

Figure 2

APPENDIX TM3-10-1

EXISTING HYDROLOGY RESULTS

EXCERPTS FROM PALO VERDE FDS

FIGURE 2
PALO VERDE FLOW EQUATIONS

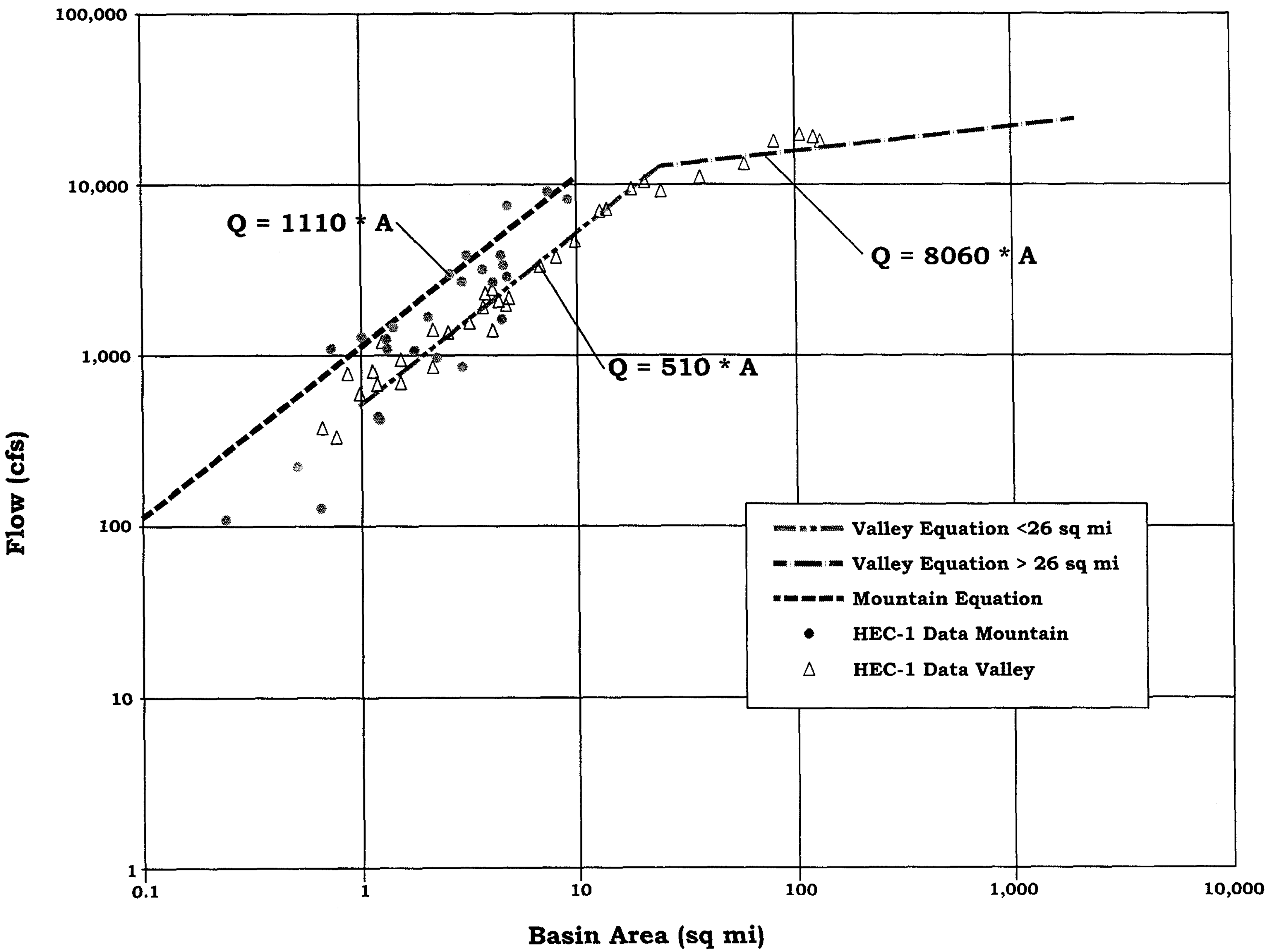


Table D.2C: Flow Calculations
Palo Verde Watershed Zone A Floodplain Delineation Study
FCD Project No. 2000C021

Wash	Basin ID No.	Concentration Point	Location		Area [sqmls]	Equation [cfs]	Rounded [cfs]
T2N-R7W-S15E	C45B	C45-06	Glendale Ave. and 435th Ave.		0.449	229	230
DIVERSION IN MAIN WASH	(EAST BRANCH)	C45-06	Glendale Ave. and 435th Ave.	33%	0.148	76	80
DIVERSION TO T2N-R7W-S15W	(WEST BRANCH)	C45-06	Glendale Ave. and 435th Ave.	67%	0.301	153	150
	C45B,C45A	C45-03	Bethany Home Rd. and 427th Ave.		0.960	489	490
WASH 08	C96	C96-03	Camelback Rd. and 419th Ave.		0.755	385	390
T2N-R7W-S26E	T2N-R7W-S15W,T2N-R7W-S15E	C39-12	Bethany Home Rd. and 427th Ave.		2.358	1202	1200
DIVERSION TO T2N-R7W-S26W	(WEST BRANCH)	C36-12	Bethany Home Rd. and 427th Ave.	35%	0.825	421	420
DIVERSION IN MAIN WASH	(EAST BRANCH)	C39-09	Bethany Home Rd. and 427th Ave.	65%	1.533	782	780
	T2N-R7W-S15W,T2N-R7W-S15E,C39B	C39-06	Camelback Rd. and 419th Ave.		2.156	1100	1100
	T2N-R7W-S15W,T2N-R7W-S15E,C39B,C39A	C39-03	Interstate 10 and 411th Ave.		2.382	1215	1220
T2N-R7W-S26W	DIV-T2N-R7W-S26E	C36-12	Bethany Home Rd. and 427th Ave.		0.825	421	420
	DIV-T2N-R7W-S26E,C36B	C36-09	Camelback Rd. and 419th Ave.		1.056	539	540
	DIV-T2N-R7W-S26E,C36B,WASH 08	C36-06	Camelback Rd. and 419th Ave.		1.811	924	920
	DIV-T2N-R7W-S26E,C36B,WASH 08,C36A	C36-03	Interstate 10 and 419th Ave.		1.923	981	980
NO WASH	C48	C48-03	Interstate 10 and 411th Ave.		0.416	212	210
T2N-R7W-S25W	C51	C51-03	Interstate 10 and 411th Ave.		0.383	196	200
NO WASH	C104	C104-03	Northern Ave. and 427th Ave.		0.202	103	100
WASH 30	C102	C102-03	Glendale Ave. and 419th Ave.		0.727	371	370
T2N-R7W-S10	C60B	C60-15	Northern Ave. and 427th Ave.		0.245	125	130
	C60B,C104	C60-12	Northern Ave. and 427th Ave.		0.447	228	230
	C60B,C104,WASH 30	C60-06	Glendale Ave. and 419th Ave.		1.174	599	600
	C60B,C104,WASH 30,C60A	C60-03	Bethany Home Rd. and 419th Ave.		2.039	1040	1040
T2N-R7W-S25E	FROM FLUME #4 OUTFLOW		FROM FLUME #4 OUTFLOW		0.800	408	410
	C54E	C54-21	Glendale Ave. and 427th Ave.		1.485	757	760
	C54E,C54D	C54-18	Bethany Home Rd. and 419th Ave.		1.985	1013	1010
	C54E,C54D,T2N-R7W-S10	C54-15	Bethany Home Rd. and 419th Ave.		4.025	2053	2050
	C54E,C54D,T2N-R7W-S10,C54C	C54-12	Camelback Rd. and 411th Ave.		4.684	2389	2390
	C54E,C54D,T2N-R7W-S10,C54C,C54B	C54-09	Camelback Rd. and 411th Ave.		5.202	2653	2650
	C54E,C54D,T2N-R7W-S10,C54C,C54B,C54A	C54-03	Interstate 10 and 403rd Ave.		5.677	2895	2900
WASH 10	C98B	C98-06	Bethany Home Rd. and 411th Ave.		0.848	433	430
	C98B,C98A	C98-03	Camelback Rd. and 411th Ave.		1.796	916	920
T2N-R6W-S30W	C57B	C57-09	Camelback Rd. and 411th Ave.		0.266	136	140
	C57B,WASH 10	C57-06	Camelback Rd. and 411th Ave.		2.063	1052	1050

Table D.2C: Flow Calculations
Palo Verde Watershed Zone A Floodplain Delineation Study
FCD Project No. 2000C021

Wash	Basin ID No.	Concentration Point	Location		Area [sqmls]	Equation [cfs]	Rounded [cfs]
	C57B,WASH 10,C57A	C57-03	Interstate 10 and 403rd Ave.		2.567	1309	1310
T2N-R6W-S30E	C63	C63-03	Interstate 10 and 403rd Ave.		0.162	83	80
T2N-R7W-S02	C75	C75-03	Northern Ave. and 411th Ave.		0.706	360	360
T2N-R6W-S19	FROM FLUME #5 OUTFLOW			Flume 5	0.800	408	410
	C69E	C69-15	Northern Ave. and 419th Ave.		1.238	632	630
	C69E,C69D	C69-12	Northern Ave. and 411th Ave.		1.521	776	780
	C69E,C69D,C69C	C69-09	Glendale Ave. and 411th Ave.		2.056	1049	1050
	C69E,C69D,C69C,C69B	C69-06	Camelback Rd. and 403rd Ave.		2.812	1434	1430
	C69E,C69D,C69C,C69B,C69A	C69-03	Camelback Rd. and 403rd Ave.		3.234	1649	1650
WASH 31	C108	C108-03	Bethany Home Rd. and 403rd Ave.		1.025	523	520
T2N-R6W-S18E	C78C	C78-12	Northern Ave. and 403rd Ave.		0.768	392	390
	C78C,C78B	C78-09	Bethany Home Rd. and 403rd Ave.		1.473	751	750
	C78C,C78B,WASH 31	C78-06	Bethany Home Rd. and 403rd Ave.		2.498	1274	1270
	C78C,C78B,WASH 31,C78A	C78-03	Bethany Home Rd. and 403rd Ave.		2.875	1466	1470
T2N-R6W-S18W	FROM FLUME #6 OUTFLOW			Flume 6	0.800	408	410
	C72C	C72-15	Northern Ave. and 411th Ave.		1.353	690	690
	C72C,T2N-R7W-S02	C72-12	Northern Ave. and 411th Ave.		2.059	1050	1050
	C72C,T2N-R7W-S02,C72B	C72-09	Bethany Home Rd. and 403rd Ave.		2.831	1444	1440
	C72C,T2N-R7W-S02,C72B,T2N-R6W-S18E	C72-06	Bethany Home Rd. and 403rd Ave.		5.706	2910	2910
	C72C,T2N-R7W-S02,C72B,T2N-R6W-S18E,C72A	C72-03	Camelback Rd. and 403rd Ave.		5.947	3033	3030
WASH 32	C118	C118-03	Glendale Ave. and 395th Ave.		0.612	312	310
NO WASH	DIV-T1S-R6W-S29E	C112-09	Olive Ave. and 403rd Ave.		0.431	220	220
	DIV-T1S-R6W-S29E,C112	C112-03	Northern Ave. and 395th Ave.		0.737	376	380
NO WASH	C110	C110-03	Bethany Home Rd. and 395th Ave.		0.304	155	160
NO WASH	C106	C106-03	Indian School Rd. and 403rd Ave.		0.441	225	230
DIVERSION TO BASIN C81	(SOUTH BRANCH)		Indian School Rd. and 403rd Ave.	71%	0.313	160	160
DIVERSION TO T1S-R6W-S29E	(WEST BRANCH)		Indian School Rd. and 403rd Ave.	29%	0.128	65	70
T1S-R6W-S29E	FROM FLUME #7 OUTFLOW			Flume 7	0.580	296	300
(WINTERS WASH)	C66H	C66-39	Peoria Ave. and 403rd Ave.		0.744	379	380
DIVERSION TO BASIN C112	(WEST BRANCH)	C112-09	Peoria Ave. and 403rd Ave.	58%	0.431	220	220
DIVERSION TO MAIN WASH	(EAST BRANCH)	C66-38	Peoria Ave. and 403rd Ave.	42%	0.312	159	160
	C66H,C66G	C66-36	Northern Ave. and 395th Ave.		0.842	429	430
	C66H,C66G,C112	C66-33	Northern Ave. and 395th Ave.		1.579	805	810
	C66H,C66G,C112,C66F	C66-30	Northern Ave. and 395th Ave.		1.798	917	920

Table D.2[illegible]ow Calculations
Palo Verde Watershed Zone A Floodplain Delineation Study
FCD Project No. 2000C021

Wash	Basin ID No.	Concentration Point	Location		Area [sqmls]	Equation [cfs]	Rounded [cfs]
WASH 29	D29	D29-03	Interstate 10 and 397th Ave.		1.190	607	610
NO WASH	D91	D91-03	Glendale Ave. and 379th Ave.		0.267	136	140
T2N-R6W-S22	D48B	D48-06	Glendale Ave. and 379th Ave.		0.754	385	390
	D48B,Basin D91	D48-03	Glendale Ave. and 379th Ave.		1.022	521	520
	D48B,Basin D91,D48A	D48-03	Camelback Rd. and 379th Ave.		1.998	1019	1020
T2N-R6W-S02	D51D	D51-12	Olive Ave. and 363rd Ave.		0.302	154	150
	D51D,D51C	D51-09	Olive Ave. and 363rd Ave.		0.821	419	420
	D51D,D51C,D51B	D51-06	Northern Ave. and 371st Ave.		1.822	929	930
	D51D,D51C,D51B,D51A	D51-03	Northern Ave. and 371st Ave.		2.152	1098	1100
T3N-R6W-S27S	D54B	D54-06	Peoria Ave. and 363rd Ave.		0.824	420	420
	D54B,D54A	D54-03	Olive Ave. and 371st Ave.		1.417	723	720
T1N-R6W-20E	FROM FLUME #10 OUTFLOW				**3.040**	**1550**	**1550**
DIVERSION TO BASIN 111	(WEST BRANCH)	D111-05	FLUME #10 EXIT	60%	1.824	930	930
DIVERSION TO BASIN D45I	(SOUTHWEST BRANCH)	D45-39	FLUME #10 EXIT	40%	1.216	620	620
	D45I	D45-39	Cactus Rd. and 363rd Ave.		1.308	667	670
DIVERSION TO WASH 25	(NORTHWEST BRANCH)	D21-16	Cactus Rd. and 363rd Ave.	35%	0.458	233	230
DIVERSION IN MAIN WASH	(SOUTHWEST BRANCH)	D45-36	Cactus Rd. and 363rd Ave.	65%	0.850	433	430
	D45I,D45H	D45-33	Olive Ave. and 371st Ave.		1.508	769	770
	D45I,D45H,T3N-R6W-S27S	D45-30	Olive Ave. and 371st Ave.		2.925	1492	1490
	D45I,D45H,T3N-R6W-S27S,D45G	D45-27	Northern Ave. and 371st Ave.		3.070	1566	1570
	D45I,D45H,T3N-R6W-S27S,D45G,T2N-R6W-S02	D45-24	Northern Ave. and 371st Ave.		5.222	2663	2660
	D45I,D45H,T3N-R6W-S27S,D45G,T2N-R6W-S02,D45F	D45-21	Glendale Ave. and 371st Ave.		5.619	2866	2870
	D45I,D45H,T3N-R6W-S27S,D45G,T2N-R6W-S02,D45F,D45E	D45-18	Bethany Home Rd. and 379th Ave.		6.505	3317	3320
	D45I,D45H,T3N-R6W-S27S,D45G,T2N-R6W-S02,D45F,D45E,D45D	D45-15	Bethany Home Rd. and 379th Ave.		7.107	3624	3620
	D45I,D45H,T3N-R6W-S27S,D45G,T2N-R6W-S02,D45F,D45E,D45D,D45C	D45-12	Camelback Rd. and 379th Ave.		7.434	3791	3790
	D45I,D45H,T3N-R6W-S27S,D45G,T2N-R6W-S02,D45F,D45E,D45D,D45C,T2N-R6W-S22	D45-09	Camelback Rd. and 379th Ave.		9.432	4810	4810
	D45I,D45H,T3N-R6W-S27S,D45G,T2N-R6W-S02,D45F,D45E,D45D,D45C,T2N-R6W-S22,D45B	D45-06	Indian School Rd. and 379th Ave.		9.698	4946	4950
	D45I,D45H,T3N-R6W-S27S,D45G,T2N-R6W-S02,D45F,D45E,D45D,D45C,T2N-R6W-S22,D45B,D45A	D45-03	Interstate 10 and 379th Ave.		9.877	5037	5040
NO WASH	D78	D78-03	Indian School Rd. and 395th Ave.		0.090	46	50
DIVERSION TO BASIN D01A	(SOUTH BRANCH)		Indian School Rd. and 395th Ave.	66%	0.059	30	30

Table D.2[illegible]ow Calculations
Palo Verde Watershed Zone A Floodplain Delineation Study
FCD Project No. 2000C021

Wash	Basin ID No.	Concentration Point	Location		Area [sqmls]	Equation [cfs]	Rounded [cfs]
DIVERSION TO BASIN D01B	(EAST BRANCH)		Indian School Rd. and 395th Ave.	34%	0.031	16	20
T2N-R6W-S32N	DIV1-BASIN D78	D01-06	Indian School Rd. and 395th Ave.		0.031	16	20
	DIV1-BASIN D78,D01B,DIV-T1N-R6W-S18	D01-06	Indian School Rd. and 395th Ave.		12.740	6498	6500
	DIV1-BASIN D78,D01B,DIV-T1N-R6W-S18,DIV2-BASIN D78	D01-03	Indian School Rd. and 395th Ave.		12.800	6528	6530
	DIV1-BASIN D78,D01B,DIV-T1N-R6W-S18,DIV2-BASIN D78,D01A	D01-03	Interstate 10 and 395th Ave.		12.915	6587	6590
WASH 24	D96	D96-03	Glendale Ave. and 395th Ave.		0.774	395	400
DIVERSION TO T2N-R6W-S05S	(EAST BRANCH)	D96-03	Glendale Ave. and 395th Ave.	28%	0.217	110	110
DIVERSION TO T1S-R6W-S29E	(SOUTH BRANCH-AREA C)	C66-24	Glendale Ave. and 395th Ave.	72%	0.557	284	280
NO WASH	D129	D129-03	Northern Ave. and 395th Ave.		0.339	173	170
T2N-R6W-S05S	D06C	D06-12	Northern Ave. and 395th Ave.		0.618	315	320
	D06C,D129	D06-09	Northern Ave. and 395th Ave.		0.957	488	490
	D06C,D129,D06B	D06-06	Glendale Ave. and 395th Ave.		1.309	667	670
	D06C,D129,D06B,DIV-WASH 24	D06-06	Glendale Ave. and 395th Ave.		1.525	778	780
	D06C,D129,D06B,DIV-WASH 24,D06A	D06-03	Glendale Ave. and 387th Ave.		2.260	1152	1150
NO WASH	D94	D94-03	Glendale Ave. and 387th Ave.		0.062	32	30
NO WASH	D119	D119-03	Peoria Ave. and 395th Ave.		0.179	91	90
T3N-R6W-S29	D119	D119-03	Peoria Ave. and 395th Ave.		0.179	91	90
	D119,D12	D12-03	Olive Ave. and 387th Ave.		0.833	425	430
T3N-R6W-S33	D18B	D18-06	Olive Ave. and 387th Ave.		0.965	492	490
	D18B,D18A	D18-03	Olive Ave. and 387th Ave.		1.415	722	720
T3N-R6W-S21	FROM FLUME #9 OUTFLOW			Flume 9	0.100	51	50
	D27	D27-03	Peoria Ave. and 387th Ave.		0.708	361	360
DIVERSION TO T2N-R6W-S05N	(WEST BRANCH)	D15-15	Peoria Ave. and 387th Ave.	84%	0.595	303	300
DIVERSION TO T3N-R6W-S27W	(EAST BRANCH)	D24-12	Peoria Ave. and 387th Ave.	16%	0.113	58	60
T2N-R6W-S05N	DIV-T3N-R6W-S21	D15-15	Peoria Ave. and 387th Ave.		0.595	303	300
	DIV-T3N-R6W-S21,D15C	D15-12	Olive Ave. and 387th Ave.		0.888	453	450
	DIV-T3N-R6W-S21,D15C,T3N-R6W-S33	D15-09	Olive Ave. and 387th Ave.		2.303	1175	1180
	DIV-T3N-R6W-S21,D15C,T3N-R6W-S33,D15B	D15-06	Northern Ave. and 387th Ave.		2.972	1516	1520
	DIV-T3N-R6W-S21,D15C,T3N-R6W-S33,D15B,D15A	D15-03	Northern Ave. and 387th Ave.		3.272	1669	1670

Table D.2[illegible]ow Calculations
Palo Verde Watershed Zone A Floodplain Delineation Study
FCD Project No. 2000C021

Wash	Basin ID No.	Concentration Point	Location		Area [sqmls]	Equation [cfs]	Rounded [cfs]
T2N-R6W-S05W	FROM FLUME #8 OUTFLOW			Flume 8	0.430	219	220
	D09C	D09-15	Olive Ave. and 387th Ave.		0.803	410	410
	D09C,T3N-R6W-S29	D09-12	Olive Ave. and 387th Ave.		1.636	834	830
	D09C,T3N-R6W-S29,D09B	D09-09	Northern Ave. and 387th Ave.		2.685	1369	1370
	D09C,T3N-R6W-S29,D09B,T2N-R6W-S05N	D09-06	Northern Ave. and 387th Ave.		5.957	3038	3040
	D09C,T3N-R6W-S29,D09B,T2N-R6W-S05N,D09A	D09-03	Northern Ave. and 387th Ave.		5.988	3054	3050
NO WASH	D114	D114-03	Cactus Rd. and 379th Ave.		0.049	25	30
T3N-R6W-S27E	D30B	D30-06	Peoria Ave. and 379th Ave.		0.193	99	100
DIVERSION TO MAIN WASH	(WEST BRANCH)	D30-06	Peoria Ave. and 379th Ave.	52%	0.101	51	50
DIVERSION TO T2N-R6W-S05E	(EAST BRANCH)		Peoria Ave. and 379th Ave.	48%	0.093	47	50
	D30B,D30A	D30-03	Peoria Ave. and 379th Ave.		0.151	77	80
T3N-R6W-S27W	FROM BOX CULVERT #3 OUTFLOW (Add in at D24-09)				**4.150**	**2117**	**2120**
	DIV-T3N-R6W-S21	D24-12	Peoria Ave. and 379th Ave.		0.113	58	60
	DIV-T3N-R6W-S21,D24B,D114	D24-09	Peoria Ave. and 379th Ave.		0.563	287	290
	DIV-T3N-R6W-S21,D24B,D114, BOX CULVERT #3	D24-09	Peoria Ave. and 379th Ave.		4.713	2404	2400
	DIV-T3N-R6W-S21,D24B,D114, BOX CULVERT #3,T3N-R6W-S27E	D24-06	Peoria Ave. and 379th Ave.		4.864	2481	2480
	DIV-T3N-R6W-S21,D24B,D114, BOX CULVERT #3,T3N-R6W-S27E,D24A	D24-03	Olive Ave. and 379th Ave.		4.898	2498	2500
T3N-R6W-S21E	FROM BOX CULVERT #3 OUTFLOW (Add in at D24-09)				**4.150**	**2117**	**2120**
	D114	D24-09	Peoria Ave. and 379th Ave.		4.199	2141	2140
	D114, D24B (FROM T3N-R6W-S27W)	D24-09	Peoria Ave. and 379th Ave.		4.600	2346	2350
NO WASH	FROM BOX CULVERT #2 OUTFLOW				**0.687**	**350**	**350**
	DIV-T1N-R6W-S20E (Cpt D111-05), CULVERT #2, D111	D111-03	Cactus Rd. and 363rd Ave.		2.572	1312	1310
DIVERSION TO T2N-R6W-S05E	(NORTHWEST BRANCH)	D21-18	Cactus Rd. and 363rd Ave.	60%	1.543	787	790
DIVERSION TO WASH 25	(SOUTHWEST BRANCH)	D21-15	Peoria Ave. and 371st Ave.	40%	1.029	525	530
WASH 25	DIV-T1N-R6W-S20E	D21-16	Cactus Rd. and 363rd Ave.		0.458	233	230
	DIV-T1N-R6W-S20E,DIV-BASIN D111	D21-16	Cactus Rd. and 363rd Ave.		1.486	758	760
T2N-R6W-S05E	DIV-Basin D111	D111-03	Cactus Rd. and 363rd Ave.		1.543	787	790
	FROM TWO CMP'S OUTFLOW	**D21-18**			**1.625**	829	830
	DIV-Basin D111,D21F	D21-18	Peoria Ave. and 371st Ave.		2.000	1020	1020
	DIV-Basin D111,D21F,D21E	D21-15	Peoria Ave. and 371st Ave.		2.734	1394	1390
	DIV-Basin D111,D21F,D21E,WASH 25	D21-15	Peoria Ave. and 371st Ave.		4.220	2152	2150
	DIV-Basin D111,D21F,D21E,WASH 25,D21D	D21-12	Olive Ave. and 379th Ave.		4.602	2347	2350
	DIV-Basin D111,D21F,D21E,WASH 25,D21D,DIV-T3N-R6W-S27E	D21-12	Olive Ave. and 379th Ave.		4.695	2395	2400
	DIV-Basin D111,D21F,D21E,WASH 25,D21D,DIV-T3N-R6W-S27E,T3N-R6W-S27W	D21-09	Olive Ave. and 379th Ave.		9.593	4893	4890

Table D.2[illegible]ow Calculations
Palo Verde Watershed Zone A Floodplain Delineation Study
FCD Project No. 2000C021

Wash	Basin ID No.	Concentration Point	Location		Area [sqmls]	Equation [cfs]	Rounded [cfs]
	DIV-Basin D111,D21F,D21E,WASH 25,D21D,DIV-T3N-R6W-S27E,T3N-R6W-S27W, D21C	D21-07	Northern Ave. and 387th Ave.		10.121	5162	5160
	DIV-Basin D111,D21F,D21E,WASH 25,D21D,DIV-T3N-R6W-S27E,T3N-R6W-S27W, D21C,D21B	D21-06	Northern Ave. and 387th Ave.		10.167	5185	5190
	DIV-Basin D111,D21F,D21E,WASH 25,D21D,DIV-T3N-R6W-S27E,T3N-R6W-S27W, D21C,D21B,D21A	D21-03	Northern Ave. and 387th Ave.		10.259	5232	5230
T1N-R6W-S18	T2N-R6W-S05E,T2N-R6W-S05W	D03-27	Northern Ave. and 387th Ave.		16.247	8286	8290
	T2N-R6W-S05E,T2N-R6W-S05W,D03G	D03-24	Northern Ave. and 387th Ave.		16.397	8363	8360
	T2N-R6W-S05E,T2N-R6W-S05W,D03G,D94,T2N-R6W-S05S	D03-21	Northern Ave. and 387th Ave.		18.719	9547	9550
	T2N-R6W-S05E,T2N-R6W-S05W,D03G,D94,T2N-R6W-S05S,D03F	D03-18	Bethany Home Rd. and 395th Ave.		19.730	10063	10060
	T2N-R6W-S05E,T2N-R6W-S05W,D03G,D94,T2N-R6W-S05S,D03F,D03E	D03-15	Bethany Home Rd. and 395th Ave.		20.234	10319	10320
	T2N-R6W-S05E,T2N-R6W-S05W,D03G,D94,T2N-R6W-S05S,D03F,D03E,D03D	D03-12	Camelback Rd. and 395th Ave.		21.216	10820	10820
	T2N-R6W-S05E,T2N-R6W-S05W,D03G,D94,T2N-R6W-S05S,D03F,D03E,D03D,D03 C	D03-09	Indian School Rd. and 395th Ave.		21.507	10969	10970
DIVERSION TO BASIN D01B	(WEST BRANCH)		Indian School Rd. and 395th Ave.	58%	12.474	6362	6360
DIVERSION TO MAIN WASH	(EAST BRANCH)		Indian School Rd. and 395th Ave.	42%	9.033	4607	4610
	T2N-R6W-S05E,T2N-R6W-S05W,D03G,D94,T2N-R6W-S05S,D03F,D03E,D03D,D03 C,D03B	D03-06	Indian School Rd. and 395th Ave.		9.177	4681	4680
	T2N-R6W-S05E,T2N-R6W-S05W,D03G,D94,T2N-R6W-S05S,D03F,D03E,D03D,D03 C,D03B,D03A	D03-03	Interstate 10 and 387th Ave.		9.310	4748	4750
T2N-R6W-S27	DIV-T1S-R6W-S27		Camelback Rd. and 363rd Ave.		0.209	107	110
	DIV-T1S-R6W-S27,D72	D72-03	Thomas Rd.and 371st Ave.		0.740	377	380
NO WASH	D117	D117-03	Camelback Rd. and 371st Ave.		0.363	185	190
WASH 26	D26	D26-06	Bethany Home Rd. and 363rd Ave.		0.991	505	510
DIVERSION IN MAIN WASH	(WEST BRANCH)		Bethany Home Rd. and 363rd Ave.	70%	0.694	354	350
DIVERSION TO WASH 27	(EAST BRANCH)		Bethany Home Rd. and 363rd Ave.	30%	0.297	152	150
	D26,D121	D121-03	Bethany Home Rd. and 371st Ave.		0.836	426	430
WASH 27	DIV-WASH 26		Bethany Home Rd. and 371st Ave.		0.297	152	150
T2N-R6W-S28	D57E	D57-15	Glendale Ave. and 371st Ave.		0.550	280	280
	D57E,D57D	D57-12	Bethany Home Rd. and 371st Ave.		0.977	498	500
	D57E,D57D,WASH 26	D57-11	Bethany Home Rd. and 371st Ave.		1.812	924	920
	D57E,D57D,WASH 26,D57C	D57-09	Camelback Rd. and 371st Ave.		2.023	1032	1030
	D57E,D57D,WASH 26,D57C,D117	D57-07	Camelback Rd. and 371st Ave.		2.385	1217	1220
DIVERSION IN MAIN WASH	(WEST BRANCH)	D57-07	Camelback Rd. and 371st Ave.	30%	0.716	365	370

Kimley-Horn
and Associates, Inc.

APPENDIX TM3-10-2

EXISTING HYDROLOGY RESULTS

EXCERPTS FROM LUKE WASH FDS

Evaluation of Manning's n-Value on Peak Flows

The selection of Manning's "n" values impacts both hydrologic and hydraulic modeling results. In order to evaluate the impact of Manning's n-value on the peak flows, a sensitivity analysis was conducted by reducing the n-values from 0.005 to 0.01 for the channel routing operations in the HEC-1 model for both shallow-and-wide and well-defined wash cases. The modeling results were listed in Appendix D6 which shows that the n-value reduction has more significant impact on the peak flows for shallow-and-wide washes than well-defined washes.

4.5 Final Results

4.5.1 Hydrologic Analysis Results

Eight HEC-1 hydrologic models were developed for four (4) scenarios (without dike, with both dikes, with I-10 only, and with UPRR only); and two (2) storm durations (100-year, 24-hour, and 100-year, 6-hour). Peak flows from all of the 8 models are summarized in Table 4.3 on the following pages. The maximum flow at each of the concentration points and the representative model that produces the maximum flow is identified. Note that if the maximum flow is generated by more than one model the selection order is as follows: 24-hour model first, then without dike model, and finally, with both dikes. The maximum peak flows for the 100-year storm are also shown in Exhibit A6. The output files for all of the HEC-1 models are presented in the Appendix D7.

The HEC-1 model names are summarized below:

Condition	100-year, 24-hour	100-year, 6-hour
No Dike	EC24NODK.DAT	EC06NODK.DAT
With Dike (I-10 & UPRR)	EC24DIKE.DAT	EC06DIKE.DAT
With I-10 Dike	EC24I10.DAT	EC06I10.DAT
With UPRR Dike	EC24UPRR.DAT	EC06UPRR.DAT

The electronic files for the HEC-1 models are provided on the CD in Exhibit A7 (inside front cover).

Table 4.3 Peak Flow Summary Table (continued)

Model => Hydrograph Name	Hydrologic Modeling Peak Flow Summary EC24DIKE (cfs)	EC06DIKE (cfs)	EC24I10 (cfs)	EC06I10 (cfs)	EC24UPRR (cfs)	EC06UPRR (cfs)	EC24NODK (cfs)	EC06NODK (cfs)	Maximum Flow (cfs)	Maximum Flow Model
C20b	1156	983	1165	983	1140	972	1150	978	**1165**	EC24I-10
46k	510	690	510	690	510	690	510	690	**690**	EC06NODK
46j	296	397	296	397	296	397	296	397	**397**	EC06NODK
C46j	469	615	469	615	469	615	469	615	**615**	EC06NODK
46i	290	393	290	393	290	393	290	393	**393**	EC06NODK
C46i	307	432	307	432	307	432	307	432	**432**	EC06NODK
CC46i	753	937	753	937	753	937	753	937	**937**	EC06NODK
46h	351	470	351	470	351	470	351	470	**470**	EC06NODK
C46h	867	1033	867	1033	867	1033	867	1010	**1033**	EC06DIKE
54b	262	357	262	357	262	357	262	357	**357**	EC06NODK
54a	346	472	346	472	346	472	346	472	**472**	EC06NODK
C54a	538	718	538	718	538	718	538	718	**718**	EC06NODK
52a	518	686	518	686	518	686	518	686	**686**	EC06NODK
C52a	981	1126	981	1126	981	1126	981	1126	**1126**	EC06NODK
CC46h	1733	1720	1733	1720	1733	1720	1733	1709	**1733**	EC24NODK
46g	277	372	277	372	277	372	277	372	**372**	EC06NODK
C46g	1523	1591	1523	1591	1523	1591	1523	1562	**1591**	EC06DIKE
46f	415	547	415	547	415	547	415	547	**547**	EC06NODK
C46f	1636	1689	1636	1689	1636	1689	1636	1660	**1689**	EC06DIKE
46e	248	334	248	334	248	334	248	334	**334**	EC06NODK
C46e	1524	1588	1524	1588	1524	1588	1524	1565	**1588**	EC06DIKE
56a	274	374	274	374	274	374	274	374	**374**	EC06NODK
CC46e	1529	1588	1529	1588	1529	1588	1529	1565	**1588**	EC06DIKE
46d	332	451	332	451	332	451	332	451	**451**	EC06NODK
C46d	1401	1424	1401	1424	1401	1424	1401	1421	**1424**	EC06DIKE
46c	186	253	186	253	186	253	186	253	**253**	EC06NODK
C46c	1404	1421	1404	1421	1404	1421	1404	1418	**1421**	EC06DIKE
46b	316	431	316	431	316	431	316	431	**431**	EC06NODK
C46b	1361	1353	1361	1353	1361	1353	1361	1350	**1361**	EC24NODK
50g	168	225	168	225	168	225	168	225	**225**	EC06NODK
50f	268	360	268	360	268	360	268	360	**360**	EC06NODK
C50f	267	360	267	360	267	360	267	360	**360**	EC06NODK
50e	196	264	196	264	196	264	196	264	**264**	EC06NODK
C50e	228	304	228	304	228	304	220	304	**304**	EC06NODK
50d	197	266	197	266	197	266	197	266	**266**	EC06NODK
C50d	206	277	206	277	206	277	206	277	**277**	EC06NODK
50c	325	433	325	433	325	433	325	433	**433**	EC06NODK
C50c	520	614	520	614	520	614	521	614	**614**	EC06NODK
50b	216	290	216	290	216	290	216	290	**290**	EC06NODK
C50b	582	688	582	688	582	688	582	688	**688**	EC06NODK
50a	522	645	522	645	522	645	522	645	**645**	EC06NODK
C50a	752	854	752	854	752	854	761	843	**854**	EC06DIKE
CC46b	1689	1550	1689	1550	1689	1550	1688	1549	**1689**	EC24DIKE
46a	481	595	481	595	481	595	481	595	**595**	EC06NODK
C46a	1617	1497	1617	1497	1617	1497	1616	1503	**1617**	EC24DIKE
48b	187	253	187	253	187	253	187	253	**253**	EC06NODK
48a	213	291	213	291	213	291	213	291	**291**	EC06NODK
C48a	212	291	212	291	212	291	212	291	**291**	EC06NODK
CC48a	1632	1495	1632	1495	N/A	N/A	N/A	N/A	**1632**	EC24DIKE
CC44a					646	696	646	705	**705**	EC06NODK
44f	227	304	227	304	227	304	227	304	**304**	EC06NODK
44e	329	440	329	440	329	440	329	440	**440**	EC06NODK
C44e	542	683	542	683	542	683	542	683	**683**	EC06NODK
44d	522	650	522	650	522	650	522	650	**650**	EC06NODK
C44d	672	813	672	813	672	813	672	803	**813**	EC06DIKE
44c	301	400	301	400	301	400	301	400	**400**	EC06NODK
C44c	635	758	635	758	635	758	635	752	**758**	EC06DIKE

Table 4.3 Peak Flow Summary Table (continued)

	Hydrologic Modeling Peak Flow Summary									
Model => Hydrograph Name	EC24DIKE (cfs)	EC06DIKE (cfs)	EC24I10 (cfs)	EC06I10 (cfs)	EC24UPRR (cfs)	EC06UPRR (cfs)	EC24NODK (cfs)	EC06NODK (cfs)	Maximum Flow (cfs)	Maximum Flow Model
35a	69	96	69	96	69	96	69	96	**96**	EC06NODK
DUMMY	1271	1358	1271	1358	1271	1358	1271	1358	**1358**	EC06NODK
DUMMY	3834	2114	4140	2278	3841	2118	4144	2282	**4144**	EC24NODK
79b	427	581	427	581	427	581	427	581	**581**	EC06NODK
79a	486	665	486	665	486	665	486	665	**665**	EC06NODK
C79a	779	948	779	948	779	948	779	948	**948**	EC06NODK
80b	296	404	296	404	296	404	296	404	**404**	EC06NODK
80a	331	450	331	450	331	450	331	450	**450**	EC06NODK
C80a	453	617	453	617	453	617	453	617	**617**	EC06NODK
81b	367	495	367	495	367	495	367	495	**495**	EC06NODK
81a	121	165	121	165	121	165	121	165	**165**	EC06NODK
C81a	345	465	345	465	345	465	345	465	**465**	EC06NODK
DUMMY	3834	2109	4139	2268	3841	2112	4144	2272	**4144**	EC24NODK
82b	268	368	268	368	268	368	268	368	**368**	EC06NODK
82a	508	669	508	669	508	669	508	669	**669**	EC06NODK
C82a	510	619	510	619	689	808	689	815	**815**	EC06NODK
83l	545	719	545	719	545	719	545	719	**719**	EC06NODK
83k	322	442	322	442	322	442	322	442	**442**	EC06NODK
C83k	863	1031	863	1031	863	1031	863	1031	**1031**	EC06NODK
83j	141	195	141	195	141	195	141	195	**195**	EC06NODK
C83j	811	962	811	962	811	962	811	962	**962**	EC06NODK
89b	282	389	282	389	282	389	282	389	**389**	EC06NODK
89a	197	279	197	279	197	279	197	279	**279**	EC06NODK
C89a	349	498	349	498	349	498	349	498	**498**	EC06NODK
CC83j	1119	1191	1119	1191	1119	1191	1119	1191	**1191**	EC06NODK
88a	221	302	221	302	221	302	221	302	**302**	EC06NODK
C88a	1261	1291	1261	1291	1261	1291	1261	1291	**1291**	EC06NODK
83i	319	444	319	444	319	444	319	444	**444**	EC06NODK
C83i	1320	1309	1320	1309	1320	1309	1320	1309	**1320**	EC24NODK
83h	219	299	219	299	219	299	219	299	**299**	EC06NODK
C83h	1489	1432	1489	1432	1489	1432	1489	1432	**1489**	EC24NODK
83g	420	559	420	559	420	559	420	559	**559**	EC06NODK
C83g	1516	1408	1516	1408	1516	1408	1516	1408	**1516**	EC24NODK
83f	156	218	156	218	156	218	156	218	**218**	EC06NODK
C83f	1519	1408	1519	1408	1519	1408	1519	1408	**1519**	EC24NODK
83e	607	743	607	743	607	743	607	743	**743**	EC06NODK
C83e	1457	1261	1457	1261	1457	1261	1428	1261	**1457**	EC24DIKE
83d	205	282	205	282	205	282	205	282	**282**	EC06NODK
C83d	1371	1193	1371	1193	1371	1193	1349	1193	**1371**	EC24DIKE
86a	339	476	339	476	339	476	339	476	**476**	EC06NODK
CC83d	1384	1184	1384	1184	1384	1184	1362	1184	**1384**	EC24DIKE
83c	306	416	306	416	306	416	306	416	**416**	EC06NODK
C83c	1342	1125	1342	1125	1342	1125	1323	1125	**1342**	EC24DIKE
87b	135	190	135	190	135	190	135	190	**190**	EC06NODK
87a	229	312	229	312	229	312	229	312	**312**	EC06NODK
C87a	228	311	228	311	228	311	228	311	**311**	EC06NODK
CC83c	1387	1128	1387	1128	1387	1128	1368	1128	**1387**	EC24DIKE
83b	322	439	322	439	322	439	322	439	**439**	EC06NODK
C83b	1335	1056	1335	1056	1335	1056	1320	1056	**1335**	EC24DIKE
85b	251	344	251	344	251	344	251	344	**344**	EC06NODK
85a	281	382	281	382	281	382	281	382	**382**	EC06NODK
C85a	287	405	287	405	287	405	287	405	**405**	EC06NODK
CC83b	1359	1044	1359	1044	1359	1044	1344	1044	**1359**	EC24DIKE
83a	202	275	202	275	202	275	202	275	**275**	EC06NODK
C83a	1318	1004	1318	1004	1318	1004	1305	1004	**1318**	EC24DIKE
84b	301	411	301	411	301	411	301	411	**411**	EC06NODK
84a	268	366	268	366	268	366	268	366	**366**	EC06NODK

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APPENDIX TM3-10-3

EXISTING HYDROLOGY RESULTS

EXCERPTS FROM JACKRABBIT WASH FDS

3.5 Final Results

3.5.1 General

The results of this study are summarized in Tables F-1 through F-4. Evaluation of the results indicate that peak flow rates for the major concentration points on Jackrabbit Wash and Star Wash result from the 100-year 24-hour duration storm. The 6-hour duration storm typically produced higher peaks on the smaller portions of the watershed. Therefore, care must be taken in selecting a peak discharge at any particular point of interest. The HEC-1 output files for both the 6-hour and 24-hour storms are included as a part of this report. Both of these printouts reflect use of channel transmission losses. A separate run was done for the 100-year 24-hour storm which did not include channel losses. The results of the analyses are included in Table F-3 for comparison.

3.5.2 Discussion of Results

The results for both storms are lower in magnitude than was anticipated. The peak discharges at critical points in the watershed have a yield, in cubic feet per second per square mile (cfs/sm), lower than has been seen for similar watersheds using different modeling methodology. An example would be to examine the results for concentration point 38. The 100-year 6-hour model yielded a peak discharge of 7,500 cfs at this location, which is the Jackrabbit Wash crossing of the CAP canal. The watershed area at this point is 319 square miles. Refer to Sheet 3 of Exhibit "C". The USBR developed a peak discharge of 25,500 cfs for a 100-year 6-hour storm at this same location. However, the 6-hour model often yielded higher peaks than the 24-hour model for smaller watersheds. The lower 6-hour peaks for the larger watersheds is due to the use of the Queen Creek precipition aerial reduction curve and the higher precipitation losses resultant from the use of the Green & Ampt loss equation.

The 100-year 24-hour peak discharge of 33,200 cfs at the above mentioned location is much more reasonable. This peak also falls within the Log Pearson III analysis statistical envelope for representative washes in Maricopa County, contained herein as Figure 2.

The final results are summarized in Tables F-1 through F-4. Table F-1 for instance, contains a summary of peak discharges at key locations in the watershed. These peaks are arranged alphabetically by wash name, in an upstream to downstream secondary order. The HEC-1 identifier is the name used on the exhibit maps and the HEC-1 input files to pin point the type of HEC-1 operation and the location on the watershed. The following is a descriptive list of the nomenclature used throughout all tables in the report, and in the HEC-1 computer models:

HEC-1 Computer Model Nomenclature

HEC-1 Identifier	Description
6A	Hydrograph identifier for sub-basin 6A. Refers to sub-basin A in major basin 6.
C44	Hydrograph identifier for concentration point 44. More than one hydrograph has been combined at this location. Point 44 is a physical location on the watershed which is labeled on Exhibit "C".
CP44E	The resultant hydrograph at concentration point 44 was split using the HEC-1 diversion operation. This defines the hydrograph diverted to the East Fork of Coyote Wash.
C38I	Hydrograph identifier for concentration point 38. The "I" symbolizes this is an inflow hydrograph to a reservoir route operation.
C84.1	Hydrograph identifier for concentration point 84. The "1" symbolizes this is an intermediate hydrograph for a wash immediately upstream of C84. This hydrograph will be combined with one or more intermediate hydrographs to produce hydrograph C84.
C850	Hydrograph identifier at concentration point 85. The "0" symbolizes this is an outflow hydrograph from a reservoir route.
R36-37	Hydrograph resultant from a normal depth channel route from concentration point 36 downstream to concentration point 37.
DT9IE	The hydrograph from sub-basin 9I was split using the HEC-1 diversion operation. This defines the hydrograph diverted to the East Ponding Area.
BC460	The outflow hydrograph from the reservoir route at concentration point 46 has been written to disk in the Tape 21 file using an HEC-1 BI operation. The hydrograph has been recalled from disk for continued use in the HEC-1 model.

TABLE F-1

Summary of Peak Discharges At Key Locations On The Watershed

HEC-1 Identifier	Description	Peak Discharge		Area (sm)
		6-Hour	24-Hour	
C44	Coyote Wash Upstream of Split	5,200	7,800	34.5
CP44W	Coyote Wash (West Fork) Downstream of Split	2,300	3,600	34.5
CP44E	Coyote Wash (East Fork) Downstream of Split	2,500	4,100	34.5
C119	Coyote Wash (West Fork) at 371st Avenue	900	1,500	36.4
C99	Daggs Wash at Hassayampa River	1,900	3,000	28.1
C12	Jackrabbit Wash at Deadhorse Wash	7,800	18,800	79.1
C33	Jackrabbit Wash at Vulture Mine Road	6,100	21,100	138.1
C34	Jackrabbit Wash at Wickenburg Road	5,600	20,000	140.3
R34-37	Jackrabbit Wash Upstream of Confluence with W.F.J.R.W.	5,500	19,700	140.3
C37	Jackrabbit Wash at W.F. Jackrabbit Wash	5,400	19,800	148.7
C38I.1	Jackrabbit Wash Upstream of Confluence with Star Wash	4,900	19,300	152.4
C38I	Jackrabbit Wash at CAP Canal CAP-5 (upstream)	7,500	33,200	319.2
C38I	Jackrabbit Wash at CAP Canal CAP-5 (downstream)	7,500	33,200	319.2
C94	Jackrabbit Wash at East Fork Coyote Wash	2,900	33,600	363.1
C98	Jackrabbit Wash at Hassayampa River	600	32,500	372.1
R36-37	Jackrabbit Wash (W.F.) Upstream of Confluence with J.R.W	2,300	2,900	8.4
6A	Jackrabbit Wash (West Fork) at Vulture Mine Road	2,800	3,000	3.7
C36	Jackrabbit Wash (West Fork) at Wickenburg Road	2,400	3,000	8.4
C84.1	Powerline Wash Upstream of Confluence with Star Wash	2,800	5,000	34.9
C84.2	Star Wash Upstream of Confluence with Powerline Wash	6,900	14,000	125.7
C84	Star Wash at Powerline Wash	7,100	17,600	160.6
C38I.2	Star Wash Upstream of Confluence with Jackrabbit Wash	5,400	17,300	166.8

TABLE F-3B

100-YEAR 24-HOUR RESULTS
IN NUMERIC ORDER BY TYPE

HEC-1 Identifier	Peak Discharge W/O Losses (cfs)	Peak Discharge W/ Losses (cfs)	Time To Peak (cfs)	Drainage Area (sq mi)	Discharge W/O Losses (cfs/sm)	Discharge W/ Losses (cfs/sm)
14A	134	134	12.00	0.1	1489	1489
14B	42	42	12.00	0.0	1400	1400
15A	1903	1903	12.33	3.6	530	530
15B	1517	1517	12.42	2.1	729	729
15C	817	817	12.17	1.8	446	446
15D	1364	1364	12.50	2.9	475	475
16A	1080	1080	12.42	1.9	557	557
17A	1570	1570	12.50	2.2	724	724
18A	117	117	12.08	0.3	468	468
18B	1662	1662	12.33	1.8	918	918
18C	1526	1526	12.50	1.9	803	803
18D	2518	2518	12.58	3.6	699	699
18E	2930	2930	12.50	3.8	765	765
18F	859	859	12.17	0.8	1074	1074
18G	1713	1713	12.50	2.0	844	844
18H	2413	2413	12.25	2.6	917	917
18I	2198	2198	12.42	2.6	855	855
18J	1992	1992	12.33	2.4	848	848
18K	898	898	12.08	0.8	1123	1123
18L	2119	2119	12.25	2.4	883	883
18M	1131	1131	12.58	1.5	754	754
18N	1655	1655	12.67	2.4	690	690
18O	877	877	12.25	0.9	974	974
18P	1206	1206	12.42	1.4	887	887
18Q	1248	1248	12.25	1.1	1104	1104
18R	1447	1447	12.75	2.2	667	667
18S	1327	1327	12.25	1.4	983	983
18T	269	269	12.08	0.4	690	690
19A	78	78	12.00	0.1	1300	1300
19B	829	829	12.08	0.8	1077	1077
C2	8964	8963	12.50	12.4	723	723

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APPENDIX TM3-10-4

EXISTING HYDROLOGY RESULTS

EXCERPTS FROM BUCKEYE/SUN VALLEY ADMS

Table 4-3
Hydrologic Responses for Various Storm Events (Peak Discharge and Time to Peak – Existing Condition)

Station	Area	10-YR 6-HR			10-YR 24-HR			100-YR 6-HR			100-YR 24-HR		
	$[mi^2]$	Peak [cfs]	T_p [hr]	Unit Discharge $[cfs/mi^2]$	Peak [cfs]	T_p [hr]	Unit Discharge $[cfs/mi^2]$	Peak [cfs]	T_p [hr]	Unit Discharge $[cfs/mi^2]$	Peak [cfs]	T_p [hr]	Unit Discharge $[cfs/mi^2]$
A	4.91	313	4.9	64	734	12.9	149	1,578	4.9	321	1,858	12.9	378
A1	1.11	515	4.3	464	490	12.3	441	1,193	4.3	1,075	1,104	12.3	995
A2A	0.48	192	4.8	400	135	12.8	281	422	4.7	879	325	12.7	677
A2B	1.18	343	4.7	291	341	12.7	289	919	4.7	779	824	12.6	698
A3	3.73	397	4.9	106	738	12.9	198	1,673	4.9	449	1,855	12.9	497
B	4.62	337	6.8	73	488	14.8	106	1,146	6.3	248	1,333	14.2	289
B1	0.6	241	4.6	402	178	12.6	297	523	4.6	872	416	12.6	693
B2	0.44	161	4.7	366	108	12.7	245	361	4.7	820	277	12.7	630
B2RB	2.19	581	4.7	265	720	12.7	329	1,644	4.6	751	1,704	12.6	778
B3	1.99	370	4.8	186	451	12.8	227	1,142	4.8	574	1,104	12.8	555
B3R	2.64	513	4.9	194	720	12.9	273	1,719	4.8	651	1,835	12.8	695
C	10.69	772	6.3	72	1,341	14.0	125	2,831	5.7	265	3,502	13.6	328
C1	3.64	965	4.8	265	1,154	12.8	317	2,185	4.8	600	2,307	12.8	634
C2	1.86	360	4.8	194	442	12.8	238	1,130	4.8	608	1,105	12.7	594
C3	3.79	358	5.3	94	602	13.2	159	1,411	5.2	372	1,507	13.2	398
C3R	5.51	859	5.3	156	1,197	13.2	217	2,494	5.1	453	2,721	13.1	494
C4	1.4	521	4.6	372	522	12.6	373	1,308	4.5	934	1,211	12.5	865
C4R	9.29	766	6.3	82	1,339	14.0	144	2,832	5.8	305	3,437	13.7	370
E	31.24	543	9.3	17	1,967	16.4	63	3,535	8.3	113	5,760	16.0	184
E1	0.96	385	4.5	401	349	12.5	364	894	4.5	931	790	12.5	823
E2A	0.8	290	4.8	363	243	12.8	304	680	4.7	850	572	12.7	715
E2B	0.47	207	4.7	440	151	12.6	321	450	4.6	957	352	12.6	749
E2C	0.72	278	4.7	386	224	12.7	311	658	4.6	914	541	12.6	751
E3	2.49	354	5.1	142	460	13.1	185	1,149	5.1	461	1,130	13.0	454
E3RB	1.42	387	4.9	273	380	12.9	268	1,053	4.8	742	958	12.8	675
E4	3.04	232	5.5	76	378	13.4	124	923	5.4	304	966	13.4	318
E4RA	5.42	414	6.3	76	746	14.0	138	1,978	5.7	365	2,205	13.6	407
E4RB	6.05	761	5.2	126	1,303	13.1	215	2,569	5.1	425	3,032	13.1	501
E5	1.31	251	4.9	192	259	12.9	198	713	4.9	544	645	12.9	492
E5R	16.98	594	7.1	35	1,652	14.8	97	3,330	6.7	196	4,827	14.6	284
E6	2.04	408	4.8	200	491	12.8	241	1,228	4.8	602	1,194	12.8	585
E6R	29.2	551	8.7	19	2,019	15.9	69	3,596	7.8	123	5,888	15.6	202
F1	3.1	702	4.8	226	882	12.8	285	1,773	4.8	572	1,868	12.8	603
F2	2.21	466	4.8	211	579	12.8	262	1,306	4.8	591	1,333	12.8	603
F3	0.74	176	4.8	238	137	12.8	185	454	4.8	614	375	12.8	507
F3R	5.31	815	4.8	153	1,357	12.8	256	2,573	4.8	485	3,030	12.8	571
G1	1.12	358	4.7	320	346	12.7	309	927	4.7	828	819	12.6	731
H1	1.07	141	4.8	132	134	12.8	125	497	4.8	464	472	12.8	441
H2	1.4	136	5.3	97	153	13.3	109	446	5.3	319	432	13.3	309