North Peoria Area Drainage Master Plan

NON F.I.S.

Technical Data Notebook

Book 1 of 2

January 2002

Prepared for the
Flood Control District
of Maricopa County

and the
City of Peoria

Project No. 82000146
Contract FCD 99-45

NORTH PEORIA AREA DRAINAGE MASTER PLAN

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Technical Data Notebook

Book 1 of 2

PREPARED FOR:

FLOOD CONTROL DISTRICT
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and
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EXECTUTIVE SUMMARY

At the request of the City of Peoria, the Flood Control District of Maricopa County (District), under the authority of Arizona Revised Statutes Title 48, Chapter 21, initiated the North Peoria Area Drainage Master Plan (North Peoria ADMP). The North Peoria ADMP is a regional approach to watershed management. The District prefers a regional approach to watershed and floodplain management because it enables the District to develop flood control strategies that are both sustainable and sensitive to the environment. This approach works to minimize the public cost of protecting citizens from flooding that may result from private and public development's cumulative effect on drainage characteristics. The North Peoria ADMP provides a uniform and coordinated approach to watershed management. A multi-faceted approach will ensure that present and future residents are protected from the damaging effects of flooding.

The North Peoria ADMP study area encompasses approximately 73 square miles within unincorporated Maricopa County and the City of Peoria. Numerous watersheds drain the area to the Agua Fria River. Major watercourses draining to the Agua Fria River are Morgan City Wash, nine unnamed washes, Caterpillar Tank Wash, and Twin Buttes Wash. Approximately 66 linear miles of watercourses are considered in the development of the North Peoria ADMP.

Within non-urbanized/rural watersheds natural environmental hazards associated with runoff from storm events exist. Without sufficient planning and management, natural hazards are compounded as development occurs within a watershed. In order to protect private and public property, natural environmental hazards and hazards created by urbanization are identified. Environmental hazards associated with storm runoff are categorized into flood hazards and erosion hazards. As part of the North Peoria ADMP, approximately 36 linear miles of new floodplain delineation and 54 miles of erosion hazard zone delineation was conducted.

The North Peoria ADMP provides a regional approach to flood control management. Development of flood control management alternatives and policies that forms the foundation of the plan takes into account engineering, environmental, landscape, social, and economic considerations. Watershed management alternatives are developed to mitigate/minimize the effect of urbanization on storm water runoff and conveyance while recognizing the values of the community and the opportunity to protect the unique characteristics of the region. The primary purpose for flood control management alternative development and evaluation is to develop a range of plans that provides public safety from flood and erosion hazards, determine the cost and benefits of each alternative, qualitatively determine impacts of the alternative on identified environmental resources, and select a preferred management plan.

Flood control management alternatives developed and evaluated for the North Peoria ADMP are categorized into two groups, watercourse based alternatives and storm water storage alternatives. Watercourse management alternatives evaluated included a non-structural, a partial structural, a low impact structural, a full structural and a no action. Storm water storage alternatives evaluated include the standard practice of retaining the volume of flow from the 100-year, 2-hour event, in stream, in-line detention alternative and an in-stream, off-line retention alternative Descriptions of the five watercourse management alternatives evaluated are:

- The full structural alternative is based on current federal, state and local floodplain management regulations that allow encroachment into the floodway fringe. The full structural alternative typically requires at a minimum, structural stabilization of wash side slopes for the entire reach.

- The partial structural alternative also is based on current floodplain management regulations, however the partial structural solution is applied at only specific locations along the watercourse.

- The low impact structural alternative allows for development activity to occur within the erosion hazard zone as long as the activity does not significantly alter the natural form and function of the watercourse.

- The non-structural alternative defines a corridor that allows the watercourse to function naturally.

- The no action (do nothing) alternative provides flood control management based on current federal, state, and local floodplain management regulations that allows encroachment into the floodway fringe. Typically, under current regulations encroachments into the floodway fringe are allowed on a piece meal fashion without taking into consideration the effect of the encroachment or collective encroachments on the entire watercourse.

Flood control management alternatives are evaluated on how well each alternative meets the goals of the North Peoria ADMP. The evaluations of the alternatives are based on weighted elements of four criteria. The criteria are Public Safety, Social Impacts, Environmental Impacts and Economic Impacts. Preferred alternatives selected for the plan are based on the overall score that an alternative receives in the evaluation process relative to the other alternatives evaluated.

The preferred watercourse based flood control management alternative recommended by the plan is the non-structural alternative. The non-structural alternative defines a corridor that allows the watercourse to function naturally and is defined by the 100-year floodplain, erosion hazard zone, and a buffer, if applicable, between human activity and a wash corridor. The plan recognizes that there may be situations in which development activities may be required or desired within the erosion hazard zone, for this situation the plan presents a low impact structural alternative. Channelization is not a preferred flood control management alternative, however the plan also recognizes that there may be situations in which channelization may be required. The preferred storm water storage alternative is the standard practice of retaining the volume from the 2-hour, 100-year rainfall event, however this practice may not be practical for certain portions of the study area. The standard retention practices if implemented within in an entire watershed would have negative impacts in regards to sustaining native vegetation along watercourses. The plan offers two

alternatives to the standard practice, they are, the in-stream, off-line retention and in-stream, in-line detention. The in-stream, off-line retention is the preferred alternative of the two.

Implementation of and guidance provide by the plan is based on a set of management goals, objectives, and policies for each of the four elements of the plan. The elements are Environmental Hazard Identification, Development and Planning Considerations, Environmental, and Multiple-Use Opportunities.

The North Peoria ADMP is one of the many tools that have been developed to guide growth and development in the study area so that impacts of urbanization on the environment are minimized. The focus of the North Peoria ADMP is on flood and erosion control management, however the plan takes into consideration the impacts of different flood control management alternatives on environmental, cultural, and visual resources and looks at multi-use opportunities. The intent of this plan is to work in conjunction with other planning documents and ordinances developed by the City of Peoria and Maricopa County. The plan is to be used by policy makers in the City of Peoria and Maricopa County, future residents, and developers when making decisions concerning development in the area.

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Unnamed Wash 1

Non-Structural Alternative

Partial Structural Alternative

Unnamed Wash 2

Non-Structural Alternative

Partial Structural Alternative

Unnamed Wash 3

Non-Structural Alternative

Partial Structural Alternative

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Caterpillar Tank Wash

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Whites Peak

East Garambullo

West Garambullo

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West Fork Whites Peak

Whites Peak

East Garambullo

West Garambullo

Updated HEC-RAS Model (Non-Structural Model)

Twin Buttes Wash

Caterpillar Tank Wash

West Fork Whites Peak

Whites Peak

East Garambullo

West Garambullo

Full Structural Alternative

Twin Buttes Wash

Caterpillar Tank Wash

West Fork Whites Peak

Whites Peak

East Garambullo

West Garambullo

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1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

At the request of the City of Peoria the Flood Control District of Maricopa County (District) under the authority of Arizona Revised Statutes Title 48, Chapter 21 initiated the North Peoria Area Drainage Master Plan (North Peoria ADMP). The study area considers approximately 73 square miles north of the alignment for Beardsley Road and west of the alignment of Lake Pleasant Road.

The North Peoria ADMP is a regional approach to watershed management. The District prefers a regional approach to watershed and floodplain management because it enables the District to develop flood control strategies that are both sustainable and sensitive to the environment. This approach works to minimize the public cost of protecting citizens from flooding that may result from private and public development's cumulative effect on drainage characteristics. The North Peoria ADMP provides a uniform and coordinated approach to watershed management. A multi-faceted approach will ensure that present and future residents are protected from the damaging effects of flooding.

Development of the North Peoria ADMP includes public coordination, survey and mapping, hydraulics, hydrology, sedimentation and geomorphic evaluations, environmental and visual resources overviews, identification of flood hazard, identification of erosion hazards, policies to help guide development and formulation of alternative drainage solutions.

1.2 PURPOSE OF REPORT

This report, the North Peoria Area Drainage Master Plan-Technical Data Notebook, documents hydrology and hydraulic data, assumptions, procedures and criteria used in conducting analyses, evaluations and overviews of the various tasks defined in the scope of work.

As part of the scope of work for the North Peoria ADMP, topographic field surveys, topographic mapping, floodplain/watershed hydrology and hydraulics, sedimentation and geomorphic evaluations, landscape character and visual assessment, recreational opportunities evaluations, plant communities and biological resources identification, cultural resources identification, historical character evaluation, environmental regulatory review, water quality assessment and investigation of existing policies were conducted. Brief summaries of the results of the various analyses, assessments and evaluations are present in following sections of this report. Reports generated for the various analyses, assessments and evaluations are provided as attachments to this report. The following is a list of Attachments:

- Attachment 1-Filed Survey Report
- Attachment 2-Hydrology and Hydraulics
- Attachment 3-Sedimentation Engineering and Geomorphic Evaluation Technical Memorandums
- Attachment 4-Landscape Character and Visual Assessment Report
- Attachment 5-Multi-Use Opportunities Assessment Report
- Attachment 6-Plant Communities and Biological Resources
- Attachment 7-Historic Character Assessment Report
- Attachment 8-Cultural Resources Assessment Report
- Attachment 9- Environmental Regulatory Records Review
- Attachment 10-Investigation of Existing Ordinances, Policies, Regulations and Standards Affecting Storm Water Drainage
- Attachment 11- Floodplain/Erosion Hazard Maps

1.3 DESCRIPTION OF STUDY AREA

The North Peoria ADMP study area encompasses approximately 73 square miles within unincorporated Maricopa County and the City of Peoria. Numerous watersheds drain the area to the Agua Fria River. Major watercourses draining to the Agua Fria River are Morgan City Wash, three unnamed washes, Caterpillar Tank Wash and Twin Buttes Wash. Figure 1-1 displays the location of the study area in relationship to Maricopa County and City of Peoria corporate boundaries. Figure 1-2 displays major watercourses that drain the study area to the Agua Fria River, specific planning areas delineated by unique physical characteristics, and photographs of some of the physical characteristic of the area.

Physical characteristics of watersheds vary throughout the study area. The Hieroglyphic Mountains underlie the central and northern portion of the study area and are characterized by a variety of peak, ridge, wash and valley landforms. Terrain slopes within the Hieroglyphic Mountains range from less than 10 percent to greater than 25 percent. Rock outcrop and rock fragments typify soil constituents within the Hieroglyphic Mountains. Within in the northern and central areas washes are typically incised within rock or well-cemented alluvial material. The eastern and southern areas are characterized with terrain slopes of less than 10 percent and are underlain typically by alluvial material. Sinuous natural channels that cut into alluvial material typify washes draining watersheds in the eastern and southern portions of the area. With the exception of the lower reach of Morgan City Wash, washes draining the study area watersheds are ephemeral. Springs deliver water to the lower reach of Morgan City Wash providing flow year around.

1.4 PROJECT GOALS

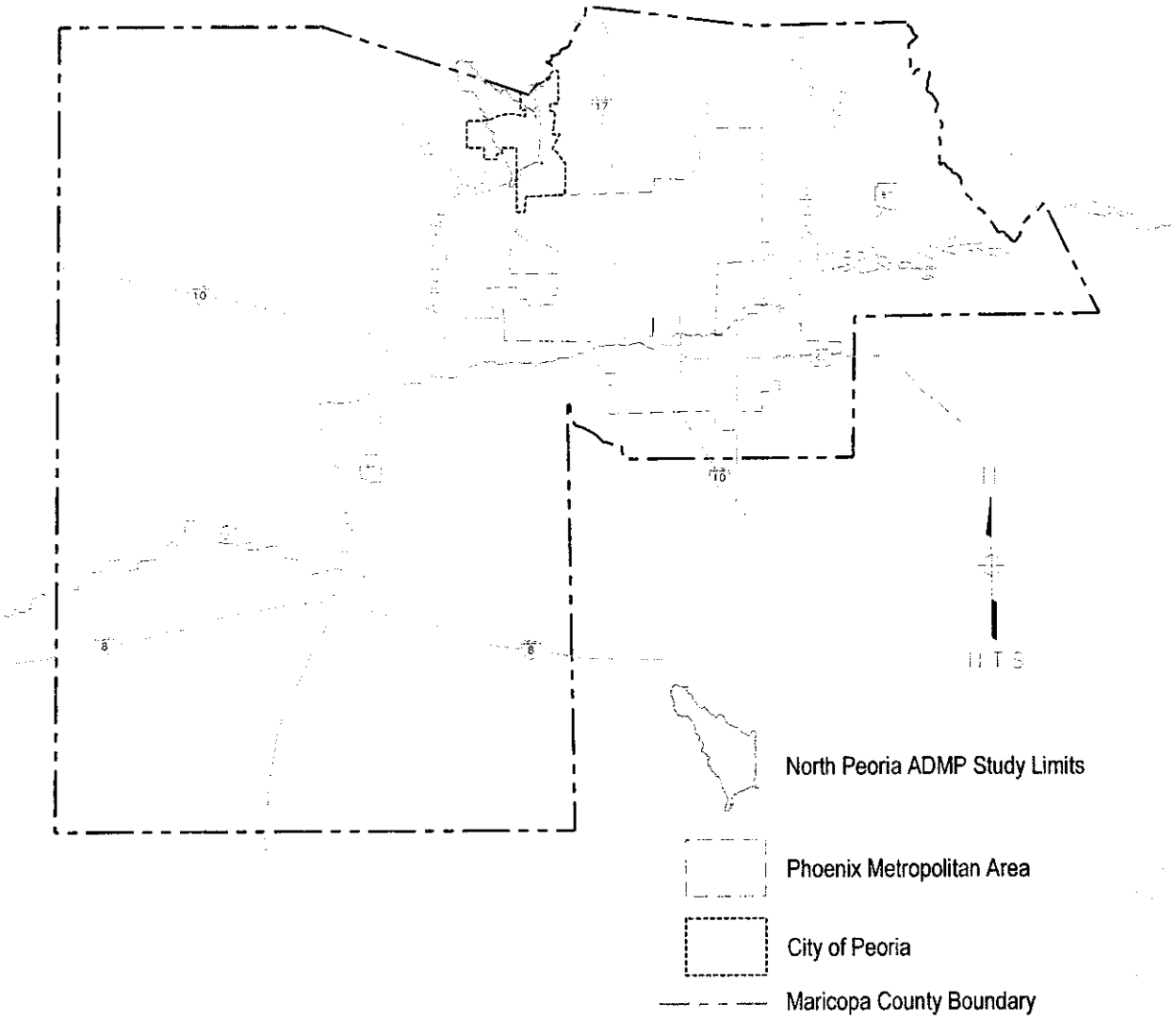
The major objective of this study is to identify sustainable non-structural flood control solutions for the study area. It is the object of the District to develop a comprehensive drainage plan, that when properly implemented will minimize or eliminate the need for structural flood control solutions following urbanization.

The North Peoria ADMP provides a regional approach to watershed management. It presents a holistic management approach in that watershed management solutions take into account environmental, landscape, social and economic considerations. Watershed management alternatives are developed to mitigate/minimize the effect of urbanization on storm water runoff and conveyance while recognizing the values of the community and the opportunity to protect the unique characteristics of the region. A holistic approach insures that public's safety and quality of life is maintained. Goals of the North Peoria ADMP are:

- Identify flood and erosion hazards along major watercourses.
- Develop policies and strategies to protect residents from flood and erosion hazards.
- Preserve the natural flood control function of the existing washes and channels.
- Incorporate public and private interests, issues and concerns.
- Minimize future expenditures of public funds for flood control and emergency management.
- Consider environmental and landscape characteristics of the watershed in the development of watershed management alternatives.
- Minimize disturbance of existing floodplain and floodway ecosystem and habitats.
- Consider multiple-use activities for floodplain areas.

Figure 1-1

Vicinity Map



NORTH PEORIA AREA DRAINAGE MASTER PLAN

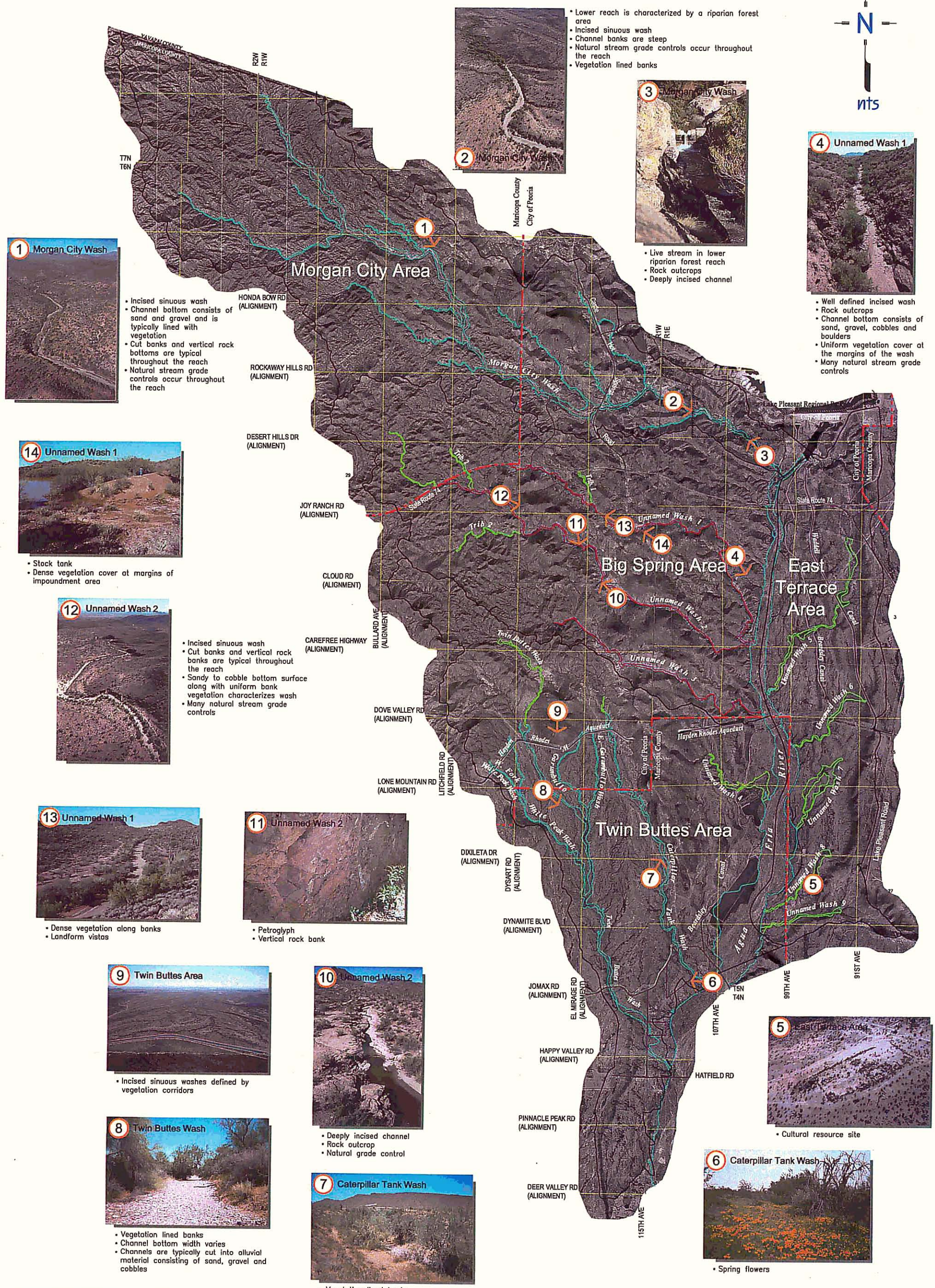


Figure 1-2
Vicinity & Physical Characteristics

1.5 ACKNOWLEDGEMENTS

The success of developing this document is attributed to the many individuals who contributed their professional expertise and shared belief that with appropriate planning, public safety and quality of life can be maintained for the citizens of Maricopa County and the City of Peoria. Our sincere appreciation is extended to the following governmental bodies, agencies, individuals and consultants for their help and perspective while developing the North Peoria Area Drainage Master Plan:

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Mike Eagan, Landscape Architect, DFD Architecture

Laura Patty, Visual Resources, DFD Architecture

Renee Chilton, Public Involvement, RH & Associates

2.0 DATA COLLECTION

Data relevant to the project such as previous hydraulics and hydrologic reports for floodplain delineation, existing topographic mapping, historical flooding information, as-built plans for existing structures, FEMA Flood Hazard Boundary Maps, floodplain delineation work maps, drainage reports and site plans for proposed development, drainage improvement plans; park, recreation, land-use, transportation, trails, and utility plans; general and area specific planning documents and drainage manuals were collected from various sources and reviewed.

In addition to historical or existing data, field surveys were conduct for topographic mapping, hydraulic analyses and planning tasks. Data collected for the North Peoria ADMP are categorized into one of the following categories: Survey, Mapping Reference Material, Existing Facilities and Existing Regulatory Criteria and Development Guidelines.

2.1 SURVEY

As part of the North Peoria ADMP field surveys were conducted to establish aerial mapping control points, to establish elevation reference markers and to provide ground cross-sections for approximate method floodplain delineation for areas that existing mapping was not available. Valco Surveying Corporation provided the horizontal and vertical control used for the detailed mapping. That data is documented in a separate report entitled North Peoria Area Drainage Master Plan, Attachment 1 Filed Survey Report. Also included in that report are descriptions of the elevation reference marks (ERM's) established for this study.

2.2 MAPPING

Topographic mapping utilized for the North Peoria ADMP was either obtained from a number of sources or developed as part of this study. The following summary lists topographic data utilized for this study:

- United States Geological Survey (USGS) 7.5 Minute Quadrangle Maps:

Baldy Mountain:	Revised in 1978, Published in 1983, 20-foot contour interval (CI), National Geodetic Vertical Datum (NGVD) of 1929.
Biscuit Flat:	1965 mapping from 1962 photography, photo revised 1981, 20-foot CI, NGVD of 1929.
Calderwood Butte:	Published 1972, 10-foot CI, NGVD of 1929.
Garfias Mountain:	1965 mapping from 1962 photography, photo revised 1978, 40-foot CI, NGVD of 1929.
Governors Peak:	1965 mapping from 1962 photography, photo revised 1978, 40-foot CI, NGVD of 1929.
Hedgepeth Hills:	Published 1972, 10-foot CI, NGVD of 1929
Hieroglyphic Mnts. SW:	Revised 1978, published 1982, 20-foot CI, NGVD of 1929.

- Detailed mapping prepared for the Agua Fria River Floodplain Delineation Study Re-Study, FCD 95-5, aerial photography flight date September 1987. Mapping scale is 1 inch = 400 feet with a contour interval of 4 feet.

- Detailed mapping prepared for the Flood Insurance Study for Caterpillar Tank and Twin Buttes Washes From Agua Fria to CAP Canal, Maricopa County, FCD 90-09, aerial photography flight date September 13, 1990. Mapping scale is 1 inch = 400 feet with a contour interval of 4 feet.

- Detailed mapping prepared for the Morgan City Wash Floodplain Delineation Study FCD 89-15, aerial mapping conducted in 1989. Mapping scale is 1 inch = 200 feet with a contour interval of 4 feet.

- Detailed mapping prepared for CMX from aerial photography ranging from 1993 to 1998 at a contour interval of 2 feet.

- Detail mapping prepared as part of this study for detailed hydraulic study reaches were prepared by Cooper Aerial Surveys Company (Cooper). The aerial photography flight date was 18 February 2000. The mapping was prepared at a scale of 1 inch = 400 feet with a contour interval of 2 feet. The horizontal and vertical datum's are NAD83 and NGVD29 respectively. The horizontal projection is Arizona State Plane, central zone.

2.3 REFERENCE DOCUMENTS

Reference material used in the study was obtained from the Flood Control District of Maricopa County, City of Peoria or Stantec's and subconsltant's reference libraries. Reference material is subcategorized into Reports, Manuals, Planning Documents, Improvement/Concept Plans and Construction Plans. The following reference material was utilized in the study:

2.3.1 Reports

AGK Engineers, Inc. (AGK), (1991). *Flood Insurance Study for Caterpillar Tank and Twin Buttes Washes From Agua Fria River to C.A.P. Canal Maricopa County, Arizona*, prepared for Flood Control District of Maricopa County (FCDMC).

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Governor's Riparian Habitat Task Force, October 1990, *Final Report and Recommendations of the Governor's Riparian Habitat Task Force, Executive Order 91-6*, submitted to the Honorable Rose Mofford, Governor of the State of Arizona.

Tetra Tech, Inc., March 2001, *Upper Cave Creek & Apache Wash Watercourse Master Plan-Attachment 8-Alternatives Analysis Report.*

Water Resources Research Center, University of Arizona, October 1999, Issue Paper #21, *Riparian Ecosystem Restoration in the Gila River Basin: Opportunities and Constraints*, Workshop Proceedings, April 8-9, 1999, Tucson, AZ.

2.3.2 Manuals/Guidelines

Arizona Department of Transportation, 1994, *Drainage Design Manual.*

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Chow, 1959, *Open Channel Hydraulics.*

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City of Tucson, Arizona, July 3, 1990, Ordinance 7579, Article VIII, Watercourse Amenities, Safety, and Habitat.

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Dodson & Associates Inc., April 1991, *ProHEC2, Users Manual.*

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Maricopa County, Arizona, August 4, 1986, *Flood Regulations for Maricopa County.*

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Thomsen, B.E., Hjalmarson, H.W., 1991, U.S. Department of the Interior, U.S. Geological Survey, *Estimating Manning's Roughness Coefficients for Stream Channels and Flood Plains in Maricopa County, Arizona.*

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2.3.3 Planning Documents

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City of Peoria, November 1999, *Lake Pleasant/North Peoria Area Plan.*

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Erie & Associates, Inc., October 29, 1999, *Saddleback Heights- Drainage Master Plan.*

Maricopa County, Arizona, 1997, Comprehensive Plan- *Maricopa County 2020, Eye to the Future.*

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Task Engineering Company, Inc., October 29, 1999, *Saddleback Heights Traffic Impact Study.*

2.3.4 Improvement/ Concept Plans

DMJM Arizona Inc., 5/4/98, *Lake Pleasant Christian Conference Center.*

Gilbertson Associates Inc., November 24, 1999, *Overall Site Plan, Quintero Golf and Country Club.*

Gilmore Graves Inc., October 20, 2000, *Preliminary Development Plan, State Lands 720.*

Hook Engineering, Inc., Undated, preliminary Site Plan, Tierra del Rio.

Lake Pleasant Group, September 8, 2000, *Preliminary Concept Plan, Lake Pleasant 244 Acres.*

LVA Urban Design Studio, 9/25/2000, *Development Master Plan, Saddleback Heights.*

LVA Urban Design Studio, 10/04/2000, *Development Master Plan, Lakeland Village.*

LVA Urban Design Studio, 10/05/2000, *General Development Plan, White Peak Ranch.*

2.3.5 Construction Drawings

United States Department of the Interior, Bureau of Reclamation, August 1978, *Granite Reef Aqueduct, Reach 9, Plan and Profile.*

United States Department of the Interior, Bureau of Reclamation, May 1984, *Waddell Canal, Plan and Profile.*

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2.4 EXISTING FACILITIES

As part of the North Peoria ADMP existing drainage facilities are identified. Drainage facilities consist of man-made facilities and natural washes. Man-made drainage facilities identified in the study area consist of culvert structures at wash crossings of roadways and irrigation canals and earthen dams. Earthen dams, typically located in watercourses, impound water for livestock. The locations of man-made facilities identified in the study area are presented in Figure 2-1. In addition to the location of man-made facilities, existing Effective Federal Emergency Management Agency (FEMA) floodplain delineation, and floodplain delineation developed as part of this study and irrigation canals are also presented on Plate 1.

2.5 EXISTING DRAINAGE REGULATIONS AND POLICIES

An investigation of potential drainage problems for the North Peoria Area ADMP study area that might occur if existing ordinances, policies, regulations, and criteria are not sufficient to mitigate potential flooding due to development was conducted as part of the North Peoria Area Drainage Master Plan. Ordinances, policies, regulations, and criteria from communities that have areas physically similar to the North Peoria ADMP study area, along with interviewing individuals from these communities, forms the basis of this investigation. Documents from Pima County, the City of Tucson, the City of Mesa, the City of Scottsdale, the City of Peoria, the City of Mesa and Maricopa County are used. Results of the investigation are presented in the report entitled North Peoria Area Drainage Master Plan Technical

Data Notebook, Attachment 9 Investigation of Existing Ordinances, Policies, Regulations and Standards Affecting Storm Water Drainage.

3.0 ENVIRONMENTAL OVERVIEW

3.1 INTRODUCTION

An environmental overview was conducted as part of the North Peoria ADMP. As part of the overview significant biological, archaeological and historic resources in the area are identified. In addition to the identification of significant resources, an environmental regulatory record review is conducted to identify location of known hazardous material sites. The overview also includes a listing of environmental permits and approvals required for the implementation of proposed structural improvements. The overview also includes a water quality element in which best management practices are presented as development guidelines.

The results of the environmental overview are used in the alternative analysis process to determine the effects of each alternative on environmental resources. The objective is to avoid and minimize impacts to environmental resources when feasible.

3.2 ECOLOGICAL ASSESSMENT

An ecological assessment was conducted as part of the North Peoria ADMP. Ecological resources including vegetation community, wildlife, sensitive species and critical habitat, and wetlands were identified and located. Results of the assessment are provided in the report entitled North Peoria Area Drainage Master Plan Technical Data Notebook, Attachment 6-Plant Communities and Biological Resources. The report address four topics related to biological resources within the project area: 1) describing and mapping vegetation communities to the association level, 2) overview the potential occurrence of sensitive, threatened, and endangered species, 3) assessing sensitive or special status habitats, and 4) discussing how changing the water flow regime within the washes could alter vegetation along the washes.

3.3 CULTURAL RESOURCES ANALYSIS

As part of the North Peoria ADMP, a cultural resource assessment (a Class I literature review) was conducted for the project area. This report presents the results of that

assessment. In summary, approximately 7,703 acres of the project area have been previously surveyed, out of an approximately 46,720 acres total. This computes to approximately 17 percent coverage of the project area, with 83 percent of the project area not surveyed. A total of 239 surveys were accomplished within the project area. A total of 325 archaeological sites were observed, with 278 of those prehistoric, 35 of those historic, and 12 of those multi-component sites.

The immediate goals of the cultural resource assessment were: to identify all known prehistoric and historic cultural resources within the project area; to identify historic land use within the project area; to assess the extent and adequacy of the project area's cultural resource survey coverage, and to develop prehistoric and historic character interpretive themes based on the research results.

The results of the assessment are formulated into a report entitled North Peoria Area Drainage Master Plan Technical Data Notebook, Attachment 8-Cultural Resources Assessment Report. This report includes a description of the specific findings of all the identified cultural resources within the project area, including there: location; site size; site type; site characteristics; and bibliographic reference

3.4 HISTORIC CHARACTER

At the request of the District, a comprehensive historic character evaluation was conducted as part of the North Peoria ADMP. The evaluation develops general descriptions of the prehistoric and historic time periods and the types of evidence found at sites within the project area associated with each of them. This is followed with specific examples or "type sites" for each period, which includes photos, drawings and maps to better illustrate what life was like during each particular time period, with emphasis on the historic landscape and humans adaptation to it. Results of the evaluation are presented in the report entitled North Peoria Area Drainage Master Plan Technical Data Notebook, Attachment 7-Historic Character Assessment Report.

3.5 ENVIRONMENTAL REGULARTORY RECORDS REVIEW

The Environmental Regulatory Records Review has been conducted in compliance with standards suggested by the American Society for Testing and Materials (ASTM) procedure E-1527-97. The purpose of the review is to identify and document the locations of any regulatory sites within or adjacent to the project area. Sites are briefly described with location, type of regulated substance or waste at the site, the extent of the contamination, the status of the site (closed or open), remediation plans for the site and the named potentially responsible party(s) if available.

A report has been prepared that includes a description of the project area, a review of regulatory agency records and databases, summary and recommendations, and is presented as North Peoria Area Drainage Master Plan Technical Data Notebook, Attachment 10-Environmental Regulatory Records Review.

3.6 ENVIRONMENTAL PERMITS AND APPROVALS

At a minimum, any construction occurring as a result of the ADMP will require the following:

Federal

NPDES Storm Water Permit. The Clean Water Act Amendments of 1987 require that certain types of storm water discharges be permitted under the National Pollutant Discharge Elimination System (NPDES). Construction activities that disturb more than five acres are included in this program. Submittal of a Notice of Intent (NOI) as well as development of a Storm Water Pollution Prevention Plan (SWPPP) is necessary.

Section 404 Permit. This section of the Clean Water Act requires the issuance of a permit for the discharge of dredged or fill material into waters of the United States. Specific categories of activity may qualify for Nationwide permits, however, the

maximum impact allowable under Nationwide permits is usually one-tenth of an acre. Projects causing more than this level of impact will require an Individual Permit.

Maricopa County

Floodplain Use Permit. Prior to constructing any addition or alteration to a building, structure, land or other use within a delineated flood plain, a Floodplain permit is required.

Earth Moving Permit. Any earth moving operation affecting more than .10 acre requires a permit from the County Control Officer. The permit applies to industrial, commercial and institutional uses and includes governmental agencies.

3.7 TITLE VI ENVIRONMENTAL JUSTICE ASSESSMENT

The general definition of Environmental Justice is the fair treatment of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no specific group of people should bear a disproportionate share of the negative environmental impacts of municipal, industrial or commercial operations or the execution of federal, state, local, and tribal programs and policies. Executive Order 12898 requires that federal actions assess impacts to low-income, Native American and minority populations. Specifically, the Order outlines the following responsibilities of federal agencies for federal actions:

> *Considerations of environmental justice are included to the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions....*

The potential proposed construction within the project area is minimal, even if a full structural alternative were chosen. The project area is largely uninhabited. Although large scale residential development is expected to occur in the future, there is no evidence that minorities would be unfairly impacted by the project. On the contrary, every individual that will be residing in the project area will benefit from the implementation of the proposed alternative

There is no indication that the location and operation of the proposed structures conflicts with the principals and goals of the concept of environmental justice.

3.8 STORM WATER QUALITY

3.8.1 Introduction

The purpose of this section is to present water quality issues and best management practices (BMP's) for maintaining water quality as related to the Environmental Protection Agency's (EPA) Phase II' National Pollutant Discharge Elimination System (NPDES) Storm Water Program that may be appropriate to the North Peoria ADMP study area. The Storm Water Phase II rule was published on December 8, 1999, and generally requires operators of small MS4s in urbanized areas to develop and implement a storm water management program, which addresses six minimum control measures. The Phase II Rule covers on a nationwide basis all small MS4s located in "urbanized areas" as defined by the Bureau of Census. The Bureau of Census defines an urbanized area as "An Urbanized area is a land area comprising one of more places- central place(s)- and the adjacent densely settled surrounding area- urban fringe- that together has a residential population of at least 50,000 and an overall population density of at least 1,000 people per square mile"(USA EPA December 1999).

Discussion concerning both non-structural and structural BMP's are presented, however the focus of this report is to present discussions concerning structural BMP's for post construction runoff control for residential and commercial developments and transportation facilities consistent with EPA Phase II storm water regulation. Potential BMP's derived from the EPA's, BMP's menu that may be applicable to the

North Peoria ADMP study area are compared to proposed flood control management alternatives to determine compatibility between BMP's and flood control management alternatives.

3.8.2 Issues

Storm water quality is becoming an integral element of storm water management. Urban runoff pollutants include metals and other contaminants from automobiles and household chemicals, pathogens from pet waste, nitrogen and phosphorus from fertilizers and chemicals, oxygen-demanding substances from sediment, petroleum hydrocarbons from solvents and automobiles, and synthetic organic from household cleaners and pesticides. Roads and parking lots provide a direct path for conveying pollutants into storm sewers and surface waters such as fertilizers and pesticides that are washed from landscapes and sediment that leaves construction sites. In addition, a high percentage of impervious material and low rate of infiltration in urban settings causes habitat modification and loss, increased flooding, decreased biological diversity and increased sedimentation and erosion. In order to in sure water quality and to minimize and manage pollutants form interning a storm drain or watercourse EPA's Phase II Rule defines six minimum control measures for MS4s, that when implemented will minimize discharge of pollutants to receiving waterbodies. Minimum control measures as presented in Storm Water Phase II Final Rule, Small MS4 Storm Water Program Overview (USA EPA, January 2000) are:

- ***Public Education and Outreach***

  Distributing educational materials and performing outreach to inform citizens about the impacts polluted storm water runoff discharges can have on water quality.

- ***Public Participation/Involvement***

  Providing opportunities for citizens to participate in program development and implementation, including effectively publicizing public hearings

and/or encouraging citizen representatives on a storm water management panel.

- ***Illicit Discharge Detection and Elimination***

  Developing and implementing a plan to detect and eliminate illicit discharges to the storm sewer system (includes developing a system map and informing the community about hazards associated with illegal discharges and improper disposal of waste).

- ***Construction Site Runoff Control***

  Developing, implementing, and enforcing an erosion and sediment control program for construction activities that disturb 1 or more acres of land (controls could include silt fences and temporary storm water detention ponds).

- ***Post-Construction Runoff Control***

  Developing, implementing, and enforcing a program to address discharges of post-construction storm water runoff from new development and redevelopment areas. Applicable controls could include preventative actions such as protecting sensitive areas (e.g., wetlands) or the use of structural BMPs such as grassed swales or porous pavement.

- ***Pollution Prevention/Good Housekeeping***

  Developing and implementing a program with the goal of preventing or reducing pollutant runoff from municipal operations. The program must include municipal staff training on pollution prevention measures and techniques (e.g., regular street sweeping, reduction in the use of pesticides or street salt, or frequent catch-basin cleaning).

EPA recommends that the minimum measures be implemented through the development of BMP's. BMP's are grouped into two categories, structural BMP's

and non-structural BMP's. Structural BMP's are facilities that function to remove pollutants from storm water either at the pollutant source or at the outfall to receiving waterbodies. Non-Structural BMP's includes a range of pollution prevention, education, institutional management and development practices.

As a requirement of Phase II Storm Water NPDES Regulations, the City of Peoria and Maricopa County must develop, implement, and enforce a program to address storm water runoff from new development and redevelopment projects that disturb greater than or equal to one acre. The program must ensure that controls are in place that prevent or minimize water quality impacts and the community must: (1) develop and implement strategies that include a combination of structural and/or non-structural BMPs, (2) use regulatory mechanism to address post-construction runoff from new development and redevelopment projects and (3) ensure long-term operation and maintenance of BMPs.

In addition, the community must define BMPs and set measurable goals for each BMP. EPA recommends that the BMPs chosen be appropriate for the local community; minimize water quality impacts; and attempt to maintain pre-development runoff conditions. In addition EPA recommends an approach that integrates the control of storm water peak flows and the protection of natural channels to sustain the physical and chemical properties of aquatic habitat.

3.8.3 Best management Practices

Storm water BMP's can be developed to meet the specific needs and environment of a community. An underlying BMP goal for new development is to develop BMP's so that the discharge rate, volume and pollutant loading of storm water runoff are the same as pre-development values. The EPA recommends that BMP's selection be based upon, flow control, pollutant removal and pollutant source reductions factors.

3.8.3.1 Flow control

Typically urbanization increases the amount of storm water runoff from watersheds. Increased flow rates can cause stream channel instability and associated degradation.

High velocities detach significant amounts of suspended solids and associated pollutants such as nutrients and metals from urban landscapes and erode stream banks and channels, which also increases suspended solid concentrations. For new development areas an effective method of controlling storm water quality is to limit the amount rainfall converted to runoff.

3.8.3.2 Pollutant Removal

Pollutants in storm water can be removed by a variety of mechanisms. Mechanisms include, sedimentation (particulate removal by gravitation settling), flotation (separation of particulate that float), filtration (removal of particulate through a porous medium), infiltration (removal of particulate through ground filtration), adsorption (removal of dissolved metals by bonding to clay particles), biological uptake (removal of nutrients by biological uptake), biological conversion (conversion of complex and/or toxic organic compounds into less harmful compounds by the action of aquatic microorganisms) and degradation (volatilization, hydrolysis and proteolysis of a variety of organic compounds..

3.8.3.3 Pollutant Source Reductions

Reduction of pollutants at the sources is an effective non-structural BMP. Pollutant source reductions is a management approach that prevents or removes pollutants from the urban landscape prior to rainfall.

3.8.4 Example of Best Management Practices

The most effective method of controlling impacts from storm water discharges is to limit the amount of rainfall that is converted to runoff. Site design techniques that incorporate onsite storage and infiltration and reduce the amount of impervious or directly connected impervious surfaces accomplish this. BMP's should be designed in consideration of the storm water quality storm. Runoff from the storm water quality storm (or first flush) is the initial storm water runoff from an area that contains the majority of pollutants. Potential BMP's that a community may use as part of their plan include:

- Detention Basin. Detention basins temporarily detain a portion of storm water runoff a short period of time. A controlled orifice typically regulates outflow. The function of a detention basin to remove pollutants of potential water quality concern can be limited. Providing an element that would retain the volume of flow from the water quality storm event (first flush) could enhance removal of pollutants in a detention basin.

- Retention Basin. Retention basins stores storm water until it percolates into the ground or evaporates. Retention basins provide both water quantity and quality control. Water quality is provided primarily through sedimentation and infiltration mechanisms.

- Constructed Wetlands. Constructed wetlands are permanent pools, which support plant species. Pollutants are removed through biological uptake, infiltration and sedimentation. Biological uptake requires that the vegetation is periodically harvested to remove nutrients taken up by the vegetation.

- Infiltration Trench. An infiltration trench is a shallow excavated trench, which is backfilled with stone, allowing for infiltration and percolation.

- Porous Pavement. Porous Pavement is an alternative to conventional pavement. Finer asphalt materials, pavers, or alternative materials allow infiltration into the subsoil. The application of porous pavement as a BMP is limited to areas that are not exposed to high volumes of traffic and heavy equipment or areas exposed to high sediment yield rates. Porous pavement requires periodic maintenance to remove sediment from pores.

- Sand Filter. Runoff from the water quality storm event may be diverted and contained within a sand filter. The runoff is filtered through the sand and return to the runoff conveyance system. Other media, such as peat or compost can also be utilized.

- Bioretention. Bioretention is retention in landscape areas (water harvesting). Bioretention is a variation of a sand filter where the sand is replaced with plant bedding material. Storm water flow infiltrates through the bedding material and pollutants are removed by a number of mechanisms including sedimentation, infiltration, biological uptake and adsorption (depending of the presence of clay material). Designed for the water quality storm, this BMP is well suited to parking lots

- Grass Swales. Grass swales are linear features with flat slopes. Slow velocities allow filtering of pollutants. This BMP is good for highways because of its linear nature. Grass swales are designed for peak flows rather than volume like detention/retention basins.

- Grass Filter Strips. Grass filter strips are densely vegetated sections of land designed to accept sheet flow runoff from parking lots, highways and rooftops. Pollutants are primarily removed by infiltration and biological uptake.

- Vegetated Buffers. Vegetated buffers are natural areas retained along washes. Research has shown that increasing buffer width and condition tends to keep streams healthier. A minimum width of 50 –100 ft is recommended.

- Manufactured Products. A variety of manufactured products/catch basin treatments are available. These items are designed to treat an array of pollutants.

3.8.5 Conclusions

BMP's integrated into landscaping areas such as bioretention and vegetated swales and dual use detention/retention basins and naturally vegetated buffer systems along streams, utilized in conjunction with development policies which minimize

impervious cover, are effective methods to address storm water quality in the North Peoria ADMP study area.

Flood control management alternatives developed for the North Peoria ADMP included non-structural, low impact structural, partial structural and full structural alternatives for watercourses and retention and detention alternatives for storm water storage. The compatibility of a flood control management alternative and BMP's is related to the function of the alternative to remove pollutants from storm water. Structural alternatives for watercourses tend to reduce floodplain widths, remove natural vegetation and increases flow velocity, ultimately reducing opportunities for sedimentation and infiltration mechanisms to reduce pollutant loading. The greater the amount of structural improvements constructed along a watercourse relates to fewer opportunities for natural pollutant reduction mechanisms to function. Storm water storage facilities offer the best opportunities for managing water quality with a retention facility offering the greatest opportunities. Detention facilitates typically do not detain the first flush from a storm event sufficiently for pollutant reduction mechanisms to be effective, however pollutant reduction opportunities could be incorporated into a design of a detention basin by providing an element that captures and treats the first flush. Inline detention basin scenarios (detention basin within a watercourse) or retention basins located adjacent to a watercourses that functions to reduce peak flow rates would have minimal impact on managing water quality in watersheds in which there is a high density land use, such as commercial, industrial, high density residential or residential.

3.8.6 References

Wyoming Department of Environmental Quality, Water Quality Division, February 1999. Draft Urban Best Management Practices for Nonpoint Source Pollution. Point and Nonpoint Source Program,

Massachusetts Department of Fisheries, Wildlife and Environmental Law Enforcement, June 4, 1997. Fact Sheet #8: Functions of Riparian Areas for Pollution Prevention.

U.S. Environmental Protection Agency, August 1999. Preliminary Data Summary of Urban Storm Water Best Management Practices.

U.S. Environmental Protection Agency, January 1999. Storm Water Phase II Final Rule, Urbanized Areas: Definition and Description.

U.S. Environmental Protection Agency, January 2000. Storm Water Phase II Final Rule, Small MS4 Storm Water Program Overview.

U.S. Environmental Protection Agency, last modified 5/31/2001. Post-Construction Storm Water Management in New Development and Redevelopment Fact Sheet, EPA, Office of Water.

4.0 LANDSCAPE CHARACTER AND VISUAL RESOURCES

4.1 GENERAL

The goals of the Landscape Character and Visual Assessment evaluations conducted as part of the North Peoria ADMP are to 1) assess the Scenic Qualities of the existing natural and cultural features; 2) assess the existing visual conditions or scenic integrity and secondly, consider what areas might be appropriate for restoration; 3) identify existing major viewing points and landmarks with the intent that they be focal points for possible flood control projects; 4) identify areas to be considered for preservation and opportunities for scenic enhancement; 5) develop landscape character themes (including existing, future and historic) that could be incorporated into the design of watershed management alternatives, and 6) develop landscape design guidelines that will achieve the desired character theme(s) as they apply to desired flood control measures. Results of the assessments are presented in a report entitled North Peoria Area Drainage Master Plan Technical Data Notebook, Attachment 4-Landscape Character and Visual Assessment Report.

5.0 MULTI-USE OPPORTUNITIES

5.1 GENERAL

As part of the North Peoria ADMP, an assessment of the opportunities and limitations for integrating multiple-use functions into the project was conducted. The purpose of this assessment is to serve as a basis for the formulation of alternatives that will fully provide flood control functions while maximizing opportunities to meet local community needs for recreation, open space, protection and enhancement of natural landscape and local community character and alternative forms of transportation. The results of the assessment are presented in the report entitled North Peoria Area Drainage Master Plan Technical Data Notebook, Attachment 5-Multiple-Use Opportunities Assessment Report.

6.0 LAND OWNERSHIP

6.1 GENERAL

Land ownership for the project area was determined from a land ownership database provided by the District. The database, 1999 vintage, is developed from assessor parcel ownership maps. Land ownership categories and locations of Private, State of Arizona, Federal (USA), Maricopa County and the City of Peoria identified in the study area are displayed on Figure 6-1 along with existing FEMA floodplains and floodplains delineated as part of this study. The land ownership database was utilized to identify landowners to request their input to the project, to invite landowners to public workshops and to notify landowners of the results of the floodplain delineation conducted as part of the project.

NORTH PEORIA AREA DRAINAGE MASTER PLAN

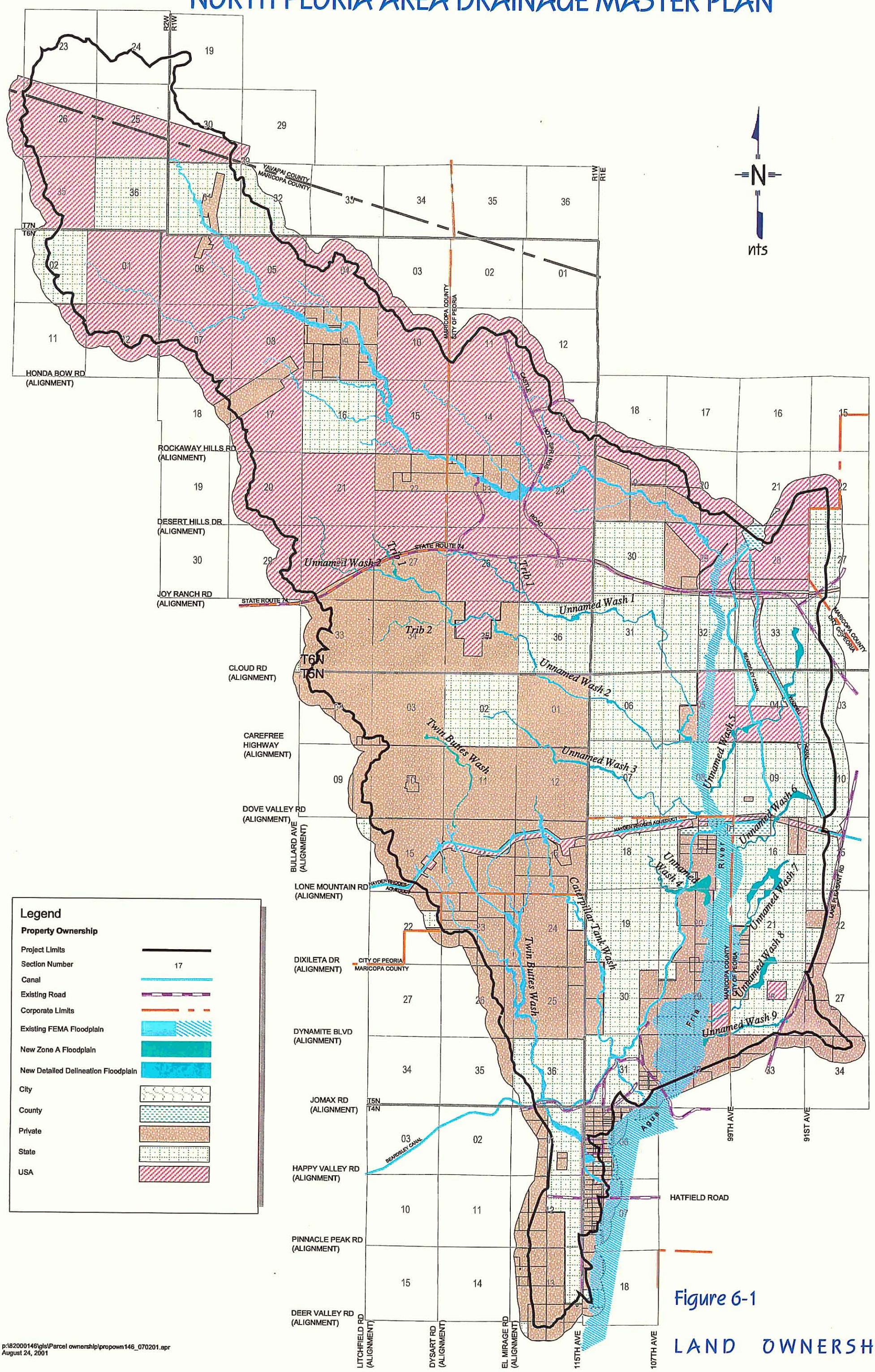


Figure 6-1

LAND OWNERSHIP

p:\82000146\gis\Parcel ownership\propown146_070201.apr
August 24, 2001

7.0 HYDROLOGY

7.1 GENERAL

Watershed hydrologic modeling is conducted in accordance with the methodologies set forth in the Drainage Design Manual for Maricopa County, Volume I, Hydrology, (Flood Control District of Maricopa County, 1995). Modeling is performed for both existing and future watershed conditions for multiple storm frequencies. The analytical methods employed for these studies are the Rational Method and rainfall-runoff modeling. Rainfall-runoff modeling is accomplished using the US Army Corps of Engineers (COE) HEC-1 Computer Program, version 4.1, dated June 1998. Both the 6- and 24-hour duration storms are modeled for each frequency (2-, 5-, 10-, 25-, 50- and 100-year) for both existing and future watershed conditions. Two storm durations are used in order to determine which storm results in the higher magnitude of peak discharge and runoff volumes at the various locations in the watershed. The rainfall depth-duration-frequency statistics for both the 6- and 24-hour storm durations are obtained from the NOAA Atlas II, Arizona. The rainfall distributions used are the SCS Type II for the 24-hour storm and the 6-hour storm patterns suggested in the Design Manual. Rainfall losses are estimated using the Green and Ampt infiltration equation with additional consideration for surface retention losses and impervious areas. The Clark Unit Hydrograph is used for runoff hydrograph development for all subbasins in the watershed. Runoff hydrographs are routed through the watershed using Modified Puls channel storage routing. Storage routing at crossings of existing structures is accomplished using the Modified Puls reservoir routing option of HEC-1. Retention of the increased runoff due to future watershed conditions is based on the 100-year, 2-hour rainfall depth.

The Rational Method relates the rainfall intensity, a runoff coefficient and drainage area to generate a peak discharge. The rainfall intensity is estimated using the rainfall intensity-duration-frequency relation in the Design Manual. Selection of the runoff coefficient is based on the existing condition land use for the 100-year storm.

The purpose of the hydrologic analysis is to estimate peak discharges for each storm event for both existing and future watershed conditions at key flow concentration locations in the watershed. In general, those locations are:

- Major wash confluence's and major culvert crossings of existing facilities.
- Beginning and ending points in addition to intermediate points of washes designated for floodplain delineation, and
- Sufficient locations along the washes for the determination of flooding hazard.

The computed peak discharges, volumes, and/or hydrographs are used in hydraulic and hydrologic analyses conducted for this study. Analyses utilizing the hydrologic models and results of the hydrologic models conducted as part of the North Peoria Area Drainage Master Plan are:

- Delineation of 100-year floodplain at selected locations.
- Sedimentation engineering and geomorphic analyses.
- Hydraulic evaluation of alternatives that propose encroachment into the 100-year floodplain.
- Hydraulic evaluation of detention and retention alternatives.
- Estimation of ponding limits upstream of wash crossings of canals.

Methodologies and assumptions used to develop the base existing and future condition hydrologic models developed for the study area and the results of the models are presented in the report entitled North Peoria Area Drainage Master Plan Technical Data Notebook, Attachment 2-Hydrology and Hydraulics.

8.0 FLOODPLAIN HYDRAULICS

8.1 GENERAL

Floodplain hydraulic analyses are performed in accordance with the guidelines and specifications set forth in FEMA 37, Flood Insurance Study Guidelines and Specifications for Study Contractors and State Standard SS 2-91, Requirement for Floodplain Delineation in Riverine Environments. Detailed floodplain and floodway limits are determined for three separate unnamed watercourses totaling approximately 18 miles. The flooding limits for these watercourses are determined using the COE HEC-RAS Computer Program, version 3.0, dated January 2001. Approximate method floodplains are determined for several unnamed watercourses totaling approximately 18 miles. The flooding limits for these watercourses are based on a normal depth analysis using the Manning's equation.

Methodologies and assumptions used to develop the hydraulic models for the delineation of floodplains developed for the study area and the results of the models are presented in the report entitled North Peoria Area Drainage Master Plan Technical Data Notebook, Attachment 2-Hydrology and Hydraulics. Hydraulic analyses conducted to model proposed alternatives are presented and discussed in the Alternatives Formulation Section of this report.

9.0 SEDIMETATION ENGINEERING AND GEOMORPHIC EVALUATIONS

9.1 GENERAL

The primary objective of the sedimentation engineering and geomorphic evaluation is to provide a qualitative assessment of potential erosion and scour within the drainage network of the North Peoria ADMP project area. The evaluations conducted focused on the following:

- Identification of stream reaches that have experienced historical and/or recent long term degradation or aggradation.
- Identification of stream reaches that have experienced historical and/or recent lateral instability or stability.
- Identification of stream reaches with existing sedimentation problems, such as at bridges, dip crossings, or existing structures.
- Identification of historical and recent stream responses to development in the watershed and along watercourses.
- Identification of points of natural grade control.
- Identification existing sediment sources in the watershed.
- Delineation erosion hazard zones for selected watercourses.
- Estimation of existing and future sediment yields for the study area.
- Assessment of sedimentation and geomorphic impacts on channel stability from, sand and gravel mining in the Agua Fria River on its tributaries within the project area; floodplain encroachment;

channelization with engineering bank protection; roadway crossings; retention/detention alternatives and utility crossings.

- Development of best management practice recommendations for management of sediment and scour at drainage crossings and other structural features.

- Development of low-impact structural alternatives based on managing a watercourse by allowing development to occur within the erosion hazard zone but out of the 100-year floodplain.

Methodologies and assumptions used in the sedimentation engineering and geomorphic evaluations and the results of the evaluations are presented in the report entitled North Peoria Area Drainage Master Plan Technical Data Notebook, Attachment 3-Sedimentation Engineering and Geomorphic Evaluation Technical Memorandums.

10.0 ENVIROMETAL HAZARDS DELINEATION

10.1 GENERAL

Floodplain delineation and erosion hazard zones form the basis for the identification of natural environmental hazards within the study area. Floodplain delineations used in this study are from a number of sources, whereas erosion hazard zones are developed as part of this study. Table 10-1 lists a summary of floodplain delineation studies and erosion hazard zones utilized for each planning area in this study. Table 10-1 also lists the figure number where the item may be viewed.

Table 10-1

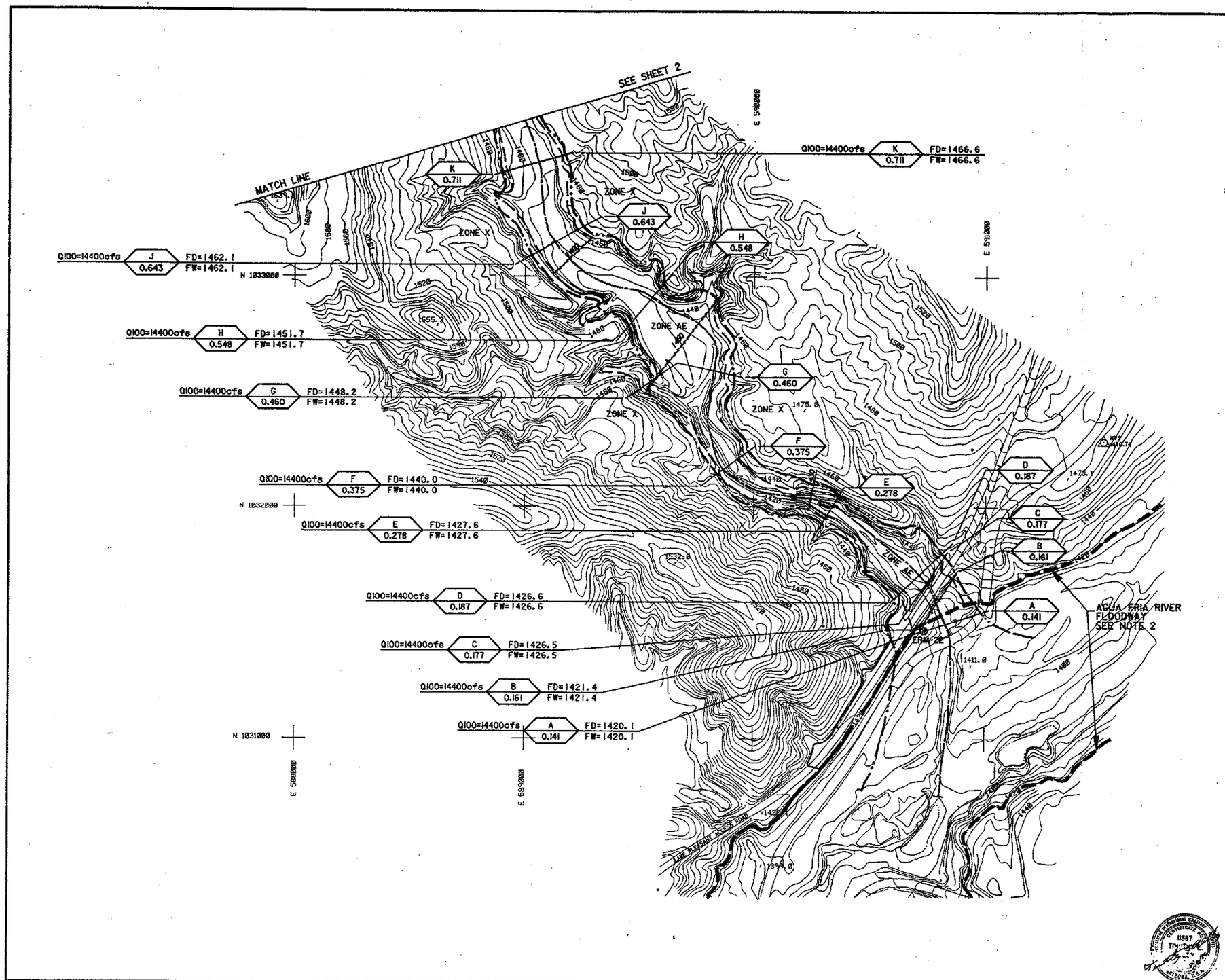
Floodplain Erosion Hazard Map Summary

Planning Area	Floodplain	Erosion Hazard	Figure Number	Remarks
Morgan City Area	Morgan City Wash detail floodplain delineation conducted under FCD Contract 89-15	Conducted under FCD Contract 99-45	Figure 10-1, Sheets 1 through 12	Erosion hazard zones are mapped on copies of original Mylar's. Maps are scanned and reduced to fit an 11" X 17" size paper. Full size maps (24"X 36") are provide as Attachment 11
Big Springs Area	Detail Hydraulic Analysis for Unnamed Washes 1, under FCD Contract 99-45	Conducted under FCD Contract 99-45	Figure 10-2, Sheets 1 through 6	Erosion hazard zones and floodplain delineation are displayed on a photo base (date) obtained from the District. Full size maps (24"X 36") are provide as Attachment 11. Full size maps reduced to fit 11" X 17" paper are provided as figures.
Big Springs Area	Detail Hydraulic Analysis for Unnamed Wash 2, under FCD Contract 99-45	Conducted under FCD Contract 99-45	Figure 10-3, Sheets 1 through 6	Erosion hazard zones and floodplain delineation are displayed on a photo base (date) obtained from the District. Full size maps (24"X 36") are provide as Attachment 11. Full size maps reduced to fit 11" X 17" paper are provided as figures.

Table 10-1 Cont.

Floodplain Erosion Hazard Map Summary

Planning Area	Floodplain	Erosion Hazard	Figure Number	Remarks
Big Springs Area	Detail Hydraulic Analysis for Unnamed Wash 3. under FCD Contract 99-45	Conducted under FCD Contract 99-45	Figure 10-4, Sheets 1 through 4	Erosion hazard zones and floodplain delineation are displayed on a photo base (date) obtained from the District. Full size maps (24"X 36 ") are provide as Attachment 11. Full size maps reduced to fit 11" X 17" paper are provided as figures.
Big Springs Area	Approximate method delineation of tributaries to Unnamed Wash 1 and 2 and the upper reach of Unnamed Wash 2 conducted under FCD Contract 99-45.	Conducted under FCD Contract 99-45	Figure 10-5, Sheets 1 through 4	Erosion hazard zones and floodplain delineation are displayed on a photo base (date) obtained from the District. Full size maps (24"X 36") are provide as Attachment 11. Full size maps reduced to fit 11" X 17" paper are provided as figures.
Twin Buttes Area	Detail Delineation of Twin Buttes Wash, Caterpillar Tank Wash , West For Whites Peak Wash, Whites Peak Wash, East Garambullo Wash and West Garambulow Wash conducted under FCD Contract 90-09 and approximate method study for the upper reaches of Twin Buttes Wash, Caterpillar Tank Wash and Unnamed wash 4 conducted under FCD Contract 99-45	Conducted under FCD Contract 99-45	Figure 10-6, Sheets 1 through 16	Digital files of floodplain boundaries obtained from the District and Erosion Hazard Zones are displayed on aerial photo base (date) obtained from the District. Floodplain delineation has been adjusted to be consistent with work maps and is considered approximate. Full size maps (24"X 36") are provide as Attachment 11. Full size maps reduced to fit 11" X 17" paper are provided as figures.



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FLOOD DELINEATION STUDY OF MORGAN CITY WASH

LEGEND

- Erosion Hazard Boundary
- 100-Yr. Floodplain Boundary
- Floodway Boundary
- Hydraulic Base Line With River Mile — M4.0 M5.0
- Cross Section — Q100=10000cfs, B 1200, FD = 100yr. WSE, FW = FLOODWAY WSE, B 1200
- Elevation Reference Marks — ERM-4
- Base Flood Elevations — 2180
- Zone Designations — ZONE AE

ELEVATION REFERENCE MARKS

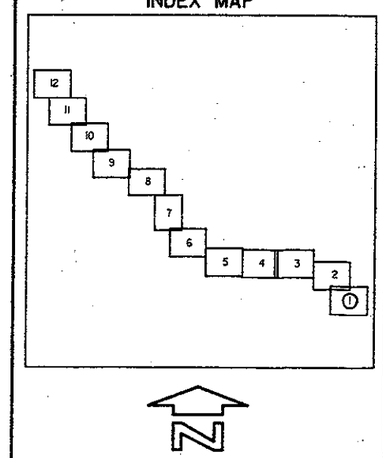
NOTE: All Elevation Are Based On National Geodetic Vertical Datum Of 1927

I.D. NUMBER	ELEVATION (FT.)	DESCRIPTION/LOCATION
ERM-22	1412.28	A 5/8" REBAR SET IN CONCRETE APPROX. 105FT. SOUTH OF CENTERLINE OF MORGAN CITY WASH, AND APPROX. 50FT EAST OF CENTERLINE OF NEW WADDELL DAM ROAD, AND AT THE SOUTHEAST CORNER OF NEW WADDELL DAM ROAD BRIDGE MARKED ERM#22

NOTES:

1. CROSS SECTION STATION 10,000.0 IS HYDRAULIC BASE LINE EXCEPT AS NOTED
2. AGUA FRIA RIVER FLOODWAY PER FLOOD INSURANCE STUDY, MARICOPA COUNTY, ARIZONA AND UNINCORPORATED AREAS, FEDERAL EMERGENCY MANEGEMMENT AGENCY, EFFECTIVE DATE APRIL 15, 1988 PERFORMED BY : JERRY R. JONES ASSO. INC. UNDER JOB NO. 286-080.01

INDEX MAP



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	BY	DATE		DATE	SHEET
Design	B.R. Jolly P.E.	8-16-90	SUBMITTED BY		1
Design Chk.	T.E. Kelly P.E.	8-16-90	RECOMMENDED BY		
Plans	S.S Obertello	8-16-90	APPROVED BY		OF 12
Plans Chk.	B.R. Jolly P.E.	8-16-90	CHIEF ENGINEER AND GENERAL MANAGER		

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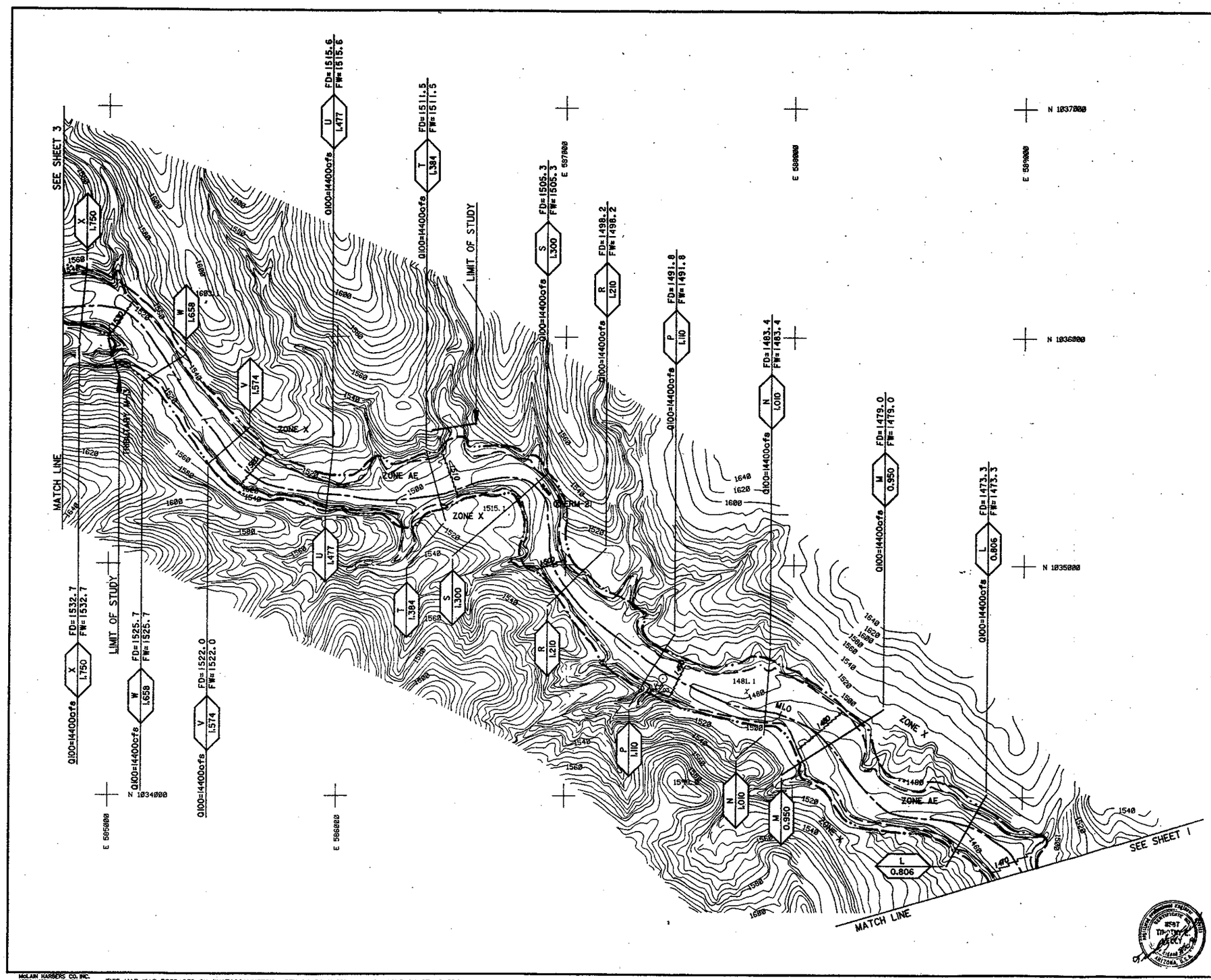


FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FLOOD DELINEATION STUDY OF MORGAN CITY WASH

LEGEND

Erosion Hazard Boundary
100-Yr. Floodplain Boundary
Floodway Boundary
Hydraulic Base Line With River Mile — M4.0 M5.0
Cross Section — Q100=XXXcfs; FD = 100-yr. WSE; FW = FLOODWAY WSE
Elevation Reference Marks — ERM-4
Base Flood Elevations — 2180
Zone Designations — ZONE AE

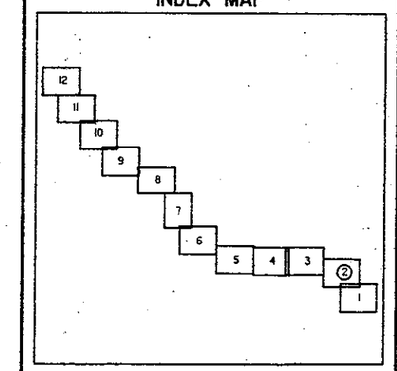
ELEVATION REFERENCE MARKS

NOTE: All Elevation Are Based On National Geodetic Vertical Datum Of 1927

I.D. NUMBER	ELEVATION (FT.)	DESCRIPTION/LOCATION
ERM-21	1497.435	BEGINNING AT POINT MORGAN EAST THENCE 0.08 MI. SE. IN MORGAN CITY WASH TO ERM#21 A 5/8" REBAR SET IN CONCRETE APPROX. 37 FT. NE. OF CENTERLINE OF MORGAN CITY WASH AT NORTHERN EDGE OF BEND IN WASH, AND AT TOE DIRT EMBANKMENT BY ROCK WALL MARKED - ERM#21

NOTE:
CROSS SECTION STATION 10,000.0 IS HYDRAULIC BASE LINE EXCEPT AS NOTED

INDEX MAP



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CONTOUR INTERVAL = 4' FEET

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Plans	S.S Obertello	8-16-90	APPROVED BY	DATE
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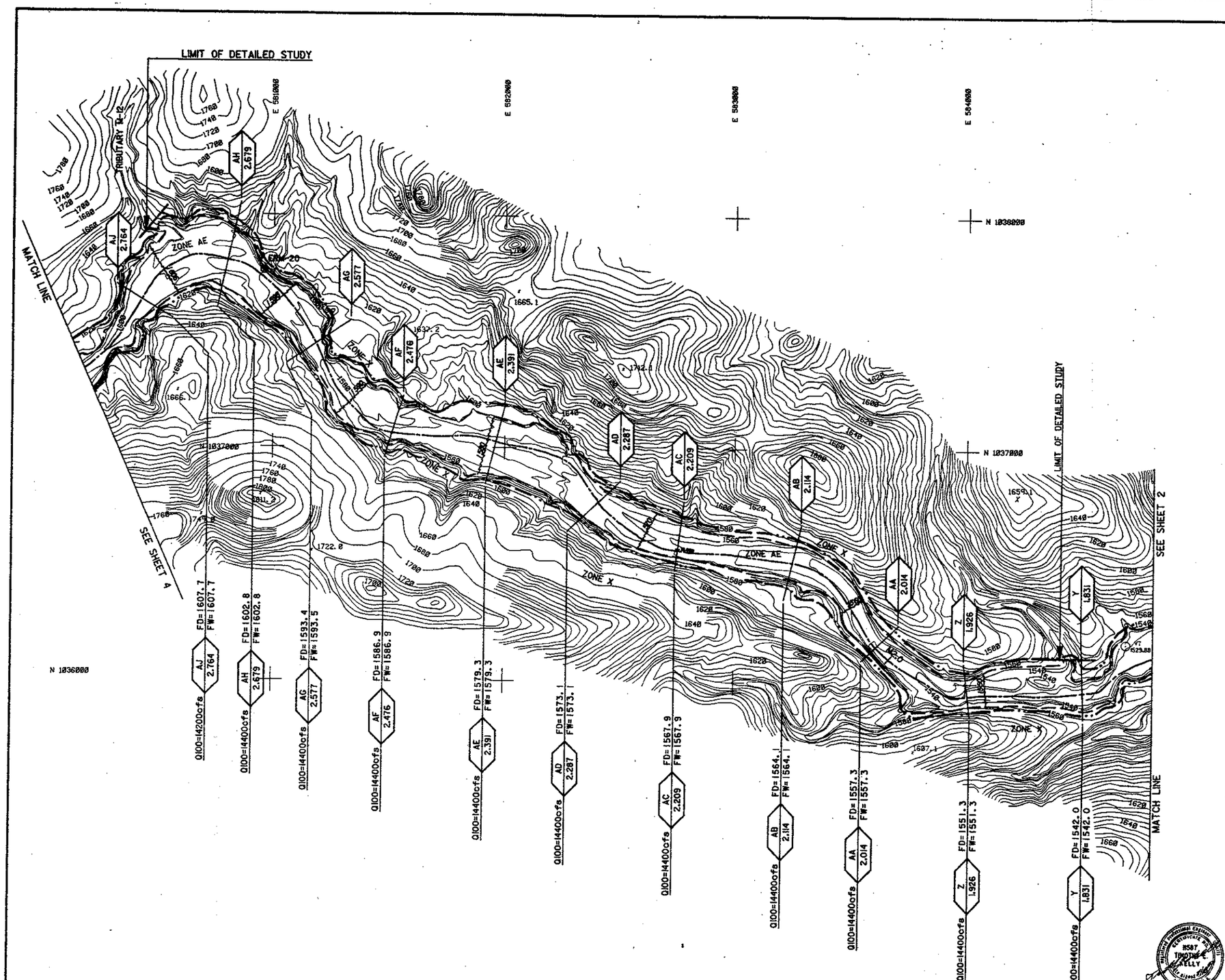


FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FLOOD DELINEATION STUDY OF MORGAN CITY WASH

LEGEND

- Erosion Hazard Boundary
- 100-Yr. Floodplain Boundary
- Floodway Boundary
- Hydraulic Base Line With River Mile — M4.0 M5.0
- Cross Section — 100+XX/XX/Q=Q; FD = 100yr. WSE; FW = FLOODWAY WSE; LOC
- Elevation Reference Marks — ERM-4
- Base Flood Elevations — 2180
- Zone Designations — ZONE AE

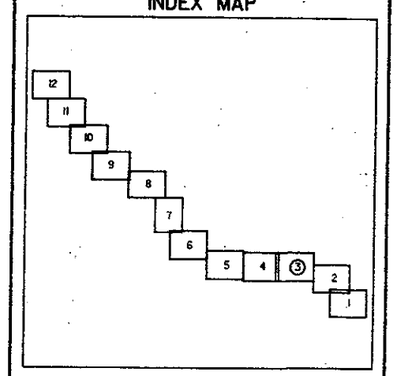
ELEVATION REFERENCE MARKS

NOTE: All Elevation Are Based On National Geodetic Vertical Datum Of 1927

I.D. NUMBER	ELEVATION (FT.)	DESCRIPTION/LOCATION
ERM-20	1590.715	BEGINING AT POINT MORGAN EAST THENCE 1.44 MI. NW IN MORGAN CITY WASH TO ERM#20, A5/8" REBAR SET IN CONCRETE APPROX 26 FT. NE. OF CENTERLINE OF NORTHERN FORK OF MORGAN CITY WASH, AND NEAR NE. JUNCTION OF CHALKY SPRING AT NORTH FORK OF MORGAN CITY WASH MARKED "ERM-20"

NOTE:
CROSS SECTION STATION 10,000.0 IS HYDRAULIC BASE LINE EXCEPT AS NOTED

INDEX MAP



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CONTOUR INTERVAL = 4' FEET

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Design Chk.	T.E. Kelly P.E.	8-16-90	RECOMMENDED BY	DATE	
Plans	S.S Obertello	8-16-90	APPROVED BY	DATE	
Plans Chk.	B.R. Jolly P.E.	8-16-90	CHIEF ENGINEER AND GENERAL MANAGER		OF 12

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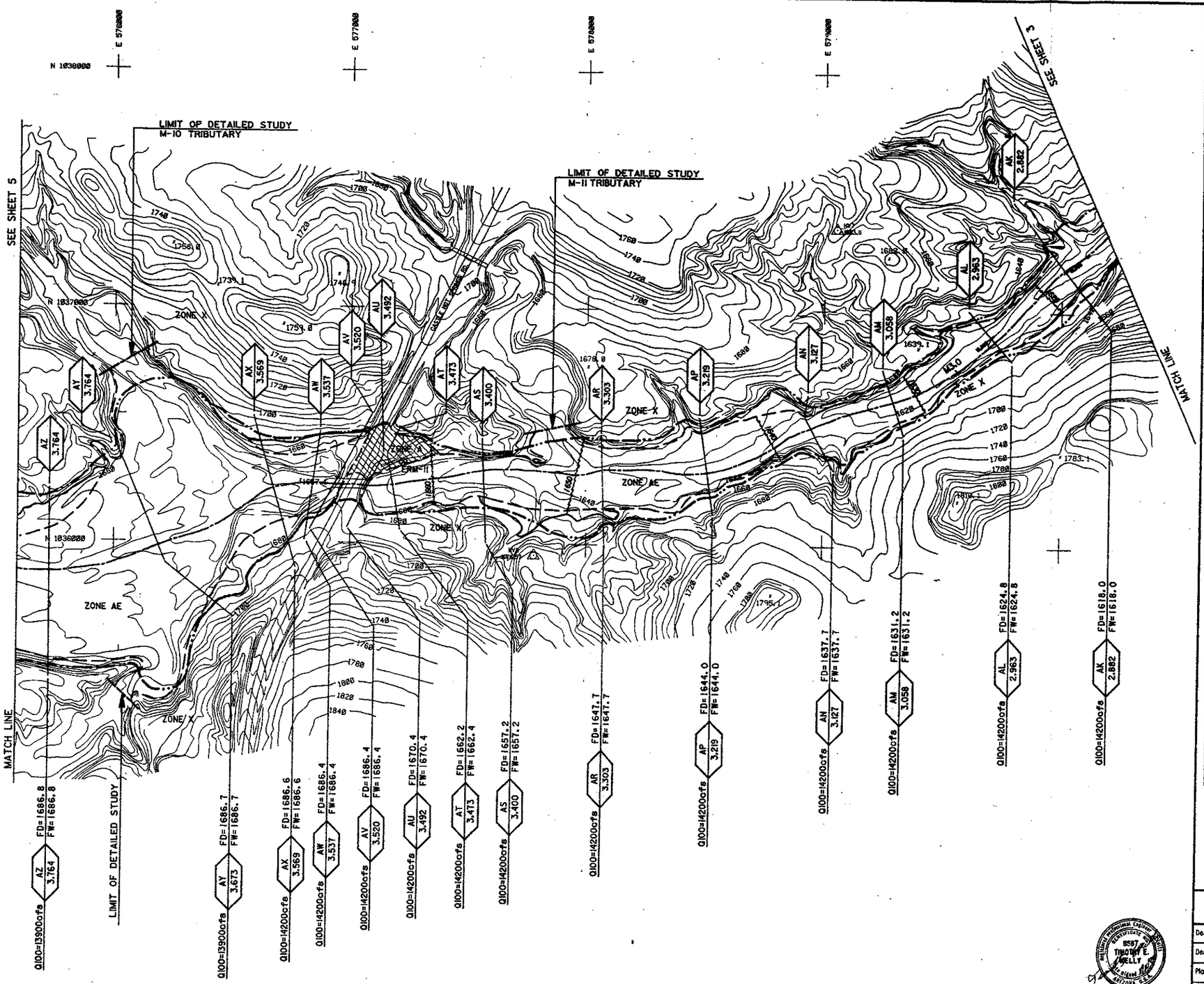
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FLOOD DELINEATION STUDY OF MORGAN CITY WASH



LEGEND

- Erosion Hazard Boundary
- 100-Yr. Floodplain Boundary
- Floodway Boundary
- Hydraulic Base Line With River Mile — M4.0 M5.0
- Cross Section — 100-YR.Q=xxxxcfs; FD = 100yr. WSE; FW = FLOODWAY WSE
- Elevation Reference Marks — ERM-4
- Base Flood Elevations — 2180
- Zone Designations — ZONE AE

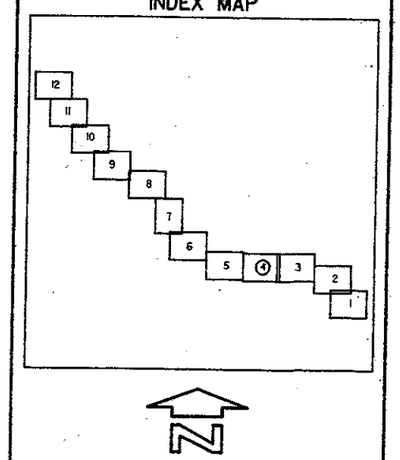
ELEVATION REFERENCE MARKS

NOTE: All Elevation Are Based On National Geodetic Vertical Datum Of 1927

I.D. NUMBER	ELEVATION (FT.)	DESCRIPTION/LOCATION
ERM-11	1662.677	FROM THE INTERSECTION OF LAKE PLEASANT ROAD AND CASTLE HOT SPRINGS ROAD THENCE 1.23 MI. SOUTH ON CASTLE HOT SPRINGS ROAD TO ERM#11, A U.S. B.R. BC AT CENTERLINE STATION CASTLE HOT SPRINGS ROAD 71+20.09 AT 150 FT. RIGHT (EAST) AT 4FT. BARBED WIRE FENCE CORNER RUNNING NORTHERLY AND SOUTHERLY MARKED ERM#11

NOTE:
CROSS SECTION STATION 10,000.0 IS HYDRAULIC BASE LINE EXCEPT AS NOTED

INDEX MAP



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Plans	S.S Obertello	8-16-90	APPROVED BY		
Plans Chk.	B.R. Jolly P.E.	8-16-90	CHIEF ENGINEER AND GENERAL MANAGER		OF 12

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Tucson, Arizona 85719

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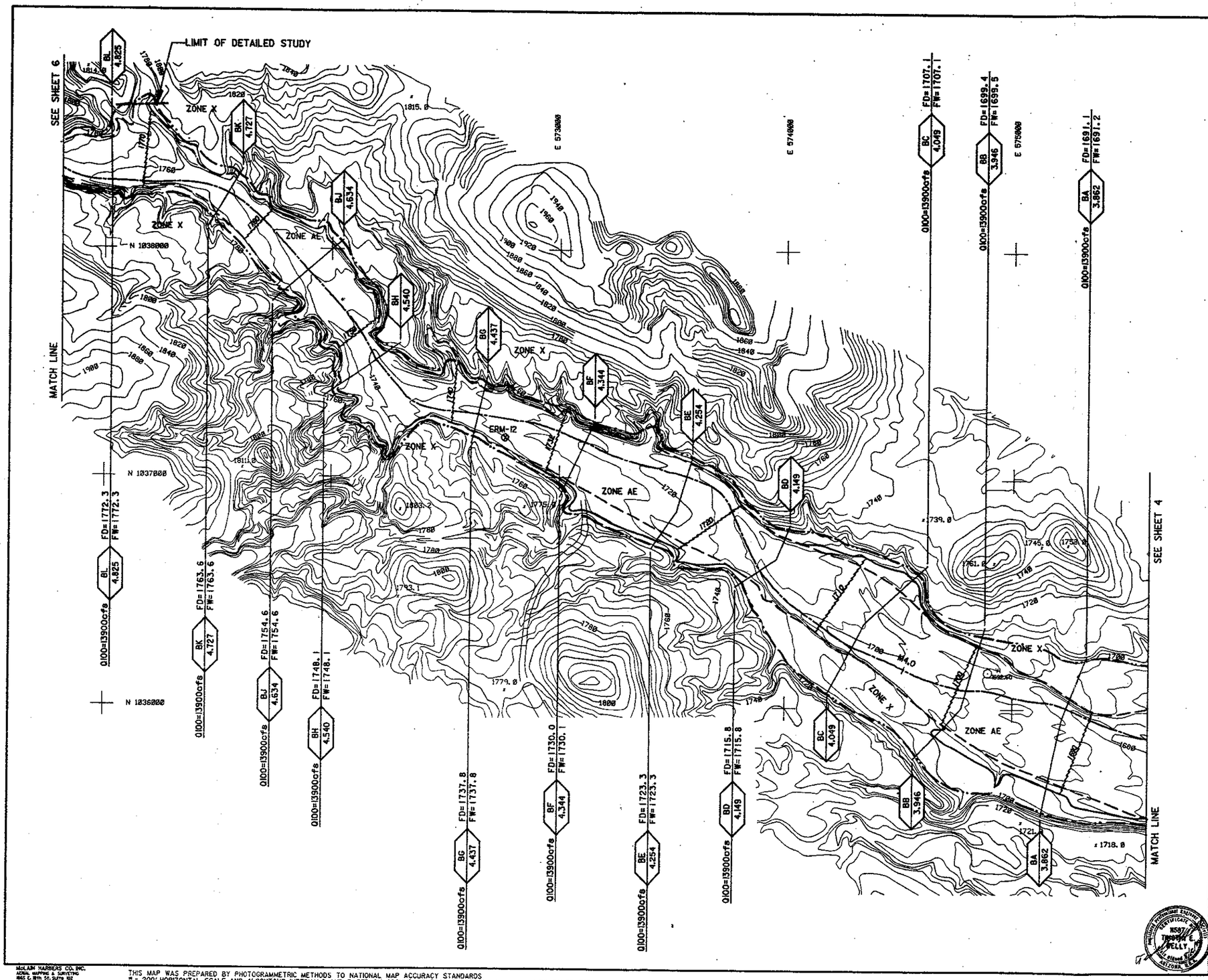
1" = 200' HORIZONTAL SCALE AND 4' CONTOUR INTERVALS AND BASED ON GROUND CONTROL SURVEY DATA PROVIDED BY BAKER ENG.



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FLOOD DELINEATION STUDY OF MORGAN CITY WASH

LEGEND

- Erosion Hazard Boundary
- 100-Yr. Floodplain Boundary
- Floodway Boundary
- Hydraulic Base Line With River Mile — M4.0 M5.0
- Cross Section — Q100=XXXXcfs; FD = 100-yr. WSE; FW = FLOODWAY WSE
- Elevation Reference Marks — ERM-4
- Base Flood Elevations — 2180
- Zone Designations — ZONE AE

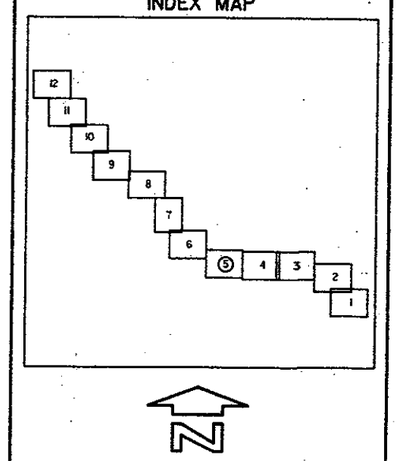
ELEVATION REFERENCE MARKS

NOTE: All Elevation Are Based On National Geodetic Vertical Datum Of 1927

I.D. NUMBER	ELEVATION (FT.)	DESCRIPTION/LOCATION
ERM-12	1732.120	BEGIN AT POINT ; MORGAN WEST, THENCE 0.05 MI. NW IN MORGAN CITY WASH TO ERM#12, A ½" REBAR SET IN CONCRETE APPROX. 111 FT. SW OF CENTERLINE OF MORGAN CITY WASH AND 88 FT. SE FROM ABANDONED (WELL) AND 1.5 FT. SE OF SE FACE OF ABANDONED CONCRETE WATER TROUGH ; MARKED ERM#12

NOTE:
CROSS SECTION STATION 10,000.0 IS HYDRAULIC BASE LINE EXCEPT AS NOTED

INDEX MAP



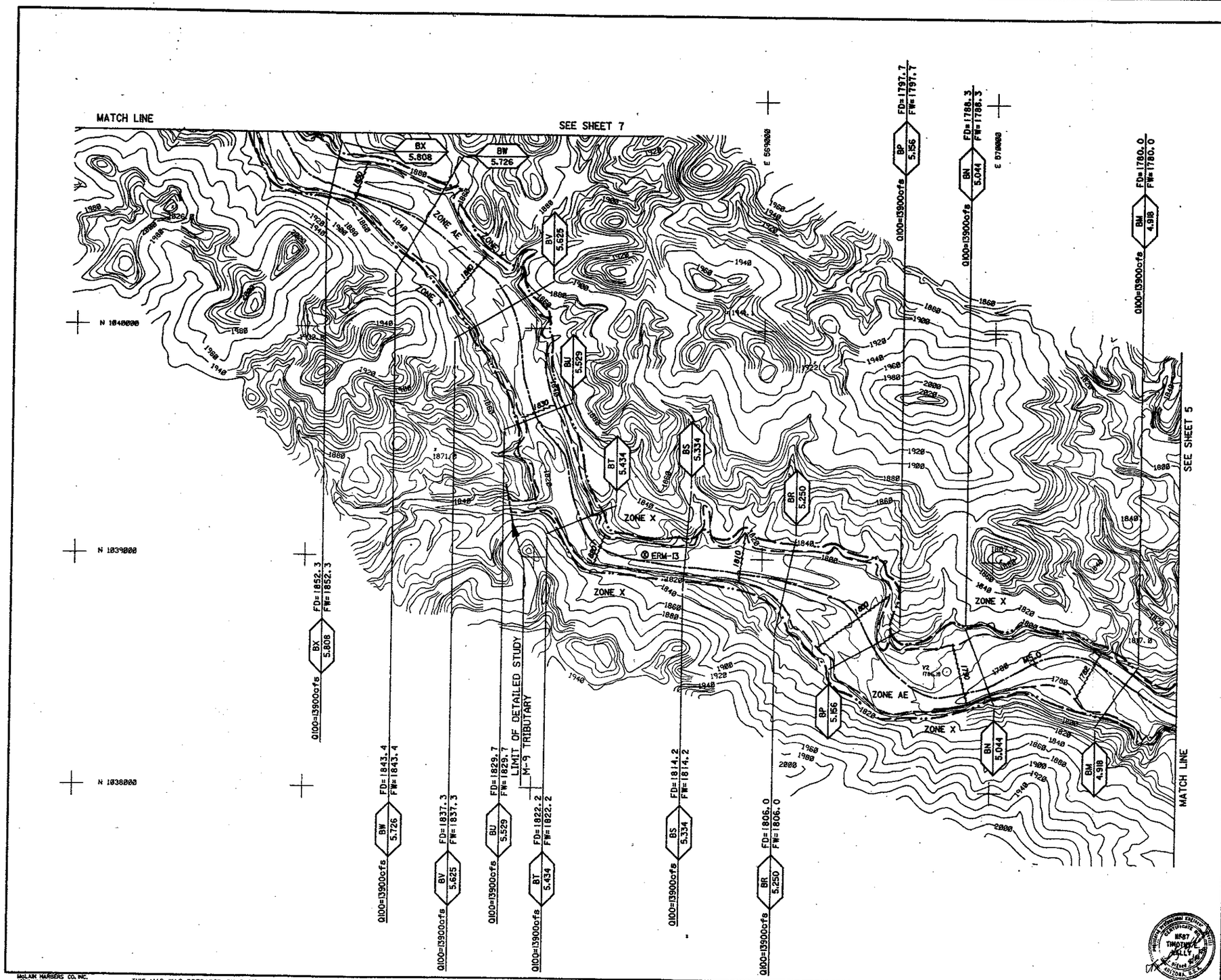
CONTOUR INTERVAL = 4' FEET

Michael Baker, Jr., Inc.
4105 North 20th Street, Suite 220
Phoenix, Arizona 85016

	BY	DATE	SUBMITTED BY	DATE	SHEET
Design	B.R. Jolly P.E.	6-15-79			5
Design Chk.	T.E. Kelly P.E.		RECOMMENDED BY	DATE	
Plans	S.S Obertello	8-16-79	APPROVED BY	DATE	
Plans Chk.	B.R. Jolly P.E.	8-16-79	CHIEF ENGINEER AND GENERAL MANAGER		OF 12

MOLAIR HARBERS CO. INC.
AERIAL MAPPING & SURVEYING
1665 E. 8th St. Ste. 102
Tucson, Arizona 85719

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS
1" = 200' HORIZONTAL SCALE AND 4' CONTOUR INTERVALS AND BASED ON GROUND CONTROL SURVEY DATA PROVIDED BY BAKER ENG.



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FLOOD DELINEATION STUDY OF MORGAN CITY WASH

LEGEND

- Erosion Hazard Boundary
- 100-Yr. Floodplain Boundary
- Floodway Boundary
- Hydraulic Base Line With River Mile — M4.0 M5.0
- Cross Section — XX=XXXXcfs; FD = 100-Yr. WSE; FW = FLOODWAY WSE
- Elevation Reference Marks — ERM-4
- Base Flood Elevations — 2180
- Zone Designations — ZONE AE

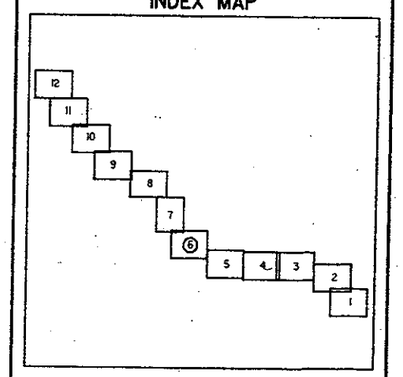
ELEVATION REFERENCE MARKS

NOTE: All Elevation Are Based On National Geodetic Vertical Datum Of 1927

I.D. NUMBER	ELEVATION (FT.)	DESCRIPTION/LOCATION
ERM-13	1806.195	BEGINING AT POINT; MORGAN WEST, THENCE 1.05 MI. N.W. IN MORGAN CITY WASH TO ERM-13, A 5/8" REBAR SET IN CONCRETE; APPROX. 29' N.E. OF CENTERLINE OF MORGAN CITY WASH IN AN ALLUVIAL DEPOSIT. MARKED ERM-13

NOTE:
CROSS SECTION STATION 10,000.0 IS HYDRAULIC BASE LINE EXCEPT AS NOTED

INDEX MAP



N

200 0 200 400
scale

CONTOUR INTERVAL = 4' FEET

Michael Baker, Jr., Inc.
4105 North 20th Street, Suite 220
Phoenix, Arizona 85016

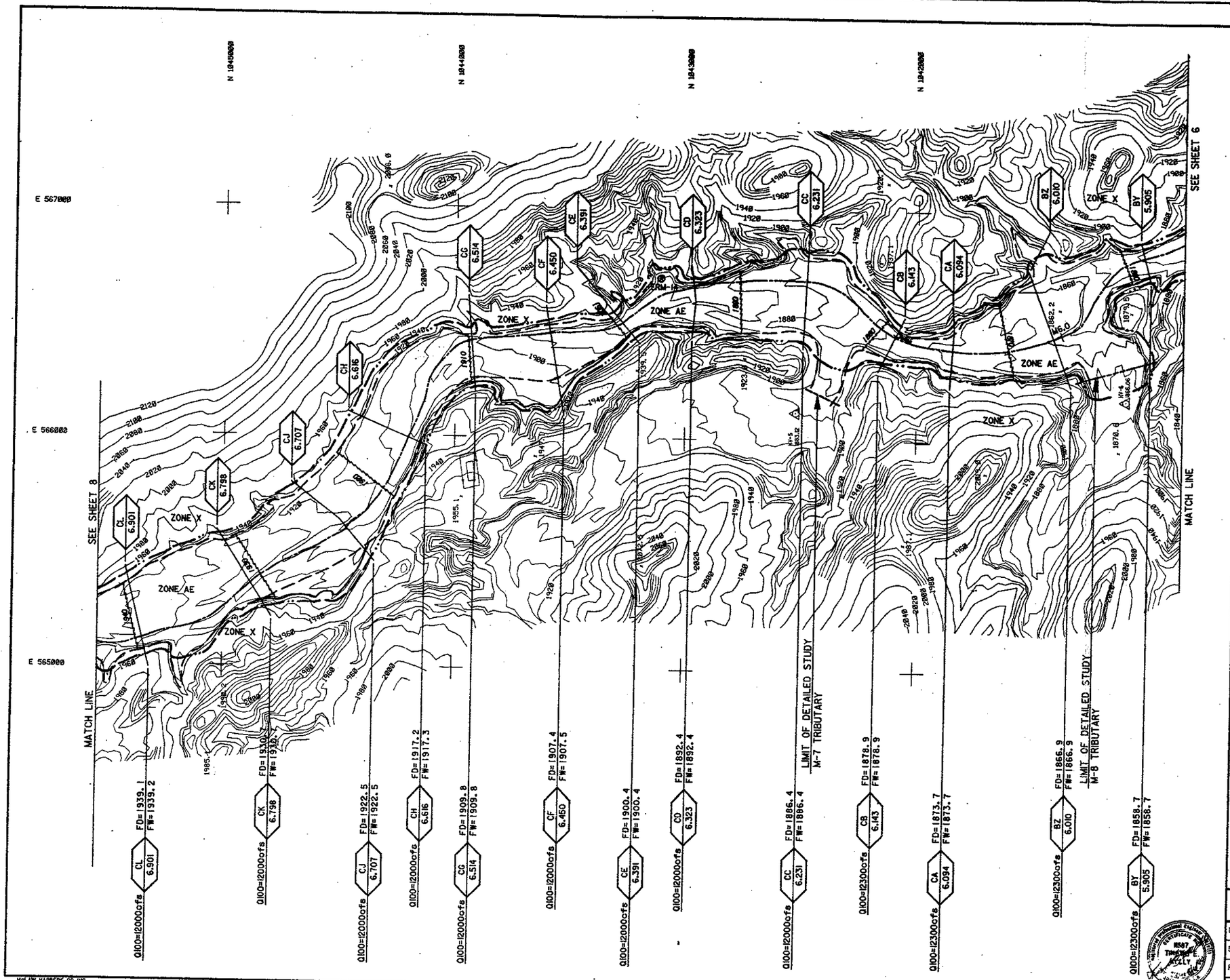
	BY	SIGN	SUBMITTED BY	DATE
Design	B.R. Jolly P.E.			
Design Chk.	T.E. Kelly P.E.		RECOMMENDED BY	DATE
Plans	S.S Obertello		APPROVED BY	DATE
Plans Chk.	B.R. Jolly P.E.		CHIEF ENGINEER AND GENERAL MANAGER	

SHEET 6 OF 12

REGISTERED PROFESSIONAL ENGINEER (CIVIL) No. 27 TIMOTHY E. KELLY ARIZONA U.S.A.

McLAIN HARBERS CO. INC.
AERIAL MAPPING & SURVEYING
645 E. 8th St. Suite 102
Tucson, Arizona 85705

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS
1" = 200' HORIZONTAL SCALE AND 4' CONTOUR INTERVALS AND BASED ON GROUND CONTROL SURVEY DATA PROVIDED BY BAKER ENG.



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FLOOD DELINEATION STUDY OF MORGAN CITY WASH

LEGEND

Erosion Hazard Boundary

100-Yr. Floodplain Boundary

Floodway Boundary

Hydraulic Base Line With River Mile — M4.0 M5.0

Cross Section — 100=XXXXcfs; FD = 100yr. WSE; FW = FLOODWAY WSE

Elevation Reference Marks — ERM-4

Base Flood Elevations — 2180

Zone Designations — ZONE AE

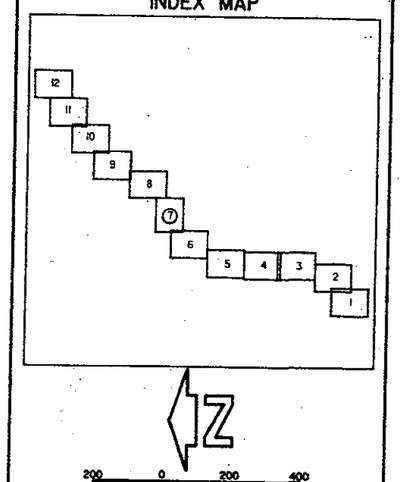
ELEVATION REFERENCE MARKS

NOTE: All Elevation Are Based On National Geodetic Vertical Datum Of 1927

I.D. NUMBER	ELEVATION (FT.)	DESCRIPTION/LOCATION
ERM-14	1891.945	BEGINING AT POINT: MORGAN WEST, THENCE 2.10 MI. N.W. IN MORGAN CITY WASH TO ERM-14, A 3/8" REBAR SET IN CONCRETE: APPROX. 73' N.E. OF CENTERLINE OF MORGAN CITY WASH AND APPROX. 20' SOUTH OF EDGE OF ROCK WALL. MARKED "ERM-14"

NOTE:
CROSS SECTION STATION 10,000.0 IS HYDRAULIC BASE LINE EXCEPT AS NOTED

INDEX MAP



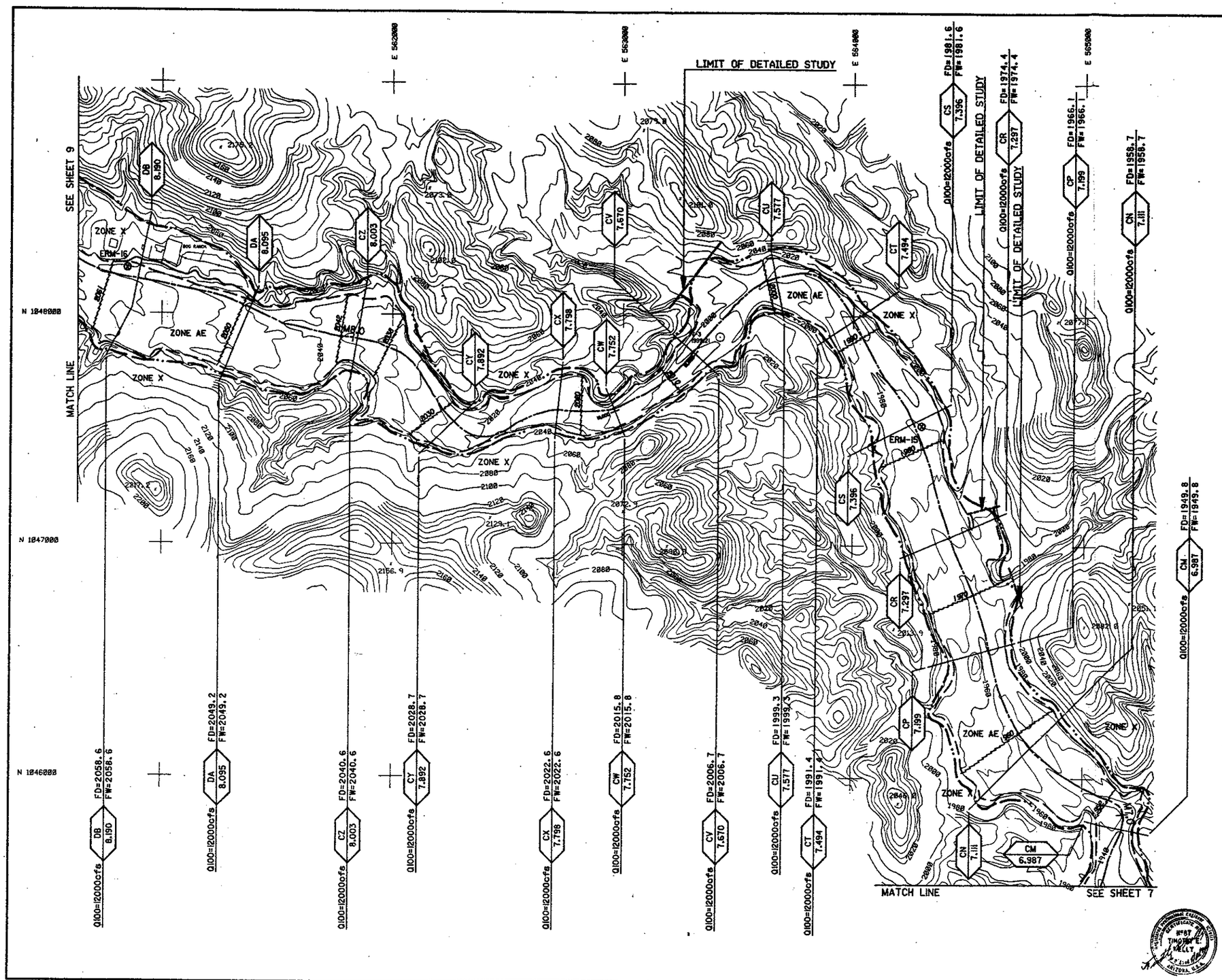
CONTOUR INTERVAL = 4' FEET

Michael Baker, Jr., Inc.
4105 North 20th Street, Suite 220
Phoenix, Arizona 85016

	BY	DATE		DATE	SHEET
Design	B.R. Jolly P.E.	4-24-90	SUBMITTED BY		7
Design Chk.	T.E. Kelly P.E.	4-24-90	RECOMMENDED BY		
Plans	S.S Obertello	5-16-90	APPROVED BY		OF 12
Plans Chk.	B.R. Jolly P.E.	5-16-90	CHIEF ENGINEER AND GENERAL MANAGER		

McLAIN HARBERS CO. INC.
AERIAL MAPPING & SURVEYING
1880 E. 16th St. Suite 102
Tucson, Arizona 85719

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS
1" = 200' HORIZONTAL SCALE AND 4' CONTOUR INTERVALS AND BASED ON GROUND CONTROL SURVEY DATA PROVIDED BY BAKER ENG.



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FLOOD DELINEATION STUDY OF MORGAN CITY WASH

LEGEND

- Erosion Hazard Boundary / 100-Yr. Floodplain Boundary
- Floodway Boundary
- Hydraulic Base Line With River Mile — M4.0 M5.0
- Cross Section — 100=XXXXcfs; FD = 100yr. WSE; FW = FLOODWAY WSE
- Elevation Reference Marks — ERM-4
- Base Flood Elevations — 2180
- Zone Designations — ZONE AE

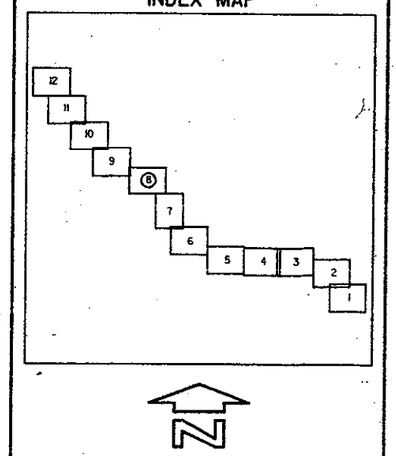
ELEVATION REFERENCE MARKS

NOTE: All Elevation Are Based On National Geodetic Vertical Datum Of 1927

I.D. NUMBER	ELEVATION (FT.)	DESCRIPTION/LOCATION
ERM-15	1976.50	BEGINNING AT POINT; MORGAN WEST, THENCE 3.15 MI. N.W. IN MORGAN CITY WASH TO ERM-15, A 3/8" REBAR SET IN CONCRETE APPROX. 28' N.E. OF CENTERLINE OF MORGAN CITY WASH, AND APPROX. 0.15 MI. N.W. OF TULE SPRING IN MORGAN CITY WASH, MARKED "ERM-15"
ERM-16	2055..85	BEGINING AT POINT MORGAN WEST, THENCE 4.00 MI. N.W. IN MORGAN CITY WASH TO ERM-16, A 3/8" REBAR SET IN CONCRETE, APPROX. 40' N.E. OF CENTERLINE OF MORGAN CITY WASH, AND APPROX. 6' SOUTH OF SOUTH FACE OF CONCRETE WELL PAD, AND APPROX. 26' S.E. OF EAST SIDE DRIVEWAY ENTRANCE TO BOG RANCH PROPERTY, MARKED "ERM-16"

NOTE:
CROSS SECTION STATION 10,000.0 IS HYDRAULIC BASE LINE EXCEPT AS NOTED

INDEX MAP



CONTOUR INTERVAL = 4' FEET

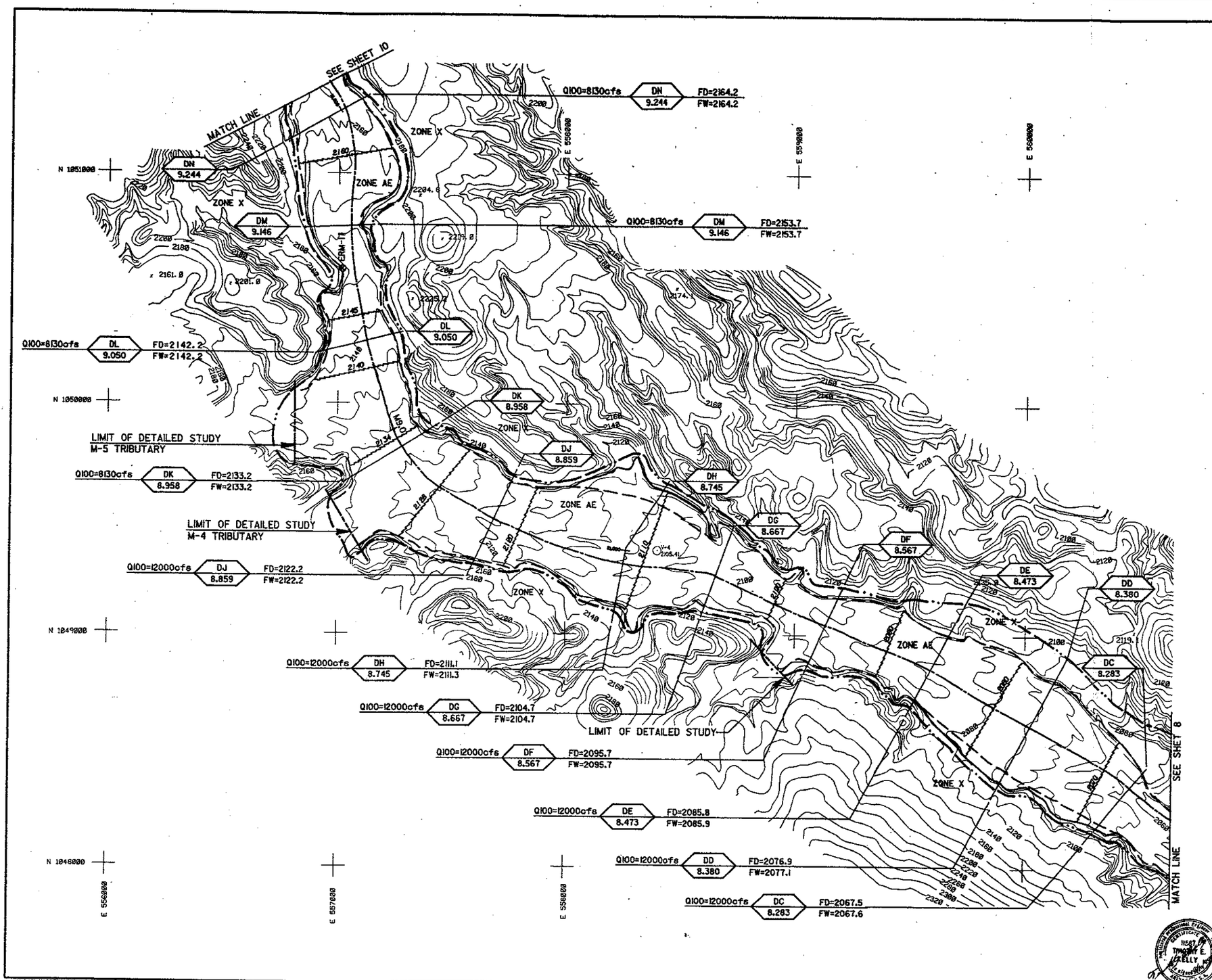
Michael Baker, Jr., Inc.
4105 North 20th Street, Suite 220
Phoenix, Arizona 85016

	BY	DATE	SUBMITTED BY	DATE
Design	B.R. Jolly P.E.	8-16-90		
Design Chk.	T.E. Kelly P.E.	8-16-90	RECOMMENDED BY	DATE
Plans	S.S Obertello	8-16-90	APPROVED BY	DATE
Plans Chk.	B.R. Jolly P.E.	8-16-90	CHIEF ENGINEER AND GENERAL MANAGER	

SHEET 8 OF 12

McLAIN HARBERS CO. INC.
AERIAL MAPPING & SURVEYING
1645 E. 18th St. Suite 102
Tucson, Arizona 85719

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS
1" = 200' HORIZONTAL SCALE AND 4' CONTOUR INTERVALS AND BASED ON GROUND CONTROL SURVEY DATA PROVIDED BY BAKER ENG.



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FLOOD DELINEATION STUDY OF MORGAN CITY WASH

LEGEND

- Erosion Hazard Boundary
- 100-Yr. Floodplain Boundary
- Floodway Boundary
- Hydraulic Base Line With River Mile — M4.0 M5.0
- Cross Section — Q100=XXXcfs, FD = 100-Yr. WSE, FW = FLOODWAY WSE
- Elevation Reference Marks — ERM-4
- Base Flood Elevations — 2180
- Zone Designations — ZONE AE

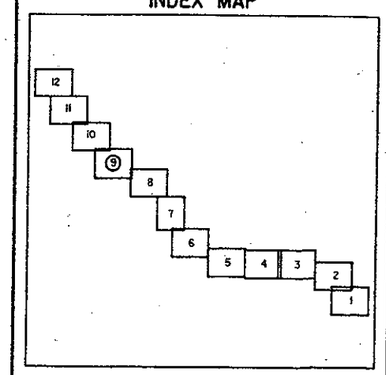
ELEVATION REFERENCE MARKS

NOTE: All Elevation Are Based On National Geodetic Vertical Datum Of 1927

I.D. NUMBER	ELEVATION (FT.)	DESCRIPTION/LOCATION
ERM-17	2155.02	BEGINING AT POINT MORGAN WEST THENCE 5.04 MI. NW IN MORGAN CITY WASH TO ERM#17, A 5/8" REBAR SET IN CONCRETE APPROX. 48 FT. SOUTHWEST OF CENTERLINE OF MORGAN CITY WASH, MARKED ERM#17

NOTE:
CROSS SECTION STATION 10,000.0 IS HYDRAULIC BASE LINE EXCEPT AS NOTED

INDEX MAP



N

200 0 200 400
scale
CONTOUR INTERVAL = 4' FEET

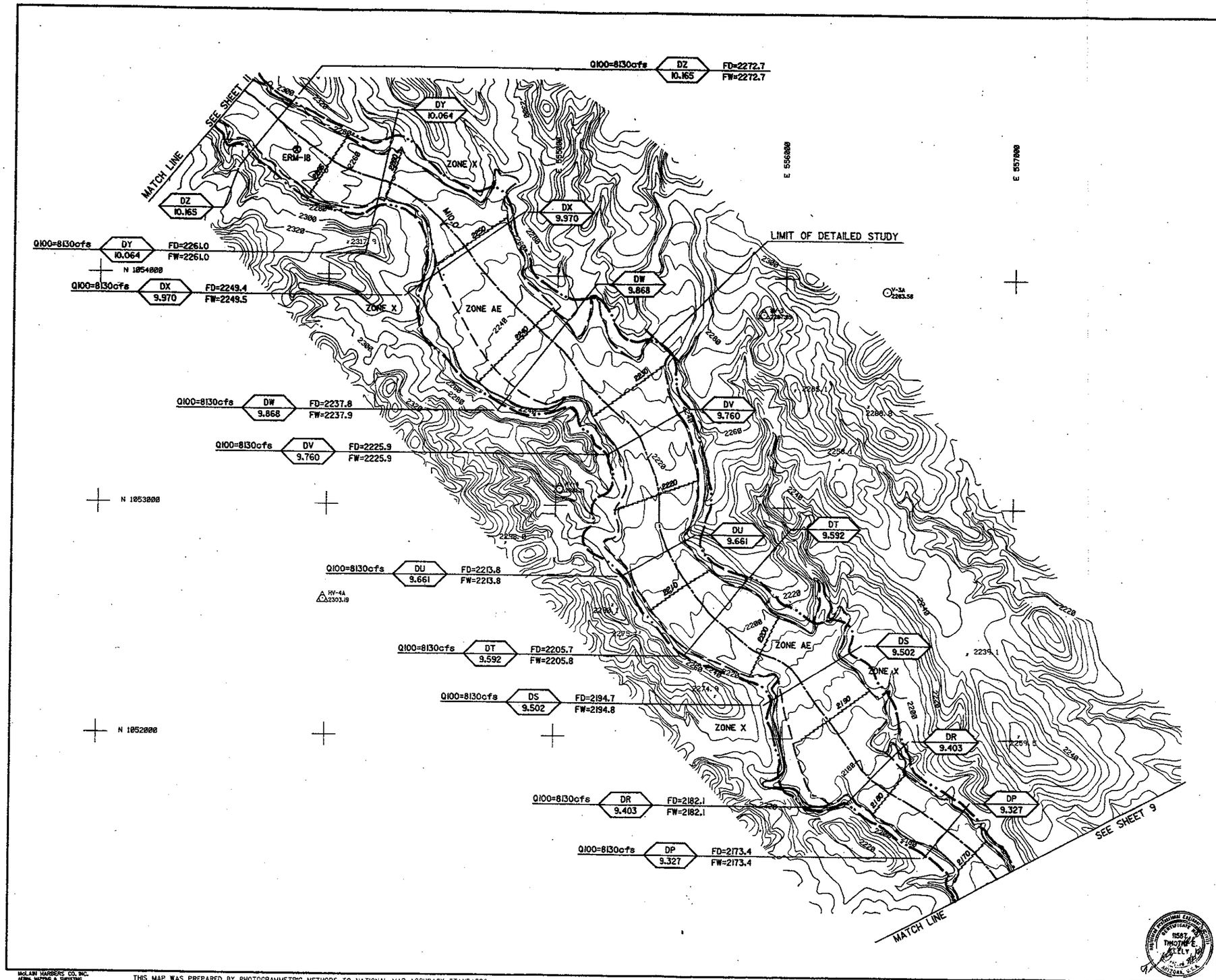
Michael Baker, Jr., Inc.
4105 North 20th Street, Suite 220
Phoenix, Arizona 85016

	BY		SUBMITTED BY	DATE	SHEET
Design	B.R. Jolly P.E.	8-16-96			9
Design Chk.	T.E. Kelly P.E.	8-16-96	RECOMMENDED BY	DATE	
Plans	S.S. Obertello	8-16-96	APPROVED BY	DATE	
Plans Chk.	B.R. Jolly P.E.	8-16-96	CHIEF ENGINEER AND GENERAL MANAGER		OF 12

REGISTERED PROFESSIONAL ENGINEER (CIVIL) 11567 TIMOTHY E. KELLY ARIZONA, U.S.A.

McLAIN HARBERS CO. INC.
AERIAL MAPPING & SURVEYING
1955 S. 9TH ST. Suite 102
TUCSON, ARIZONA 85713

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS
1" = 200' HORIZONTAL SCALE AND 4' CONTOUR INTERVALS AND BASED ON GROUND CONTROL SURVEY DATA PROVIDED BY BAKER ENG.



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FLOOD DELINEATION STUDY OF MORGAN CITY WASH

LEGEND

- Erosion Hazard Boundary
- 100-Yr. Floodplain Boundary
- Floodway Boundary
- Hydraulic Base Line With River Mile — M4.0 M5.0
- Cross Section — Q100=XXXcfs, FD = 100yr. WSE, FW = FLOODWAY WSE
- Elevation Reference Marks — ERM-4
- Base Flood Elevations — 2180
- Zone Designations — ZONE AE

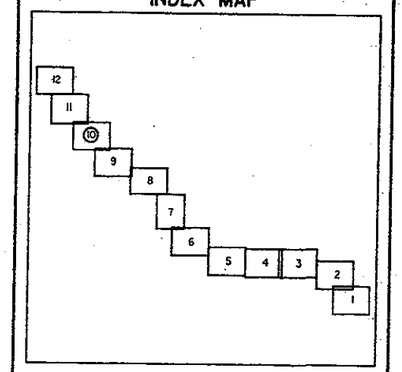
ELEVATION REFERENCE MARKS

NOTE: All Elevation Are Based On National Geodetic Vertical Datum Of 1927

I.D. NUMBER	ELEVATION (FT.)	DESCRIPTION/LOCATION
ERM-18	2268.18	BEGIN AT POINT MORGAN WEST, THENCE 6.05 MI. NW IN MORGAN CITY WASH TO ERM#18, A ⅝" REBAR SET IN CONCRETE APPROX. 56 FT. SOUTHWEST OF CENTERLINE OF MORGAN CITY WASH, AND APPROX. 0.10 MI. NW OF 4 FT. BARBED WIRE FENCE GATE IN MORGAN CITY WASH. MARKER ERM#18

NOTE:
CROSS SECTION STATION 10,000.0 IS HYDRAULIC BASE LINE EXCEPT AS NOTED

INDEX MAP



N

200 0 200 400
scale

CONTOUR INTERVAL = 4' FEET

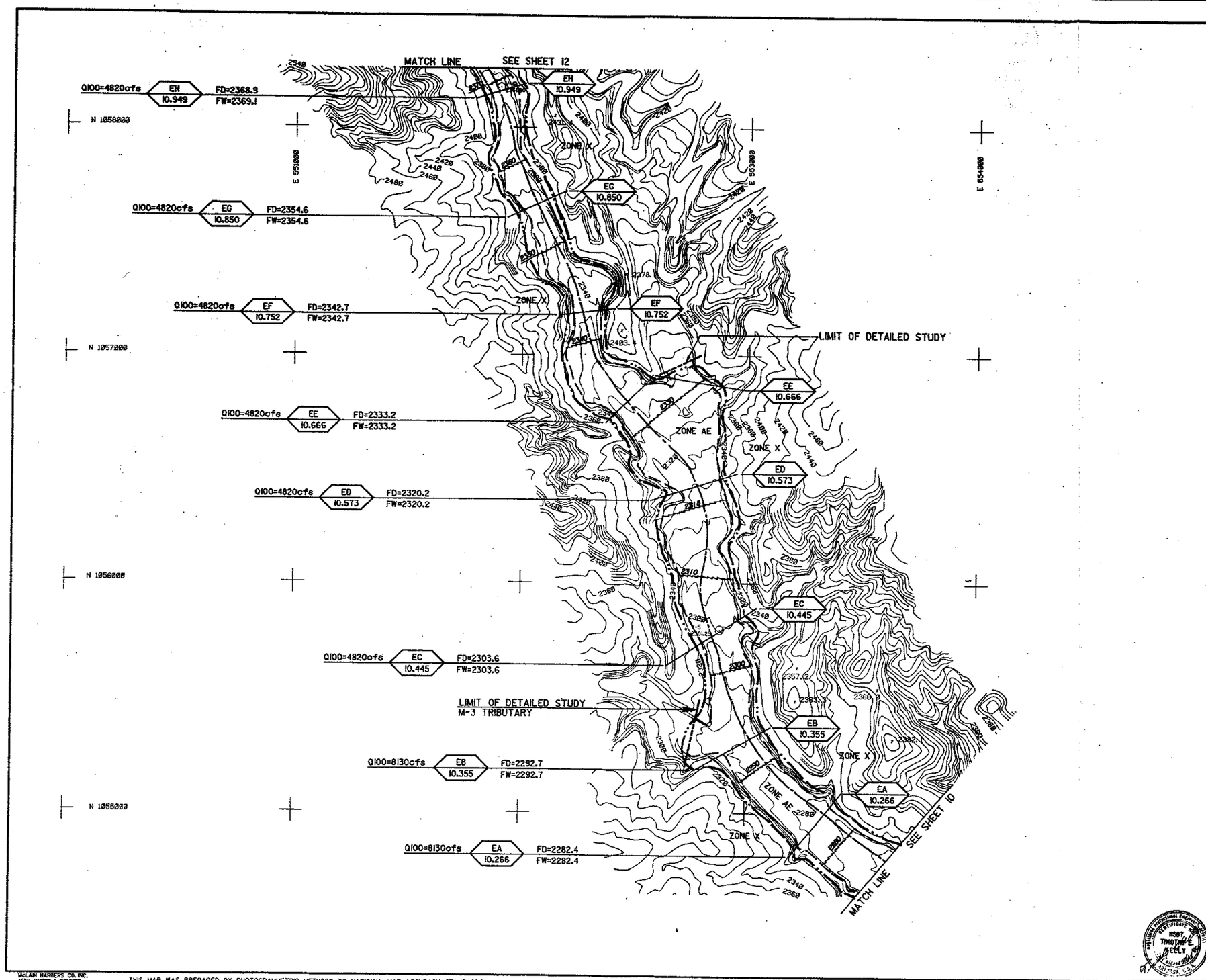
Michael Baker, Jr., Inc.
4105 North 20th Street, Suite 220
Phoenix, Arizona 85016

	BY	DATE		DATE	SHEET
Design	B.R. Jolly P.E.	8-16-94	SUBMITTED BY		10
Design Chk.	T.E. Kelly P.E.	8/16/94	RECOMMENDED BY		
Plans	S.S. Oberteiko	8-16-94	APPROVED BY		
Plans Chk.	B.R. Jolly P.E.	8-16-94	CHIEF ENGINEER AND GENERAL MANAGER		OF 12

REGISTERED PROFESSIONAL ENGINEER (CIVIL) CERTIFICATE NO. 11587 TIMOTHY E. KELLY ARIZONA, U.S.A.

McLAIN HARRIS CO. INC.
AERIAL MAPPING & SURVEYING
660 E. 29th St. Suite 8E
Tucson, Arizona 85713

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS
1" = 200' HORIZONTAL SCALE AND 4' CONTOUR INTERVALS AND BASED ON GROUND CONTROL SURVEY DATA PROVIDED BY BAKER ENG.



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FLOOD DELINEATION STUDY OF MORGAN CITY WASH

LEGEND

Erosion Hazard Boundary	
100-Yr. Floodplain Boundary	
Floodway Boundary	
Hydraulic Base Line With River Mile	M4.0 M5.0
Cross Section	Q100=XXXcfs 8 100 FD = 100yr. WSE FW = FLOODWAY WSE 8 100
Elevation Reference Marks	ERM-4
Base Flood Elevations	2180
Zone Designations	ZONE AE

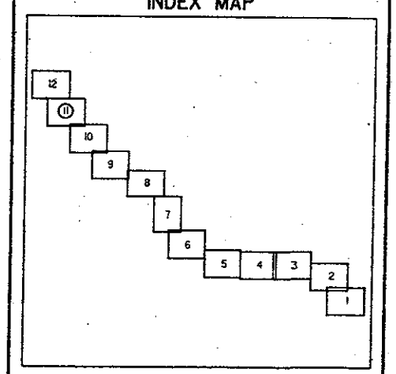
ELEVATION REFERENCE MARKS

NOTE: All Elevation Are Based on National Geodetic Vertical Datum Of 1927

I.D. NUMBER	ELEVATION (FT.)	DESCRIPTION/LOCATION
NONE		

NOTE:
CROSS SECTION STATION 10,000.0 IS HYDRAULIC BASE LINE EXCEPT AS NOTED

INDEX MAP



N

200 0 200 400
scale

CONTOUR INTERVAL = 4' FEET

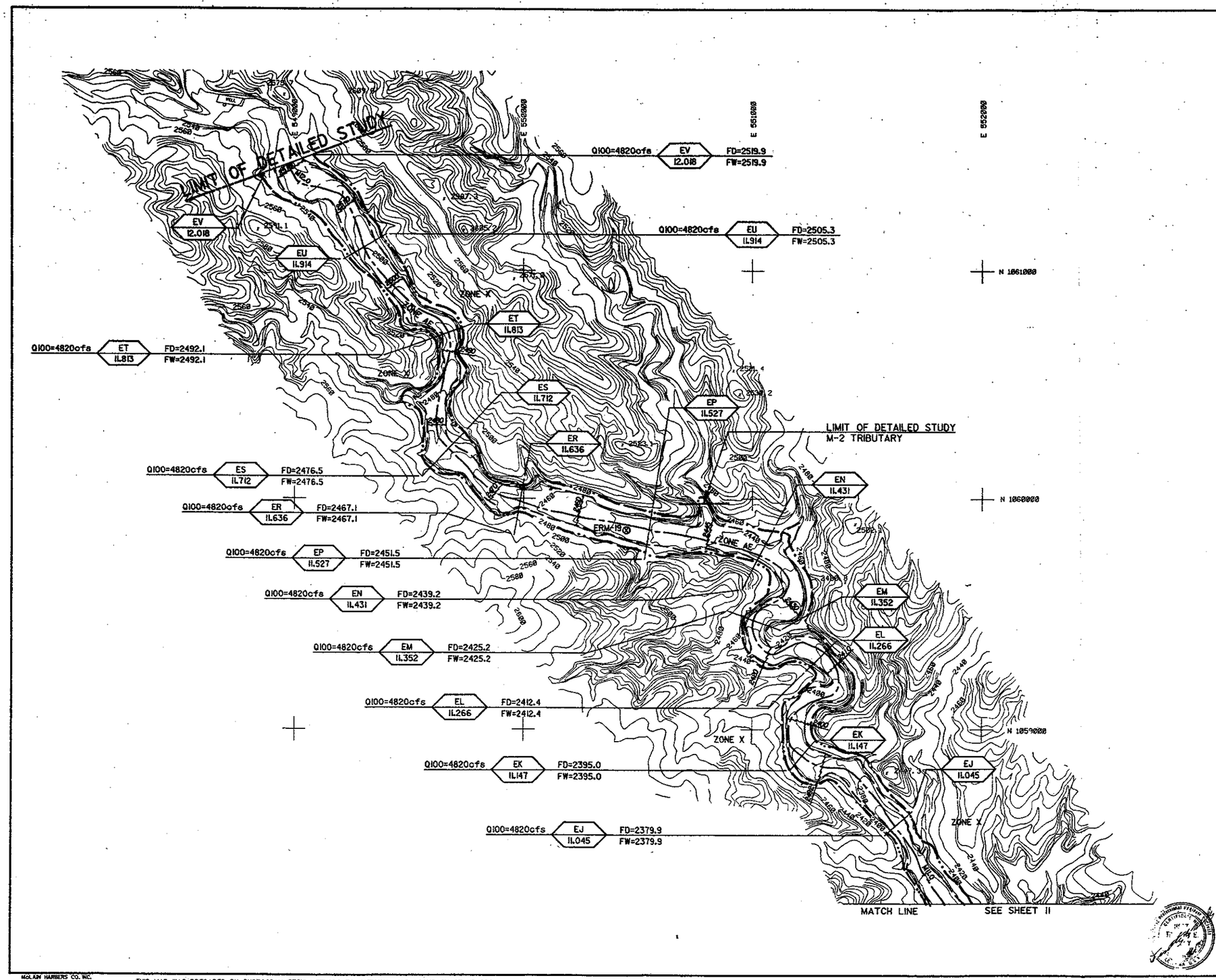
Michael Baker, Jr., Inc.
4105 North 20th Street, Suite 220
Phoenix, Arizona 85016

	BY	DATE	SUBMITTED BY	DATE
Design	B.R. Jolly P.E.	8-6-90		
Design Chk.	T.E. Kelly P.E.	8/16/90	RECOMMENDED BY	DATE
Plans	S.S. Obertello	8-16-90	APPROVED BY	DATE
Plans Chk.	B.R. Jolly P.E.	8-16-90	CHIEF ENGINEER AND GENERAL MANAGER	

SHEET 11 OF 12

McLAIN HARBERS CO. INC.
AERIAL MAPPING & SURVEYING
3665 E. 44th St. Suite 102
Tucson, Arizona 85713

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS
1" = 200' HORIZONTAL SCALE AND 4' CONTOUR INTERVALS AND BASED ON GROUND CONTROL SURVEY DATA PROVIDED BY BAKER ENG.



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FLOOD DELINEATION STUDY OF MORGAN CITY WASH

LEGEND

- Erosion Hazard Boundary
- 100-Yr. Floodplain Boundary
- Floodway Boundary
- Hydraulic Base Line With River Mile — M4.0 M5.0
- Cross Section — Q100=XXXXcfs; FD = 100yr. WSE; FW = FLOODWAY WSE; 8 L00
- Elevation Reference Marks — ERM-4
- Base Flood Elevations — 2180
- Zone Designations — ZONE AE

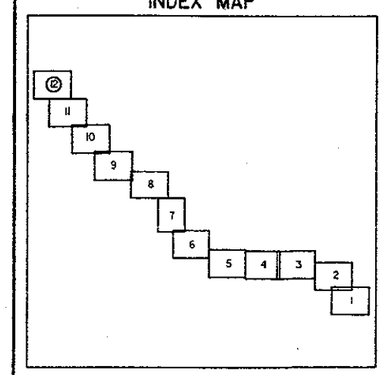
ELEVATION REFERENCE MARKS

NOTE: All Elevation Are Based On National Geodetic Vertical Datum Of 1927

I.D. NUMBER	ELEVATION (FT.)	DESCRIPTION/LOCATION
ERM-19	2450.86	BEGIN AT POINT MORGAN WEST THENCE 7.75 MI. NW IN MORGAN CITY WASH TO ERM#19, A 5/8" REBAR SET IN CONCRETE (AT 6.25 MI., BEAR TO THE RIGHT WHERE MORGAN CITY WASH STREAMBED FORKS IN TWO DIRECTIONS) APPROX. 24 FT. SOUTHWEST OF CENTERLINE OF MORGAN CITY WASH, AND APPROX. 0.60 MI. SOUTHWEST OF WELL IN NORTHERN REGION OF MORGAN CITY WASH, MARKED ERM#19

NOTE:
CROSS SECTION STATION 10,000.0 IS HYDRAULIC BASE LINE EXCEPT AS NOTED

INDEX MAP



N

200 0 200 400
scale
CONTOUR INTERVAL = 4' FEET

Michael Baker, Jr., Inc.
4105 North 20th Street, Suite 220
Phoenix, Arizona 85016

	BY	DATE	SUBMITTED BY	DATE	SHEET
Design	B.R. Jolly P.E.	5-16-90			12
Design Chk.	T.E. Kelly P.E.	5-16-90	RECOMMENDED BY	DATE	
Plans	S.S Obertello	5-16-90	APPROVED BY	DATE	
Plans Chk.	B.R. Jolly P.E.	5-16-90	CHIEF ENGINEER AND GENERAL MANAGER		OF 12

MOLAIN HARBERS CO. INC.
AERIAL MAPPING & SURVEYING
8865 E. 9th St. Suite 102
Tucson/Arizona 85715

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS
1" = 200' HORIZONTAL SCALE AND 4' CONTOUR INTERVALS AND BASED ON GROUND CONTROL SURVEY DATA PROVIDED BY BAKER ENG.

LEGEND

100-YR FLOODPLAIN BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
EROSION HAZARD ZONE	
CROSS SECTION	3.456 — 3.456
FLOOD ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
SECTION LINE	

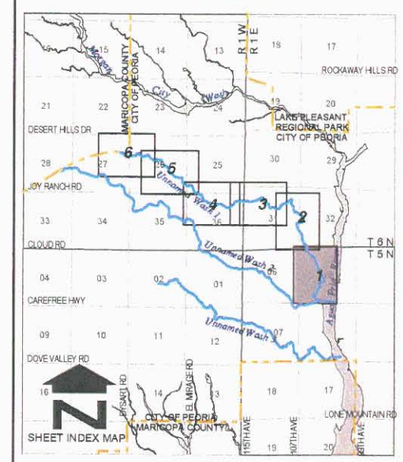
NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1998 VALUES.

3- ALL SECTION LINES ARE APPROXIMATE.

4- EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



NO	REVISION	BY	DATE
2			
1			

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA AREA DRAINAGE MASTER PLAN FLOODPLAIN AND EROSION HAZARD MAP UNNAMED WASH 1 F.C.D. CONTRACT NO. 99-45

Stantec Consulting Inc.
8211 South 48th Street
Phoenix, AZ 85044-5355 U.S.A.
Tel: (602) 438-2200
Fax: (602) 431-9562
www.stantec.com

	BY	DATE
DESIGN	MCG	04/01
DESIGN CHK.	PJE	04/01
PLANS	NKD / HAR	04/01
PLANS CHK.	PJE	04/01

Figure 10-2

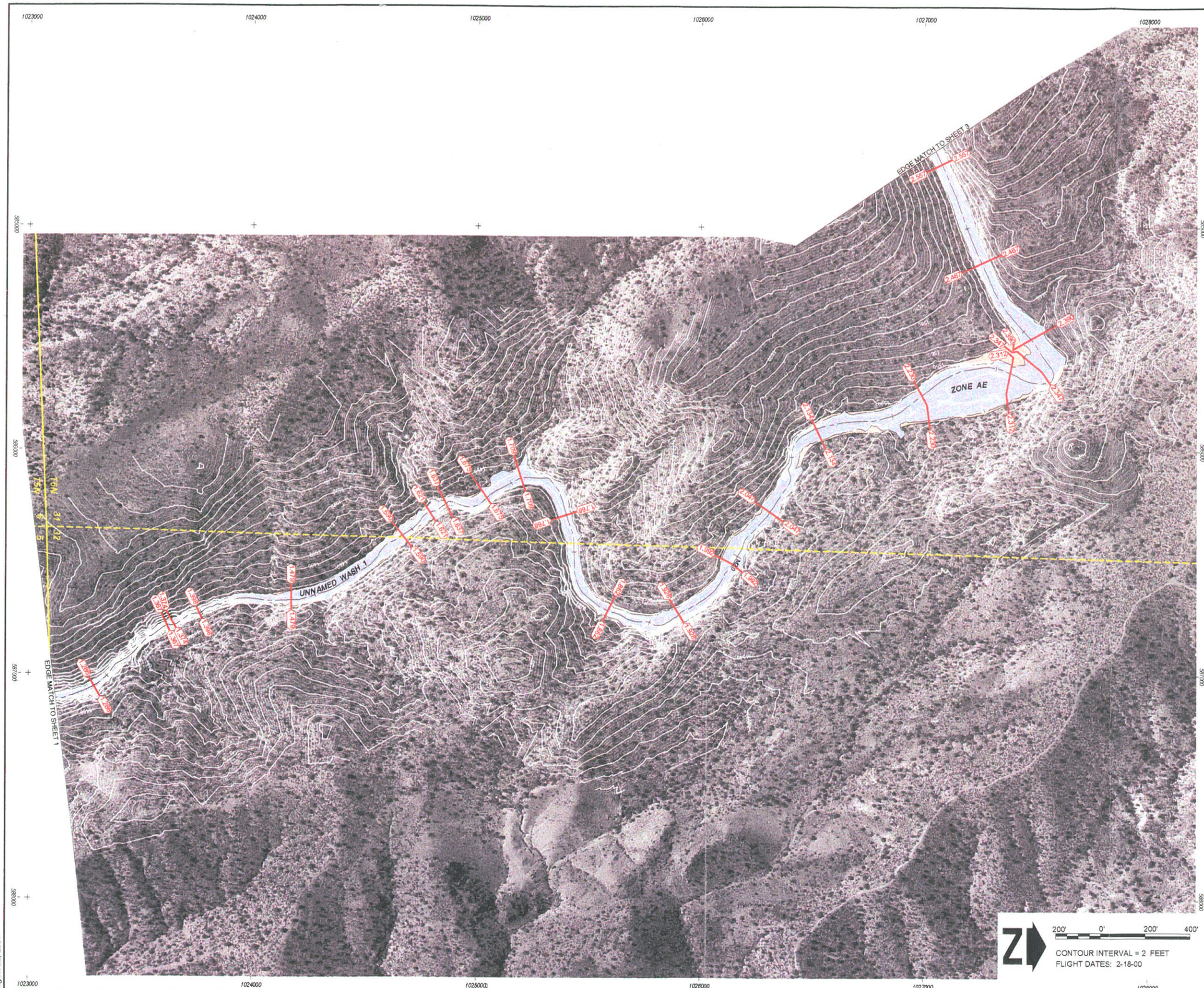
SHEET 1 OF 6

P:\82000146\gis\erosion\unnamed1_erosion.apr
August 22, 2001

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 400' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS.

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.



LEGEND

100-YR FLOODPLAIN BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
EROSION HAZARD ZONE	
CROSS SECTION	3.456 — 3.456
FLOOD ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
SECTION LINE	

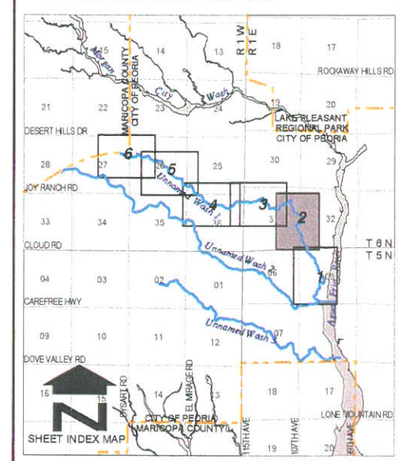
NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1998 VALUES.

3- ALL SECTION LINES ARE APPROXIMATE.

4- EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODPLAIN AND EROSION HAZARD MAP
UNNAMED WASH 1
F.C.D. CONTRACT NO. 99-45

Stantec Consulting Inc.
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DESIGN	MCG	04/01
DESIGN CHK.	PJE	04/01
PLANS	NKD / HAR	04/01
PLANS CHK.	PJE	04/01

Figure 10-2

SHEET 2 OF 6

P:\62000146\gis\erosion\unnamed1_erosion.apr
August 22, 2001

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 400' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS.

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.

LEGEND

100-YR FLOODPLAIN BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
EROSION HAZARD ZONE	
CROSS SECTION	3.456 — 3.456
FLOOD ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
SECTION LINE	

NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

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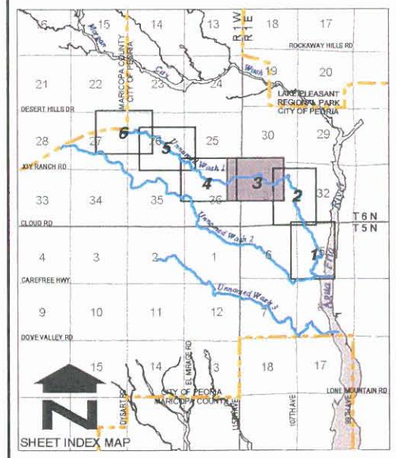
3- ALL SECTION LINES ARE APPROXIMATE.

4- EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODPLAIN AND EROSION HAZARD MAP
UNNAMED WASH 1
F.C.D. CONTRACT NO. 99-45

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PLANS	NKD / HAR	01/01
PLANS CHK.	PJE	01/01

Figure 10-2

SHEET 3 OF 6

P:\82000146\gis\erosion\unnamed1_erosion.apr
August 22, 2001

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA
PROVIDED BY VALCO SURVEYING CORP.

LEGEND

100-YR FLOODPLAIN BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 M13.0
EROSION HAZARD ZONE	
CROSS SECTION	3.456 — 3.456
FLOOD ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
SECTION LINE	

NOTES

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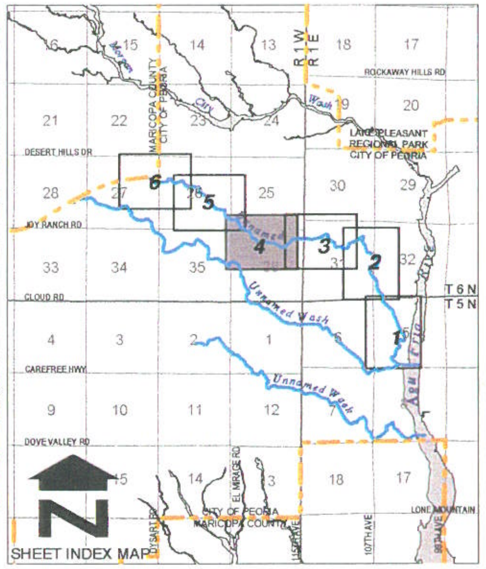
3- ALL SECTION LINES ARE APPROXIMATE.

4- EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



SHEET INDEX MAP

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FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODPLAIN AND EROSION HAZARD MAP
UNNAMED WASH 1
F.C.D. CONTRACT NO. 99-45

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PLANS CHK.	PJE	01/01

Figure 10-2 SHEET 4 OF 6

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 400' HORIZONTAL SCALE AND 2 'CONTOUR INTERVALS.

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.

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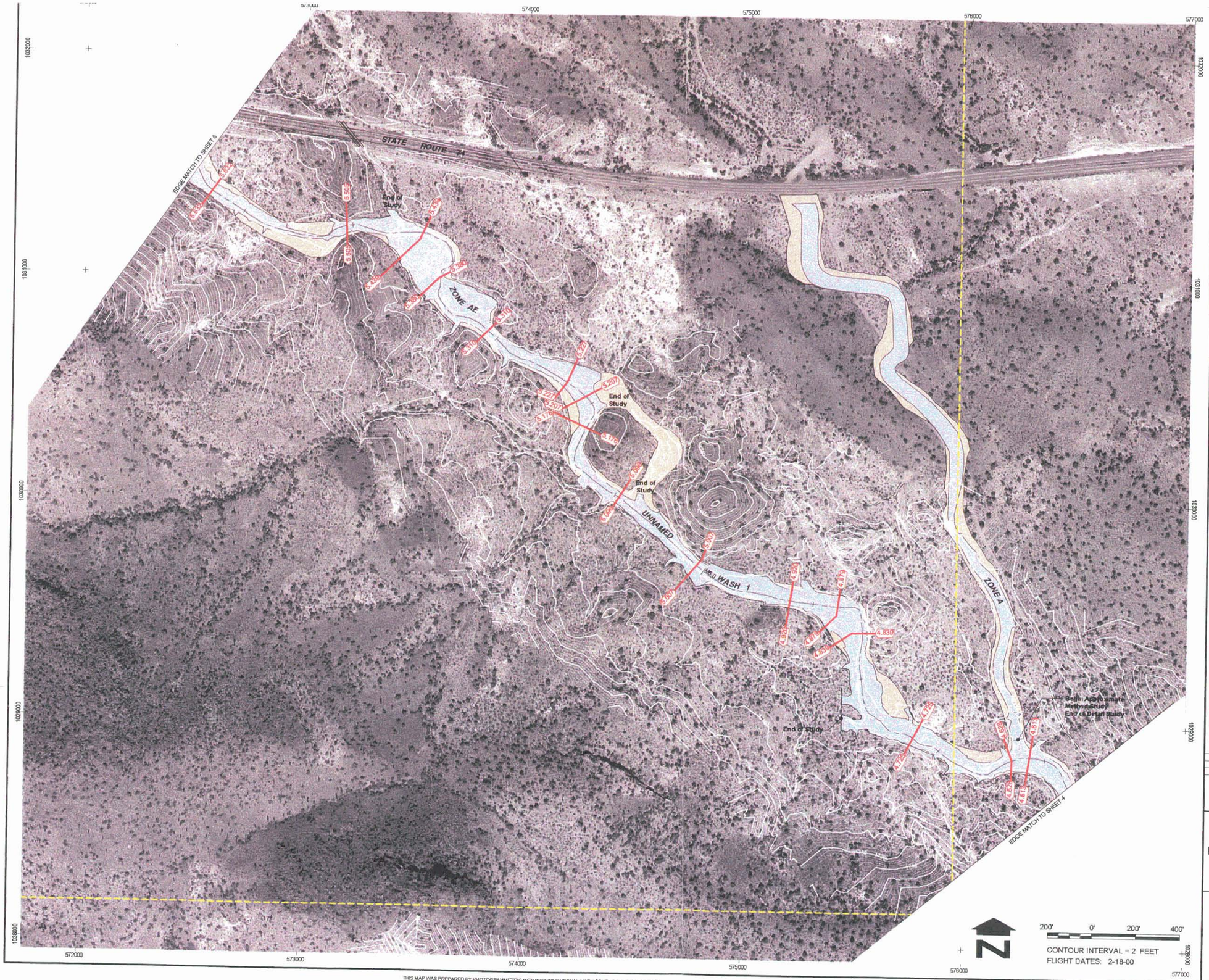
August 22, 2001



LEGEND

100-YR FLOODPLAIN BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
EROSION HAZARD ZONE	
CROSS SECTION	3.456 — 3.456
FLOOD ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
SECTION LINE	

NOTES

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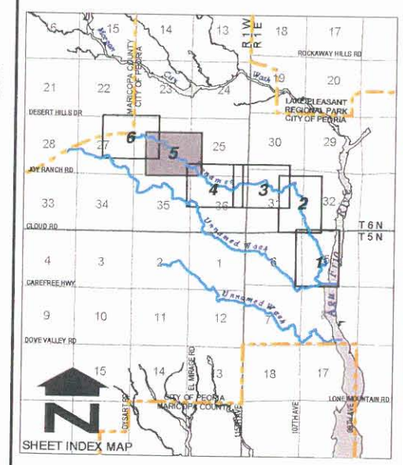
3- ALL SECTION LINES ARE APPROXIMATE.

4- EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



NO	REVISION	BY	DATE
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODPLAIN AND EROSION HAZARD MAP
UNNAMED WASH 1
F.C.D. CONTRACT NO. 99-45

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PLANS	NKD / HAR	01/01
PLANS CHK.	PJE	01/01

Figure 10-2

SHEET 5 OF 6

P:\82000146\gis\erosion\unnamed1_erosion.apr
August 22, 2001

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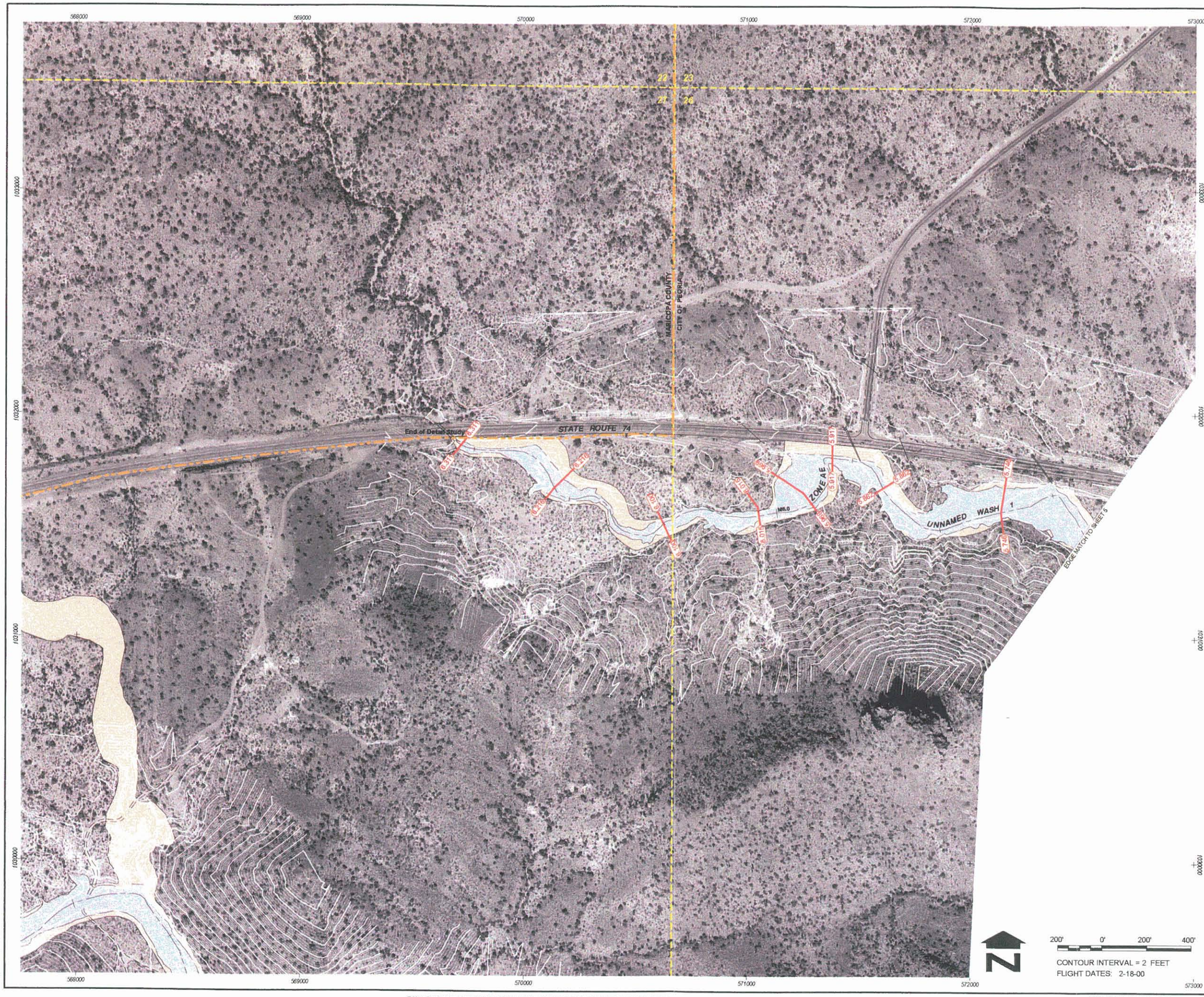

LEGEND

100-YR FLOODPLAIN BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
EROSION HAZARD ZONE	
CROSS SECTION	3.456 — 3.456
FLOOD ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
SECTION LINE	

NOTES

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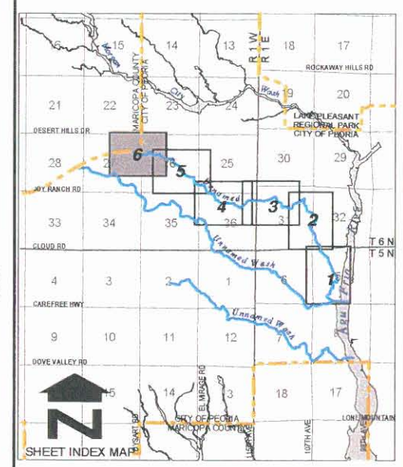
3- ALL SECTION LINES ARE APPROXIMATE.

4- EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



NO	REVISION	BY	DATE
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODPLAIN AND EROSION HAZARD MAP
UNNAMED WASH 1
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Figure 10-2

SHEET 6 OF 6

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August 22, 2001

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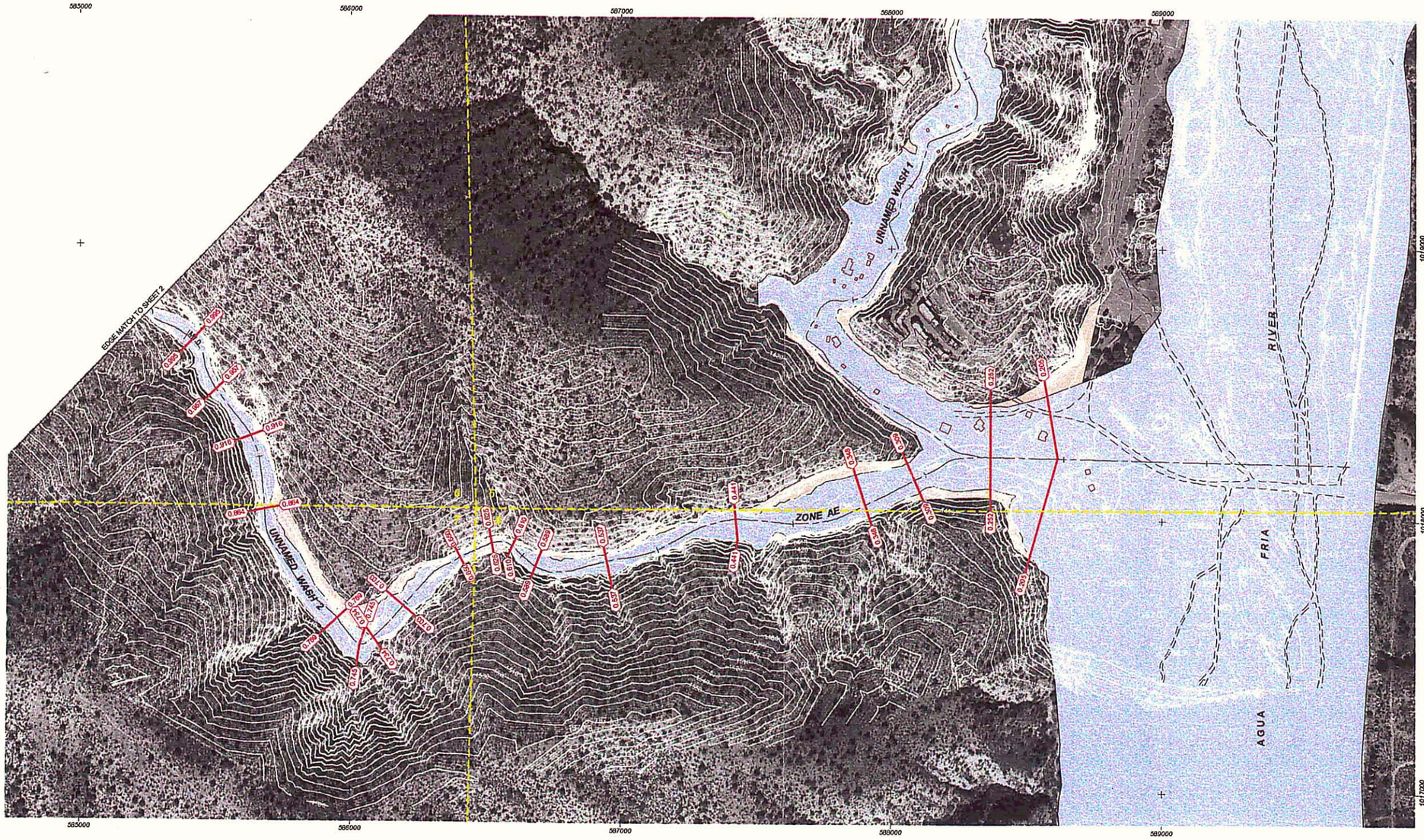

LEGEND

100-YR FLOODPLAIN BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
EROSION HAZARD ZONE	
CROSS SECTION	3.456 — 3.456
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
SECTION LINE	

NOTES

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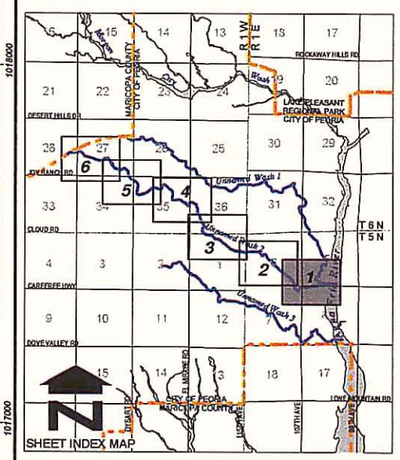
4- EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



NO	REVISION	BY	DATE
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODPLAIN AND EROSION HAZARD MAP
UNNAMED WASH 2
F.C.D.CONTRACT NO. 99-45

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Figure 10-3

SHEET 1 OF 6

200' 0' 200' 400'

CONTOUR INTERVAL = 2 FEET
FLIGHT DATES: 2-18-00

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 400' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS.

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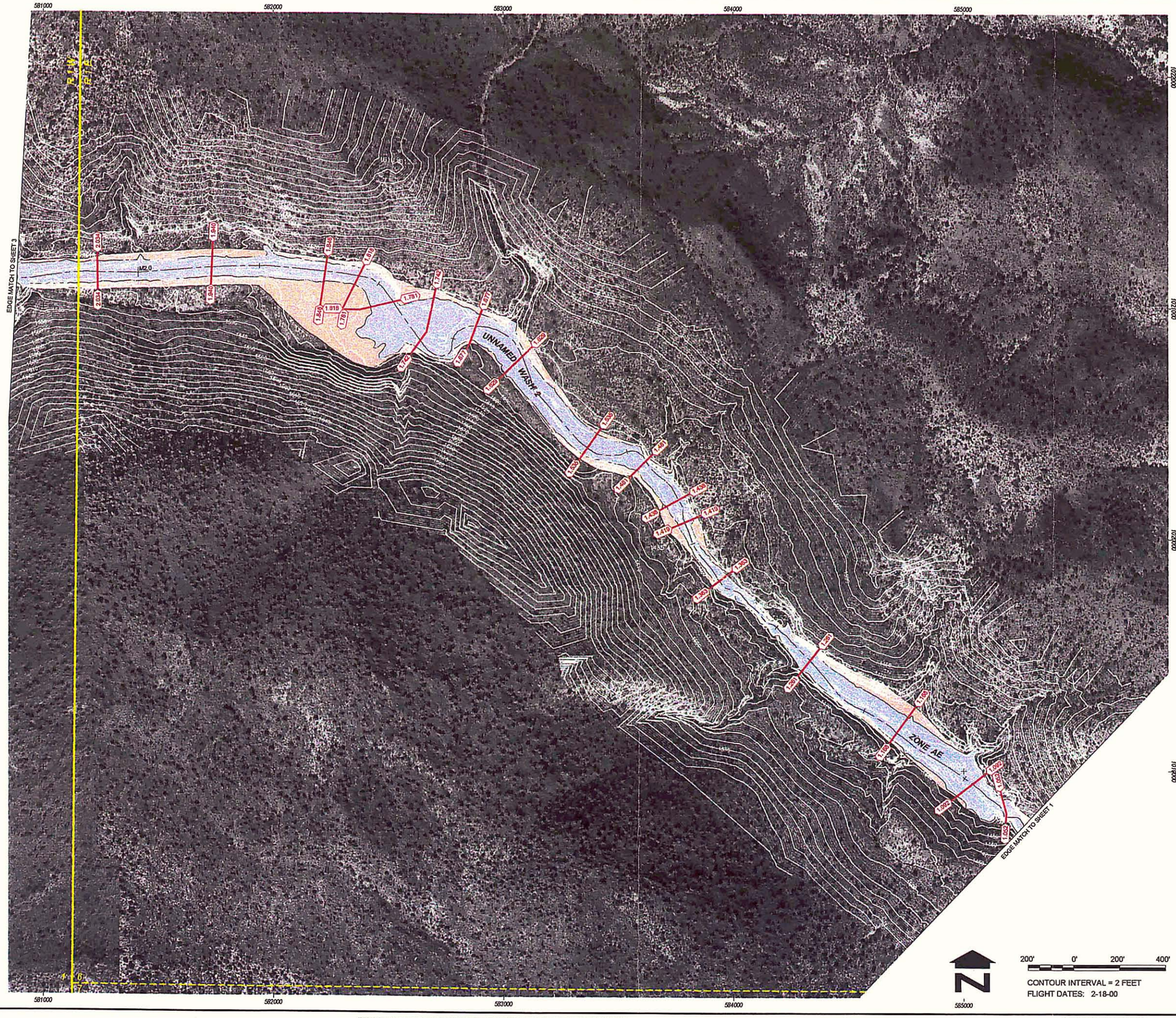
August 23, 2001



LEGEND

100-YR FLOODPLAIN BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
EROSION HAZARD ZONE	
CROSS SECTION	3.456 — 3.456
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
SECTION LINE	

NOTES

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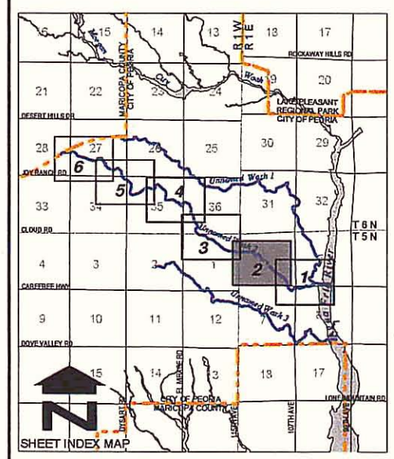
3- ALL SECTION LINES ARE APPROXIMATE.

4- EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



NO	REVISION	BY	DATE
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODPLAIN AND EROSION HAZARD MAP
UNNAMED WASH 2
F.C.D. CONTRACT NO. 99-45

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PLANS	NKD /HAR	01/01
PLANS CHK.	PJE	01/01

Figure 10-3

SHEET 2 OF 6

P:\82000146\gis\erosion\unnamed2_erosion.apr
August 23, 2001

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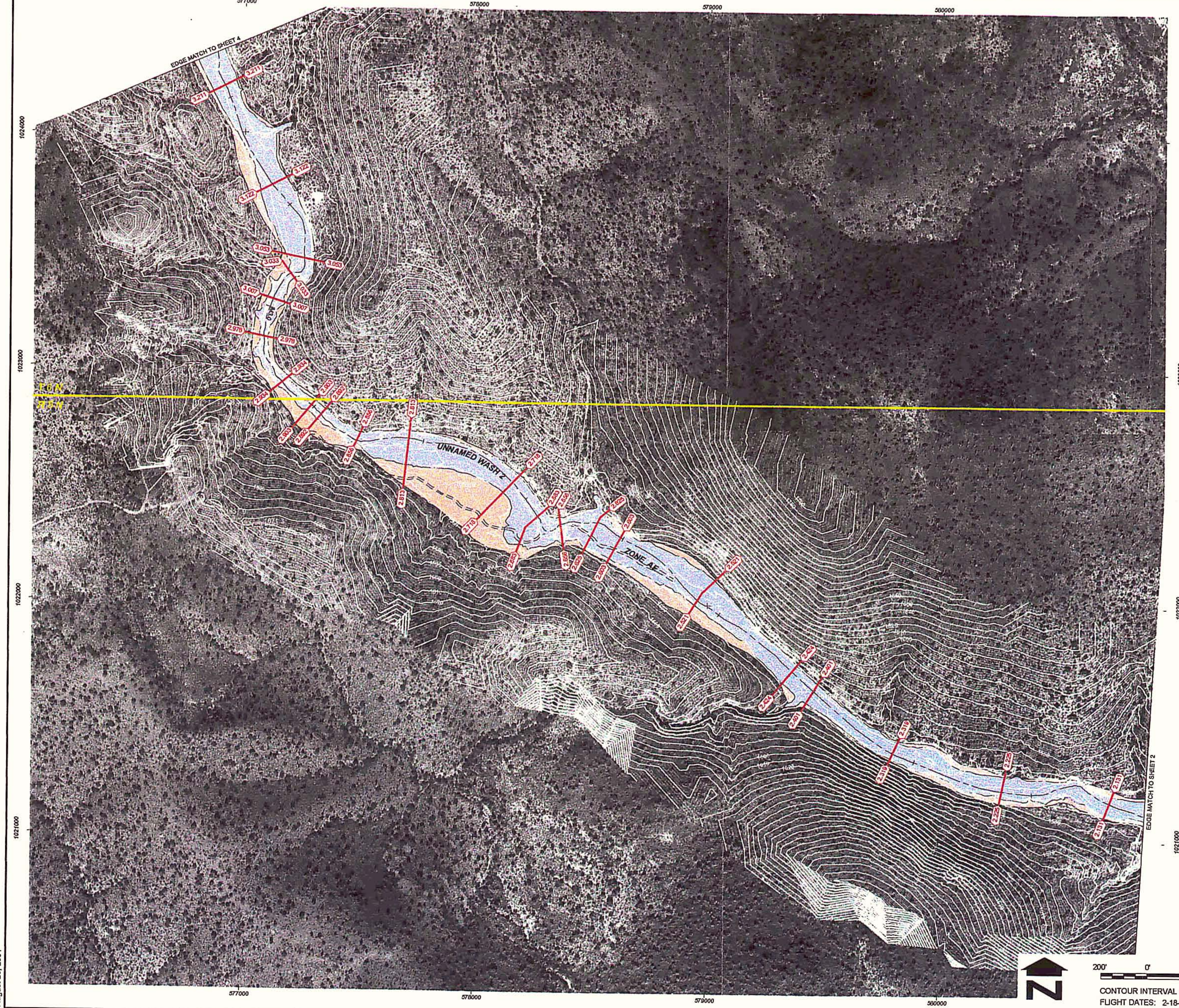
COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.



CONTOUR INTERVAL = 2 FEET
FLIGHT DATES: 2-18-00

LEGEND

100-YR FLOODPLAIN BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 M13.0
EROSION HAZARD ZONE	
CROSS SECTION	3.456 — 3.456
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
SECTION LINE	

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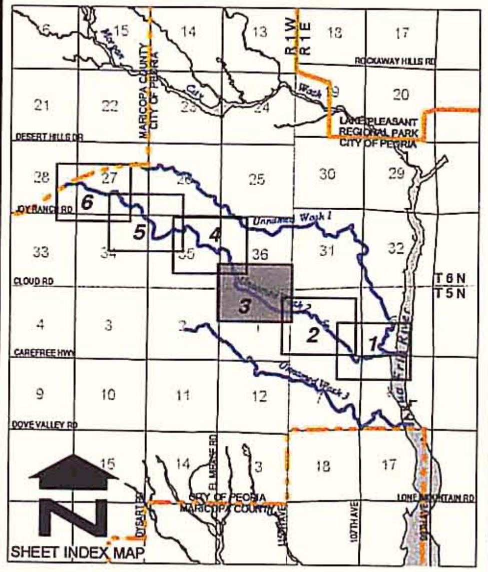

NO	REVISION	BY	DATE
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA AREA DRAINAGE MASTER PLAN FLOODPLAIN AND EROSION HAZARD MAP UNNAMED WASH 2

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PLANS CHK.	PJE	01/01

Figure 10-3

SHEET 3 OF 6

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 400' HORIZONTAL SCALE AND 2 'CONTOUR INTERVALS.

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.

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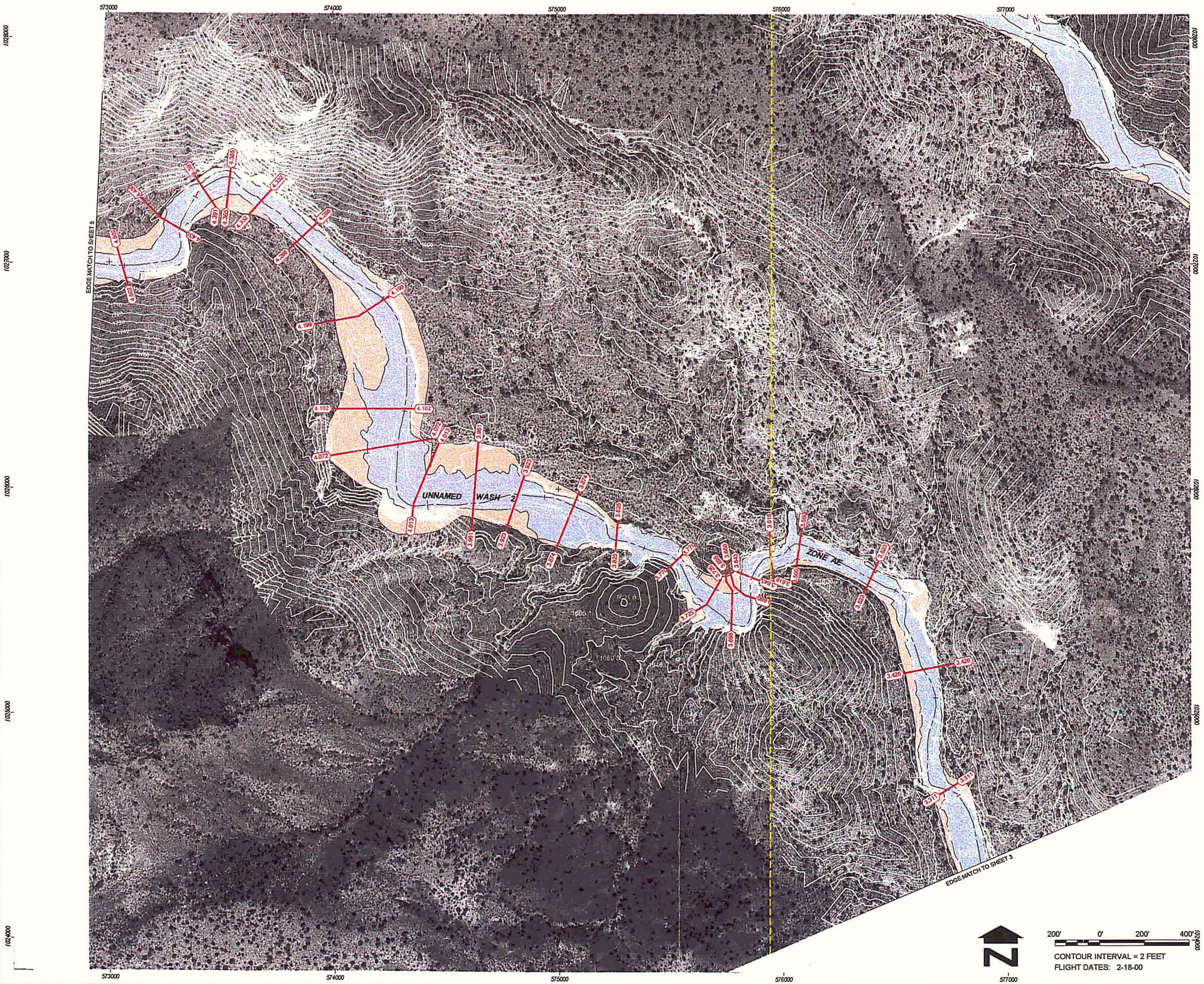

LEGEND

100-YR FLOODPLAIN BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 M13.0
EROSION HAZARD ZONE	
CROSS SECTION	3.456 — 3.456
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
SECTION LINE	

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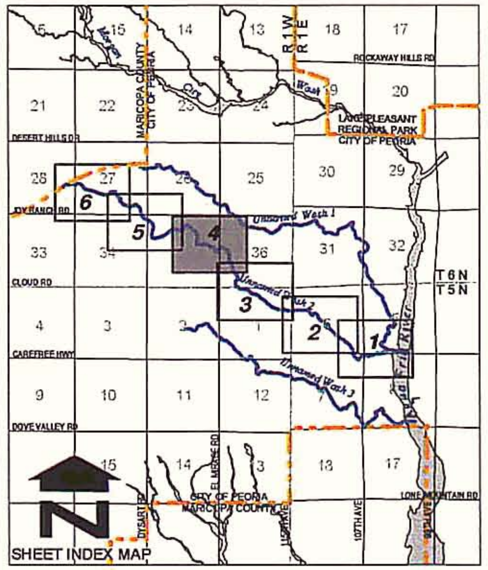

SHEET INDEX MAP

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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODPLAIN AND EROSION HAZARD MAP
UNNAMED WASH 2
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PLANS	NKD / HAR	01/01
PLANS CHK.	PJE	01/01

Figure 10-3 SHEET 4 OF 6

200' 0' 200' 400'

CONTOUR INTERVAL = 2 FEET
FLIGHT DATES: 2-18-00

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 400' HORIZONTAL SCALE AND 2 'CONTOUR INTERVALS.

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.

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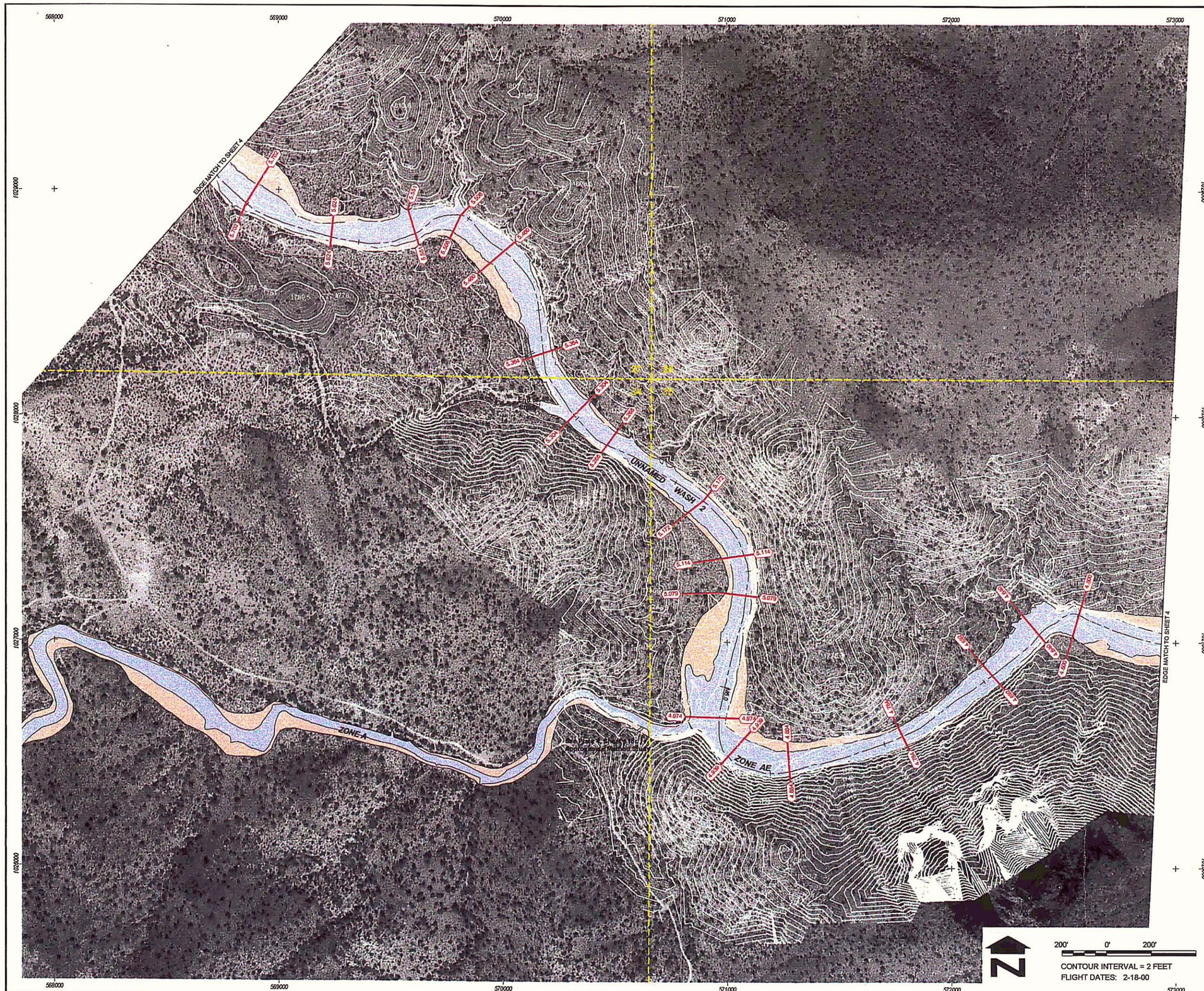

LEGEND

100-YR FLOODPLAIN BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
EROSION HAZARD ZONE	
CROSS SECTION	3.456 — 3.456
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
SECTION LINE	

NOTES

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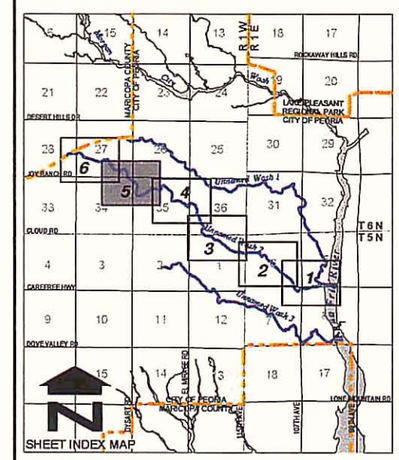

NO	REVISION	BY	DATE
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	BY	DATE
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DESIGN CHK.	PJE	01/01
PLANS	NKD / HAR	01/01
PLANS CHK.	PJE	01/01

Figure 10-3

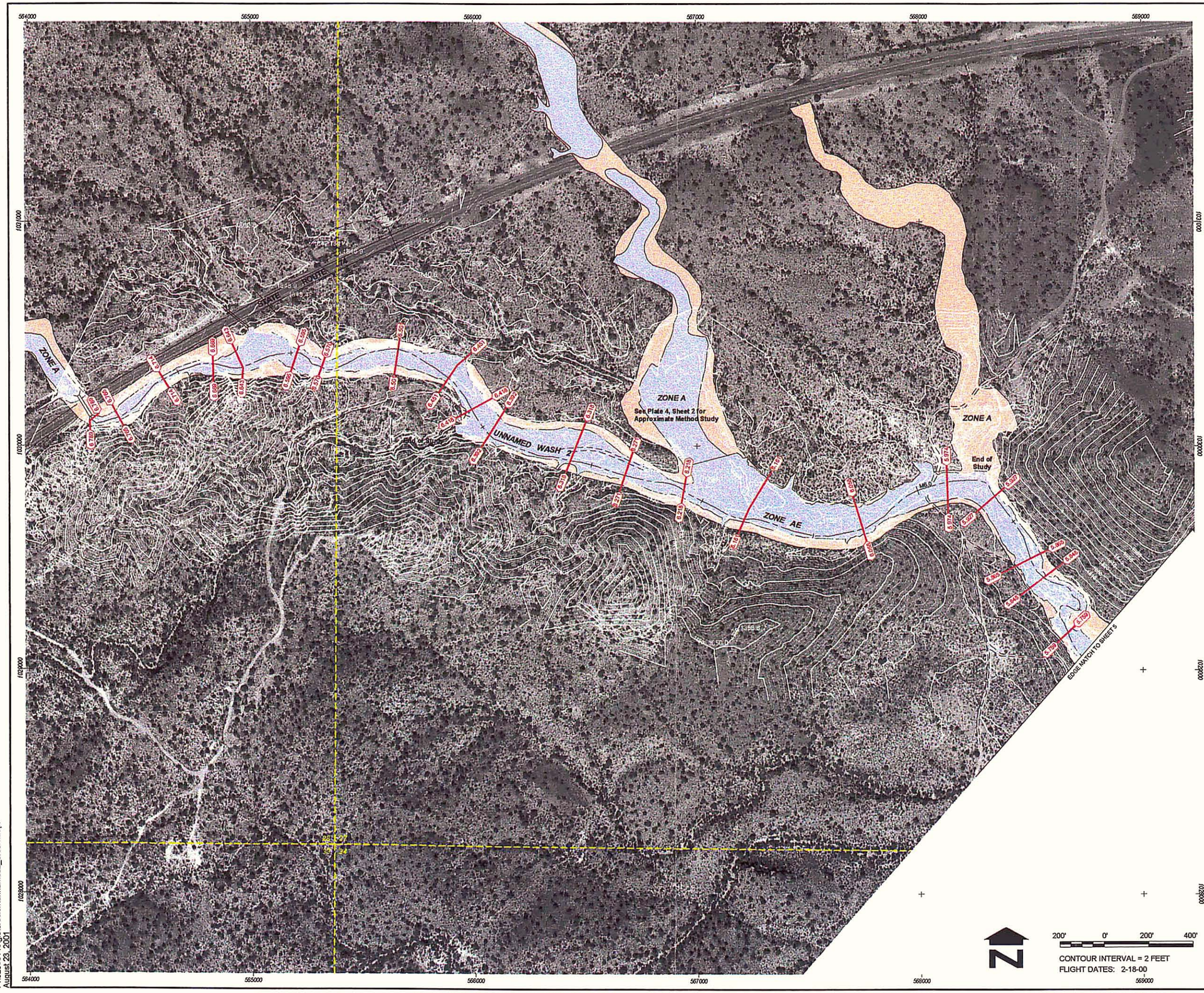
SHEET 5 OF 6

P:\82000146\gis\erosion\unnamed2_erosion.apr
August 23, 2001

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 400' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS.

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.



LEGEND

100-YR FLOODPLAIN BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
EROSION HAZARD ZONE	
CROSS SECTION	3.456 — 3.456
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
SECTION LINE	

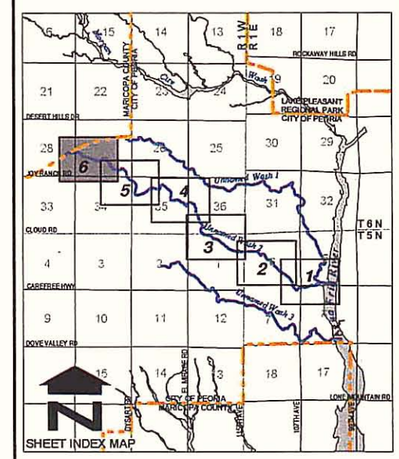
NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1998 VALUES.

3- ALL SECTION LINES ARE APPROXIMATE.

4- EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



NO	REVISION	BY	DATE
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODPLAIN AND EROSION HAZARD MAP
UNNAMED WASH 2
F.C.D. CONTRACT NO. 99-45

Stantec Consulting Inc.
10211 South 48th Street
Phoenix, Az 85044-5355 U.S.A.
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Fax: (602) 431-8582
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DESIGN CHK.	PJE	01/01
PLANS	NKD / HAR	01/01
PLANS CHK.	PJE	01/01

Figure 10-3

SHEET 8 OF 6

P:\82000146\gis\erosion\unnamed2_erosion.apr
August 23, 2001

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 400' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS.

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.

LEGEND

100-YR FLOODPLAIN BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
EROSION HAZARD ZONE	
CROSS SECTION	3.456 — 3.456
FLOOD ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
SECTION LINE	

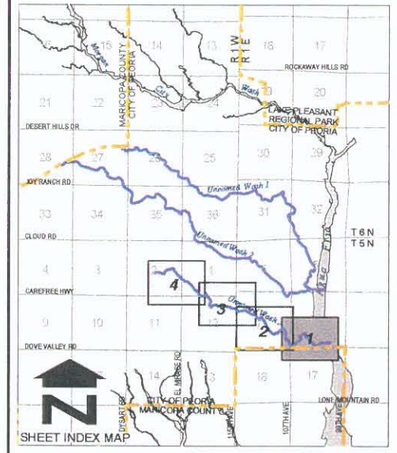
NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1998 VALUES.

3- ALL SECTION LINES ARE APPROXIMATE.

4- EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



NO	REVISION	BY	DATE
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODPLAIN AND EROSION HAZARD MAP
UNNAMED WASH 3
F.C.D. CONTRACT NO. 99-45

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DESIGN	MCG	01/01
DESIGN CHK.	PJE	01/01
PLANS	NKD / HAR	01/01
PLANS CHK.	PJE	01/01

Figure 10-4

SHEET 1 OF 4

P:\82000146\gis\erosion\unnamed3_erosion.apr
August 23, 2001

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 400' HORIZONTAL SCALE AND 2 'CONTOUR INTERVALS.

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP

200' 0' 200' 400'

CONTOUR INTERVAL = 2 FEET
FLIGHT DATES: 2-18-00

LEGEND

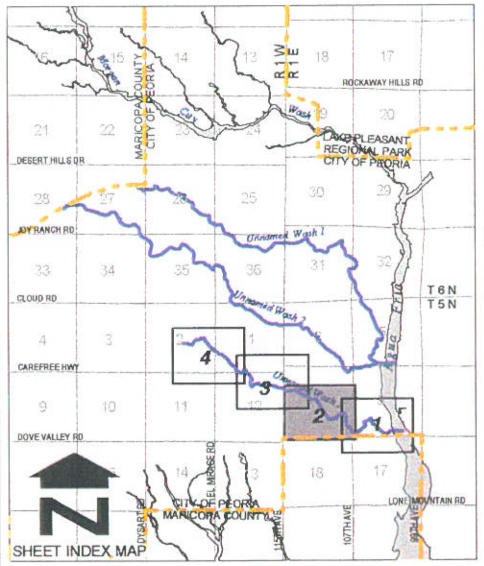
100-YR FLOODPLAIN BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 M13.0
EROSION HAZARD ZONE	
CROSS SECTION	3.456 3.456
FLOOD ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
SECTION LINE	

NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1998 VALUES.

3- ALL SECTION CORNERS ARE APPROXIMATE.



SHEET INDEX MAP

NO	REVISION	BY	DATE
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODPLAIN AND EROSION HAZARD MAP
UNNAMED WASH 3
F.C.D.CONTRACT NO. 99-45

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DESIGN	MCG	01/01
DESIGN CHK.	PJE	01/01
PLANS	NKD / HAR	01/01
PLANS CHK.	PJE	01/01

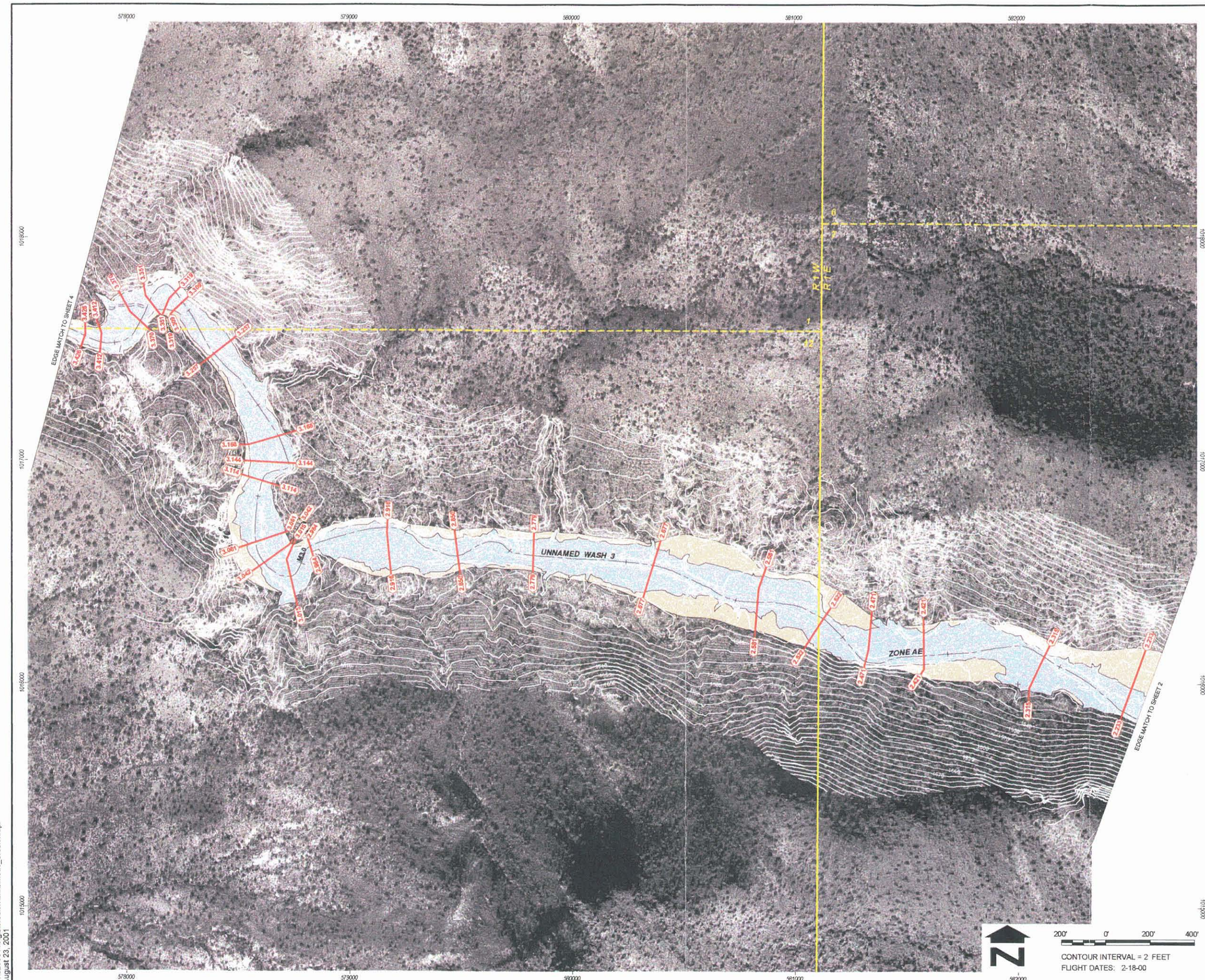
Figure 10-4 SHEET 2 OF 4

P:\82000146\gis\erosion\unnamed3_erosion.apr
August 23, 2001

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 400' HORIZONTAL SCALE AND 2 'CONTOUR INTERVALS.

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.



LEGEND

100-YR FLOODPLAIN BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
EROSION HAZARD ZONE	
CROSS SECTION	3.456 — 3.456
FLOOD ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
SECTION LINE	

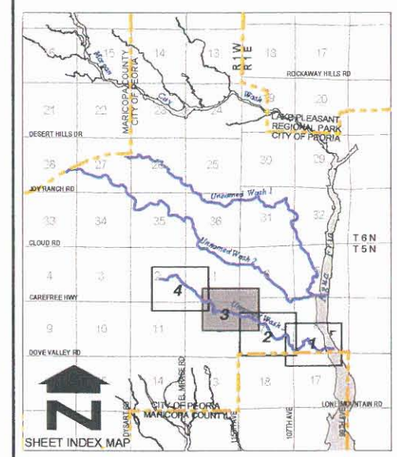
NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1998 VALUES.

3- ALL SECTION LINES ARE APPROXIMATE.

4- EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODPLAIN AND EROSION HAZARD MAP
UNNAMED WASH 3
F.C.D. CONTRACT NO. 99-45

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PLANS	NKD / HAR	01/01
PLANS CHK.	PJE	01/01

Figure 10-4

SHEET 3 OF 4

P:\82000146\gis\erosion\unnamed3_erosion.apr
August 23, 2001

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 400' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS.

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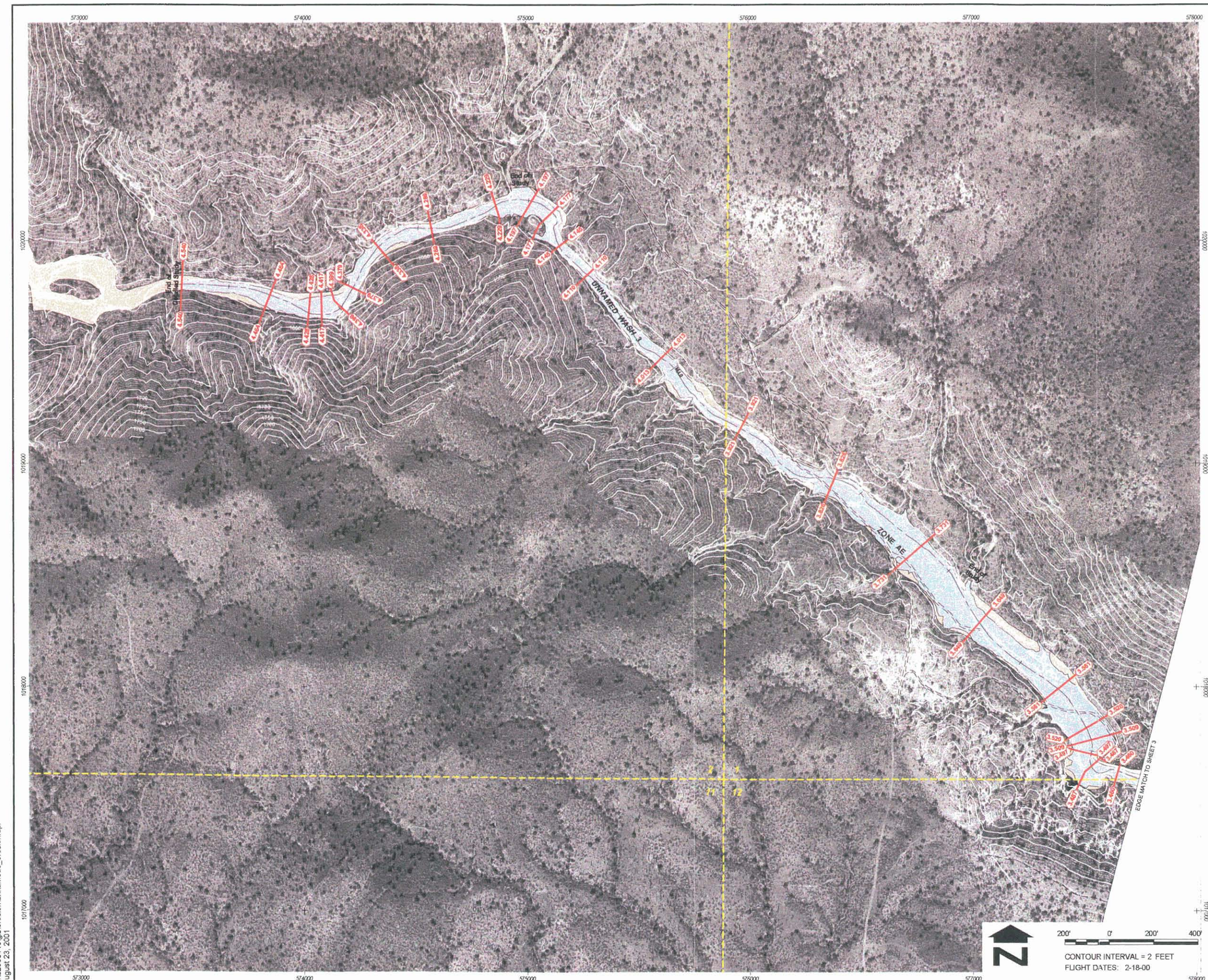
GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.



LEGEND

100-YR FLOODPLAIN BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
EROSION HAZARD ZONE	
CROSS SECTION	3.456 — 3.456
FLOOD ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
SECTION LINE	

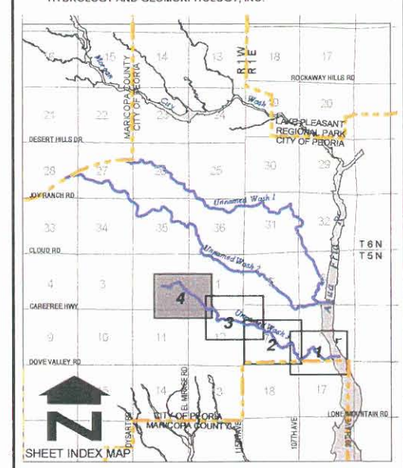
NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-386 FROM THE ADJUSTED NAVD 1998 VALUES.

3- ALL SECTION LINES ARE APPROXIMATE.

4- EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



NO	REVISION	BY	DATE
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODPLAIN AND EROSION HAZARD MAP
UNNAMED WASH 3
F.C.D. CONTRACT NO. 99-45

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DESIGN CHK.	PJE	01/01
PLANS	NKD / HAR	01/01
PLANS CHK.	PJE	01/01

Figure 10-4

SHEET 4 OF 4

P:\62000146\gis\erosion\unnamed3_erosion.apr
August 23, 2001

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 400' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS.

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.

AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

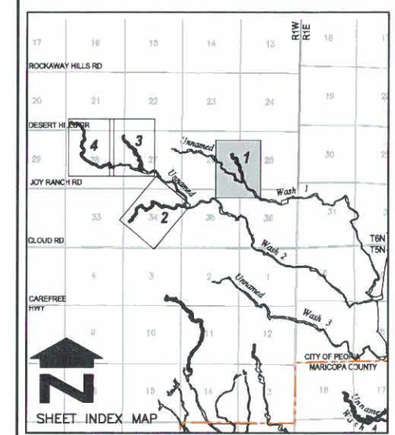
200' 0' 200' 400'

LEGEND

- ZONE A 100-YR FLOODPLAIN BOUNDARY (NEW FEMA SUBMITTAL)
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



NO.	REVISION	BY	DATE
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA AREA DRAINAGE MASTER PLAN FLOODPLAIN AND EROSION HAZARD MAP F.C.D. CONTRACT NO. 99-45

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PLANS	HAR	05.18.01
PLANS CHK.	PJE	06.06.01

FIGURE 10-5

SHEET 1 OF 4

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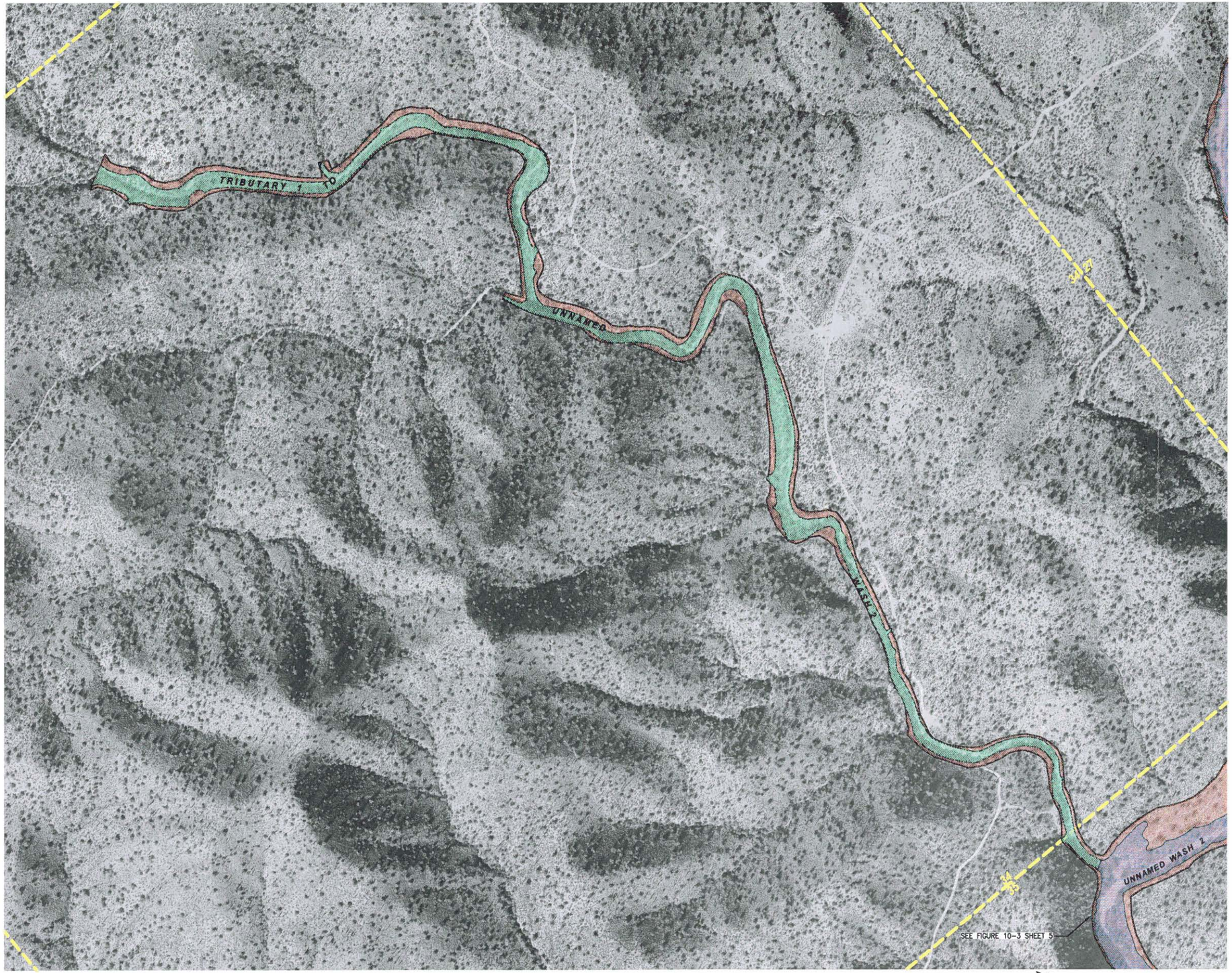


AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

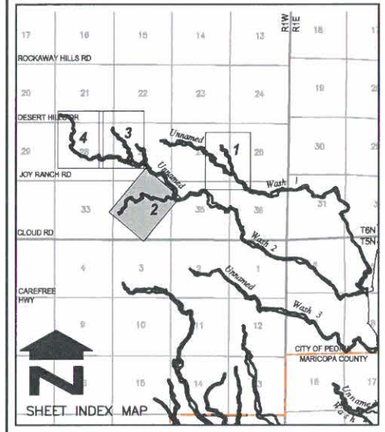
200' 0' 200' 400'

LEGEND

- ZONE A 100-YR FLOODPLAIN BOUNDARY (NEW FEMA SUBMITTAL)
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



NO.	REVISION	BY	DATE
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FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA AREA DRAINAGE MASTER PLAN FLOODPLAIN AND EROSION HAZARD MAP F.C.D. CONTRACT NO. 99-45

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DESIGN CHK.	–	–
PLANS	HAR	06.05.01
PLANS CHK.	PJE	06.13.01

FIGURE 10-5

SHEET 2 OF 4

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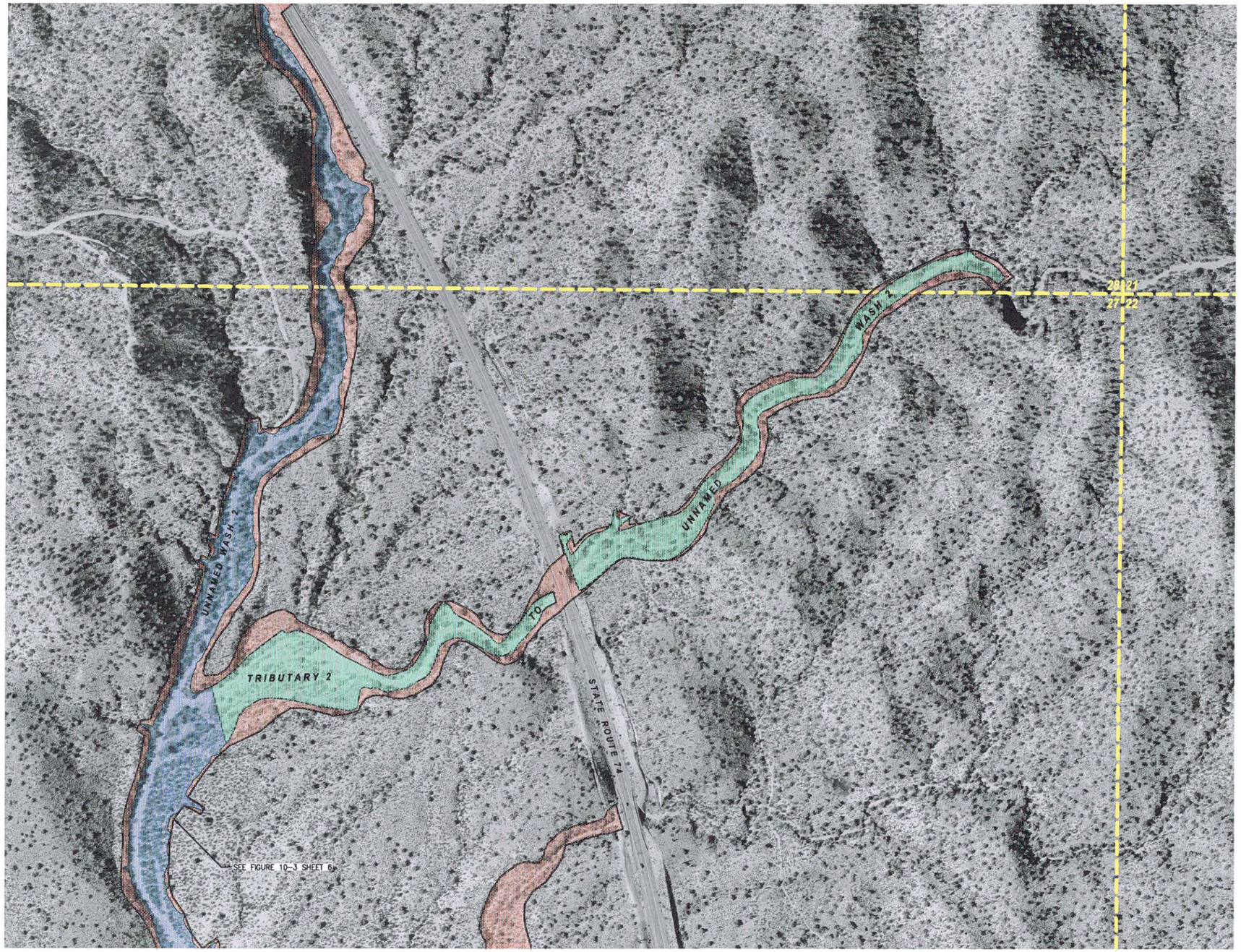
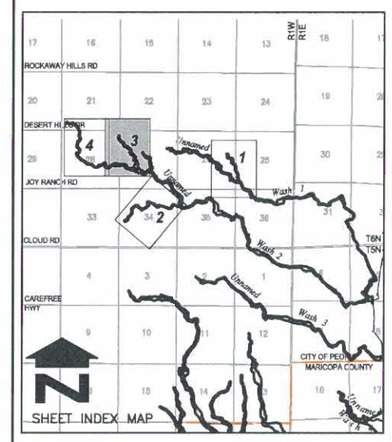


LEGEND

- ZONE A 100-YR FLOODPLAIN BOUNDARY (NEW FEMA SUBMITTAL)
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA AREA DRAINAGE MASTER PLAN FLOODPLAIN AND EROSION HAZARD MAP F.C.D. CONTRACT NO. 99-45

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DESIGN CHK.	–	–
PLANS	HAR	06.05.01
PLANS CHK.	PJE	06.13.01

FIGURE 10-5

SHEET 3 OF 4

200' 0' 200' 400'

AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

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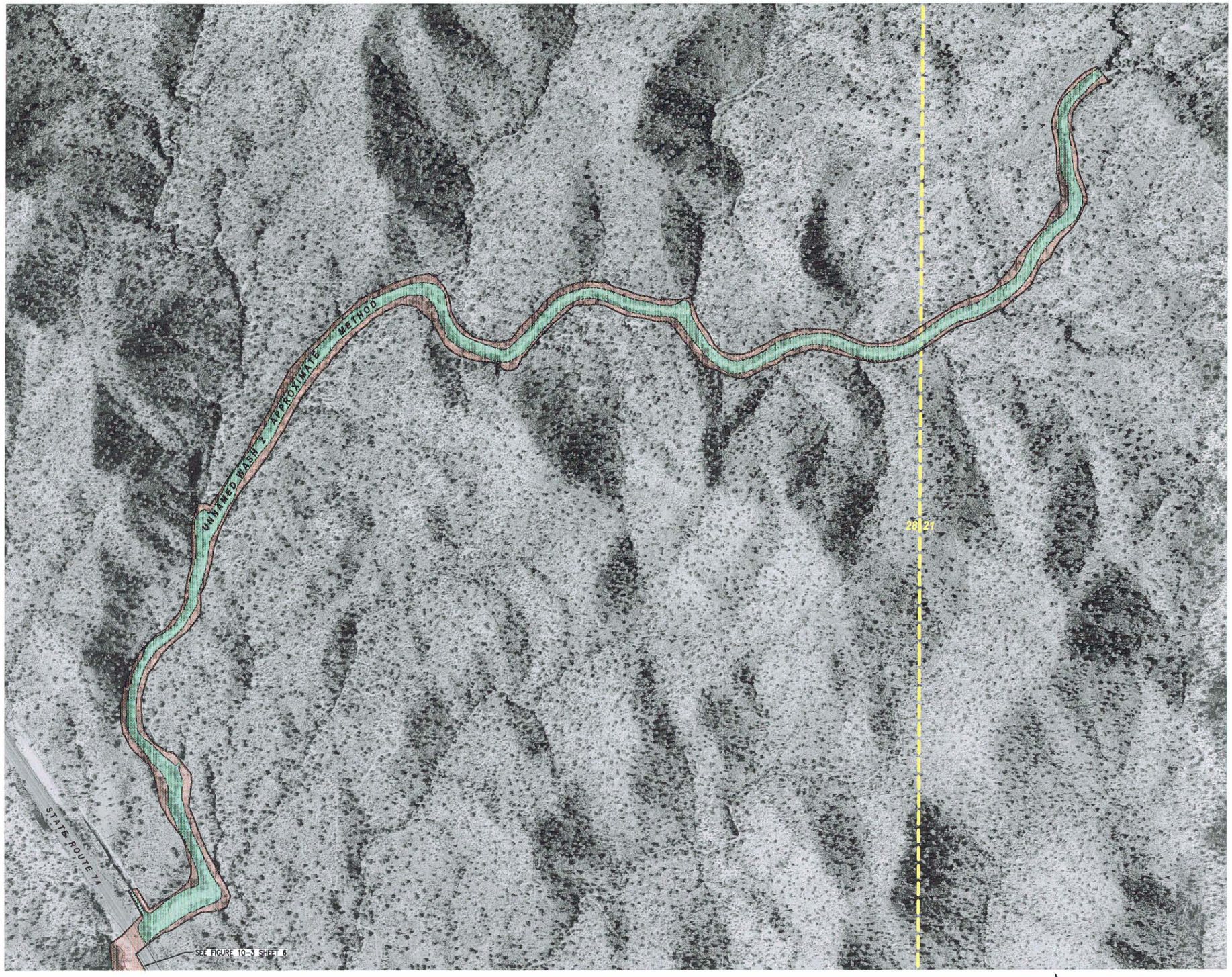

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AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

200' 0' 200' 400'

LEGEND

ZONE A 100-YR FLOODPLAIN BOUNDARY (NEW FEMA SUBMITTAL)

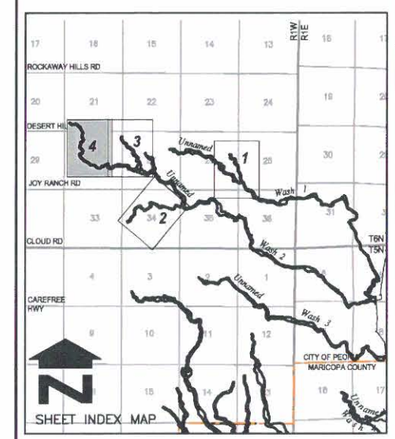
EROSION HAZARD ZONE

CORPORATE LIMITS

SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



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DESIGN CHK.	–	–
PLANS	HAR	06.05.01
PLANS CHK.	PJE	06.13.01

FIGURE 10-5

SHEET 4 OF 4

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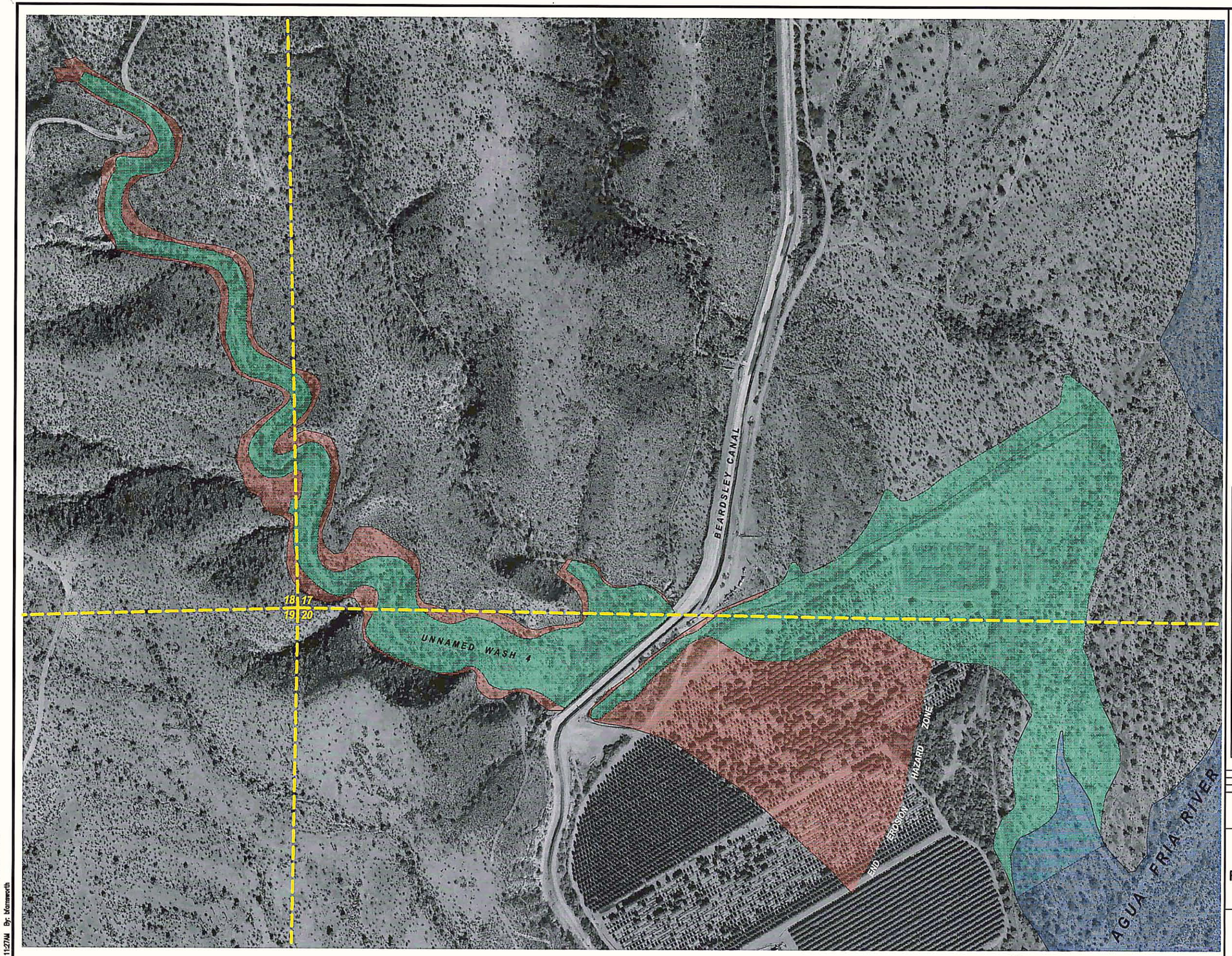


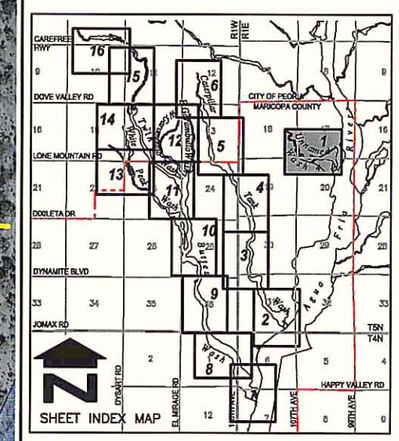
AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

LEGEND

- EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY
- ZONE A 100-YR FLOODPLAIN BOUNDARY (NEW FEMA SUBMITTAL)
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA AREA DRAINAGE MASTER PLAN FLOODPLAIN AND EROSION HAZARD MAP F.C.D. CONTRACT NO. 99-45

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www.stantec.com

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DESIGN CHK.	--	--
PLANS	HAR	05.18.01
PLANS CHK.	PJE	06.06.01

FIGURE 10-5

SHEET 1 OF 16

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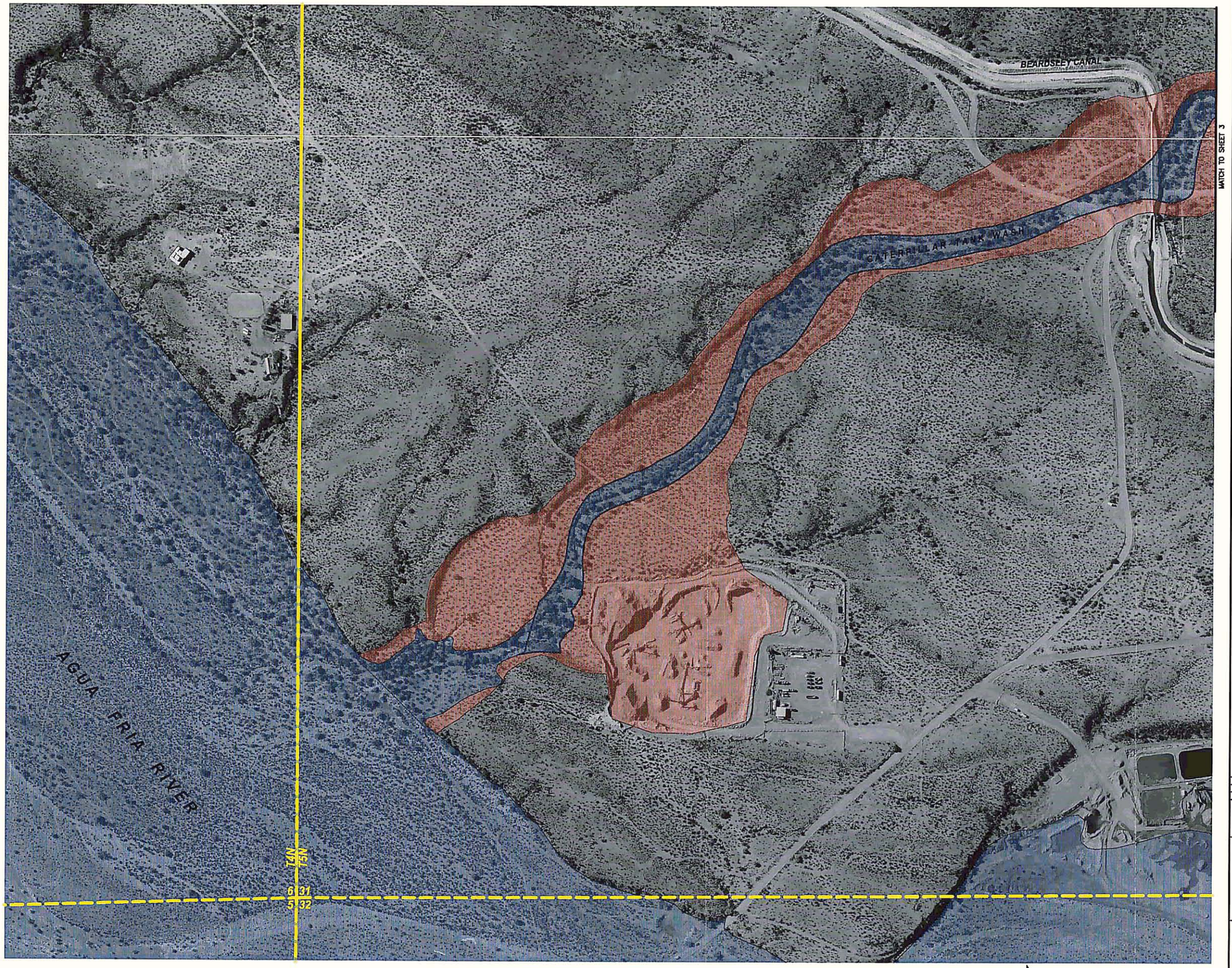


AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

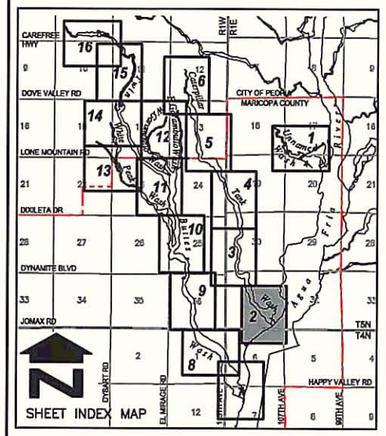
200' 0' 200' 400'

LEGEND

- EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.
3. EFFECTIVE FEMA 100-YR FLOODPLAINS ARE APPROXIMATE ONLY. FOR DETAILED INFORMATION SEE: FLOOD INSURANCE STUDY FOR CATERPILLAR TANK AND TWIN BUTTES WASHES FROM AGUA FRIA RIVER TO C.A.P. CANAL, MARICOPA COUNTY, ARIZONA, CONTRACT FCD 90-09



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DESIGN CHK.	—	—
PLANS	HAR	05.18.01
PLANS CHK.	PJE	06.06.01

FIGURE 10-5

SHEET 2 OF 16

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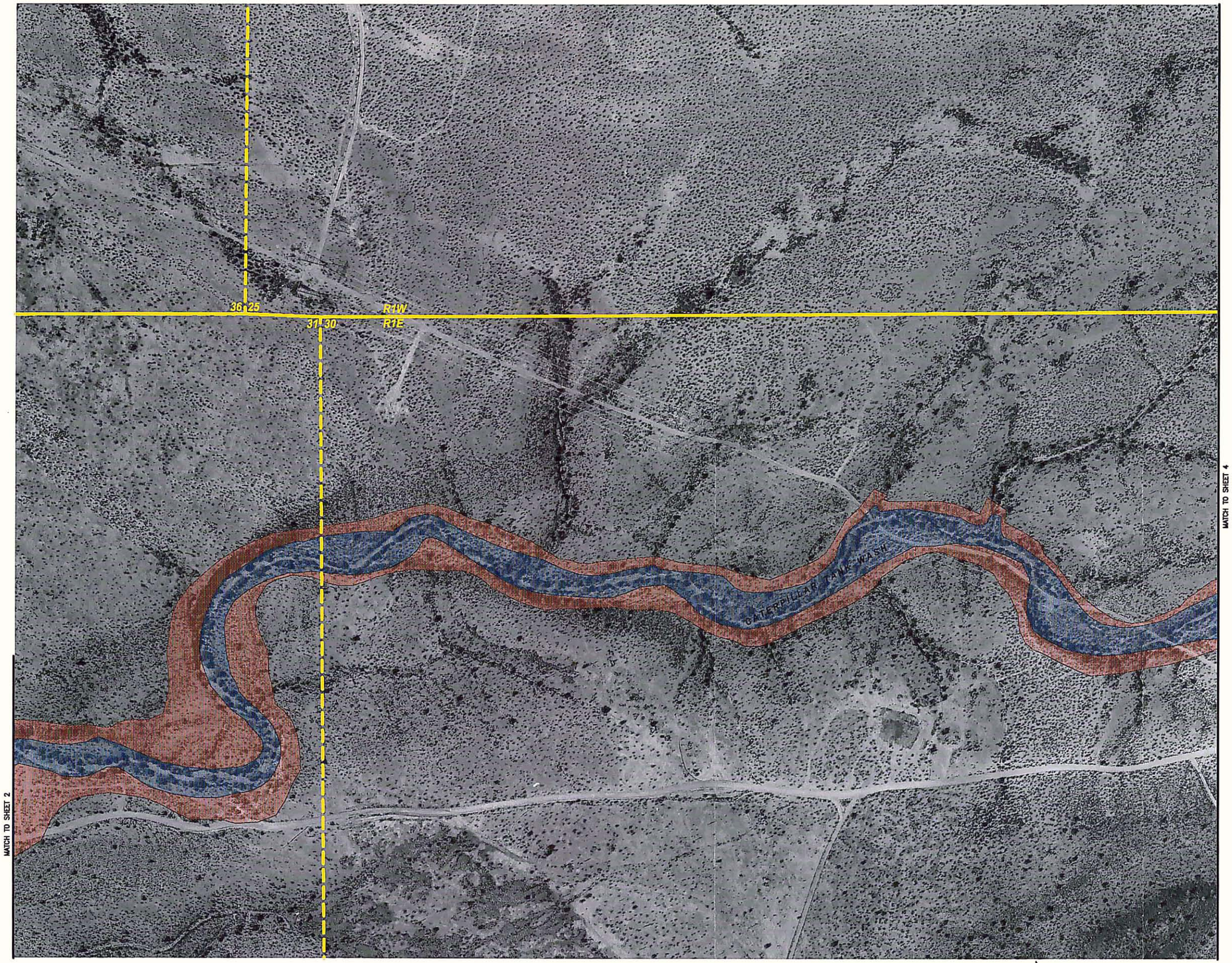
2001-12-21 10:52AM By: bfarnsworth



AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

200' 0' 200' 400'

LEGEND

EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY

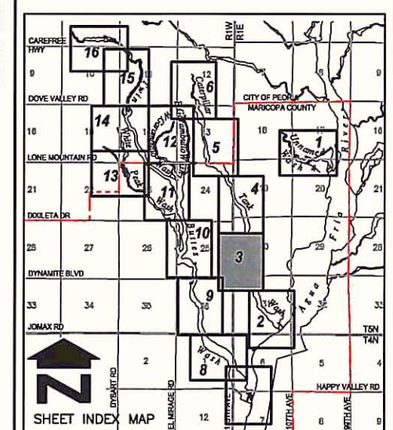
EROSION HAZARD ZONE

CORPORATE LIMITS

SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.
3. EFFECTIVE FEMA 100-YR FLOODPLAINS ARE APPROXIMATE ONLY. FOR DETAILED INFORMATION SEE: FLOOD INSURANCE STUDY FOR CATERPILLAR TANK AND TWIN BUTTES WASHES FROM AGUA FRIA RIVER TO C.A.P. CANAL, MARICOPA COUNTY, ARIZONA, CONTRACT FCD 90-09



NO.	REVISION	BY	DATE
2			
1			

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

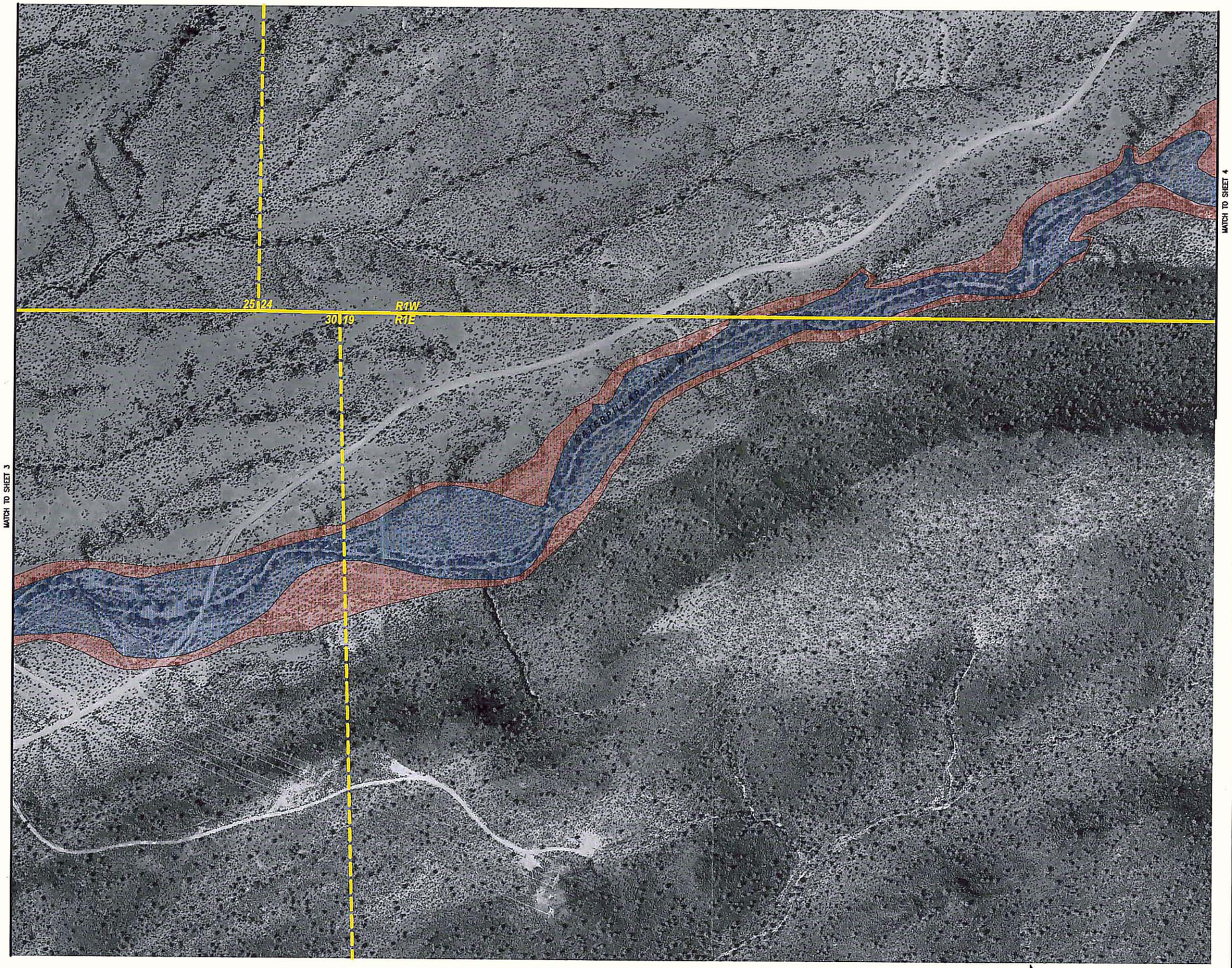
NORTH PEORIA AREA DRAINAGE MASTER PLAN FLOODPLAIN AND EROSION HAZARD MAP F.C.D. CONTRACT NO. 99-45

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ 85044-5355 U.S.A.
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

	BY	DATE
DESIGN	–	–
DESIGN CHK.	–	–
PLANS	HAR	05.18.01
PLANS CHK.	PJE	06.06.01

FIGURE 10-6

P:\62000148\Dwg\npodmp\version\2000\03area146.dwg
2001-12-21 11:13AM By: bfarnsworth



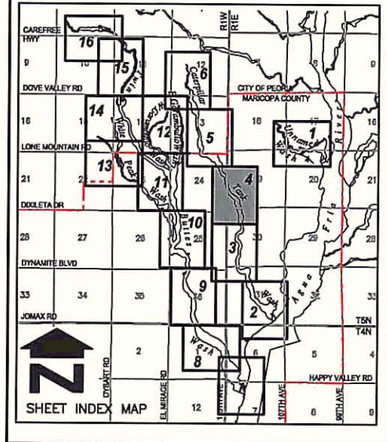
AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

LEGEND

- EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.
3. EFFECTIVE FEMA 100-YR FLOODPLAINS ARE APPROXIMATE ONLY. FOR DETAILED INFORMATION SEE: FLOOD INSURANCE STUDY FOR CATERPILLAR TANK AND TWIN BUTTES WASHES FROM AGUA FRIA RIVER TO C.A.P. CANAL, MARICOPA COUNTY, ARIZONA, CONTRACT FCD 90-09



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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA AREA DRAINAGE MASTER PLAN FLOODPLAIN AND EROSION HAZARD MAP F.C.D. CONTRACT NO. 99-45

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	BY	DATE
DESIGN	–	–
DESIGN CHK.	–	–
PLANS	HAR	05.18.01
PLANS CHK.	PJE	06.06.01

FIGURE 10-5

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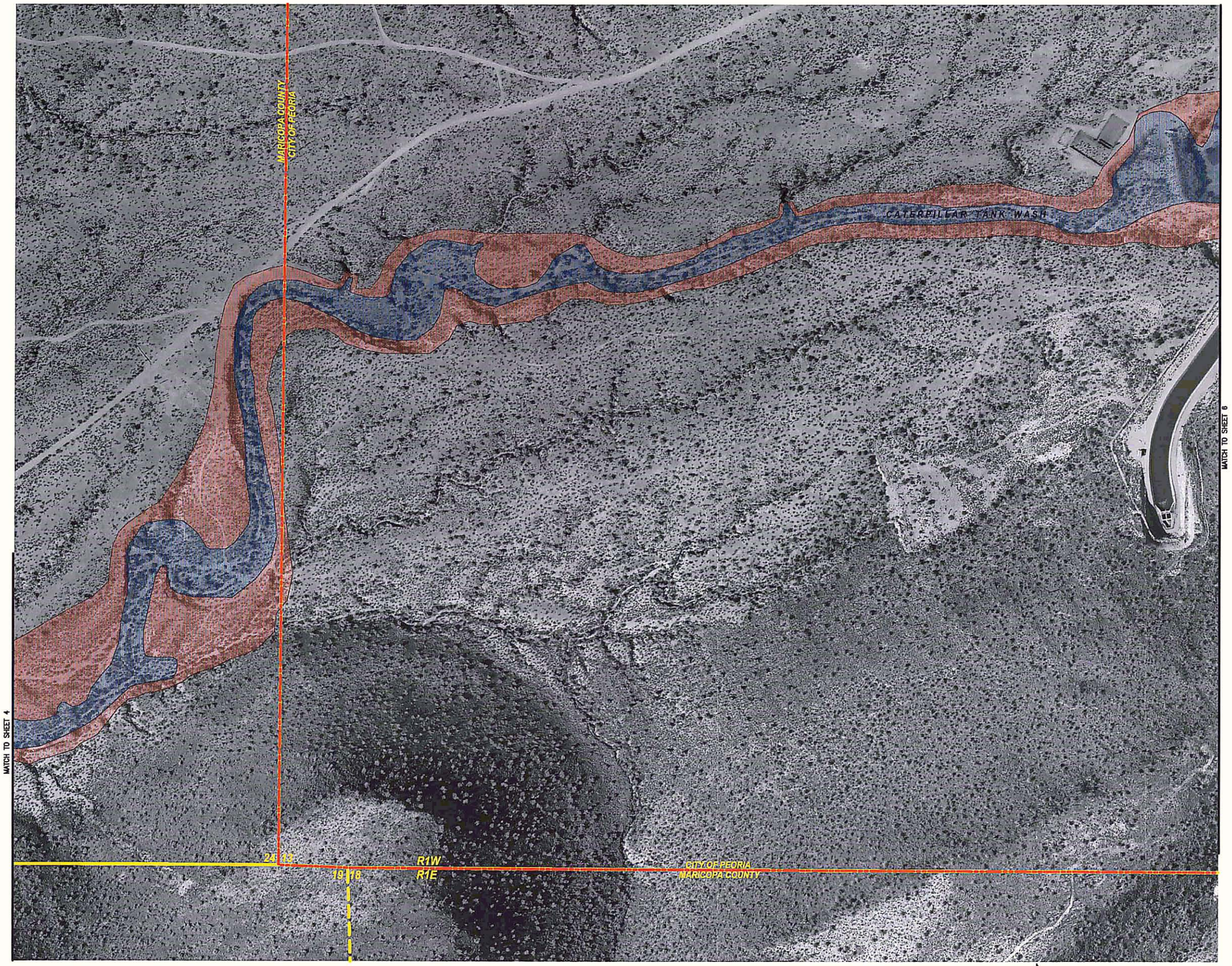
2001-12-21 10:16AM By: hfortnamorth



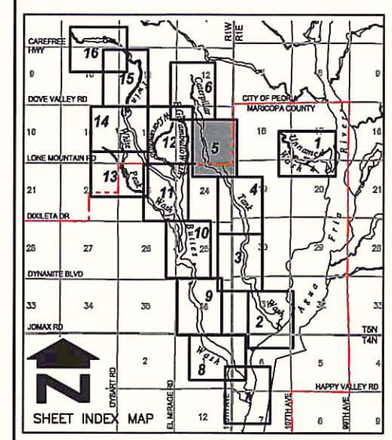
AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

LEGEND

- EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.
3. EFFECTIVE FEMA 100-YR FLOODPLAINS ARE APPROXIMATE ONLY. FOR DETAILED INFORMATION SEE: FLOOD INSURANCE STUDY FOR CATERPILLAR TANK AND TWIN BUTTES WASHES FROM AGUA FRIA RIVER TO C.A.P. CANAL, MARICOPA COUNTY, ARIZONA, CONTRACT FCD 90-09



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2			
1			

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODPLAIN AND EROSION HAZARD MAP
F.C.D. CONTRACT NO. 99-45

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	BY	DATE
DESIGN	--	--
DESIGN CHK.	--	--
PLANS	HAR	05.18.01
PLANS CHK.	PJE	06.06.01

FIGURE 10-6

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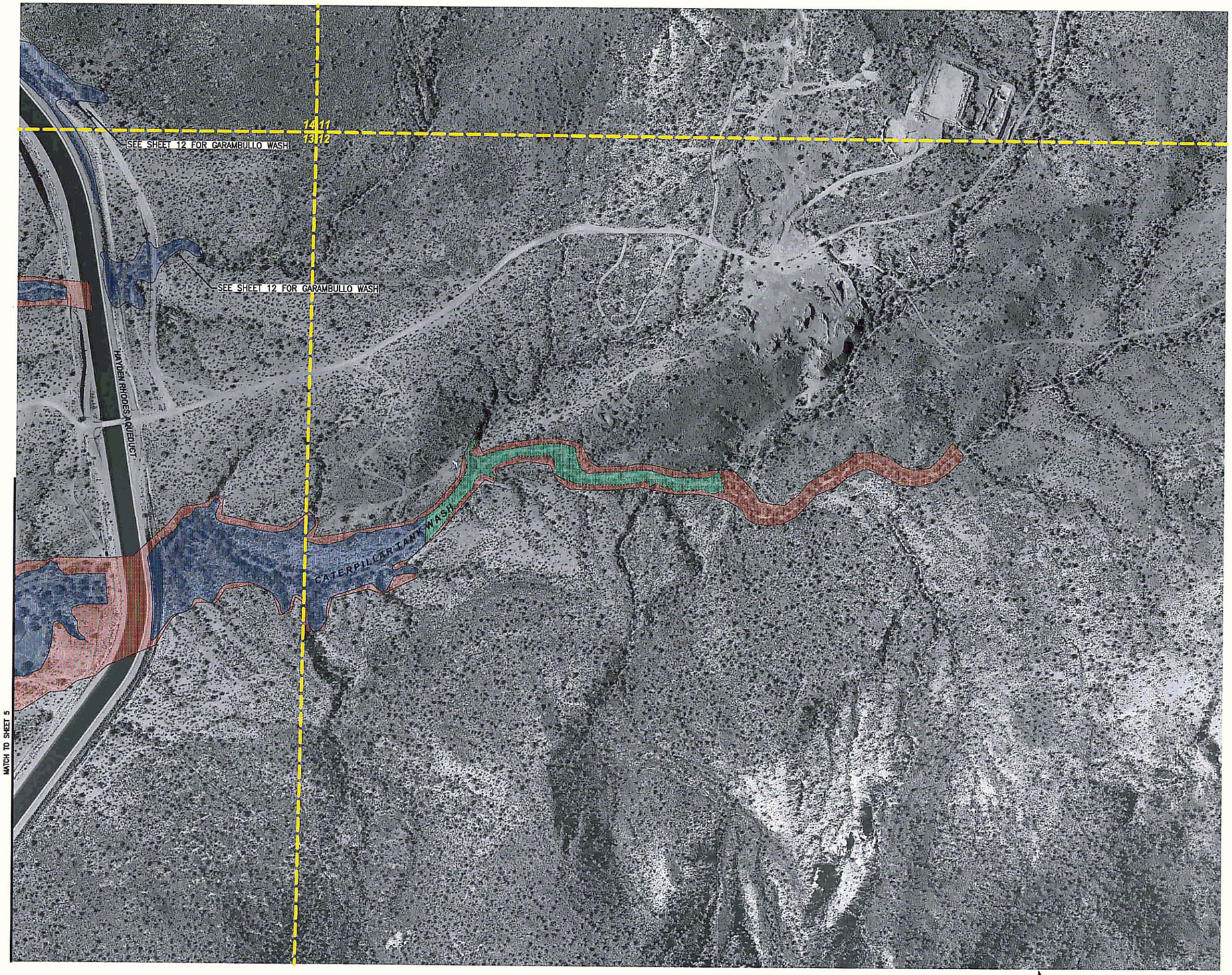
2001-12-21 09:50AM By: bformsworth



AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

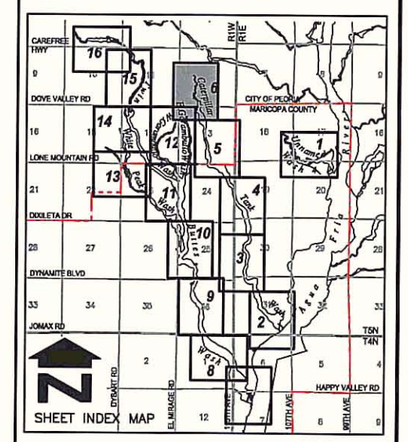
200' 0' 200' 400'

LEGEND

- EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY
- ZONE A 100-YR FLOODPLAIN BOUNDARY (NEW FEMA SUBMITTAL)
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.
3. EFFECTIVE FEMA 100-YR FLOODPLAINS ARE APPROXIMATE ONLY. FOR DETAILED INFORMATION SEE: FLOOD INSURANCE STUDY FOR CATERPILLAR TANK AND TWIN BUTTES WASHES FROM AGUA FRIA RIVER TO C.A.P. CANAL, MARICOPA COUNTY, ARIZONA, CONTRACT FCD 90-09



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PLANS	HAR	05.18.01
PLANS CHK.	PJE	06.06.01

FIGURE 10-6

SHEET 6 OF 16

P:\82000145\Dwg\npodmp\erosion\2000\06erosi146.dwg
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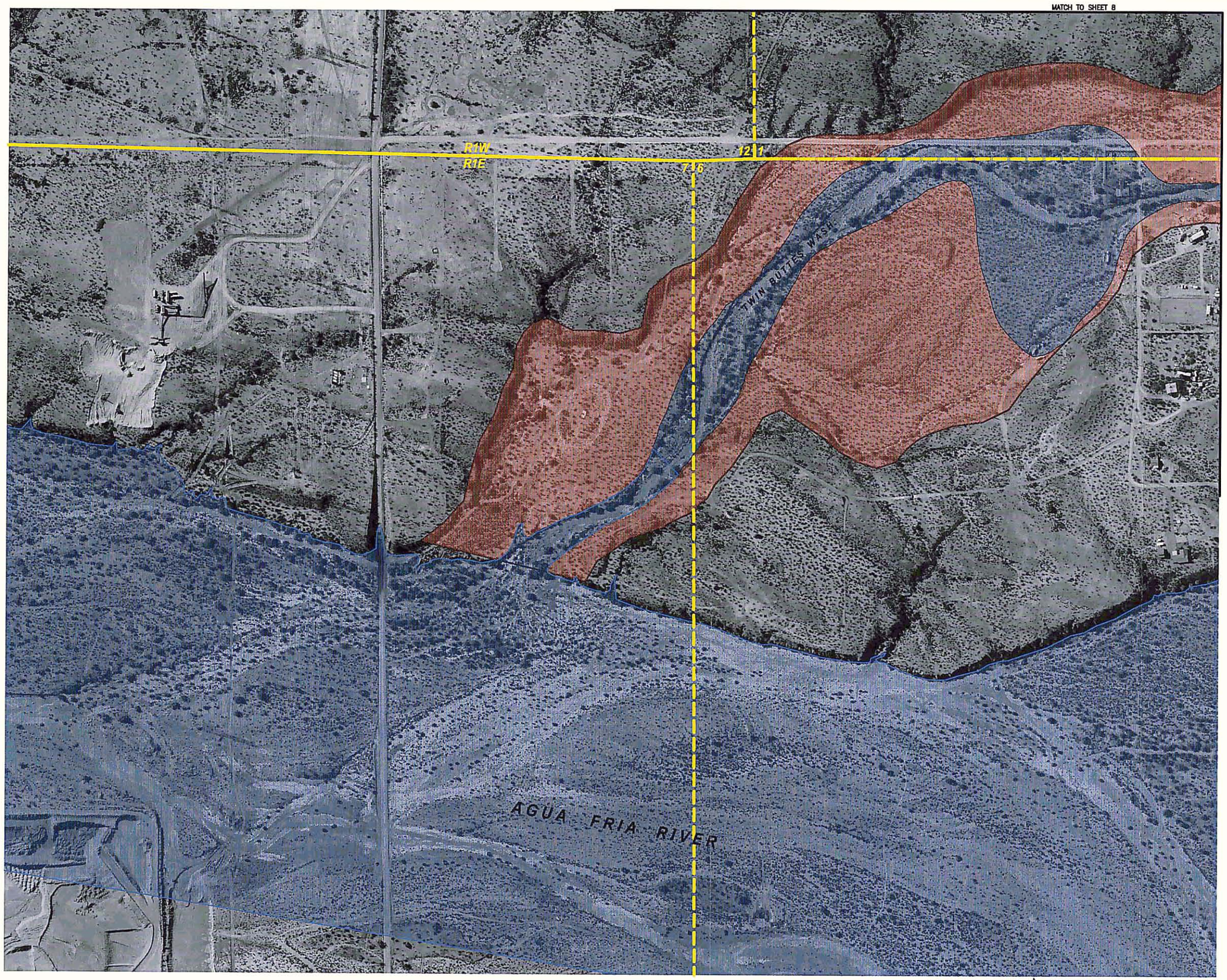
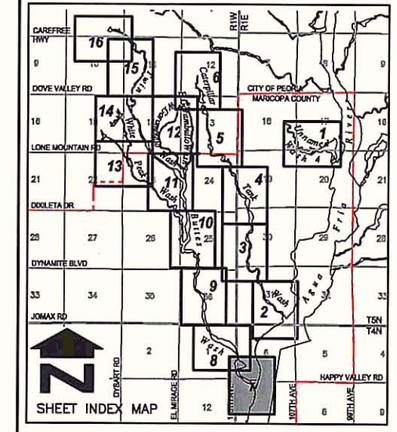


LEGEND

- EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.
3. EFFECTIVE FEMA 100-YR FLOODPLAINS ARE APPROXIMATE ONLY. FOR DETAILED INFORMATION SEE: FLOOD INSURANCE STUDY FOR CATERPILLAR TANK AND TWIN BUTTES WASHES FROM AGUA FRIA RIVER TO C.A.P. CANAL, MARICOPA COUNTY, ARIZONA, CONTRACT FCD 90-09



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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA AREA DRAINAGE MASTER PLAN FLOODPLAIN AND EROSION HAZARD MAP F.C.D. CONTRACT NO. 99-45

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DESIGN	–	–
DESIGN CHK.	–	–
PLANS	HAR	05.18.01
PLANS CHK.	PJE	06.06.01

FIGURE 10-5

SHEET 7 OF 16

200' 0' 200' 400'

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AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

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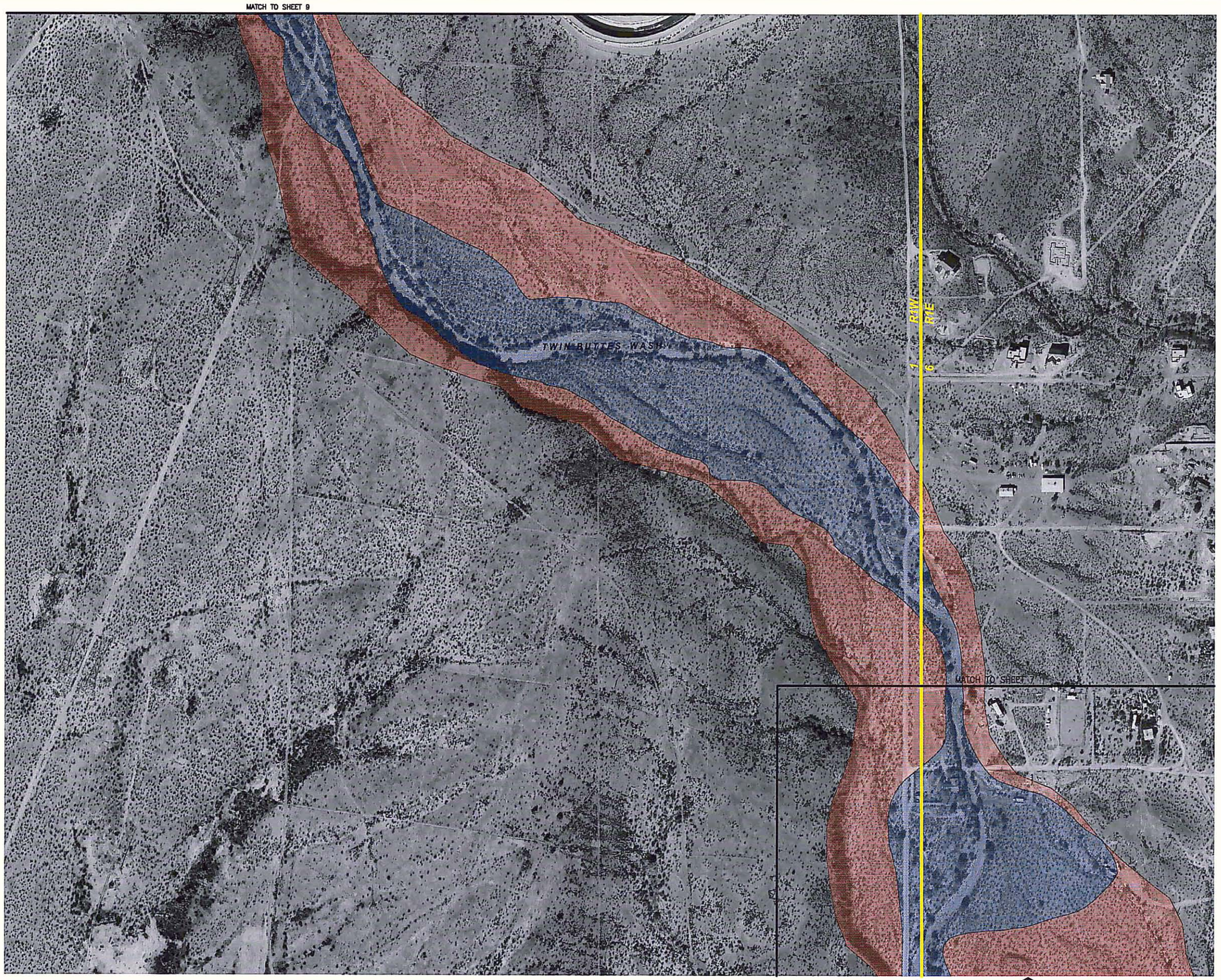


AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

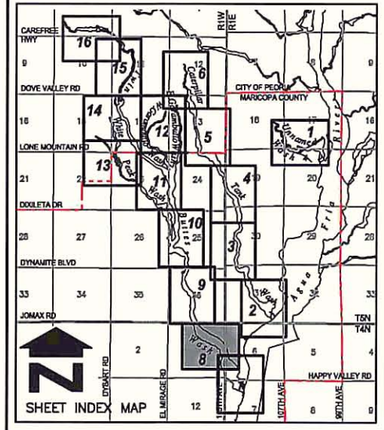
200' 0' 200' 400'

LEGEND

- EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.
3. EFFECTIVE FEMA 100-YR FLOODPLAINS ARE APPROXIMATE ONLY. FOR DETAILED INFORMATION SEE: FLOOD INSURANCE STUDY FOR CATERPILLAR TANK AND TWIN BUTTES WASHES FROM AGUA FRIA RIVER TO C.A.P. CANAL, MARICOPA COUNTY, ARIZONA, CONTRACT FCD 90-09



NO.	REVISION	BY	DATE
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA AREA DRAINAGE MASTER PLAN FLOODPLAIN AND EROSION HAZARD MAP F.C.D. CONTRACT NO. 99-45

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DESIGN	—	—
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PLANS	HAR	05.18.01
PLANS CHK.	PJE	05.06.01

FIGURE 10-6

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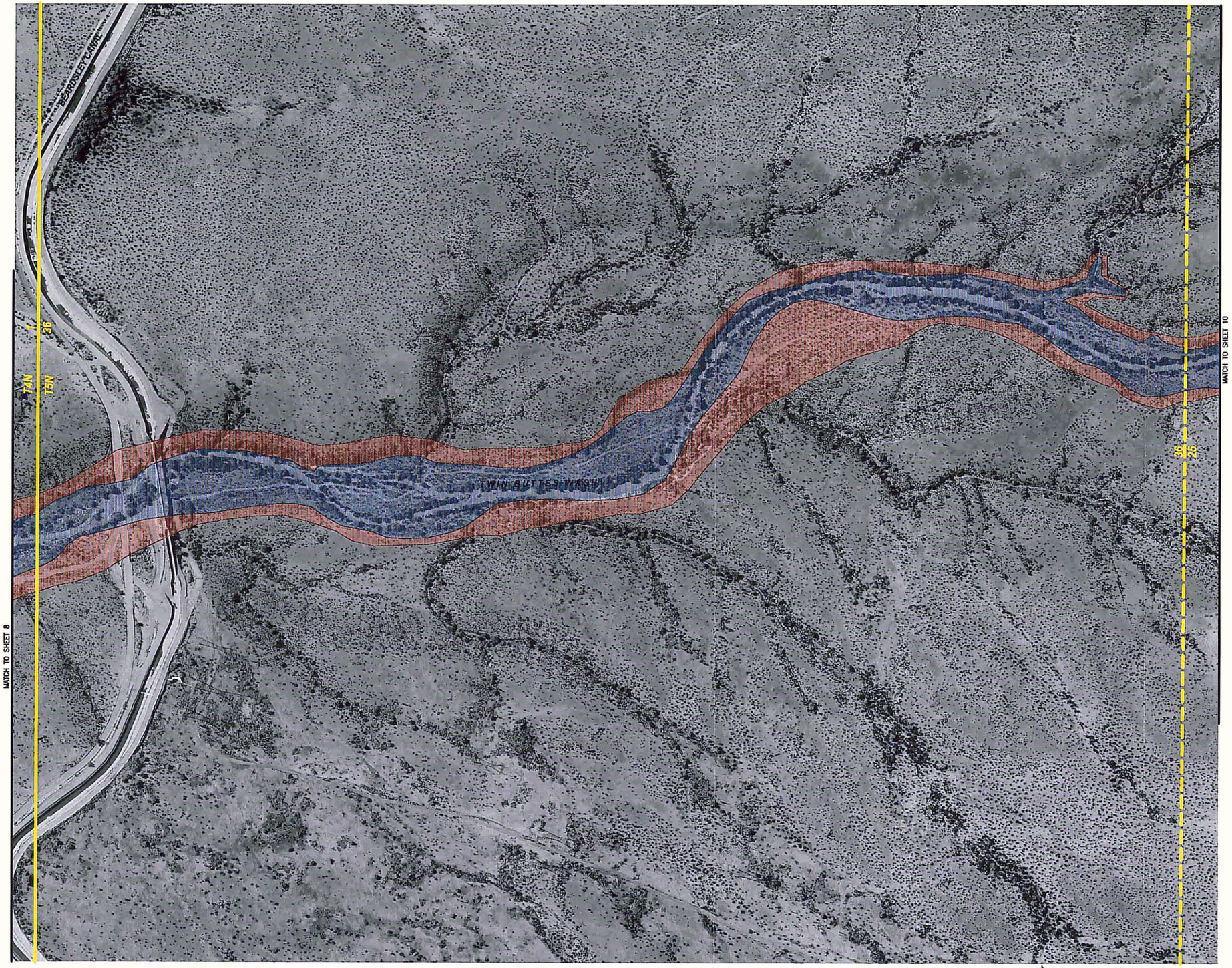


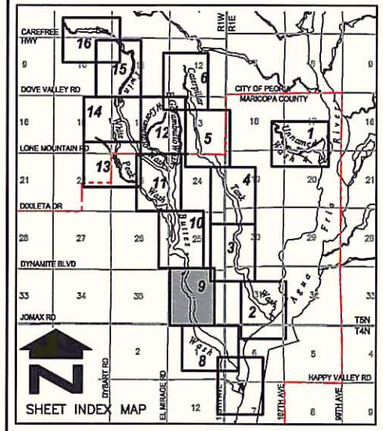
AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

LEGEND

- EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.
3. EFFECTIVE FEMA 100-YR FLOODPLAINS ARE APPROXIMATE ONLY. FOR DETAILED INFORMATION SEE: FLOOD INSURANCE STUDY FOR CATERPILLAR TANK AND TWIN BUTTES WASHES FROM AGUA FRIA RIVER TO C.A.P. CANAL, MARICOPA COUNTY, ARIZONA, CONTRACT FCD 90-09



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2			
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA AREA DRAINAGE MASTER PLAN FLOODPLAIN AND EROSION HAZARD MAP F.C.D. CONTRACT NO. 99-45

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8211 South 48th Street
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	BY	DATE
DESIGN	—	—
DESIGN CHK.	—	—
PLANS	HAR	05.18.01
PLANS CHK.	PJE	06.06.01

FIGURE 10-5

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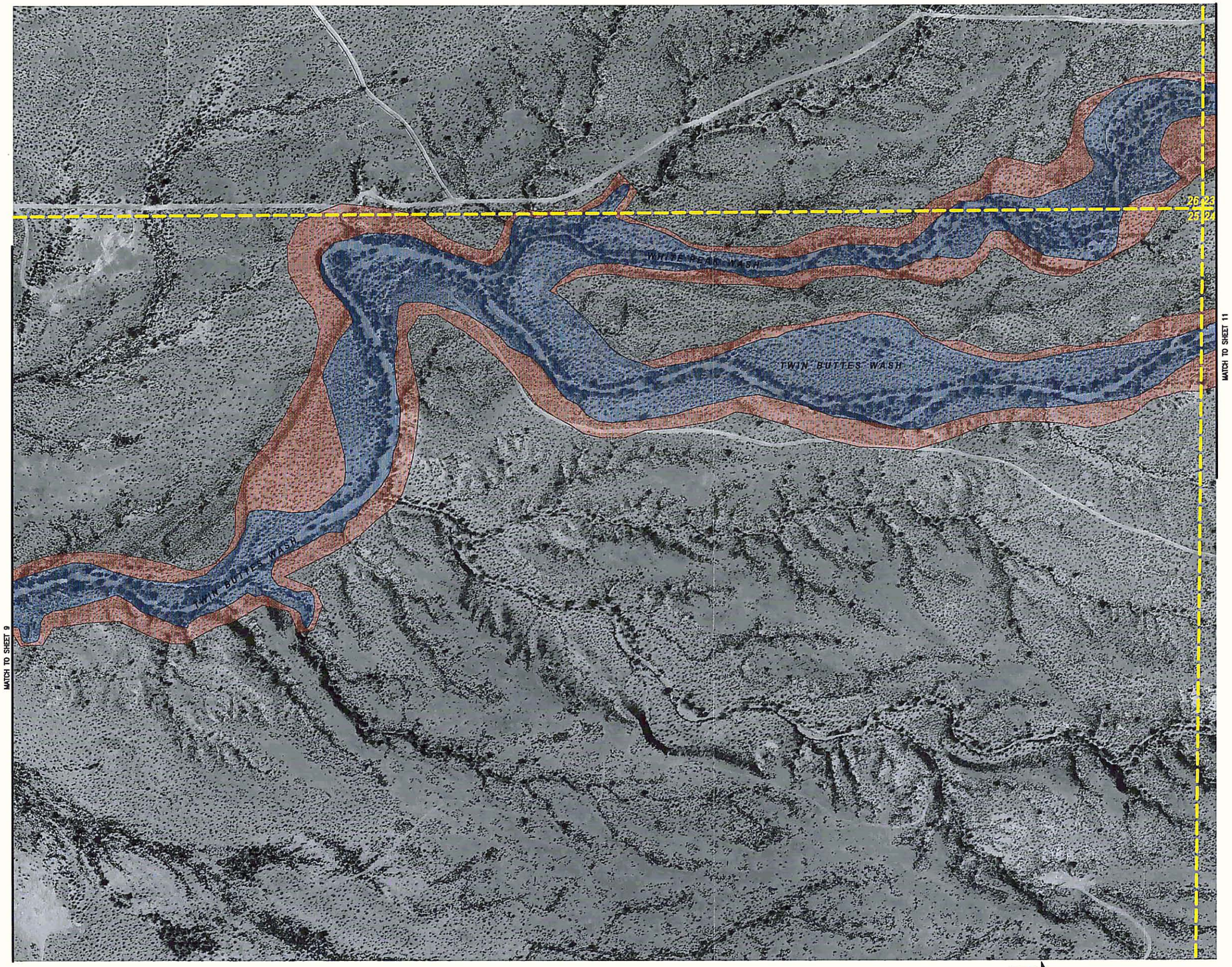


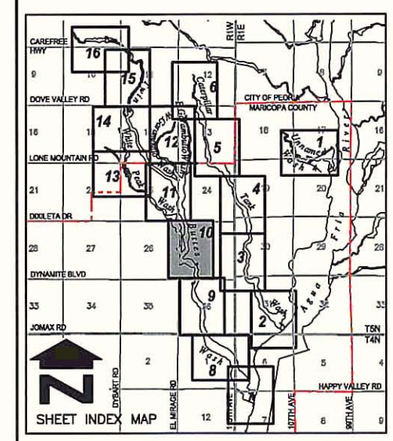
AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

LEGEND

- EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.
3. EFFECTIVE FEMA 100-YR FLOODPLAINS ARE APPROXIMATE ONLY. FOR DETAILED INFORMATION SEE: FLOOD INSURANCE STUDY FOR CATERPILLAR TANK AND TWIN BUTTES WASHES FROM AGUA FRIA RIVER TO C.A.P. CANAL, MARICOPA COUNTY, ARIZONA, CONTRACT FCD 90-09



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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

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	BY	DATE
DESIGN	--	--
DESIGN CHK.	--	--
PLANS	HAR	05.18.01
PLANS CHK.	PJE	06.06.01

FIGURE 10-6

SHEET 10 OF 16

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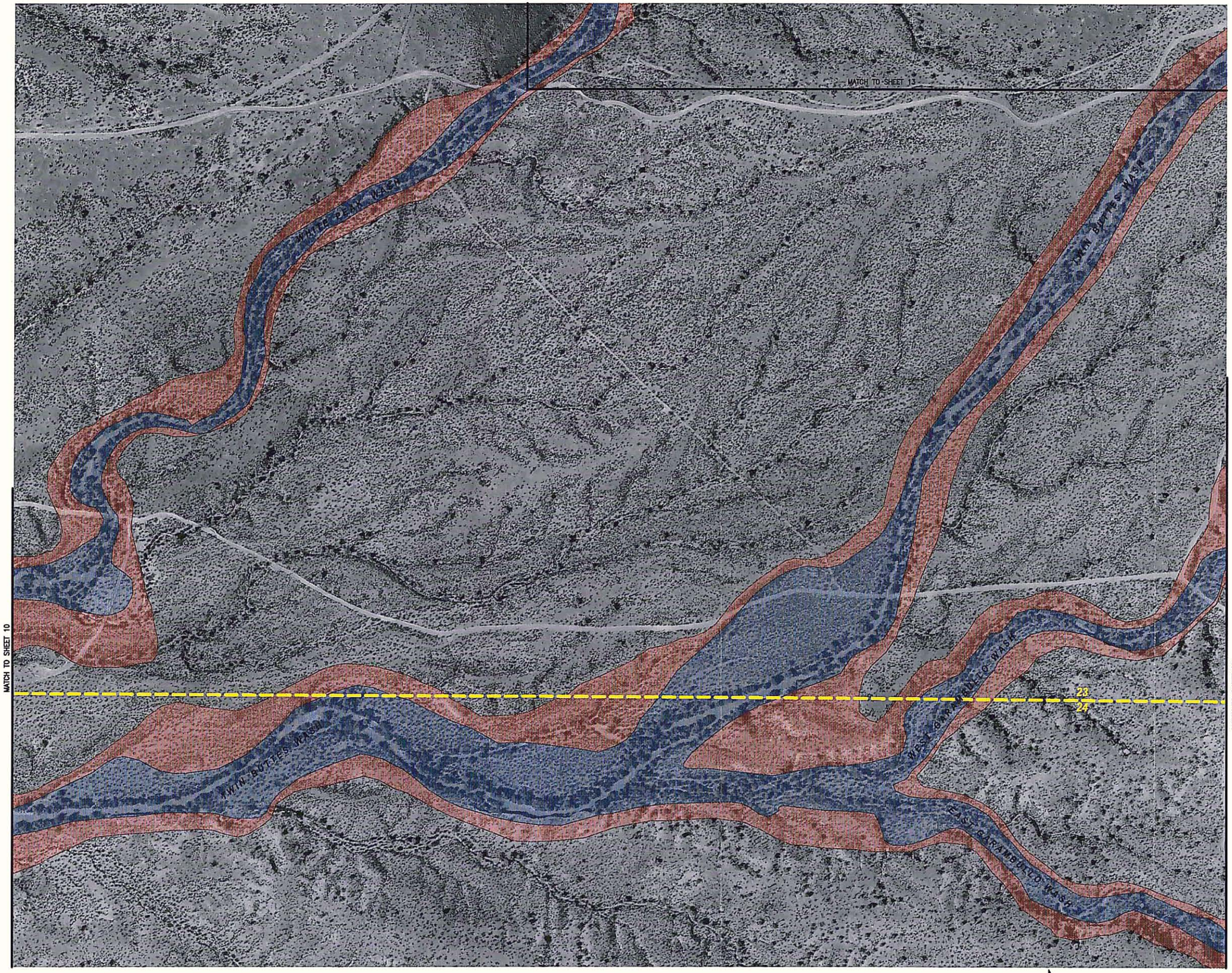
2001-12-21 08:44AM By: bfarnsworth



AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

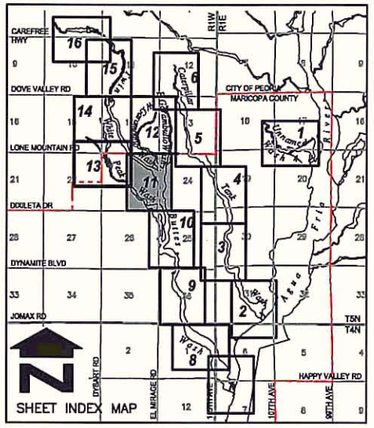
200' 0' 200' 400'

LEGEND

- EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.
3. EFFECTIVE FEMA 100-YR FLOODPLAINS ARE APPROXIMATE ONLY. FOR DETAILED INFORMATION SEE: FLOOD INSURANCE STUDY FOR CATERPILLAR TANK AND TWIN BUTTES WASHES FROM AGUA FRIA RIVER TO C.A.P. CANAL, MARICOPA COUNTY, ARIZONA, CONTRACT FCD 90-09



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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

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	BY	DATE
DESIGN	—	—
DESIGN CHK.	—	—
PLANS	HAR	05.18.01
PLANS CHK.	PJE	06.06.01

FIGURE 10-5

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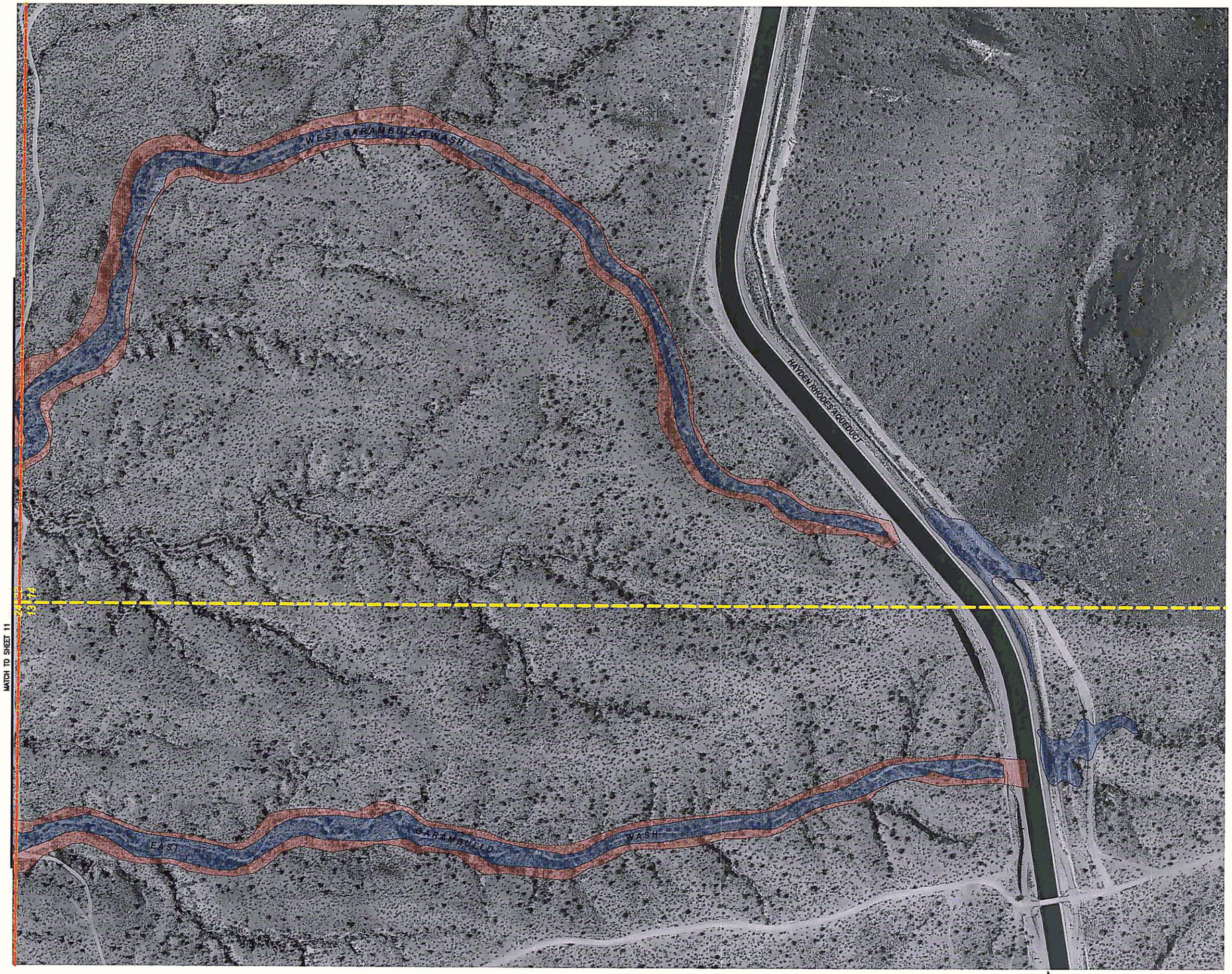


AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

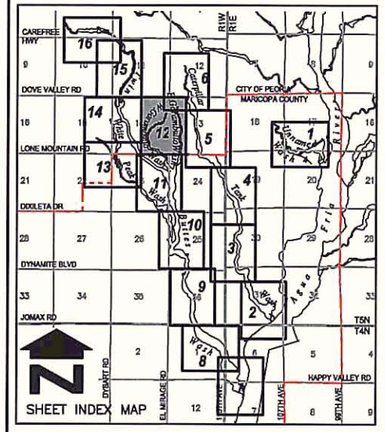
200' 0' 200' 400'

LEGEND

- EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.
3. EFFECTIVE FEMA 100-YR FLOODPLAINS ARE APPROXIMATE ONLY. FOR DETAILED INFORMATION SEE: FLOOD INSURANCE STUDY FOR CATERPILLAR TANK AND TWIN BUTTES WASHES FROM AGUA FRIA RIVER TO C.A.P. CANAL, MARICOPA COUNTY, ARIZONA, CONTRACT FCD 90-09



NO.	REVISION	BY	DATE
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

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	BY	DATE
DESIGN	–	–
DESIGN CHK.	–	–
PLANS	HAR	05.18.01
PLANS CHK.	PJE	06.06.01

FIGURE 10-6

SHEET 12 OF 16

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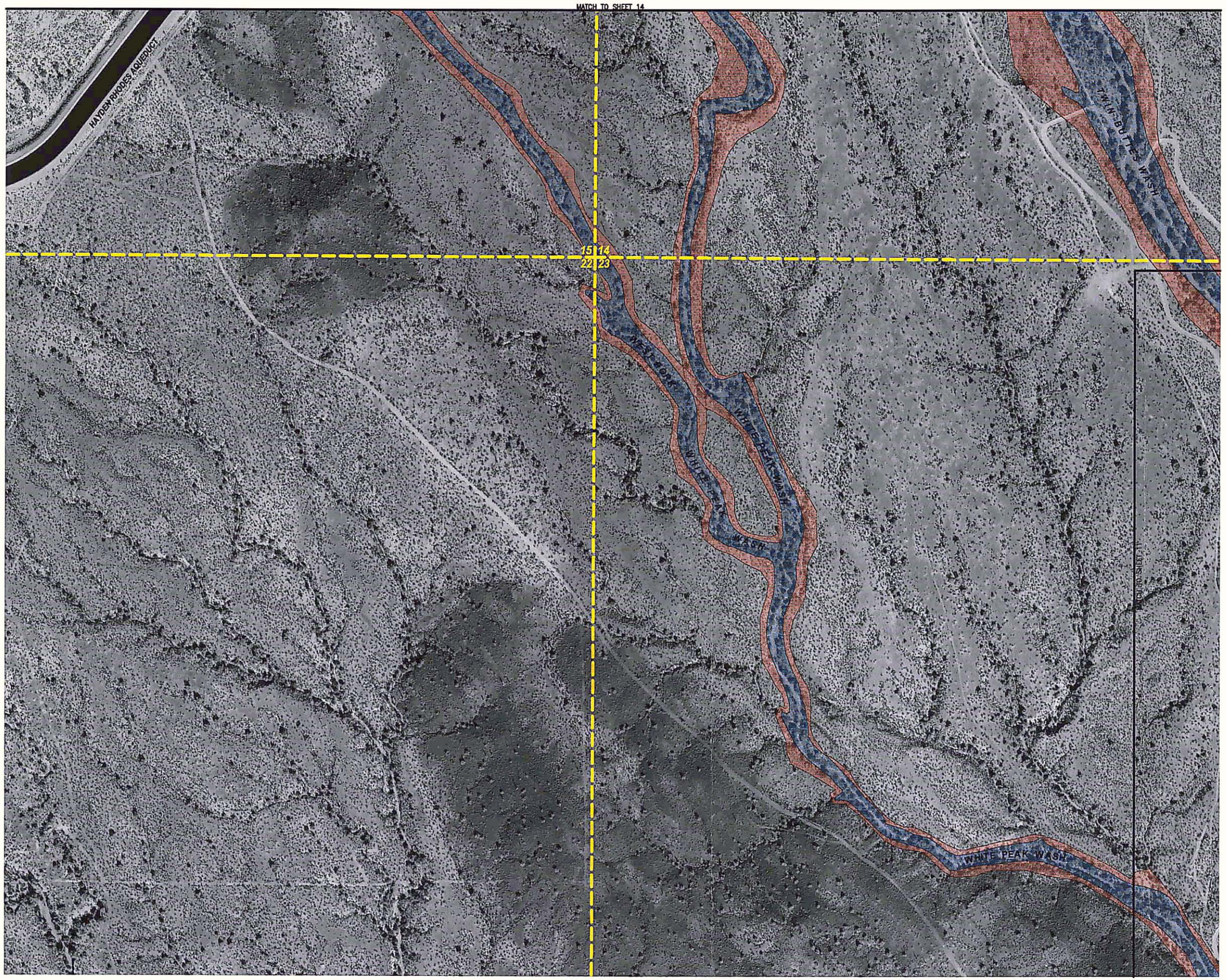

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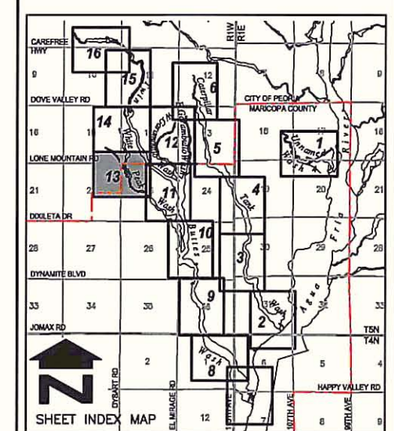
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

LEGEND

- EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.
3. EFFECTIVE FEMA 100-YR FLOODPLAINS ARE APPROXIMATE ONLY. FOR DETAILED INFORMATION SEE: FLOOD INSURANCE STUDY FOR CATERPILLAR TANK AND TWIN BUTTES WASHES FROM AGUA FRIA RIVER TO C.A.P. CANAL, MARICOPA COUNTY, ARIZONA, CONTRACT FCD 90-09



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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA AREA DRAINAGE MASTER PLAN FLOODPLAIN AND EROSION HAZARD MAP F.C.D. CONTRACT NO. 99-45

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ 85044-5355 U.S.A.
Tel. 602.438.2200
Fax. 602.431.8562
www.stantec.com

	BY	DATE
DESIGN	–	–
DESIGN CHK.	–	–
PLANS	HAR	05.18.01
PLANS CHK.	PJE	06.06.01

FIGURE 10-6

SHEET 13 OF 16

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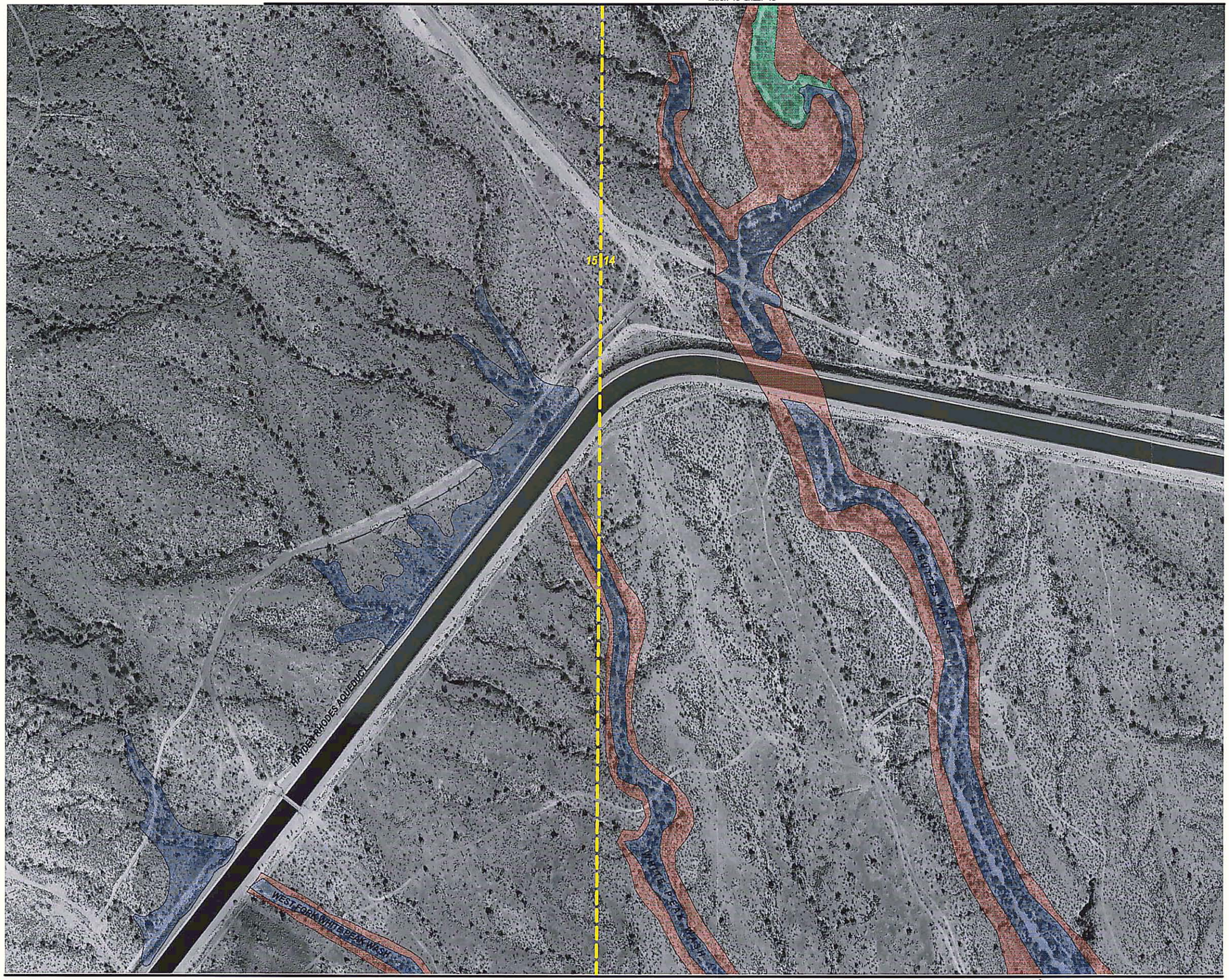

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AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

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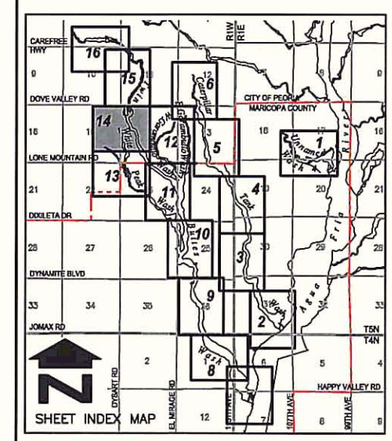
LEGEND

- EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY
- ZONE A 100-YR FLOODPLAIN BOUNDARY (NEW FEMA SUBMITTAL)
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.
3. EFFECTIVE FEMA 100-YR FLOODPLAINS ARE APPROXIMATE ONLY. FOR DETAILED INFORMATION SEE: FLOOD INSURANCE STUDY FOR CATERPILLAR TANK AND TWIN BUTTES WASHES FROM AGUA FRIA RIVER TO C.A.P. CANAL, MARICOPA COUNTY, ARIZONA, CONTRACT FCD 90-09



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FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODPLAIN AND EROSION HAZARD MAP
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PLANS CHK.	PJE	06.06.01

FIGURE 10-6

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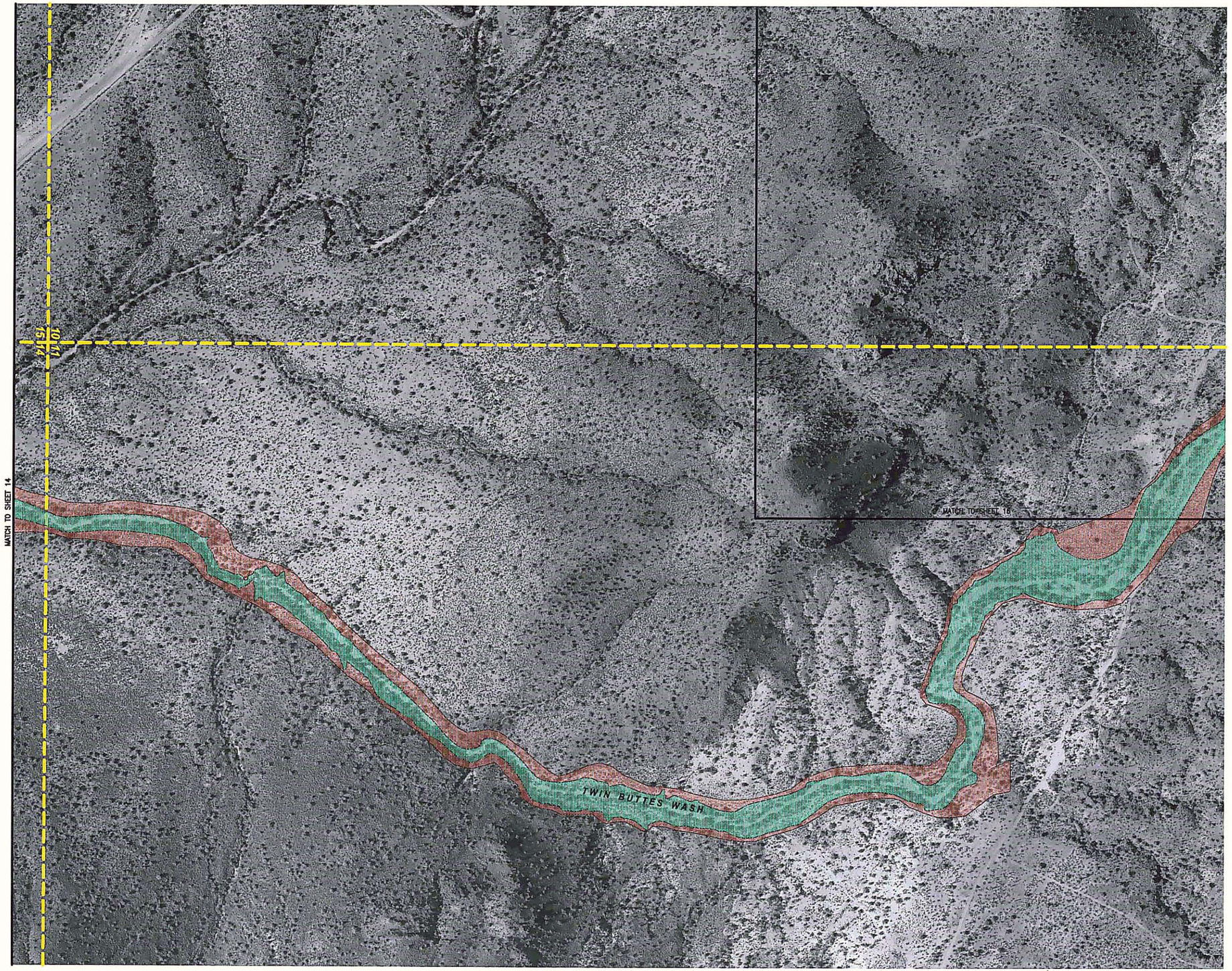

AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

LEGEND

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- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

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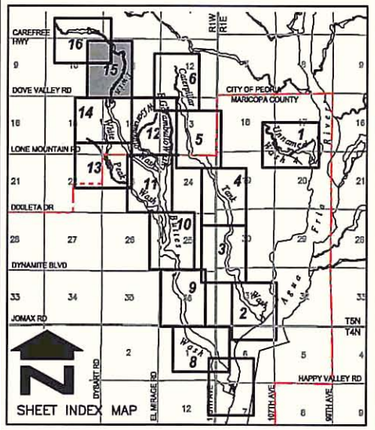
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA AREA DRAINAGE MASTER PLAN FLOODPLAIN AND EROSION HAZARD MAP F.C.D. CONTRACT NO. 99-45

Stantec Consulting Inc.
8211 South 48th Street
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PLANS CHK.	PJE	06.06.01

FIGURE 10-6

SHEET 15 OF 16

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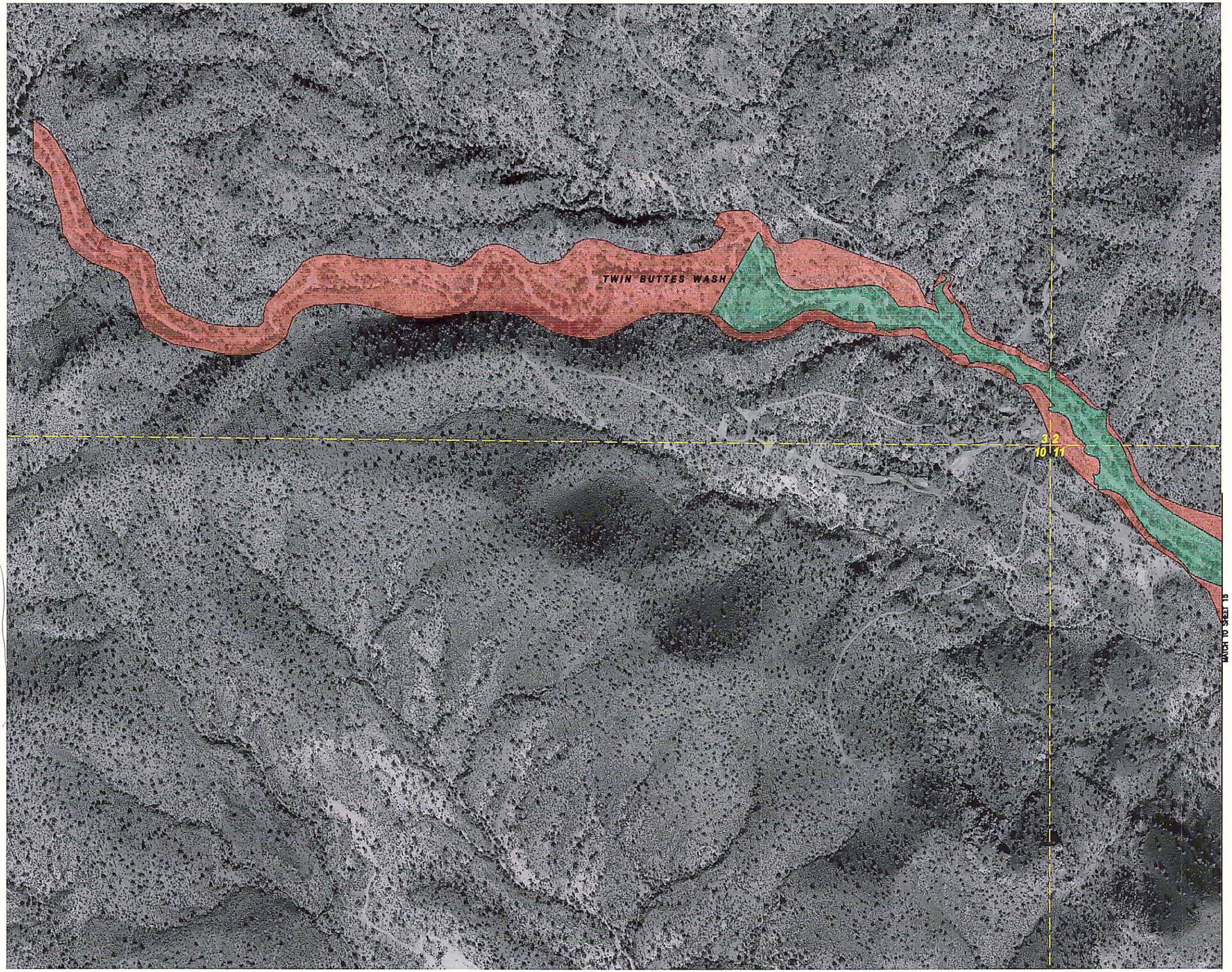
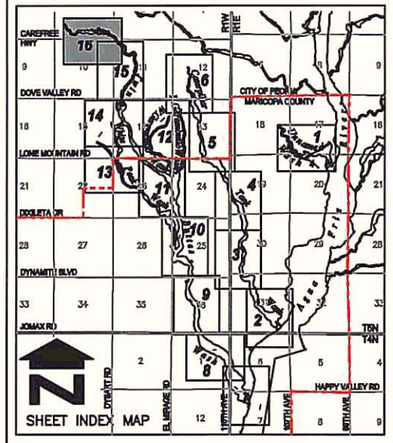


LEGEND

- ZONE A 100-YR FLOODPLAIN BOUNDARY (NEW FEMA SUBMITTAL)
- EROSION HAZARD ZONE
- CORPORATE LIMITS
- SECTION LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODPLAIN AND EROSION HAZARD MAP
F.C.D. CONTRACT NO. 99-45

Stanley Consulting Inc.
5211 South 48th Street
Phoenix AZ 85044-6355 U.S.A.
Tel. 602.438.2000
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www.stanley.com

	BY	DATE
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PLANS	HAR	05.18.01
PLANS CHK.	PJE	06.06.01

FIGURE 10-6

SHEET 16 OF 16

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AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

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11.0 ALTERNATIVES/POLICY FORMULATION AND EVALUATION

11.1 INTRODUCTION

The North Peoria ADMP provides a regional approach to watershed management. Development of watershed management alternatives and policies that forms the foundation of the plan takes into account engineering, environmental, landscape, social and economic considerations. Watershed management alternatives are developed to mitigate/minimize the effect of urbanization on storm water runoff and conveyance while recognizing the values of the community and the opportunity to protect the unique characteristics of the region. Watershed management alternatives and policies are evaluated on how well each alternative meets the goals of the North Peoria Area (ADMP).

The Alternatives/Policy Formulation and Evaluation section of the report describes physical characteristics of the area, the process and results of alternatives development, evaluation, and selection.

The project area is subdivided into four planning areas based on unique physical characteristics of the specific planning area. The four specific planning areas are the Morgan City Area, the Big Spring Area, East Terrace Area and the Twin Buttes Area. The location and boundary of the specific planning areas are displayed on Figure 1-2.

11.2 STUDY AREA EXISTING PHYSICAL CHARACTERISTICS

11.2.1 Introduction

Existing physical characteristics; cultural, ecological and visual resources and environmental hazards are identified and then compared to anticipated future land uses for development of watershed management alternatives and policies. Physical characteristics include slope of terrain, channel morphology, and the distribution and

type of vegetation. Terrain slopes within the project area are displayed on Figure 11-1. The type and distribution of vegetation series identified in the project area are presented on Figure 11-2. Environmental hazards include flood hazard zones and erosion hazard areas. Future Land-Use in the project area was determined from the City of Peoria's General Plan. Future land-use utilized in the evaluation and formulation of watershed management alternatives is displayed on Figure 11-3.

11.2.2 Morgan City Area

The Morgan City Area landform is characterized by steep topography, and incised washes that dissect the terrain. Terrain slopes range from 0 too greater than 25 percent, with the majority of the slopes ranging from 15 to 25 percent. The landform is classified as a Mountain Lands Character Unit, characterized by views of small-scale enclosed valleys and large-scale panoramic views. Views are constantly changing depending on the viewers location (DFD Architecture, 2001).

The major wash draining the area is Morgan City Wash. Morgan City Wash extends approximately 12 miles from its confluence with the Agua Fria River to the northwest. A sinuous natural channel with varying bottom width characterizes the wash. Channel bed materials in the lower riparian reach consists of sand, silts clays and at some locations, bedrock. Channel bed materials upstream of the riparian area consist predominately of sand and gravel's and at locations, bedrock. Channel banks are typically steep.

A unique riparian community exists in the lower reach of Morgan City Wash near the confluence with the Agua Fria River. The lower reach of Morgan City Wash is typified by a perennial flow .

The upper reaches of Morgan City Wash and all other watercourses in the Morgan City Area are classified as ephemeral watercourses.

NORTH PEORIA AREA DRAINAGE MASTER PLAN

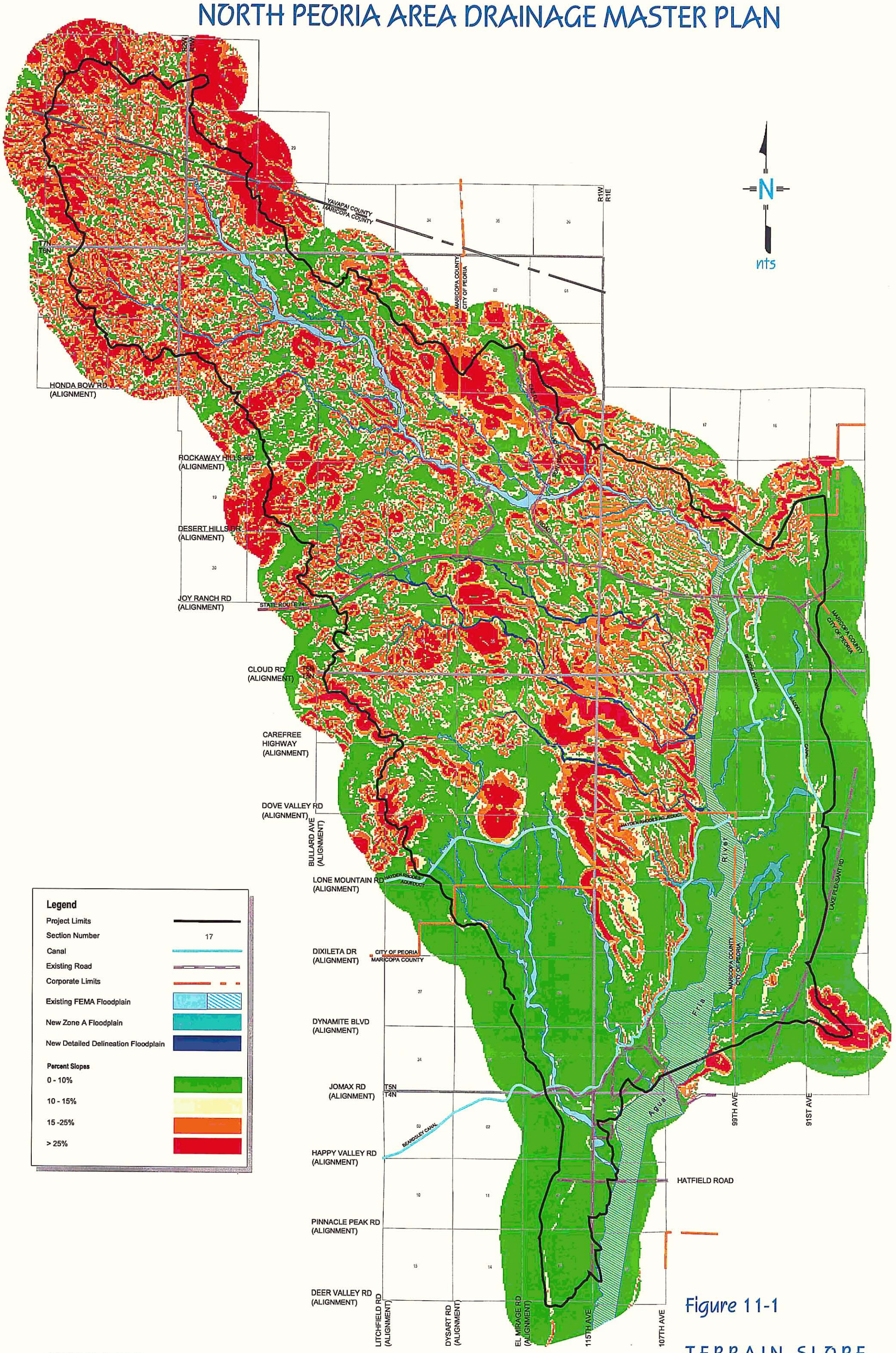

Figure 11-1

TERRAIN SLOPE

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NORTH PEORIA AREA DRAINAGE MASTER PLAN

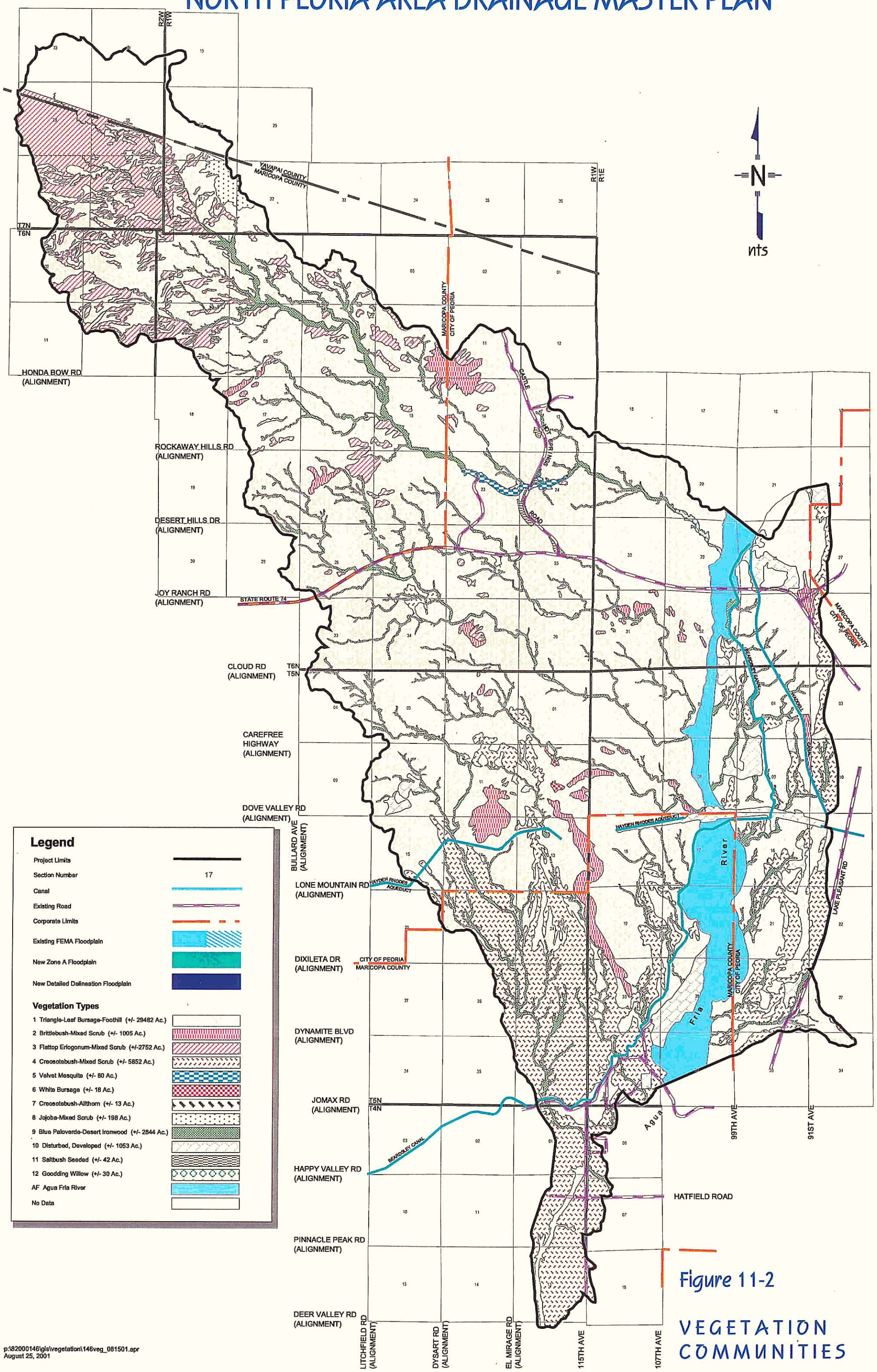

Figure 11-2

VEGETATION COMMUNITIES

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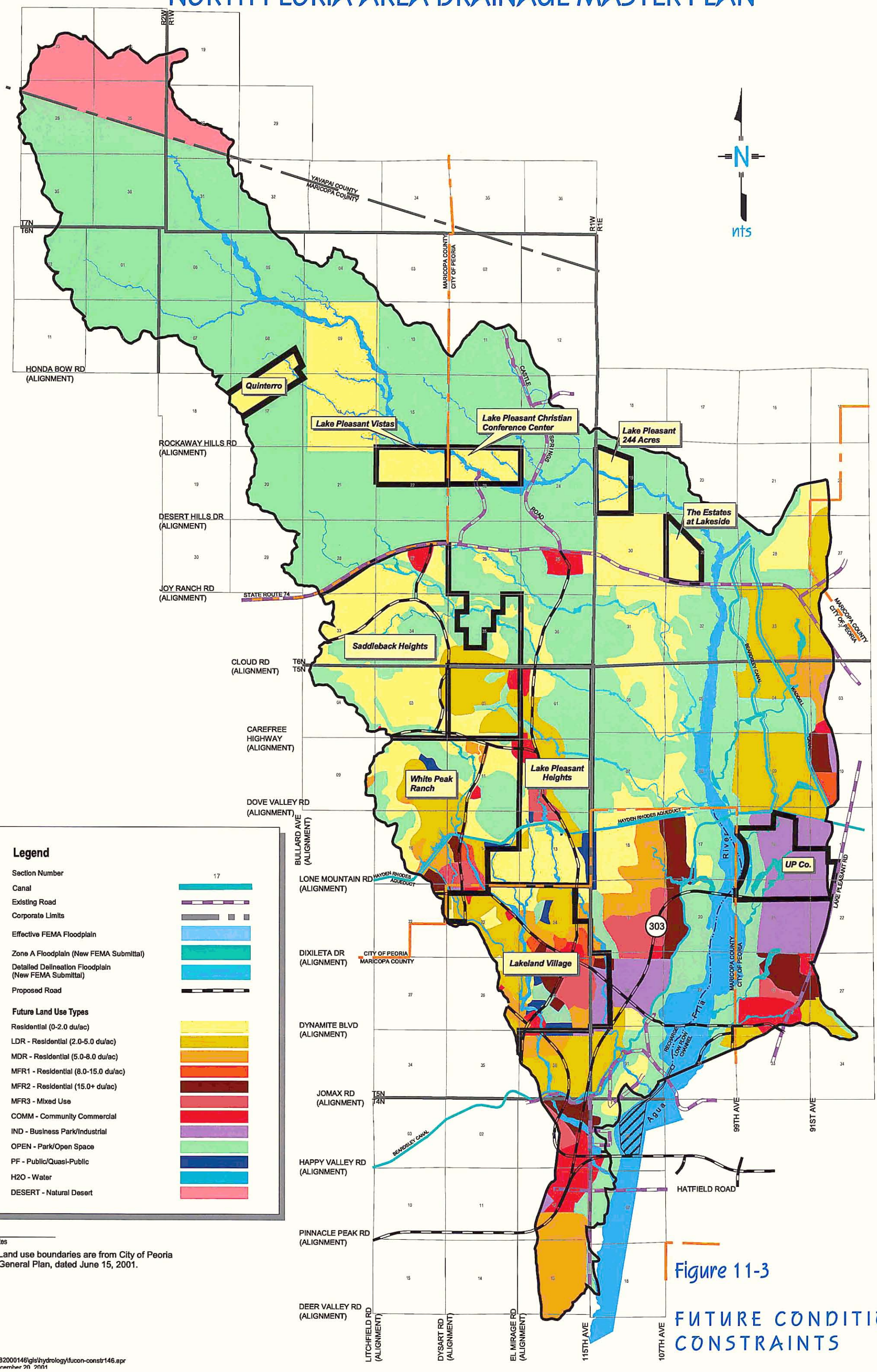

Notes

1. Land use boundaries are from City of Peoria General Plan, dated June 15, 2001.

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Figure 11-3

FUTURE CONDITION CONSTRAINTS

Plant communities identified within the Morgan City Area are Triangle-Leaf Bursage-Foothill, Brittlebush-Mix Scrub, Flattop Eriogonum-Mixed Scrub, Creosotebush-Mixed Scrub, White Bursage, Jojoba-Mixed Scrub, Saltbush Seeded and the Blue Paloverde-Desert Ironwood. The most extensive plant community is the Triangle-Leaf Bursage-Foothill. The Blue Paloverde-Desert Ironwood, Velvet Mesquite, and Godding Willow communities occurs along Morgan City Wash (Johnson & Associates, EEI, Inc. 2001).

The Morgan City Wash floodplain is typified by the floodplain boundary being coincident with the floodway boundary for most of the river reach. At locations where the floodplain boundary is not coincident with the floodway boundary the difference between the two is measured between 20 and 100 feet wide. Where there is a floodway fringe the length of the floodway fringe is between 100 and 400 feet. Average reach characteristics of the Morgan City Wash Floodplain and Erosion Hazard Zone are listed in Table 11-1.

Table 11-1

Average Reach Characteristics for Morgan City Wash

Floodplain-Erosion Hazard Zone

Reach	Average Floodplain Width	Average Floodway Width	Average Erosion Hazard Width
(RM to RM)[1]	(ft)	(ft)	(ft)
1	2	3	4
0.141 to 3.492	192	181	255
3.492 to 4.049	494	422	590
4.049 to 6.391	220	218	314
6.391 to 10.266	295	283	368
10.266 to 12.018	120	119	162

1.Reach is defined by river mile (RM).

11.2.3 Big Spring Area

The Big Spring Area landform is characterized as with the Morgan City Area, by steep topography, and incised washes that dissect the terrain. Terrain slopes range from 10 too greater than 25 percent with the majority of the slopes ranging from 10 to 15 percent. As with the Morgan City Area, the landform in the Big Spring Area is classified as a Mountain Lands Character Unit, characterized by views of small-scale enclosed valleys and large-scale panoramic views. Views are constantly changing depending on the viewers location (DFD Architecture, 2001).

Watercourses in the Big Spring Area classified as ephemeral watercourses. Three major watercourses drain the area; they are Unnamed Wash 1, Unnamed Wash 2 and Unnamed Wash 3. Unnamed Wash 1 extends approximately 7 miles from its confluence with the Unnamed Wash 2 to the north and then to the northwest. Unnamed Wash 2 extends approximately 8 miles from its confluence with the Agua Fria River to the northwest. Unnamed Wash 3 extends approximately 5 miles from its confluence with the Agua Fria River to the northwest. The three washes have similar physical characteristics; sinuous natural channels with varying bottom width, reaches that are incised in rock, typify the three washes. Channel bed materials within the washes consists of sand, gravel, boulders and bedrock. Channel banks are typically steep. Channel banks in reaches are incised in rock are vertical or near vertical

Plant communities identified within the Big Springs Area are the Triangle-Leaf Bursage-Foothill, Brittlebush-Mix Scrub, Flattop Eriogonum-Mixed Scrub, Creosotebush-Mixed Scrub, White Bursage and Blue Paloverde-Desert Ironwood. The most extensive plant community is the Triangle-Leaf Bursage-Foothill. The Blue Paloverde-Desert Ironwood communities occurs along watercourse's (Johnson & Associates, EEI, Inc. 2001).

Detailed floodplain delineation defining floodplain and floodway boundaries were conducted as part of the North Peoria ADMP for Unnamed Wash 1, 2 and 3. Approximate method floodplains for select tributaries to the three unnamed washes

are also delineated as part of the study. Erosion Hazard Zones are identified for the same detail and approximate method study floodplains as part of this study.

The three unnamed wash floodplains are typified by the floodplain boundaries being coincident with the floodway boundaries for most of the river reaches. At locations where the floodplain boundary is not coincident with the floodway boundary the maximum difference between the two is measured between approximately 20 and 100 feet. Average reach characteristics for Unnamed Wash 1, 2 and 3 floodplains and erosion hazard zones are listed in Table 11-2, Table 11-3, and Table 11-4 respectively.

Table 11-2

Average Reach Characteristics for Unnamed Wash 1

Floodplain-Erosion Hazard Zone

Reach (RM to RM) 1	Average Floodplain Width (ft) 2	Average Floodway Width (ft) 3	Average Erosion Hazard Width (ft) 4
0.046 to 0.484	138	95	194
0.484 to 2.923	71	69	98
2.93 to 6.311	118	92	142

Table 11-3

Average Reach Characteristics for Unnamed Wash 2

Floodplain-Erosion Hazard Zone

Reach (RM to RM) 1	Average Floodplain Width (ft) 2	Average Floodway Width (ft) 3	Average Erosion Hazard Width (ft) 4
0.309 to 2.813	98	82	147
2.813 to 3.033	54	54	109
3.033 to 3.211	118	91	159
3.211 to 3.825	84	84	152
3.874 to 6.789	114	83	204

Table 11-4

Average Reach Characteristics for Unnamed Wash 3

Floodplain-Erosion Hazard Zone

Reach (RM to RM) 1	Average Floodplain Width (ft) 2	Average Floodway Width (ft) 3	Average Erosion Hazard Width (ft) 4
0.144 to 0.386	128	94	239
0.386 to 1.537	59	59	89
1.537 to 1.641	125	93	133
1.641 to 2.011	73	73	77
2.011 to 4.54	119	73	166

11.2.4 East Terrace Area

Flat topography and washes dissect the terrain that characterizes the East Terrace Area landform. Terrain slopes range from 10 to greater than 25 percent with the majority of the terrain slopes being less than 10 percent. The landform is classified as a Plains Character Unit, characterized by sparse vegetation and topography that is flat and unvaried. Panoramic views of Hieroglyphic Mountains are obtained in the East Terrace Area (DFD Architecture, 2001).

The area drains to the Agua Fria River by numerous washes classified as ephemeral watercourses. Sinuous natural channels with varying bottom width cut into alluvial material typify the washes draining the East Terrace Area. Channel bed materials within the washes consists of sand, gravel and cobbles. Channel banks are typically poorly defined.

Plant communities identified within the East Terrace Area are the Triangle-Leaf Bursage-Foothill, Brittlebush-Mix Scrub, Flattop Eriogonum-Mixed Scrub, Creosotebush-Mixed Scrub, and Blue Paloverde-Desert Ironwood. The most extensive plant community is the Triangle-Leaf Bursage-Foothill. The Blue Paloverde-Desert Ironwood communities occurs along watercourse's (Johnson & Associates, EEI, Inc. 2001).

Environmental hazards related to storm water runoff, defined in the East Terrace Area are floodplains. Approximate method floodplains for 5 unnamed washes are delineated as part of the North Peoria ADMP.

Floodplains delineated in the East Terrace Area are delineated by approximate methods. At locations washes are incised, but generally their channel banks are poorly defined. Results of approximate method floodplain delineation conducted for five of the washes draining the area demonstrate that the floodplains are typically broad and shallow.

Numerous livestock tanks are located through out the area. Typically, non-engineered earthen dams constructed across a watercourse characterize stock tanks. Location of earthen dams is presented on Plate 1.

11.2.5 Twin Buttes Area

The Twin Buttes landform is characterized by steep to flat topography, and incised washes that dissect the terrain. Terrain slopes range from 10 too greater than 25 percent in the northern portion of the area and 0 to 10 percent in the southern portion of the area. Landforms in the Twin Buttes Area can be grouped into the Mountain Lands, Plains and Slopes Character Units. There is an absence of ridge, peak and valley landforms in the Slope Character Unit, however, views of the Mountain Lands landforms are offered within the Slope Character Unit (DFD Architecture, 2001).

Two major washes drain the area, they are Caterpillar Tank Wash and Twin Buttes Wash. Caterpillar Tank Wash extends approximately 5 miles from its confluence with the Agua Fria River to the north, northwest. Twin Buttes Wash extends approximately 8 miles from its confluence with the Agua Fria River to the north, northwest. The two washes have similar physical characteristics. Sinuous natural channels with varying bottom width, predominately incised in alluvial material typify the washes. Channel bed materials within the washes consists of sand, gravel and boulders and at very few locations bedrock. Channel banks are typically well defined

and steep upstream of the Beardsley Canal. Downstream of the Beardsley Canal channel banks are typically low in height or poorly defined.

Plant communities identified within the Big Springs Area are Triangle-Leaf Bursage-Foothill, Brittlebush-Mix Scrub, Creosotebush-Mixed Scrub and Blue Paloverde-Desert Ironwood. The most extensive plant community is the Creosotebush-Mixed Scrub. The Blue Paloverde-Desert Ironwood communities occurs along watercourse's (Johnson & Associates, EEI, Inc. 2001).

Environmental hazards related to storm water runoff defined in the Twin Buttes Area are floodplains and erosion hazard zones. The District under contract FCD 90-09 conducted the CAP Overchutes, Floodplain Delineation Study. The study defined floodplain and floodway boundaries along Caterpillar Tank Wash, Twin Buttes Wash, East and West Garambullo Wash, West White Peak Wash and White Peaks Wash, utilizing detail methodologies. Approximate method floodplains for reaches of Twin Buttes Wash and Caterpillar Tank Wash (upstream of the Beardsley Canal) and Unnamed Wash 4 were delineated as part of the North Peoria ADMP. Erosion Hazard Zones are identified for floodplains as part of this study.

Floodplains determined by detail methods for the Twin Buttes area are typified by the floodplain boundaries being coincident with the floodway boundaries for most of the river reaches. At locations where the floodplain boundary is not coincident with the floodway boundary, the maximum difference between the two is measured between 50 and 300 feet wide. Average reach characteristics for Caterpillar Tank Wash, Twin Buttes Wash, East and West Garambullo Wash, West White Peak Wash and White Peaks Wash, floodplains and erosion hazard zones are listed in Table 11-5.

Table 11-5

Average Reach Characteristics for Watercourses in the Twin Buttes Area

Floodplain-Erosion Hazard Zone

Wash	Reach (RM to RM)	Average Floodplain Width (ft)	Average Floodway Width (ft)	Average Erosion Hazard Width (ft)
1	2	3	4	5
Twin Buttes	0.19 to 1.91	321	169	793
Twin Buttes	1.91 to 6.38	218	158	392
Caterpillar Tank	0.019 to 0.82	96	88	504
Caterpillar Tank	0.82 to 5.04	124	88	367
Whites Peaks	Entire Watercourse	87	58	210
West Fork Whites Peak	Entire Watercourse	35	31	124
W. Garambullo	Entire Watercourse	89	51	169
E. Garambullo	Entire Watercourse	81	56	157

11.3 ALTERNATIVES DEVELOPMENT

Alternatives to be evaluated by the North Peoria ADMP were developed during the development of the scope of work for the project and through consultation with District staff and steering committee members throughout the term of the project. Flood control management alternatives are developed and evaluated as to function of the alternative to meet the goals of the North Peoria ADMP. Flood control management alternatives included structural, non-structural and the do nothing approaches. Alternatives were also developed and evaluated to aid the committee in the selection of a management application such as how a vegetation buffer should be applied or should a structure at a roadway/wash crossing consist of a culvert structure or bridge. As part of the alternative development, policies are developed as guidelines to address issues identified in the identification of cultural, ecological and visual

resources. Policies, guidelines and rules for development, are also developed that would implement a given alternative.

Alternative development and evaluation is conducted at three levels of analyses. Level 1 Analysis defines potential management alternatives that could be applied to the study area. Based on qualitative evaluation during the Level 1 Analysis alternatives are disregarded or recommended for further evaluation during the Level 2 Analysis. Level 2 Analysis consist of conducting low resolution engineering analysis based upon generalized hydraulics and cost estimates to determine their engineering feasibility and approximate cost for evaluated alternatives. Policies that would help implement the alternative are also developed during the Level 2 Analysis. Based on alternative evaluation during Level 2 Analysis the steering committee selects preferred alternatives for further evaluation. Level 3 Analysis consists of refinement of the preferred alternatives selected in the Level 2 Analysis. Implementation and funding plans and rules for development are developed during the Level 3 Analysis for the preferred alternatives.

11.3.1 Level 1 Analysis-Alternatives Development

Flood control management alternatives developed during the Level 1 Analysis are a full structural alternative, a partial structural alternative, a low impact structural alternative, a non-structural alternative no-action alternative and a detention/retention alternative. The full structural alternative is based on current federal, state and local floodplain management regulations that allow encroachment into the floodway fringe. The full structural alternative typically requires at a minimum, structural stabilization of wash side slopes for the entire reach. The partial structural alternative also is based on current floodplain management regulations, however, the partial structural solution is applied at only specific locations along the watercourse. The low impact structural alternative allows for development to occur outside of the floodplain limits but within the erosion hazard set back limits while minimizing the effect to the natural function of the watercourse. The non-structural alternative defines a corridor that allows the

watercourse to function naturally. Characteristics and application of each alternative are described in the following sections.

11.3.1.1 Watercourse Based Alternatives

Full Structural Alternative

The full structural alternative allows for encroachment into the floodplain to the floodway limit and consists of a channel with a natural bottom and side slope stabilization. The type of side slope stabilization considered is gabion mattresses and soil cement. The alternative is applied to the total watercourse reach and the assumption is made that it is constructed at one time. A cross-section of the Full Structural Alternative depicting elements of the alternative is presented as Figure 11-4.

A full structural alternative that allows for encroachments into the Twin Buttes Wash floodway downstream of the crossing of Twin Buttes Wash with 115th Avenue was developed to eliminate potential flood hazards to a residence and to the future 115th Avenue roadway. The alternative consists of a channel with a natural bottom and side slope stabilization.

Partial Structural Alternative

The partial structural alternative allows for encroachment into the floodplain to the floodway limit at specific locations such as at roadway crossings of watercourses, along roadways adjacent to watercourses and in potentially developable areas adjacent to the watercourse. The partial structural alternative is considered for watercourses that are characterized by one or more of the following:

- Incised channels within bedrock.
- In areas where the terrain within or adjacent to the floodplain is not too steep for development.

A cross-section of the Partial Structural Alternative depicting elements of the alternative is presented as Figure 11-5.

Low Impact Structural Alternative

The low impact structural alternative allows for development to occur outside of the floodplain limits but within the erosion hazard zone while minimizing the effect to the natural function of the watercourse. The low impact structural alternative also allows for active recreational use of the floodway fringe.

Characteristic's of the low impact structural alternative are presented in the report entitled North Peoria Area Drainage Master Plan Technical Data Notebook, Attachment 3-Sedimentation Engineering and Geomorphic Evaluation Technical Memorandums.

Non-Structural Alternative

The non-structural alternative defines a corridor that allows the watercourse to function naturally, preserves natural scenic views, and preserves sensitive biological habitat. The nonstructural alternative is managed and or implemented by policies, ordinances, property acquisition and multi-agency planning efforts. The non-structural alternative is defined by the limits of the 100-year floodplain, erosion hazard zone, or vegetation buffer which ever provides the greatest setback from the center of the channel. A cross-section of the Non-Structural Alternative depicting elements of the alternative is presented as Figure 11-6.

No-Action Alternative

The no action (do nothing) alternative provides flood control management based on current federal, state and local floodplain management regulations that allows encroachment into the floodway fringe. Typically, under current regulations encroachments into the floodway fringe are allowed on a piece meal fashion without taking into consideration the effect of the encroachment or collective encroachments on the entire watercourse.

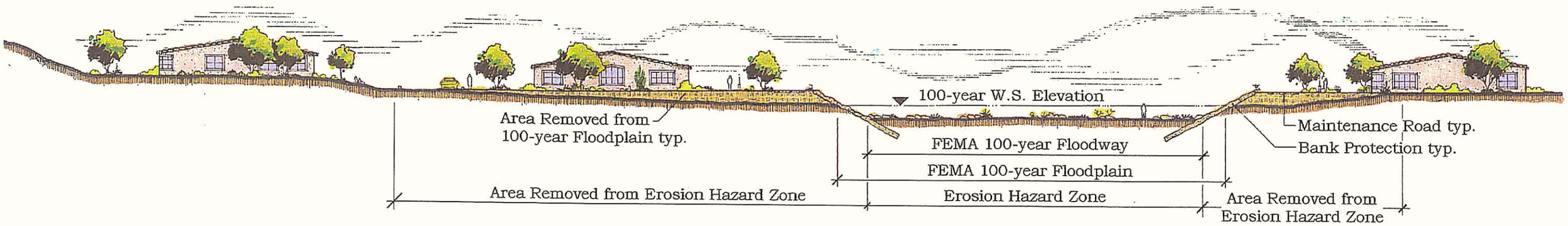

Figure 11-4
Full Structural Alternative

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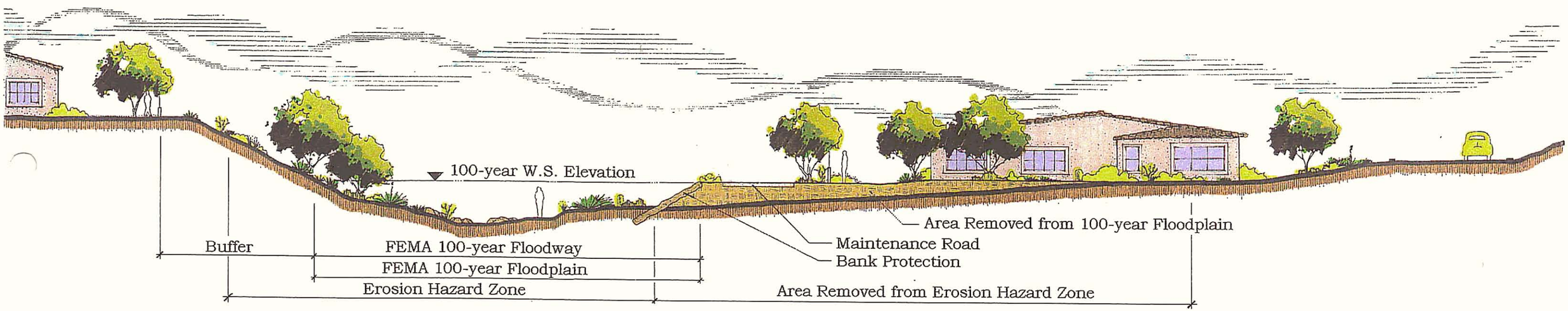

Figure 11-5
Partial Structural Alternative

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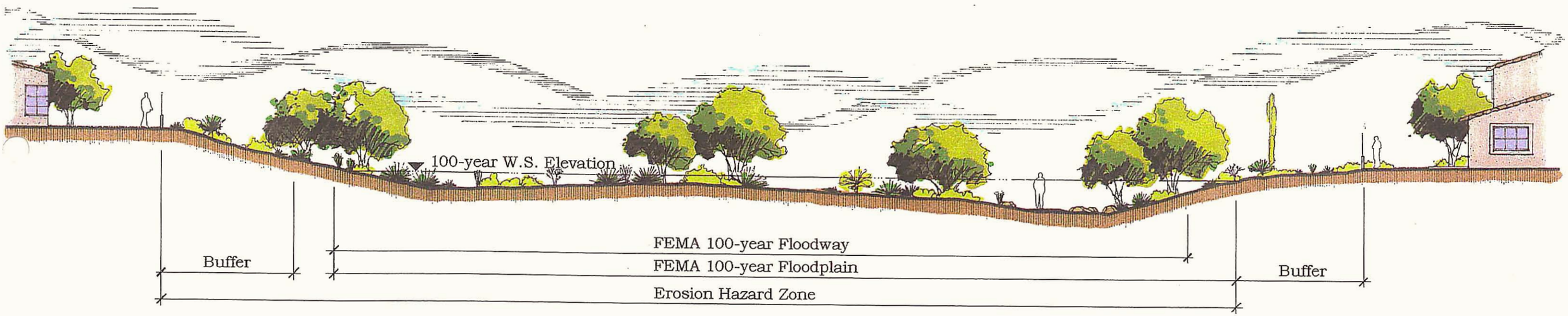


Figure 11-6
Non-Structural Alternative

P:\82000146\dwg\alternative x-sec\sections\sections.cdr

Detention/Retention Based Alternatives

Three detention/retention alternatives are developed to provide means of reducing post development peak discharges to pre-development values. The three alternatives are the standard practice of retaining the 100-year, 2-hour hydrograph volume for developed conditions, providing inline detention within watercourse, and providing off line side weir detention adjacent to a watercourse.

11.3.2 Level I Evaluation

A brainstorming meeting was conducted to evaluate the feasibility of alternatives being applied to each of the planning areas and to define potential development issues that would be addressed at a policy level in the planning effort. Results of the brainstorming meeting are grouped into three categories, watercourse based alternatives, detention/retention based alternatives, and development issues.

11.3.2.1 Watercourse Based Alternatives

Morgan City Area

The Morgan City Area is characterized by a future land use that is predominately classified as open space, land ownership that is predominately federal government, terrain with steep slopes that minimize development potential and well defined incised washes. Morgan City Wash is the major wash draining the area. Reaches of some washes are incised within bedrock. Many natural grade controls exist within the washes, thus minimizing degradation potential.

The potential development area within the floodway fringe of Morgan City Wash is minimal given that the floodway is coincidental with the floodplain boundary for the greatest part of the wash. Given the characteristic of the Morgan City Area the non-structural alternative and the no-action alternative are alternatives that were selected to be evaluated further during the Level II Analysis.

The full structural alternative was not selected for Morgan City Wash because the wash, in places, is incised within bed rock thus precluding the need for full structural

improvements. Opportunities for development in the floodway fringe are minimal or non-existent because there is not a floodway fringe or the floodway fringe is narrow.

Big Spring Area

A mix of future land-use, Federal, State and private land ownership, terrain with steep slopes that locally minimize development potential and well-defined incised washes, characterizes the Big Spring Area. The major washes draining the area are Unnamed Wash 1, 2 and 3. Future land use in the area includes open space, very low-density residential, low-density residential, mixed use and community commercial. Density of land use typically increases from north to south across the planing area with the highest density located in the watershed that Unnamed Wash 3 drains. Reaches of Unnamed Wash 1, 2 and 3, which drain the area, are incised within bedrock. Many natural grade controls exist within the washes, thus minimizing degradation potential.

Given that the floodway is coincidental with the floodplain for most reaches of the unnamed washes the development potential within the floodway fringe is minimum, however, at locations there is a potential. Given the characteristic of the Big Spring Area, the non-structural alternative, the partial structural and the no-action alternative are watercourse-based alternatives that were selected to be evaluated further during the Level II Analysis. The full structural alternative was not selected for Unnamed Wash 1, 2, and 3 because these washes, in places, are incised within bed rock thus precluding the need for full structural improvements.

East Terrace Area

The East Terrace Area is characterized by a mix of future land-use, Federal, State and private land ownership and terrain with predominately flat slopes that are dissected by numerous washes. Future land use in the area includes open space, very low-density residential, low-density residential, medium density residential, multifamily residential, industrial, mixed use and community commercial. Density of land use typically increases from north to south across the planing area with the highest

density located in the southern portion of the area. The State of Arizona owns the majority of the land in the area.

Numerous washes drain the East Terrace Area to the Agua Fria River. At some locations, washes are incised but are typically poorly defined. Results of approximate method floodplain delineation conducted for five of the washes draining the area demonstrate that the floodplains where the wash is not incised are typically broad and shallow. Given the level of hydraulic analysis conducted or available to use for the area no specific watercourse alternatives where selected for area. Policies and rules for development will be utilized to manage the East Terrace Area.

Twin Buttes Area

The Twin Buttes Area is characterized by a mix of future land-use, Federal, State and private land ownership and terrain with predominately flat slopes that are dissected by numerous washes. Future land use in the area includes open space, very low-density residential, low-density residential, medium density residential, multifamily residential, industrial, mixed use and community commercial. Density of land use typically increases from north to south across the planing area with the highest density located in the southern portion of the area. The majority of the land in the area is privately owned.

The major washes draining the area are Twin Buttes Wash, Caterpillar Tank Wash, East and West Garambullo Wash, West White Peak Wash and White Peaks Wash. Washes are typically incised within alluvial material. In the upper reaches of the major washes in the area the floodway is typically coincidental with the floodplain. Average erosion hazard zone widths ranges from 150 feet to 800 feet were as developable floodway fringe widths ranges between 50 and 300 feet.

Given the characteristics of the area the non-structural alternative, the full structural alternative, the low impact structural alternative and the no-action alternative are watercourse alternatives that were selected to be evaluated further during the Level II Analysis.

11.3.2.2 Detention/Retention Based Alternatives

Per the scope of work, the standard practice of retaining the 100-year, 2-hour hydrograph volume for developed conditions, providing in-line detention within watercourse, providing off-line side-weir detention adjacent to a watercourse and a do nothing alternative (detention/retention not required) are to be evaluated for the Big Spring Area. Results and conclusion of the evaluation are to be applied to rest of the study area.

11.3.2.3 Development Issues

Concerns that were identified my members of the steering committee during the data collection and initial evaluation that were discussed at the brainstorm meeting were formulated into planning issues. The issues are to be refined to a format of goals, objectives and policies during the Level II Analysis and will apply to the entire study area. A summary of the issues is provided in Appendix A.

11.3.3 Level II Evaluation

Alternatives designated for further study during the Level 1 Analysis are evaluated to determine their feasibility and approximate cost if applicable during the Level II Analysis. Alternatives designated for further studies are the full structural alternative, the partial structural alternative, the low impact structural alternative, non-structural alternative, the do nothing alternative and detention/retention based alternatives. Alternatives are grouped into three categories for the purpose of evaluation and discussion. The categories are, watercourse alternatives, detention/retention based alternative and development issues.

11.3.3.1 Watercourse Based Alternatives Hydraulic Evaluation

Purpose

Hydraulic evaluations are conducted to determine the feasibility, design parameters and design constraints for the full structural and partial structural alternatives. HEC RAS hydraulic models developed for floodplain delineation conducted as part of this

study are utilized to evaluated a partial structural alternative in the Big Springs Area. Watercourses evaluated in the Big Springs Area are Unnamed Wash 1, 2 and 3.

HEC- 2 hydraulic models developed for "Flood Insurance Study for Caterpillar Tank and Twin Buttes Washes From Agua Fria River to the CAP Canal (FCD 90-09, by AGK Engineers) are converted to a HEC-RAS format to evaluate full structural alternatives in the Twin Buttes Area. Watercourse evaluated in the Twin Buttes area below the CAP canal are Twin Buttes Wash, Caterpillar Tank Wash, Whites Peak Wash and West and East Garambullo Washes In the Twin Buttes Area besides hydraulic evaluation of the full structural alternative, models are developed for the following proposes:

- To compare HEC-2 model results by AGK Engineers to the converted HEC-RAS model developed for this study.

- To compare converted HEC-RAS model results to the updated HEC-RAS model (peak discharges updated) results developed for this study.

- To evaluate a full structural alternative that allows for encroachment into the floodway for the reach of Twin Buttes Wash between 115th Avenue and the confluence with the Agua Fria River. The purpose of the alternative is to provide a channel that removes a residence from the floodway and to provide protection for a future roadway along 115th Avenue alignment. This alternative is evaluated as a stand-alone alternative, and as part of the full structural alternative for the entire study reach of Twin Buttes Wash.

- To evaluate and quantify flow breakout near RM 0.66 along Twin Buttes Wash.

Methodology

Big Spring Area

Base HEC-RAS models developed for the floodplain delineation of Unnamed Wash 1, 2, and 3 (non-structural model) are revised to reflect encroachment into the floodway fringe proposed by the partial structural alternative. Methodology, input parameters and modeling considerations for the base HEC-RAS models are discussed in the North Peoria Area Drainage Master Plan Technical Data Notebook Attachment 3 Hydrology and Hydraulics. HEC-RAS models developed for the non-structural and partial structural alternatives are provided in Appendix B. The following assumptions and procedures are utilized in revising the base HEC-RAS model to reflect the partial structural alternative:

- The partial structural alternative is applied in potentially developable areas. Potentially developable areas within and adjacent to the floodway fringe are defined by two criteria. The first criterion being that the terrain of the developable area is characterized with slopes of less than 10 percent. The second criterion is that the terrain adjacent to the developable area is such that roadway access is possible. (slopes of less than 25 percent). For evaluation purposes, it is assumed that areas that were identified for the partial structural alternative, that the alternative would be constructed as one project. Plate 2 (Sheets 1 through 6), Plate 3 (Sheets 1 through 6) and Plate 4 (Sheets 1 through 4) display floodplain/floodway boundaries and terrain slope for Unnamed Wash 1, 2 and 3 respectively

- Encroachment stations are set for profile two to reflect the encroachment into the floodplain to the floodway fringe at location where the partial structural alternatives is being applied.

- Existing Condition 100-year peak discharges developed as part of this study are utilized in the evaluations.

Twin Buttes Area

HEC- 2 hydraulic models developed for "Flood Insurance Study (FIS) for Caterpillar Tank and Twin Buttes Washes From Agua Fria River to the CAP Canal (FCD 90-09, by AGK Engineers) are utilized as the base hydraulic models for analyses conducted for watercourses evaluated in the Twin Buttes Area. HEC-2 models are converted to a HEC-RAS format. Modifications to the converted HEC-RAS models are made to create a base HEC-RAS model (Non-Structural Alternative) and a model to evaluate the full structural alternative. The following assumptions, procedures, and methodologies were employed in developing the base and the structural alternative HEC-RAS models:

- The U.S. Army Corps of Engineers HEC-RAS computer program (version 3.0) is utilized to develop HEC-RAS hydraulic models.

- Manning's roughness values, expansion and contraction coefficients, starting water surface elevation and cross-section geometry listed in the HEC-2 model are utilized in the development of the HEC-RAS models.

- The HEC-2 models contained blocked flow areas defined by a X3 card, which limits flow only to a portion of cross-section for areas that are inferred as the only conveyance area for that cross-section. The levee station option of the HEC-RAS computer program was utilized to simulate the HEC-2 model blocked flow areas.

- The digital HEC-2 model for Caterpillar Tank Wash provided by the District did not match the hard copy in the "Flood Insurance Study for Caterpillar Tank and Twin Buttes Washes From Agua Fria River to the CAP Canal (FCD 90-09, by AGK Engineers). The differences included additional cross-sections, ineffective flow areas, bank stations, geometry data reach lengths and

encroachment stations. The following revisions were made to the model to be consistent with the hard copy version.

List of Modifications to Caterpillar Tanks Wash Input Files

River Mile	Modification
5.04	Changed bank station and added levee
5.02	Changed bank station and added levee
4.92	Adjust reach length
4.88	Delete cross-section
4.83	Delete cross-section
4.64	Changed bank station and levee
4.55	Changed right bank station and levee
4.45	Changed bank station and levee
4.36	Changed right bank station and levee
4.17	Changed bank station and levee
4.07	Changed geometry data from 31 data points to 10, and changed right bank station and levee
3.79	Changed left bank station and levee
3.73	Change geometry data from 45 to 30 data points and changed right bank station and levee
3.69	Changed geometry data from 47 to 33 data points and changed right bank station and levee
3.22	Changed right bank station and levee
3.03	Changed right bank station and levee
2.94	Changed left bank station and added levee
2.84	Changed right bank station and levee
2.75	Changed right bank station and levee
2.65	Changed right bank station and levee
2.56	Changed right bank station and levee
2.46	Changed left bank station and levee
2.27	Changed left bank station
1.99	Changed bank station and added levee
1.80	Changed right bank station
1.42	Changed right bank station
1.23	Changed right bank station and levee
0.019	Changed left bank station

- Converted HEC-RAS models are updated with flow discharges developed for the North Peoria ADMP to create a base HEC-RAS model to evaluate proposed alternatives.

- At locations where there is greater than 1 foot rise in water surface elevations between encroached and non-encroached conditions,

encroachment stations are relaxed to minimize that change in water surface elevations to a foot or less.

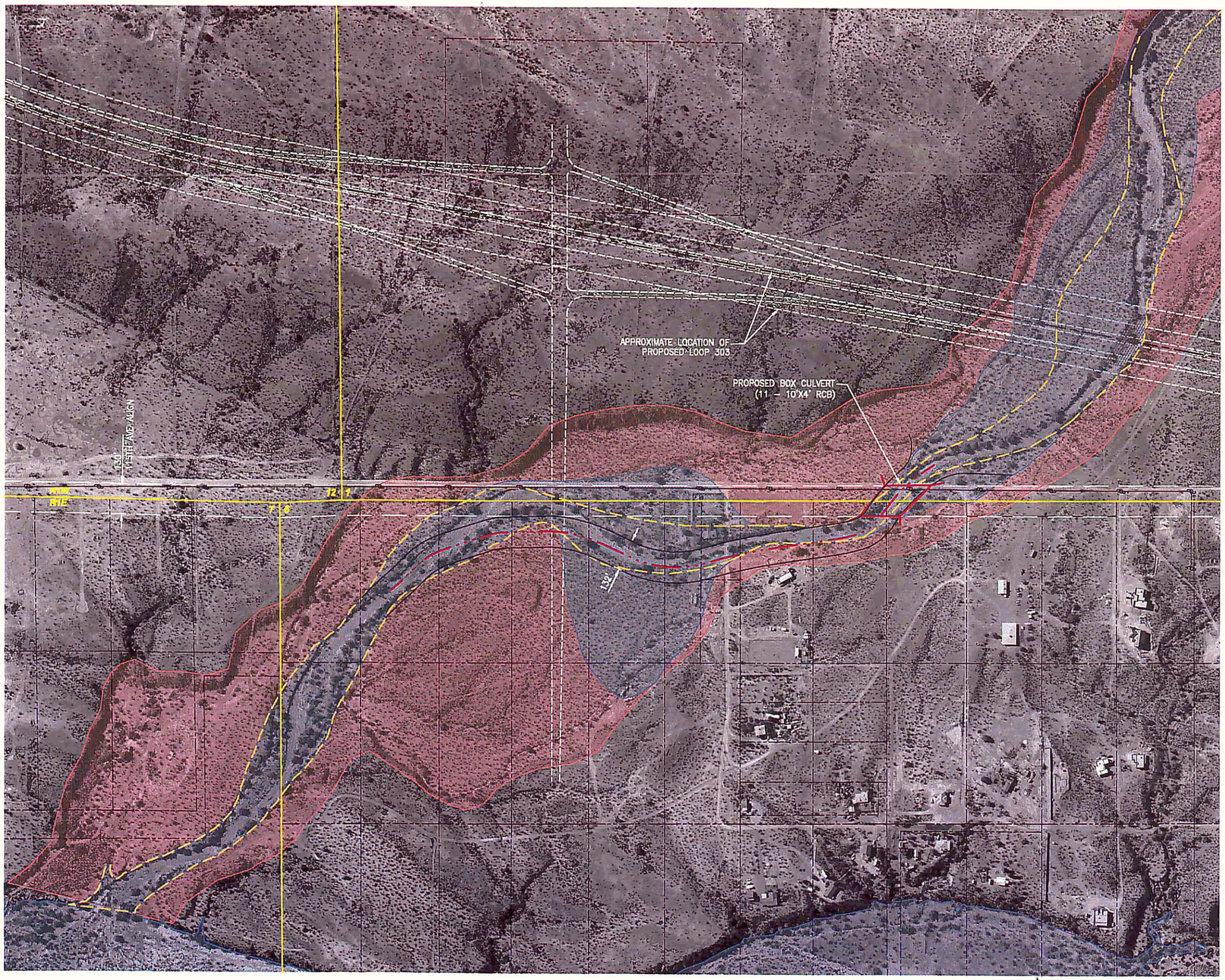
- The HEC-RAS channel improvement routine is utilized to evaluate the full structural alternative that allows encroachment to the floodway fringe. The full structural alternative is characterized by a trapezoidal channel with a uniform bottom width consistent with the limits of the floodway and 2 to 1 (horizontal to vertical) side slopes. Channel slope is consistent with existing wash slope. Banks stations are adjusted to the top edges of the proposed channel. Fill areas in the floodway fringe are set to the calculated freeboard elevation.

- The HEC-RAS channel routine is also utilized to evaluate channel improvements proposed for Twin Buttes Wash south of 115th Avenue. The alternative provides a channel that mitigates 100-year flood impacts to the alignment of 115th Avenue and to a residential structure located in the existing floodway. Channel top width and slope are optimized to provide a channel that mitigates 100-year flood impacts. Banks stations are adjusted to the top edges of the proposed channel. Proposed 115th Avenue channel improvements are displayed on Figure 11-7. Improvements are modeled in the full structural alternative hydraulic model.

- The HEC-RAS computer program lateral weir subroutine is utilized to evaluate potential flow splits.

- For reference purposes floodplain delineation work maps from the original FIS study are presented in Appendix C.

Output files for the different hydraulic models are located in Appendices D and E. Appendix D contains HEC-2 models whereas Appendix E contains HEC-RAS models for each of the washes evaluated.



AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

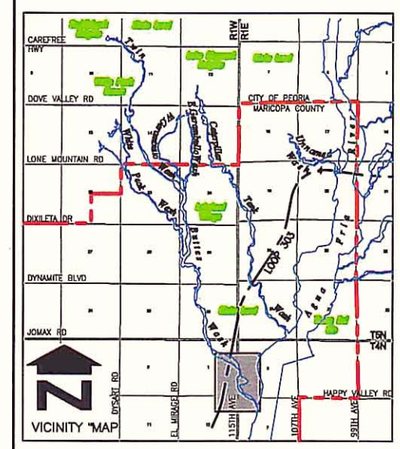
200' 0' 200' 400'

LEGEND

- EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY
- EROSION HAZARD SETBACK
- CORPORATE LIMITS
- SECTION LINE
- PROPERTY BOUNDARY
- LOOP 303 ALIGNMENT
- PROPOSED 115TH AVENUE RIGHT OF WAY
- OVERHEAD POWER
- CENTERLINE PROPOSED CHANNEL
- PROPOSED CHANNEL LIMITS
- FLOODWAY BOUNDARY

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.



NO.	REVISION	BY	DATE
2			
1			

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

NORTH PEORIA AREA DRAINAGE MASTER PLAN TWIN BUTTES WASH, 115TH AVENUE CHANNEL IMPROVEMENTS F.C.D. CONTRACT NO. 99-45

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ 85044-5355 U.S.A.
Tel. 602.436.2200
Fax. 602.431.9562
www.stantec.com

	BY	DATE
DESIGN	–	–
DESIGN CHK.	–	–
PLANS	HAR	05.18.01
PLANS CHK.	PJE	06.06.01

FIGURE 11-7

SHEET 1 OF 1

Hydraulic Modeling Results

This section of the report presents the results of the hydraulic models developed to determine the feasibility, design parameters and design constraints for the full structural and partial structural alternatives. Hydraulic models developed for each of the proposed alternatives are compared with the base hydraulic models to determine the impact of the alternative on the watercourse. Results of the hydraulic models for each alternative are also used to estimate design parameters such as free board and size of bank protection material. Results for watercourses evaluated in the Big Spring Area and the Twin Buttes Area are presented in the following sections.

Big Spring Area

Hydraulic evaluations are conducted for the non-structural alternative and the partial structural alternative for the Unnamed Wash 1, 2 and 3 within the Big Spring Area. The base HEC-RAS model for Unnamed Wash 1, 2 and 3 characterizes the elements of the non-structural alternative. Encroachment stations for the floodway profile, developed for the base models are revised to model elements (partial encroachment) of the partial structural alternative. Table 11-6, Table 11-9, and Table 11-12 lists a summary of results for selected hydraulic parameters for the non-structural alternative for Unnamed Wash 1, 2 and 3, respectively. Table 11-7, Table 11-10, and Table 11-13, lists a summary of results for selected hydraulic parameters for the partial structural alternative for Unnamed Wash 1, 2 and 3, respectively. Results are only presented for the areas where the partial structural alternative as been applied.

Models execute successfully without error messages for Unnamed Wash 1,2 and 3. The models do report several warning messages. The following are frequent warning messages reported:

- The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This is a common message received when modeling a river system that is characterized by changes in the conveyance capacity of the

channel relative to the over-bank area and varies from cross-section to cross-section

- The energy loss was greater than 1.0-ft (0.3 m) between the current and previous cross-section. The message pertaining to energy loss of greater than 1 foot is to be expected, given that cross-section spacing is 300 to 500 feet and the friction slopes are greater than 0.004 ft/ft.

- The velocity head has changed by more than 0.5-ft (0.15 m). Channel velocities generally range between 5 and 14 fps within the channel for Unnamed Wash 1, 2 and 3. A velocity difference between cross-sections of 2 fps would result in a velocity head difference of more than 0.5 feet. A change of 2 fps between cross-sections is not unreasonable.

- Warning messages from the HEC-RAS model at many locations reported that the assumed water surface elevation was set to critical depth, however the calculated water surface elevation was calculated below critical depth. This indicates a potential for supercritical flow. In the event that detail design is being pursued the designer should evaluated and design for supercritical flow conditions.

Results of the hydraulic models for the partial structural alternative are compared to results of the hydraulic model for the non-structural alternative to determine the impact of the alternative on the hydraulic properties of the watercourse. Tables 11-8, 11-11 and 11-14 list the results of the comparison of the non-structural model with the partial structure alternative for Unnamed Wash 1, 2 and 3, respectively. Negative values listed in the tables indicate a reduction in the value of the hydraulic parameters relative to the non-structural model. Positive values listed in the table indicate an

increase in the value of the hydraulic parameters relative to the non-structural model. Results are only presented for the areas where the partial structural alternative as been applied. Results of the comparison between no encroachment to partial encroachment indicate that generally there is a reduction in floodplain width at locations of encroachment into the floodway fringe along with an increase in flow velocity and depth. The greater the encroachment the greater the change in channel velocity and depth.

Table 11-6

Summary of Hydraulic Parameters

Base HEC-RAS Model Unnamed Wash 1

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
1.992	2139.9	494.3	255.8	7.5	4.7	3.5	10.3	96.0
2.047	2784.4	8.9	96.8	11.7	3.4	4.4	6.6	70.0
2.134	2882.3	6.8	0.9	10.5	2.4	1.9	6.7	67.0
2.23	1811.2	1078.5	0.2	6.4	5.5	0.9	6.5	141.7
2.312	2170.9	703.9	15.2	9.7	6.5	3.3	5.6	131.1
2.347	2021.1	0.0	868.9	6.2	0.2	3.8	7.0	168.4
2.39	2576.8	313.2	0.0	8.0	4.3	0.5	5.9	116.1
2.467	2883.1	0.8	6.1	7.9	1.3	2.2	7.0	75.0
2.557	2754.4	6.4	129.3	10.9	2.8	5.4	7.4	54.3
2.611	2632.5	257.5	0.1	10.7	4.8	0.9	8.2	75.4
2.674	2878.4	3.1	8.6	9.6	1.9	2.8	8.0	59.7
2.77	2266.1	7.6	616.2	8.5	2.4	5.9	6.8	84.2
2.813	2040.3	848.6	1.2	10.5	7.1	1.8	7.5	71.2
2.848	2857.0	15.4	17.6	9.5	3.2	2.7	7.0	88.6
2.88	2557.7	0.0	332.3	10.6	0.5	6.0	7.2	69.9
2.923	2882.9	6.4	0.8	8.7	2.2	1.4	8.1	66.2
3.015	2884.2	4.5	1.3	9.4	1.7	1.7	7.0	82.4
3.073	1606.9	0.4	722.7	6.4	1.2	4.7	5.8	152.4
3.121	1781.8	532.6	15.6	7.4	4.3	2.1	5.6	143.6
3.186	1839.5	432.3	58.2	8.5	3.6	2.0	5.7	152.8
3.274	2326.5	2.3	1.2	10.3	1.7	1.5	6.8	54.5
3.366	2327.9	1.4	0.7	10.6	1.8	1.3	5.4	66.3
3.453	2175.3	4.8	150.0	7.9	1.7	2.2	6.4	111.7
3.671	1907.5	292.7	129.8	0.9	0.5	0.3	13.1	368.0
3.706	1729.2	557.0	43.9	1.5	0.8	0.5	11.5	269.9
3.803	2235.8	25.7	68.5	4.3	1.5	1.2	7.9	122.3
3.895	1327.3	365.8	636.9	5.7	3.3	2.5	5.6	186.5
3.987	1749.3	165.9	414.7	10.0	4.3	3.9	5.0	131.5
4.077	1454.3	855.0	20.7	8.3	3.9	2.2	5.6	152.9
4.17	1706.2	3.3	620.5	11.0	2.3	4.6	5.4	100.3
4.256	1697.5	9.4	623.1	7.9	2.0	3.3	5.3	152.2
4.361	2084.2	206.2	39.6	10.1	4.4	2.8	5.5	99.9
4.412	1835.2	0.2	494.6	7.5	0.8	3.5	6.1	119.4
4.436	1464.4	842.6	23.0	9.5	5.3	2.6	4.0	149.7
4.536	2241.9	0.4	87.8	11.4	1.2	3.4	5.9	62.6
4.613	1975.0	280.5	74.5	8.1	3.7	2.2	5.8	114.9
4.628	1181.2	5.7	3.1	3.8	1.0	0.8	5.7	88.5
4.725	860.1	217.4	112.4	8.5	4.2	3.6	3.6	101.4
4.839	984.9	0.0	205.1	8.1	0.6	2.8	4.6	102.0
4.879	741.0	137.8	311.2	6.0	2.6	2.2	4.5	166.3

Table 11-6 Cont.

Summary of Hydraulic Parameters

Base HEC-RAS Model Unnamed Wash 1

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
4.92	1052.4	137.4	0.2	9.0	3.5	0.9	4.6	71.1
5.007	1018.5	100.2	71.3	8.3	4.0	2.0	5.4	82.3
5.096	1189.7	0.2	0.0	8.4	0.9	0.6	4.7	48.4
5.176	1127.2	0.0	62.8	10.0	0.5	3.2	4.5	50.2
5.207	1091.7	25.0	73.4	5.4	1.6	1.7	4.9	99.2
5.227	960.9	229.1	0.1	7.0	2.8	0.5	4.4	116.9
5.31	1189.9	0.1	0.1	9.8	0.9	0.7	4.6	40.6
5.38	359.0	0.1	830.9	5.8	0.7	3.5	3.8	120.7
5.439	1117.6	0.0	72.4	9.5	0.6	3.1	4.9	60.0
5.505	1189.8	0.1	0.1	8.5	1.0	0.8	3.6	55.7
5.632	1178.1	2.2	9.7	8.0	1.5	1.8	4.9	58.7
5.746	969.2	219.6	1.2	6.4	2.8	0.8	3.5	141.8
5.862	1189.9	0.1	0.0	9.3	0.8	0.7	4.0	48.6
5.917	733.5	0.1	16.3	8.4	0.9	2.1	4.4	40.4
5.969	388.1	361.9	0.1	4.4	1.9	0.5	4.0	214.9
6.015	749.3	0.5	0.2	8.5	1.3	1.0	3.4	42.0
6.1	497.2	1.0	251.7	8.4	1.7	4.8	3.1	66.8
6.216	715.9	3.2	30.9	6.2	1.1	1.9	3.5	96.9
6.311	749.0	0.3	0.7	9.2	1.2	1.4	3.6	34.5

Table 11-7

Summary of Hydraulic Parameters

Partial Structural Encroachment HEC-RAS Model Unnamed Wash 1

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
1.992	2139.9	494.3	255.8	7.5	4.7	3.5	10.3	96.0
2.047	2784.4	8.9	96.8	11.7	3.4	4.4	6.6	70.0
2.134	2882.3	6.8	0.9	10.5	2.4	1.9	6.7	67.0
2.23	2568.2	320.4	1.4	7.9	4.7	1.6	7.1	98.4
2.312	2677.7	177.9	34.4	10.1	3.7	4.2	6.3	123.6
2.347	1945.5	0.0	944.5	5.6	0.5	3.6	7.4	171.6
2.39	2603.4	286.6	0.0	8.4	4.4	0.0	5.8	113.9
2.467	2882.0	1.0	7.0	7.8	1.4	2.2	7.1	75.4
2.557	2757.6	5.9	126.5	11.0	2.8	5.4	7.3	54.1
2.611	2625.0	264.9	0.1	10.5	4.8	0.9	8.3	75.8
2.674	2879.0	2.8	8.2	9.7	1.8	2.8	7.9	59.6
2.77	2264.7	7.8	617.6	8.4	2.4	5.9	6.8	84.3
2.813	2041.0	847.9	1.1	10.5	7.1	1.8	7.5	71.2
2.848	2856.9	15.4	17.7	9.5	3.2	2.7	7.0	88.8
2.88	2557.8	0.0	332.2	10.6	0.5	6.0	7.2	69.9
2.923	2882.8	6.4	0.8	8.7	2.2	1.4	8.1	66.2
3.015	2884.2	4.5	1.3	9.4	1.7	1.7	7.0	82.4
3.073	1606.9	0.4	722.7	6.4	1.2	4.7	5.8	152.5
3.121	2037.8	292.2	0.0	8.2	5.5	0.0	5.8	79.9
3.186	2201.7	0.0	128.3	9.0	0.0	2.8	6.3	80.9
3.274	2321.0	6.3	2.7	9.3	1.9	1.6	7.3	57.0
3.366	2327.9	1.4	0.7	10.6	1.8	1.3	5.4	66.3
3.453	2175.3	4.8	150.0	7.9	1.7	2.2	6.4	111.7
3.671	1907.5	292.7	129.8	0.9	0.5	0.3	13.1	368.0
3.706	1729.2	557.0	43.9	1.5	0.8	0.5	11.5	269.9
3.803	2303.0	27.0	0.0	4.4	1.6	0.0	7.9	91.7
3.895	1872.5	0.0	457.5	8.0	0.0	3.9	5.6	88.7
3.987	2020.7	0.0	309.3	9.2	0.0	4.1	6.0	72.6
4.077	1421.4	885.9	22.7	7.9	3.8	2.1	5.7	154.3
4.17	1706.2	3.3	620.5	11.0	2.3	4.6	5.4	100.3
4.256	1887.4	12.4	430.2	8.5	2.3	3.7	5.4	109.9
4.361	2330.0	0.0	0.0	10.1	0.0	0.0	6.0	54.5
4.412	2328.7	1.3	0.0	8.7	1.6	0.0	6.5	59.0
4.436	1624.3	705.8	0.0	9.8	5.5	0.0	4.3	113.9
4.536	2233.9	0.6	95.5	11.1	1.3	3.4	6.0	63.4
4.613	1977.6	282.0	70.4	8.3	3.9	2.2	5.8	112.1
4.628	1181.6	5.4	3.0	3.9	1.0	0.8	5.6	88.1
4.725	1068.6	21.5	99.9	9.7	4.0	4.4	3.8	53.2
4.839	967.5	0.1	222.4	7.4	0.9	2.3	4.9	122.5
4.879	1047.3	0.0	142.7	8.5	0.0	2.4	4.5	95.2
4.92	1175.4	13.5	1.2	8.2	2.8	1.4	5.3	38.0

Table 11-7 Cont.

Summary of Hydraulic Parameters

Partial Structural Encroachment HEC-RAS Model Unnamed Wash 1

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
5.007	1027.1	98.3	64.6	8.5	4.1	2.0	5.3	80.6
5.096	1189.6	0.4	0.1	8.2	1.0	0.7	4.8	49.0
5.176	1127.2	0.0	62.8	10.0	0.5	3.2	4.5	50.2
5.207	1112.4	0.0	77.6	5.5	0.0	1.8	4.9	83.7
5.227	1075.7	114.3	0.0	8.0	3.4	0.5	4.4	71.8
5.31	1189.3	0.4	0.4	8.9	1.4	1.2	5.0	40.6
5.38	457.1	0.1	732.8	7.2	0.9	4.8	3.9	74.6
5.439	1117.0	0.1	73.0	9.5	0.6	3.1	4.9	60.3
5.505	1189.8	0.1	0.1	8.6	0.9	0.8	3.6	55.6
5.632	1177.8	2.3	9.9	8.0	1.5	1.8	4.9	58.8
5.746	1032.6	157.4	0.0	6.7	3.8	0.0	3.6	83.5
5.862	1189.9	0.1	0.0	9.3	0.8	0.7	4.0	48.6
5.917	733.5	0.1	16.4	8.4	0.9	2.1	4.4	40.4
5.969	505.4	244.2	0.4	5.3	2.7	0.8	4.3	97.4
6.015	749.3	0.5	0.2	8.5	1.3	1.0	3.4	42.0
6.1	497.2	1.0	251.7	8.4	1.7	4.8	3.1	66.8
6.216	715.9	3.2	30.9	6.2	1.1	1.9	3.5	96.9
6.311	749.0	0.3	0.7	9.2	1.2	1.4	3.6	34.5

Table 11-8

Comparison of Base HEC-RAS to Partial Structural Encroachment HEC-RAS

Unnamed Wash 1

x-sec	Difference in Discharge			Difference in Velocity			Difference in Channel Depth of Flow	Top Width Difference
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
1.992	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.047	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.134	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.23	757.0	-758.2	1.1	1.5	-0.8	0.7	0.6	-43.3
2.312	506.8	-526.0	19.2	0.4	-2.8	0.9	0.7	-7.5
2.347	-75.6	0.0	75.5	-0.7	0.3	-0.3	0.4	3.3
2.39	26.6	-26.6	0.0	0.4	0.1	-0.5	-0.2	-2.2
2.467	-1.1	0.3	0.8	-0.1	0.1	0.0	0.1	0.4
2.557	3.2	-0.4	-2.8	0.1	0.0	0.1	-0.1	-0.2
2.611	-7.5	7.5	0.0	-0.1	0.0	0.1	0.1	0.3
2.674	0.7	-0.3	-0.4	0.1	-0.1	0.0	0.0	-0.2
2.77	-1.5	0.1	1.3	0.0	0.0	0.0	0.0	0.1
2.813	0.7	-0.6	0.0	0.0	0.0	0.0	0.0	0.0
2.848	-0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.2
2.88	0.1	0.0	-0.1	0.0	0.0	0.0	0.0	0.0
2.923	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.073	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.121	256.0	-240.4	-15.6	0.8	1.2	-2.1	0.2	-63.7
3.186	362.2	-432.3	70.1	0.6	-3.6	0.8	0.5	-71.9
3.274	-5.5	4.0	1.5	-1.0	0.2	0.1	0.5	2.5
3.366	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.453	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.671	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.706	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.803	67.2	1.3	-68.5	0.1	0.1	-1.2	0.0	-30.6
3.895	545.1	-365.8	-179.4	2.3	-3.3	1.4	0.0	-97.7
3.987	271.3	-165.9	-105.4	-0.8	-4.3	0.2	1.0	-58.9
4.077	-32.9	30.8	2.1	-0.4	-0.1	-0.1	0.2	1.4
4.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.256	189.9	3.0	-192.9	0.7	0.3	0.4	0.1	-42.3
4.361	245.8	-206.2	-39.6	0.1	-4.4	-2.8	0.4	-45.4
4.412	493.5	1.1	-494.6	1.2	0.8	-3.5	0.4	-60.4
4.436	159.9	-136.9	-23.0	0.3	0.3	-2.6	0.2	-35.8
4.536	-7.9	0.2	7.7	-0.3	0.1	0.0	0.1	0.8
4.613	2.6	1.4	-4.1	0.1	0.2	0.0	-0.1	-2.8
4.628	0.4	-0.2	-0.1	0.0	0.0	0.0	0.0	-0.3
4.725	208.4	-195.9	-12.5	1.2	-0.2	0.9	0.2	-48.1
4.839	-17.4	0.1	17.3	-0.8	0.3	-0.4	0.3	20.5

Table 11-8 Cont.

Comparison of Base HEC-RAS to Partial Structural Encroachment HEC-RAS

Unnamed Wash 1

x-sec	Difference in Discharge			Difference in Velocity			Difference in Channel Depth of Flow	Top Width Difference
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
4.879	306.3	-137.8	-168.5	2.6	-2.6	0.2	0.0	-71.1
4.92	122.9	-124.0	1.0	-0.7	-0.7	0.5	0.7	-33.1
5.007	8.6	-1.9	-6.7	0.2	0.1	0.0	-0.1	-1.8
5.096	-0.2	0.1	0.0	-0.2	0.1	0.1	0.1	0.5
5.176	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.207	20.7	-25.0	4.2	0.1	-1.6	0.1	0.0	-15.4
5.227	114.8	-114.8	0.0	1.0	0.6	0.0	-0.1	-45.0
5.31	-0.6	0.3	0.3	-0.9	0.5	0.4	0.3	0.0
5.38	98.0	0.1	-98.1	1.4	0.3	1.3	0.1	-46.1
5.439	-0.6	0.0	0.6	0.0	0.0	0.0	0.0	0.2
5.505	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
5.632	-0.2	0.1	0.2	0.0	0.0	0.0	0.0	0.1
5.746	63.4	-62.2	-1.2	0.3	1.0	-0.8	0.1	-58.3
5.862	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.917	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.969	117.3	-117.7	0.3	0.8	0.8	0.4	0.2	-117.5
6.015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.216	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.311	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 11-9

Summary of Hydraulic Parameters

Base HEC-RAS Model Unnamed Wash 2

x-sec	Discharge			Velocity				
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank	Channel Depth of Flow	Top Width
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
2.625	2881.8	450.5	1237.7	8.3	4.2	4.8	6.6	167.2
2.656	4369.0	20.5	30.5	13.4	3.2	2.7	9.5	102.8
2.683	3830.2	4.4	585.4	7.0	1.3	3.3	10.5	191.0
2.718	3940.3	1.5	478.2	11.7	1.6	4.9	7.1	95.9
2.813	3349.7	25.1	1045.2	11.5	3.0	4.5	8.3	144.6
2.856	4416.7	3.3	0.0	14.4	2.1	0.8	10.8	51.4
2.892	4405.2	14.5	0.3	13.8	3.1	0.9	15.3	59.7
2.903	4419.8	0.1	0.1	13.7	0.9	0.9	10.4	57.5
3.825	2968.0	1451.6	0.3	12.5	8.0	1.2	9.2	72.0
3.874	3884.1	0.5	535.5	7.1	1.0	3.4	7.7	209.9
3.923	4378.9	40.0	1.1	9.6	1.8	1.3	6.8	142.0
3.961	4222.2	197.8	0.1	10.0	3.1	0.7	6.0	161.9
4.013	4154.5	265.4	0.0	10.5	3.1	0.7	7.1	173.2
4.072	4072.8	0.0	347.2	8.9		3.0	6.2	247.7
4.102	3852.6	1.0	566.5	10.1	1.5	3.6	6.4	197.2
4.199	4124.7	0.0	295.3	11.8	0.7	4.4	6.5	108.3
4.286	4055.6	364.4	0.0	11.5	5.6	0.5	6.4	92.0
4.332	3700.6	616.2	103.3	12.9	6.8	4.3	7.7	93.2
4.6	3930.7	0.5	488.9	13.0	1.2	4.4	9.2	109.4
4.64	3706.5	708.7	4.8	11.4	4.2	2.2	7.2	151.3
4.692	4375.6	43.5	0.9	12.1	2.5	1.6	6.9	101.2
4.784	3740.1	679.0	0.9	12.8	7.0	1.5	7.1	89.5
4.884	3974.3	444.9	0.9	11.9	5.4	1.7	6.8	106.8
4.939	3359.2	1059.9	0.9	11.9	5.4	1.6	7.4	130.4
4.974	3380.0	0.0	0.0	5.9	0.2	0.0	6.7	158.2
5.079	2811.7	0.0	568.3	12.1	0.6	6.1	6.1	84.6
5.114	2771.3	0.0	608.7	9.6	0.3	5.1	6.6	98.2
5.172	3118.0	0.0	262.0	10.7	0.6	4.1	6.0	116.0
5.266	3049.6	330.4	0.0	11.9	5.1	0.1	6.3	85.5
5.304	2620.5	759.5	0.0	7.3	3.7	0.3	7.0	148.0
5.364	3379.6	0.4	0.0	10.7	1.1	0.6	5.1	92.3
5.46	3276.7	0.8	102.6	8.8	1.3	2.3	6.4	133.9
5.508	3143.5	0.1	236.4	10.8	0.8	3.6	6.4	113.4
5.551	2147.7	1232.3	0.1	9.9	5.6	0.8	5.4	135.5
5.624	2786.4	593.6	0.0	12.3	6.5	0.7	5.8	78.7
5.702	2857.1	522.3	0.6	8.2	3.6	0.9	6.9	130.1
5.759	3380.0	0.0	0.0	12.2	0.4	0.0	6.4	60.6
5.845	2375.9	0.5	1003.6	12.9	1.2	5.7	9.6	87.0
5.865	2291.4	572.9	515.7	12.0	5.4	4.8	6.2	125.2
5.927	3062.9	0.0	317.1	11.5	0.8	4.7	5.5	93.5
5.974	2534.0	19.6	356.4	8.1	2.3	3.5	6.1	125.6
6.058	1810.5	1099.5	0.0	11.1	5.6	0.7	5.1	125.8
6.161	1632.2	1277.4	0.4	7.7	4.0	1.0	5.3	220.2

Table 11-10

Summary of Hydraulic Parameters

Partial Structural Encroachment HEC-RAS Model Unnamed Wash 2

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
2.625	2881.8	450.5	1237.7	8.3	4.2	4.8	6.6	167.2
2.656	4369.0	20.5	30.5	13.4	3.2	2.7	9.5	102.8
2.683	3971.8	4.3	444.0	7.3	1.3	3.3	10.5	112.8
2.718	4112.5	1.4	306.1	12.4	1.6	5.9	7.0	71.3
2.813	3865.8	34.1	520.1	12.8	3.5	6.6	8.5	66.5
2.856	4416.3	3.7	0.1	14.3	2.2	0.8	10.9	51.4
2.892	4405.2	14.5	0.3	13.8	3.1	0.9	15.3	59.7
2.903	4419.8	0.1	0.1	13.7	0.9	0.9	10.4	57.5
3.825	2968.0	1451.6	0.3	12.5	8.0	1.2	9.2	72.0
3.874	3884.1	0.5	535.5	7.1	1.0	3.4	7.7	209.9
3.923	4418.9	0.0	1.1	9.7	0.0	1.3	6.8	101.6
3.961	4419.9	0.0	0.1	10.5	0.0	0.8	6.0	98.0
4.013	4296.7	123.3	0.0	10.9	3.1	0.7	7.0	129.6
4.072	4208.3	0.0	211.8	8.8	0.0	3.7	6.4	136.2
4.102	4066.5	0.9	352.6	10.7	1.6	3.9	6.4	144.2
4.199	4115.1	0.1	304.8	11.6	0.8	4.3	6.6	108.7
4.286	4060.0	360.0	0.0	11.6	5.7	0.3	6.4	91.7
4.332	3700.6	616.2	103.3	12.9	6.8	4.3	7.7	93.2
4.6	3930.7	0.5	488.9	13.0	1.2	4.4	9.2	109.4
4.64	3706.5	708.7	4.8	11.4	4.2	2.2	7.2	151.3
4.692	4419.1	0.0	0.9	12.3	0.0	1.7	6.9	73.6
4.784	4328.2	88.4	3.4	13.7	5.5	2.4	7.5	60.0
4.884	4418.6	0.0	1.4	12.9	0.0	2.1	6.9	66.5
4.939	3872.0	546.8	1.2	13.7	7.5	1.9	7.4	68.4
4.974	3379.9	0.1	0.0	5.0	0.4	0.0	7.7	102.2
5.079	3288.4	0.1	91.5	13.3	1.1	5.7	6.5	49.8
5.114	3223.8	0.1	156.2	9.6	0.6	4.7	7.4	61.8
5.172	3379.8	0.2	0.0	10.7	1.1	0.0	6.3	68.7
5.266	3042.8	337.3	0.0	11.7	5.0	0.4	6.4	86.2
5.304	2624.1	755.9	0.0	7.4	3.7	0.3	6.9	147.7
5.364	3379.6	0.4	0.0	10.7	1.1	0.6	5.1	92.3
5.46	3276.7	0.8	102.6	8.8	1.3	2.3	6.4	133.9
5.508	3143.5	0.1	236.4	10.8	0.8	3.6	6.4	113.4
5.551	2147.7	1232.3	0.1	9.9	5.6	0.8	5.4	135.5
5.624	2786.4	593.6	0.0	12.3	6.5	0.7	5.8	78.7
5.702	3378.7	0.0	1.3	9.4	0.0	1.4	7.1	68.3
5.759	3380.0	0.0	0.0	12.1	0.4	0.0	6.4	60.6
5.845	2423.0	0.1	957.0	13.8	0.7	7.0	9.3	64.2
5.865	2468.0	647.6	264.4	12.6	5.8	5.9	6.3	87.9
5.927	3379.9	0.1	0.0	12.4	1.0	0.0	5.6	57.8
5.974	2873.0	37.0	0.0	8.1	2.7	0.0	6.7	76.2
6.058	1810.5	1099.5	0.0	11.1	5.6	0.7	5.1	125.8
6.161	1632.2	1277.4	0.4	7.7	4.0	1.0	5.3	220.2

Table 11-11

Comparison of Base HEC-RAS to Partial Structural Encroachment HEC-RAS

Unnamed Wash 2

x-sec	Difference in Discharge			Difference in Velocity			Difference in Channel Depth of Flow	Top Width Difference
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
2.625	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.656	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.683	141.5	-0.2	-141.4	0.3	0.0	0.0	-0.1	-78.2
2.718	172.2	-0.2	-172.0	0.7	0.0	1.0	-0.1	-24.6
2.813	516.1	9.0	-525.1	1.3	0.5	2.1	0.3	-78.1
2.856	-0.4	0.4	0.0	-0.1	0.1	0.0	0.0	0.0
2.892	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.903	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.825	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.874	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.923	40.0	-40.0	0.0	0.1	-1.8	0.0	0.0	-40.4
3.961	197.8	-197.8	0.0	0.4	-3.1	0.1	0.0	-63.9
4.013	142.2	-142.2	0.0	0.4	0.0	0.0	0.0	-43.6
4.072	135.5	0.0	-135.5	-0.2	0.0	0.7	0.2	-111.5
4.102	213.9	0.0	-213.9	0.6	0.1	0.3	0.0	-52.9
4.199	-9.6	0.0	9.6	-0.1	0.1	0.0	0.0	0.4
4.286	4.5	-4.4	0.0	0.1	0.1	-0.1	-0.1	-0.4
4.332	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.692	43.5	-43.5	0.0	0.1	-2.5	0.0	0.0	-27.5
4.784	588.1	-590.6	2.5	0.9	-1.5	0.9	0.5	-29.5
4.884	444.3	-444.9	0.6	1.0	-5.4	0.4	0.1	-40.3
4.939	512.8	-513.1	0.3	1.7	2.1	0.3	0.1	-62.0
4.974	-0.1	0.1	0.0	-0.9	0.2	0.0	1.0	-56.1
5.079	476.7	0.1	-476.8	1.2	0.4	-0.4	0.3	-34.8
5.114	452.5	0.1	-452.5	0.1	0.3	-0.4	0.8	-36.3
5.172	261.8	0.2	-262.0	0.0	0.6	-4.1	0.4	-47.3
5.266	-6.9	6.9	0.0	-0.2	-0.1	0.2	0.1	0.7
5.304	3.5	-3.5	0.0	0.0	0.0	0.0	0.0	-0.3
5.364	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.508	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.551	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.624	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.702	521.6	-522.3	0.7	1.2	-3.6	0.4	0.2	-61.8
5.759	0.0	0.0	0.0	-0.1	0.1	0.0	0.0	0.0
5.845	47.1	-0.4	-46.7	0.9	-0.4	1.3	-0.3	-22.8
5.865	176.6	74.7	-251.3	0.6	0.4	1.1	0.2	-37.3
5.927	317.0	0.1	-317.1	0.9	0.3	-4.7	0.1	-35.7
5.974	339.1	17.4	-356.4	0.0	0.5	-3.5	0.6	-49.4
6.058	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.161	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 11-12

Summary of Hydraulic Parameters

Base HEC-RAS Model Unnamed Wash 3

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
1.519	2569.4	0.5	0.1	12.5	1.4	1.0	7.8	44.2
1.537	2450.8	0.2	119.0	12.0	1.1	4.3	7.5	60.5
1.563	1528.9	1034.8	6.3	10.4	7.7	2.6	4.6	119.7
1.6	2453.5	116.5	0.0	8.0	2.5	0.6	4.2	148.5
1.641	2238.2	331.4	0.5	10.6	4.1	1.3	5.3	107.7
1.69	2198.1	0.8	1.1	7.8	1.1	1.3	6.5	61.2
1.973	1994.1	0.1	205.8	7.8	0.6	3.0	6.9	97.1
2.011	2039.8	158.2	2.0	9.6	3.1	1.8	6.3	92.8
2.05	1679.3	366.0	154.7	7.8	3.9	3.2	4.7	175.7
2.118	1901.1	0.5	298.4	8.9	1.2	2.4	6.7	179.6
2.233	2112.4	87.5	0.1	9.0	2.2	0.8	5.8	130.1
2.315	1828.7	0.3	371.0	9.8	1.2	3.8	6.2	185.3
2.421	1897.2	276.1	26.6	7.3	2.9	2.5	5.1	142.7
2.471	1972.3	226.2	1.5	8.9	2.8	1.8	5.4	157.0
2.522	2115.1	1.8	83.1	7.6	1.5	1.9	5.5	147.5
2.581	1919.3	275.8	4.9	9.2	3.0	0.9	5.8	168.1
2.677	2038.9	108.4	52.7	8.7	2.5	1.4	6.1	197.0
2.779	2003.2	123.1	73.7	9.7	2.9	2.7	6.4	117.2
2.85	1391.3	645.9	162.9	7.7	4.6	3.8	5.5	109.5
3.309	1970.1	0.2	19.8	10.7	1.1	1.9	5.3	69.5
3.319	1668.3	0.4	321.4	6.9	0.8	2.8	7.4	103.7
3.351	1500.1	434.3	55.6	5.4	2.9	2.1	5.9	109.5
3.37	1802.4	183.9	3.7	7.2	2.3	1.9	5.2	172.8
3.412	1718.7	227.1	44.2	9.6	4.0	3.2	4.9	101.0
3.426	1984.3	4.2	1.6	7.4	1.6	1.1	5.6	81.5
3.46	1989.9	0.1	0.0	10.0	0.9	0.7	5.9	49.3
3.487	1846.2	66.5	77.3	6.6	2.5	2.5	7.3	133.2
3.497	1514.1	14.1	461.8	9.2	2.7	3.9	6.4	91.7
3.509	1500.6	0.0	489.5	5.1	0.0	2.9	7.1	198.6
3.52	1283.5	177.7	528.8	5.8	2.0	3.1	6.5	174.1
3.561	1443.0	172.0	375.0	9.0	3.3	4.6	5.3	138.3
3.649	1602.2	114.0	273.8	7.1	3.1	3.7	5.3	115.2
3.731	1660.0	74.0	256.0	9.5	3.6	3.1	5.3	151.5
3.826	1637.8	0.1	352.1	8.7	0.9	4.8	5.8	88.6
3.921	1983.4	1.5	5.2	10.8	2.0	2.6	6.0	40.9
4.013	1977.2	2.8	10.0	10.2	2.3	3.5	4.5	63.8
4.11	1983.2	1.5	5.4	10.9	2.1	2.5	5.7	47.0
4.145	1988.4	0.9	0.7	11.5	1.9	1.7	6.1	44.5
4.177	1655.9	7.4	326.7	7.9	2.0	4.1	6.5	98.0

Table 11-13

Summary of Hydraulic Parameters

Partial Structural Encroachment HEC-RAS Model Unnamed Wash 3

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
1.519	2569.4	0.5	0.1	12.5	1.4	1.0	7.8	44.2
1.537	2450.8	0.2	119.0	12.0	1.1	4.3	7.5	60.5
1.563	2025.3	520.0	24.8	10.7	7.0	4.0	5.1	87.1
1.6	2569.8	0.0	0.2	7.3	0.0	1.0	4.8	91.4
1.641	2238.2	331.4	0.5	10.6	4.1	1.3	5.3	107.7
1.69	2198.1	0.8	1.1	7.8	1.1	1.3	6.5	61.2
1.973	1994.1	0.1	205.8	7.8	0.6	3.0	6.9	97.1
2.011	2039.8	158.2	2.0	9.6	3.1	1.8	6.3	92.8
2.05	2080.4	83.2	36.3	9.9	4.7	3.7	4.6	70.0
2.118	2198.5	1.5	0.0	8.9	1.4	0.0	7.4	45.2
2.233	2199.7	0.0	0.3	8.7	0.0	1.2	6.1	63.2
2.315	2199.7	0.3	0.0	12.0	1.4	0.0	6.2	41.3
2.421	2049.1	103.4	47.5	6.6	3.3	2.7	5.9	84.9
2.471	1962.7	236.0	1.4	9.0	3.3	1.8	5.3	132.6
2.522	2115.0	1.8	83.2	7.6	1.5	1.9	5.5	147.6
2.581	2200.0	0.0	0.0	11.0	0.0	0.0	5.7	49.2
2.677	2200.0	0.0	0.0	8.0	0.0	0.0	6.9	54.7
2.779	2003.2	123.1	73.7	9.7	2.9	2.7	6.4	117.2
2.85	1391.3	645.9	162.9	7.7	4.6	3.8	5.5	109.5
3.52	1283.5	177.7	528.8	5.8	2.0	3.1	6.5	174.1
3.561	1443.0	172.0	375.0	9.0	3.3	4.6	5.3	138.3
3.649	1990.0	0.0	0.0	8.2	0.0	0.0	5.7	51.1
3.731	1958.7	0.0	31.3	10.0	0.0	4.1	5.8	45.8
3.826	1989.1	1.0	0.0	9.1	1.7	0.0	6.4	48.4
3.921	1979.6	2.5	7.9	10.2	2.1	2.7	6.3	41.9
4.013	1977.5	2.7	9.8	10.3	2.3	3.5	4.4	63.7
4.11	1983.0	1.5	5.5	10.9	2.1	2.5	5.8	47.0
4.145	1988.4	0.9	0.7	11.5	1.9	1.7	6.1	44.5
4.177	1655.9	7.4	326.7	7.9	2.0	4.1	6.5	98.0

Table 11-14

Comparison of Base HEC-RAS to Partial Structural Encroachment HEC-RAS

Unnamed Wash 3

x-sec	Difference in Discharge			Difference in Velocity			Difference in Channel Depth of Flow	Top Width Difference
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
1.519	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.537	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.563	496.3	-514.8	18.5	0.3	-0.7	1.3	0.5	-32.6
1.6	116.3	-116.5	0.2	-0.7	-2.5	0.4	0.5	-57.1
1.641	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.69	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.973	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.011	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.05	401.2	-282.8	-118.4	2.1	0.8	0.5	-0.1	-105.7
2.118	297.4	1.0	-298.4	0.0	0.3	-2.4	0.8	-134.4
2.233	87.3	-87.5	0.2	-0.2	-2.2	0.4	0.3	-66.8
2.315	371.0	0.0	-371.0	2.2	0.2	-3.8	-0.1	-144.0
2.421	151.9	-172.7	20.8	-0.7	0.4	0.2	0.8	-57.8
2.471	-9.6	9.8	-0.1	0.0	0.4	0.0	0.0	-24.4
2.522	-0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
2.581	280.7	-275.8	-4.9	1.8	-3.0	-0.9	-0.2	-118.9
2.677	161.1	-108.4	-52.7	-0.7	-2.5	-1.4	0.8	-142.3
2.779	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.561	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.649	387.8	-114.0	-273.8	1.0	-3.1	-3.7	0.4	-64.1
3.731	298.7	-74.0	-224.7	0.5	-3.6	1.0	0.5	-105.7
3.826	351.2	0.8	-352.1	0.4	0.8	-4.8	0.7	-40.3
3.921	-3.8	1.1	2.7	-0.7	0.1	0.1	0.3	1.0
4.013	0.2	-0.1	-0.1	0.0	0.0	0.0	0.0	-0.1
4.11	-0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0
4.145	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.177	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Twin Buttes Area

Models execute successfully without error messages for washes studied in the Twin Buttes Area. The models do report several warning messages. The following are frequent warning messages reported:

- The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This is a common message received when modeling a river system that is characterized by changes in the conveyance capacity of the channel relative to the over-bank area and varies from cross-section to cross-section

- The energy loss was greater than 1.0-ft (0.3 m) between the current and previous cross-section. The message pertaining to energy loss of greater than 1 foot is to be expected, given that cross-section spacing is 300 to 500 feet and the friction slopes are greater than 0.004 ft/ft.

- The velocity head has changed by more than 0.5-ft (0.15 m). Channel velocities generally range between 4 and 11 fps within the channel for washes in the Twin Butte Area. A velocity difference between cross-sections of 2 fps would result in a velocity head difference of more than 0.5 feet. A change of 2 fps between cross-sections is not unreasonable.

- Warning messages from the HEC-RAS model at many locations reported that the assumed water surface elevation was set to critical depth, however the calculated water surface elevation was calculated below critical depth. This indicates a potential for supercritical flow. In the event that detail design is being pursued the designer should evaluated and design for supercritical flow conditions.

Conversion of HEC–2 Model to HEC-RAS Model Twin Buttes Wash

For Comparison purposes, water surface elevations determined for the HEC-RAS and the HEC-2 models are listed in Table 11-15. In general, the average water surface

elevation differential (difference between the original model and the HEC-RAS model) is less than 0.01 feet. The maximum difference of 1.08 feet occurred at cross-section 1.14. Both models assumed critical depth. The difference in water surface elevation is due to the different techniques HEC-2 and HEC-RAS use to compute critical depth. This is also true for cross-sections 3.69 through 3.88. The hydraulic performance of HEC-RAS model as compared to the HEC-2 model is considered acceptable for the purpose of modeling alternatives.

Table11-15

Comparison of Converted HEC-RAS and Original HEC-2 Model Results

Twin Buttes Wash

River Mile (1)	Water Surface Elevation, feet HEC-2 (2)	HEC-RAS (3)	Difference (4)
0.19	1242.24	1242.25	-0.01
0.28	1247.78	1247.77	0.01
0.38	1252.00	1252.00	0.00
0.47	1257.07	1257.09	-0.02
0.57	1263.54	1263.81	-0.27
0.66	1268.43	1268.51	-0.08
0.76	1272.93	1272.83	0.10
0.85	1275.30	1275.44	-0.14
0.95	1280.78	1280.80	-0.02
1.04	1285.40	1285.38	0.02
1.14	1290.21	1289.13	1.08
1.23	1293.40	1293.41	-0.01
1.33	1295.40	1295.38	0.02
1.42	1300.18	1300.19	-0.01
1.52	1303.30	1303.29	0.01
1.61	1306.44	1306.47	-0.03
1.70	1310.86	1310.86	0.00
1.80	1312.99	1312.99	0.00
1.84	1315.11	1315.15	-0.04
1.91	1318.16	1318.38	-0.22
1.92	1318.29	1318.48	-0.19
1.99	1321.31	1321.23	0.08
2.08	1324.23	1324.27	-0.04
2.16	1326.27	1326.14	0.13
2.27	1330.59	1330.92	-0.33
2.37	1334.48	1334.30	0.18
2.46	1337.94	1338.18	-0.24
2.56	1340.72	1340.63	0.09
2.65	1342.60	1342.60	0.00
2.75	1346.87	1346.87	0.00
2.84	1350.24	1350.24	0.00
2.94	1353.80	1353.81	-0.01
3.03	1356.88	1356.87	0.01
3.13	1359.81	1359.81	0.00
3.22	1360.68	1360.67	0.01
3.31	1365.02	1365.03	-0.01
3.41	1366.64	1366.64	0.00
3.47	1369.97	1369.97	0.00
3.50	1371.03	1370.96	0.07
3.60	1372.66	1372.61	0.05
3.69	1377.30	1376.57	0.73
3.79	1380.34	1381.03	-0.69
3.88	1383.72	1383.27	0.45
3.98	1386.74	1386.80	-0.06
4.07	1391.56	1391.22	0.34
4.17	1394.01	1393.97	0.04
4.26	1396.92	1396.97	-0.05
4.36	1401.35	1401.33	0.02
4.45	1403.97	1403.97	0.00
4.55	1409.50	1409.46	0.04
4.64	1412.48	1412.51	-0.03
4.73	1416.19	1416.27	-0.08
4.79	1419.78	1419.90	-0.12
4.92	1425.83	1425.56	0.27
5.02	1430.46	1430.64	-0.18
5.07	1433.39	1433.39	0.00
5.11	1435.83	1435.83	0.00
5.21	1440.87	1440.88	-0.01
5.30	1444.56	1444.55	0.01
5.40	1448.10	1448.09	0.01
5.49	1453.73	1453.74	-0.01
5.59	1459.82	1459.84	-0.02
5.68	1465.56	1465.55	0.01
5.78	1469.27	1469.34	-0.07
5.87	1472.31	1472.34	-0.03
5.97	1477.20	1477.18	0.02
6.06	1483.16	1483.17	-0.01
6.16	1486.88	1486.87	0.01
6.25	1492.93	1492.97	-0.04
6.34	1500.66	1500.64	0.02
6.38	1505.93	1505.92	0.01
		Maximum	1.08
		Minimum	-0.69
		Average	0.01

For Comparison purposes water surface elevations determined by the HEC-RAS and the HEC-2 models are listed in Table 11-16. The water surface elevations in column (2) are from the FEMA Flood Insurance Study report. In general, the average water surface elevation differential (difference between the original model and the HEC-RAS model) is zero feet. The maximum difference of 1.01 feet occurred at cross-section 2.75. The HEC-2 model assumed critical depth, while HEC-RAS did not. The difference in water surface elevation is due to the different techniques HEC-2 and HEC-RAS use to compute the water surface elevation at this cross-section. This is also true for cross-section 4.26. The hydraulic performance of HEC-RAS model as compared to the HEC-2 model is considered acceptable for the purpose of modeling alternatives.

Table 11-16

Comparison of Converted HEC-RAS and Original HEC-2 Model Results

Caterpillar Tanks Wash

River	Water Surface Elevation, feet			River	Water Surface Elevation, feet		
Mile	HEC-2	HEC-RAS	Difference	Mile			
(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
0.019	1262.10	1262.03	0.07	2.56	1401.20	1401.19	0.01
0.09	1265.20	1265.23	-0.03	2.65	1404.70	1404.72	-0.02
0.19	1270.70	1270.77	-0.07	2.75	1409.70	1408.69	1.01
0.28	1276.90	1276.92	-0.02	2.84	1413.60	1413.71	-0.11
0.38	1282.30	1282.38	-0.08	2.94	1417.20	1417.05	0.15
0.47	1289.90	1289.89	0.01	3.03	1419.80	1419.81	-0.01
0.57	1297.00	1297.10	-0.10	3.13	1422.90	1422.90	0.00
0.66	1305.00	1304.86	0.14	3.22	1425.60	1425.64	-0.04
0.76	1310.30	1310.33	-0.03	3.31	1429.40	1429.39	0.01
0.82	1315.80	1315.77	0.03	3.41	1433.90	1433.87	0.03
0.83	1317.10	1317.13	-0.03	3.50	1437.50	1437.53	-0.03
0.95	1324.60	1324.64	-0.04	3.60	1443.60	1443.55	0.05

Table 11-16 Cont.

Comparison of Converted HEC-RAS and Original HEC-2 Model Results

Caterpillar Tanks Wash

River Mile	Water Surface Elevation, feet			River Mile	Water Surface Elevation, feet		
	HEC-2	HEC-RAS	Difference		HEC-2	HEC-RAS	Difference
(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
1.04	1330.10	1330.12	-0.02	3.69	1446.40	1446.42	-0.02
1.14	1335.50	1335.44	0.06	3.73	1447.80	1447.71	0.09
1.23	1343.00	1343.09	-0.09	3.79	1450.50	1450.61	-0.11
1.33	1348.10	1347.99	0.11	3.88	1454.70	1454.82	-0.12
1.42	1351.80	1351.85	-0.05	3.98	1459.00	1459.27	-0.27
1.52	1356.00	1356.01	-0.01	4.07	1462.80	1462.77	0.03
1.61	1360.60	1361.03	-0.43	4.17	1466.60	1466.20	0.40
1.70	1364.50	1364.21	0.29	4.26	1468.80	1469.70	-0.90
1.80	1369.60	1369.61	-0.01	4.36	1474.70	1474.33	0.37
1.89	1375.30	1375.28	0.02	4.45	1479.60	1479.82	-0.22
1.99	1379.30	1379.34	-0.04	4.55	1483.80	1483.55	0.25
2.08	1382.70	1382.79	-0.09	4.64	1488.40	1488.46	-0.06
2.18	1385.70	1385.87	-0.17	4.73	1493.30	1493.25	0.05
2.27	1391.40	1391.32	0.08	4.92	1499.10	1499.39	-0.29
2.37	1394.30	1394.32	-0.02	5.02	1506.10	1506.10	0.00
2.46	1397.80	1397.77	0.03	5.04	1508.80	1508.83	-0.03
						Maximum	1.01
						Minimum	0.00
						Average	0.00

Conversion of HEC–2 Model to HEC-RAS Model White Peaks Wash

For comparison purposes, water surface elevations determined for the HEC-RAS and the HEC-2 models are listed in Table 11-17. In general, the average water surface elevation differential (difference between the original model and the HEC-RAS model) is less than 0.04 feet. The maximum difference of 0.79 feet occurred at cross-section 0.19. Both models assumed critical depth. The difference in water surface elevation is due to the different techniques HEC-2 and HEC-RAS use to compute critical depth. The hydraulic performance of HEC-RAS model as compared to the HEC-2 model is considered acceptable for the purpose of modeling alternatives.

Table 11-17

Comparison of Converted HEC-RAS and Original HEC-2 Model Results

White Peaks Wash

River Mile (1)	Water Surface Elevation, feet HEC-2 (2)	HEC-RAS (3)	Difference (4)	River Mile (1)	Water Surface Elevation, feet HEC-2 (2)	HEC-RAS (3)	Difference (4)
0.00	1372.70	1372.66	0.04	1.61	1436.50	1436.50	0.00
0.09	1374.70	1374.60	0.10	1.70	1442.00	1441.96	0.04
0.19	1377.20	1377.99	-0.79	1.80	1447.10	1447.30	-0.20
0.28	1379.80	1379.58	0.22	1.89	1453.50	1453.38	0.12
0.38	1383.30	1383.58	-0.28	1.97	1457.60	1457.70	-0.10
0.47	1387.40	1387.38	0.02	1.99	1458.80	1458.76	0.04
0.57	1390.70	1390.73	-0.03	2.08	1462.50	1462.55	-0.05
0.66	1396.10	1396.10	0.00	2.18	1469.50	1469.50	0.00
0.76	1398.90	1398.94	-0.04	2.27	1474.00	1474.02	-0.02
0.85	1404.00	1403.98	0.02	2.37	1478.90	1478.93	-0.03
0.95	1407.50	1407.50	0.00	2.46	1484.10	1484.12	-0.02
1.04	1412.20	1412.20	0.00	2.56	1489.60	1489.57	0.03
1.14	1416.60	1416.61	-0.01	2.65	1495.20	1495.16	0.04
1.23	1420.90	1420.89	0.01	2.75	1499.70	1499.71	-0.01
1.33	1424.70	1424.79	-0.09	2.84	1507.00	1506.97	0.03
1.42	1427.40	1427.44	-0.04	2.94	1514.50	1514.51	-0.01
1.48	1430.00	1430.04	-0.04	2.95	1515.60	1515.65	-0.05
1.52	1430.80	1430.95	-0.15			Maximum	0.79
						Minimum	0.00
						Average	-0.04

Conversion of HEC–2 Model to HEC-RAS Model West Fork White Peaks Wash

For comparison purposes water surface elevations determined for the HEC-RAS and the HEC-2 models are listed in Table 11-18. In general, the average water surface elevation differential (difference between the original model and the HEC-RAS model) is less than 0.03 feet. The maximum difference is 0.11 feet. The hydraulic performance of HEC-RAS model as compared to the HEC-2 model is considered acceptable for the purpose of modeling alternatives.

Table 11-18

Comparison of Converted HEC-RAS and Original HEC-2 Model Results
West Fork White Peaks Wash

River Mile (1)	Water Surface Elevation, feet HEC-2 (2)	HEC-RAS (3)	Difference (4)
0	1457.61	1457.61	0
0.09	1464.38	1464.37	0.01
0.19	1471	1471.01	-0.01
0.28	1479.24	1479.21	0.03
0.38	1484.96	1485.07	-0.11
0.47	1494.09	1494.11	-0.02
0.57	1501.93	1501.91	0.02
0.66	1512.35	1512.35	0
0.74	1517.33	1517.34	-0.01
		Maximum	0.11
		Minimum	0
		Average	0.03

Conversion of HEC–2 Model to HEC-RAS Model West and East Garamubllo

For comparison purposes, water surface elevations determined for the HEC-RAS and the HEC-2 models are listed in Table 11-19 and 11-20 for West and East Garambullo respectively. In general, the average water surface elevation differential (difference between the original model and the HEC-RAS model) is less than 0.07 feet. The maximum difference is 0.12 feet. The hydraulic performance of HEC-RAS model as compared to the HEC-2 model is considered acceptable for the purpose of modeling alternatives.

Table11-19

Comparison of Converted HEC-RAS and Original HEC-2 Model Results

East Garambullo

River Mile (1)	Water Surface Elevation, feet HEC-2 (2)	HEC-RAS (3)	Difference (4)
0	1419.78	1419.78	0
0.09	1422.16	1422.18	-0.02
0.14	1424.17	1424.17	0
0.19	1426.8	1426.8	0
0.28	1431.00	1430.9	0.1
0.38	1435.83	1435.71	0.12
0.47	1439.37	1439.49	-0.12
0.57	1446.08	1446.08	0
0.66	1451.92	1451.93	-0.01
0.76	1459.15	1459.17	-0.02
0.85	1464.88	1464.88	0
0.95	1471.15	1471.16	-0.01
1.04	1478.29	1478.29	0
1.14	1484.00	1484.01	-0.01
1.23	1492.52	1492.52	0
1.33	1501.21	1501.21	0
1.43	1510.76	1510.76	0
		Maximum	.12
		Minimum	0
		Average	0

Table 11-20

Comparison of Converted HEC-RAS and Original HEC-2 Model Results

West Garambullo

River Mile (1)	Water Surface Elevation, feet HEC-2 (2)	HEC-RAS (3)	Difference (4)
0	1419.8	1419.78	0.02
0.09	1422.2	1422.18	0.02
0.14	1424.2	1424.17	0.03
0.19	1424.8	1424.87	-0.07
0.28	1430	1430	0
0.38	1435.9	1435.9	0
0.47	1438.9	1438.94	-0.04
0.57	1443.0	1442.95	0.05
0.66	1448.4	1448.36	0.04
0.76	1453.2	1453.25	-0.05
0.85	1457.8	1457.81	-0.01
0.95	1463.1	1463.08	0.02
1.04	1468.3	1468.24	0.06
1.14	1474.6	1474.58	0.02
1.23	1481.2	1481.21	-0.01
1.33	1487.2	1487.16	0.04
1.42	1495.0	1495.04	-0.04
1.52	1501.8	1501.81	-0.01
1.61	1508.5	1508.46	0.04
1.69	1516.1	1516.13	-0.03
		Maximum	.07
		Minimum	0
		Average	0

Comparison of Base HEC-RAS Models to Converted HEC-RAS Models

Converted HEC-RAS models developed for Twin Buttes Wash, Caterpillar Tank Wash, West Fork White Peaks Wash, White Peaks Wash, East and West Garambullo Washes are updated to include 100-year peak discharges developed for the North Peoria ADMP. The updated HEC-RAS models are considered the base hydraulic models that will be used to model alternatives. In general, 100-year peak discharges developed for the North Peoria ADMP are greater than the discharges developed in the original Flood Insurance Study. For comparison purposes, the results of the base HEC-RAS models and the converted HEC-RAS models are listed in Tables 11-21 through 11-26. Where the difference in water surface elevation is negative, it indicates that the base HEC-RAS model records a higher water surface elevation. Generally, the results of the comparison indicate a general rise in water surface elevation at locations where the 100-year peak discharge has increased.

Table 11-21

Comparison of Converted HEC-RAS and Base HEC-RAS

Twin Buttes Wash

River Station	Converted HEC-RAS		Base HEC-RAS		Water Surface Elevation Difference
	Discharge (cfs)	Water Surface (feet)	Discharge (cfs)	Water Surface (feet)	(feet)
(1)	(2)	(3)	(4)	(5)	(6)
0.19	2746	1242.25	3775	1242.93	-0.68
0.28	2746	1247.77	3775	1248.41	-0.64
0.38	2746	1252.00	3775	1252.62	-0.62
0.47	2746	1257.09	3775	1257.67	-0.58
0.57	2746	1263.81	3775	1264.00	-0.19
0.66	2746	1268.51	3775	1268.81	-0.30
0.76	2746	1272.83	3775	1273.32	-0.49
0.85	2746	1275.44	3775	1276.26	-0.82
0.95	2746	1280.80	3775	1281.71	-0.91
1.04	2746	1285.38	3775	1285.80	-0.42
1.14	2746	1289.13	3775	1290.65	-1.52
1.23	2746	1293.41	3775	1293.41	0.00
1.33	2746	1295.38	3775	1295.65	-0.27
1.42	2746	1300.19	3775	1300.71	-0.52
1.52	2746	1303.29	3775	1303.74	-0.45
1.61	2746	1306.47	3775	1307.21	-0.74
1.70	2746	1310.86	3775	1311.16	-0.30
1.80	2746	1312.99	3775	1313.78	-0.79
1.84	2746	1315.15	3775	1315.66	-0.51
1.91	2779	1318.38	3775	1319.10	-0.72
1.92	2779	1318.48	3779	1319.19	-0.71
1.99	2779	1321.23	3779	1321.78	-0.55
2.08	2779	1324.27	3779	1324.94	-0.67
2.16	2779	1326.14	3779	1326.70	-0.56
2.27	2779	1330.92	3779	1331.15	-0.23
2.37	2779	1334.30	3779	1335.08	-0.78
2.46	2779	1338.18	3779	1338.42	-0.24
2.56	2779	1340.63	3779	1341.44	-0.81
2.65	2779	1342.60	3779	1343.31	-0.71
2.75	2779	1346.87	3779	1347.58	-0.71
2.84	2779	1350.24	3779	1350.92	-0.68
2.94	2779	1353.81	3779	1354.50	-0.69
3.03	2779	1356.87	3779	1357.56	-0.69
3.13	2779	1359.81	3779	1359.54	0.27
3.22	2779	1360.67	3779	1362.00	-1.33
3.31	2779	1365.03	3486	1365.45	-0.42
3.41	2779	1366.64	3486	1366.88	-0.24
3.47	2779	1369.97	3486	1370.14	-0.17
3.50	2779	1370.96	3486	1370.52	0.44
3.60	2424	1372.61	3486	1372.69	-0.08
3.69	2424	1376.57	2509	1376.78	-0.21

Table 11-21 Cont.

Comparison of Converted HEC-RAS and Base HEC-RAS

Twin Buttes Wash

River Station	Converted HEC-RAS		Base HEC-RAS		Water Surface Elevation Difference
	(cfs)	(feet)	(cfs)	(feet)	(feet)
(1)	(2)	(3)	(4)	(5)	(6)
3.79	2424	1381.03	2509	1381.04	-0.01
3.88	2424	1383.27	2509	1383.36	-0.09
3.98	2424	1386.80	2509	1386.83	-0.03
4.07	2424	1391.22	2509	1391.28	-0.06
4.17	2424	1393.97	2509	1394.02	-0.05
4.26	2424	1396.97	2509	1397.02	-0.05
4.36	2424	1401.33	2509	1401.40	-0.07
4.45	2424	1403.97	2509	1404.01	-0.04
4.55	2424	1409.46	2509	1409.50	-0.04
4.64	2424	1412.51	2509	1412.57	-0.06
4.73	2424	1416.27	2509	1416.29	-0.02
4.79	2163	1419.90	2509	1419.90	0.00
4.92	2163	1425.56	2057	1425.49	0.07
5.02	2163	1430.64	2057	1430.61	0.03
5.07	2163	1433.39	2057	1433.36	0.03
5.11	2163	1435.83	2057	1435.74	0.09
5.21	2163	1440.88	2057	1440.75	0.13
5.30	2163	1444.55	2057	1444.42	0.13
5.40	2163	1448.09	2057	1448.03	0.06
5.49	2163	1453.74	2057	1453.65	0.09
5.59	2163	1459.84	2057	1459.76	0.08
5.68	2163	1465.55	2057	1465.46	0.09
5.78	2163	1469.34	2057	1469.26	0.08
5.87	2163	1472.34	2057	1472.28	0.06
5.97	2163	1477.18	2057	1477.10	0.08
6.06	2163	1483.17	2057	1483.09	0.08
6.16	2163	1486.87	2057	1486.77	0.10
6.25	2163	1492.97	2057	1492.84	0.13
6.34	2163	1500.64	2057	1500.51	0.13
6.38	2163	1505.92	2057	1505.84	0.08
Maximum	0.44	Minimum	-1.52	Average	-0.28

Table 11-22

Comparison of Converted HEC-RAS and Base HEC-RAS Models

Caterpillar Tanks Wash

River Station	Converted HEC-RAS		BASE HEC-RAS		Water Surface Elevation Difference
	Discharge (cfs)	Water Surface (feet)	Discharge (cfs)	Water Surface (feet)	(feet)
(1)	(2)	(3)	(4)	(5)	(6)
0.019	1315	1262.03	1556	1262.23	-0.20
0.09	1315	1265.23	1556	1265.62	-0.39
0.19	1315	1270.77	1556	1270.95	-0.18
0.28	1315	1276.92	1556	1277.19	-0.27
0.38	1315	1282.38	1556	1282.70	-0.32
0.47	1315	1289.89	1556	1289.63	0.26
0.57	1315	1297.10	1556	1297.64	-0.54
0.66	1315	1304.86	1556	1304.71	0.15
0.76	1315	1310.33	1556	1310.96	-0.63
0.82	1315	1315.77	1556	1315.97	-0.20
0.83	1375	1317.13	1556	1317.33	-0.20
0.95	1375	1324.64	1572	1324.73	-0.09
1.04	1375	1330.12	1572	1330.39	-0.27
1.14	1375	1335.44	1572	1335.66	-0.22
1.23	1375	1343.09	1572	1343.35	-0.26
1.33	1375	1347.99	1572	1348.23	-0.24
1.42	1375	1351.85	1572	1352.11	-0.26
1.52	1375	1356.01	1572	1356.12	-0.11
1.61	1375	1361.03	1572	1361.34	-0.31
1.70	1375	1364.21	1572	1364.45	-0.24
1.80	1375	1369.61	1572	1369.79	-0.18
1.89	1375	1375.28	1572	1375.51	-0.23
1.99	1295	1379.34	1572	1379.51	-0.17
2.08	1295	1382.79	1292	1383.00	-0.21
2.18	1295	1385.87	1292	1385.69	0.18
2.27	1295	1391.32	1292	1391.43	-0.11
2.37	1295	1394.32	1292	1394.28	0.04
2.46	1295	1397.77	1292	1397.77	0.00
2.56	1295	1401.19	1292	1401.18	0.01
2.65	1295	1404.72	1292	1404.71	0.01
2.75	1295	1408.69	1292	1408.69	0.00
2.84	1295	1413.71	1292	1413.71	0.00
2.94	1295	1417.05	1292	1417.05	0.00
3.03	1295	1419.81	1292	1419.81	0.00
3.13	1295	1422.90	1292	1422.89	0.01
3.22	1295	1425.64	1292	1425.64	0.00
3.31	1295	1429.39	1292	1429.39	0.00
3.41	1295	1433.87	913	1433.57	0.30
3.50	1295	1437.53	913	1437.00	0.53
3.60	1295	1443.55	913	1443.03	0.52
3.69	1295	1446.42	913	1445.95	0.47
3.73	970	1447.71	913	1447.71	0.00
3.79	970	1450.61	913	1450.49	0.12

Table 11-22 Cont.

Comparison of Converted HEC-RAS and Base HEC-RAS Models

Caterpillar Tanks Wash

River Station	Converted HEC-RAS		BASE HEC-RAS		Water Surface Elevation Difference
	Discharge (cfs)	Water Surface (feet)	Discharge (cfs)	Water Surface (feet)	(feet)
(1)	(2)	(3)	(4)	(5)	(6)
3.88	970	1454.82	913	1454.76	0.06
3.98	970	1459.27	913	1459.16	0.11
4.07	970	1462.77	913	1462.71	0.06
4.17	970	1466.20	913	1466.20	0.00
4.26	970	1469.70	913	1469.55	0.15
4.36	970	1474.33	913	1474.22	0.11
4.45	970	1479.82	913	1479.73	0.09
4.55	970	1483.55	913	1483.46	0.09
4.64	970	1488.46	913	1488.34	0.12
4.73	970	1493.25	913	1493.16	0.09
4.92	970	1499.39	913	1499.32	0.07
5.02	970	1506.10	913	1506.10	0.00
5.04	970	1508.83	913	1508.73	0.10
Maximum	0.53	Minimum	-0.63	Average	-0.04

Table 11-23

Comparison of Converted HEC-RAS and Base HEC-RAS Models

White Peaks Wash

River Station	Converted HEC-RAS		Base HEC-RAS		Water Surface
	Discharge (cfs)	Water Surface (feet)	Discharge (cfs)	Water Surface (feet)	Elevation (feet)
(1)	(2)	(3)	(4)	(5)	(6)
0.00	721	1372.70	945	1372.66	0.00
0.09	721	1374.70	945	1374.70	-0.10
0.19	721	1377.20	945	1377.97	0.02
0.28	721	1379.80	945	1380.15	-0.57
0.38	721	1383.30	945	1383.88	-0.30
0.47	721	1387.40	945	1387.81	-0.43
0.57	721	1390.70	945	1391.61	-0.88
0.66	721	1396.10	945	1396.16	-0.06
0.76	721	1398.90	945	1399.65	-0.71
0.85	721	1404.00	945	1404.12	-0.14
0.95	721	1407.50	945	1408.29	-0.79
1.04	721	1412.20	945	1412.69	-0.49
1.14	721	1416.60	945	1417.00	-0.39
1.23	721	1420.90	945	1420.79	0.10
1.33	721	1424.70	945	1425.33	-0.54
1.42	721	1427.40	945	1427.38	0.06
1.48	599	1430.00	945	1430.78	-0.74
1.52	599	1430.80	945	1431.50	-0.55
1.61	599	1436.50	945	1437.24	-0.74
1.70	599	1442.00	945	1442.73	-0.77
1.80	599	1447.10	945	1448.46	-1.16
1.89	599	1453.50	945	1454.09	-0.71
1.97	599	1457.60	945	1458.60	-0.90
1.99	395	1458.80	372	1459.53	-0.77
2.08	395	1462.50	372	1462.46	0.09
2.18	395	1469.50	372	1469.44	0.06
2.27	395	1474.00	372	1473.94	0.08
2.37	395	1478.90	372	1478.85	0.08
2.46	395	1484.10	372	1484.04	0.08
2.56	395	1489.60	372	1489.50	0.07
2.65	395	1495.20	372	1495.07	0.09
2.75	395	1499.70	372	1499.62	0.09
2.84	395	1507.00	372	1506.90	0.07
2.94	395	1514.50	372	1514.44	0.07
2.95	395	1515.60	372	1515.55	0.10
Maxi	0.10	Minimum	-1.16	Average	-0.31

Table 11-24

Comparison of Converted HEC-RAS and Base HEC-RAS Models

West Fork White Peaks Wash

River Station	Converted HEC-RAS		Base HEC-RAS		Water Surface Elevation (feet)
	Discharge (cfs)	Water Surface (feet)	Discharge (cfs)	Water Surface (feet)	
(1)	(2)	(3)	(4)	(5)	(6)
0	294	1457.61	279	1457.61	0
0.09	294	1464.37	279	1464.31	0.06
0.19	294	1471.01	279	1470.96	0.05
0.28	294	1479.21	279	1479.21	0
0.38	294	1485.07	279	1484.97	0.1
0.47	294	1494.11	279	1494.03	0.08
0.57	294	1501.91	279	1501.86	0.05
0.66	294	1512.35	279	1512.28	0.07
0.74	294	1517.34	279	1517.27	0.07

Table 11-25

Comparison of Converted HEC-RAS and Base HEC-RAS Models

East Garambullo Wash

River Station	Converted HEC-RAS		Base HEC-RAS		Water Surface Elevation (feet)
	Discharge (cfs)	Water Surface (feet)	Discharge (cfs)	Water Surface (feet)	
(1)	(2)	(3)	(4)	(5)	(6)
0	651	1419.78	876	1419.9	-0.12
0.09	651	1422.18	876	1422.61	-0.43
0.14	651	1424.17	876	1424.7	-0.53
0.19	259	1426.8	372	1426.8	0
0.28	259	1430.9	372	1430.91	-0.01
0.38	259	1435.71	372	1436	-0.29
0.47	259	1439.49	372	1439.9	-0.41
0.57	259	1446.08	372	1446.57	-0.49
0.66	259	1451.93	372	1452.32	-0.39
0.76	259	1459.17	372	1459.7	-0.53
0.85	259	1464.88	372	1465	-0.12
0.95	259	1471.16	372	1471.56	-0.4
1.04	259	1478.29	372	1478.63	-0.34
1.14	259	1484.01	372	1484.49	-0.48
1.23	259	1492.52	372	1493.03	-0.51
1.33	259	1501.21	372	1501.48	-0.27
1.43	259	1510.76	372	1511.26	-0.5

Table 11-26

Comparison of Converted HEC-RAS and Base HEC-RAS Models

West Garambullo Wash

River Station	Converted HEC-RAS		Base HEC-RAS		Water Surface
	Discharge (cfs)	Water Surface (feet)	Discharge (cfs)	Water Surface (feet)	Elevation (feet)
(1)	(2)	(3)	(4)	(5)	(6)
0	651	1419.78	876	1419.9	-0.12
0.09	651	1422.18	876	1422.61	-0.43
0.14	651	1424.17	876	1424.7	-0.53
0.19	483	1424.87	504	1424.95	-0.08
0.28	483	1430	504	1430.03	-0.03
0.38	483	1435.9	504	1435.9	0
0.47	483	1438.94	504	1438.99	-0.05
0.57	483	1442.95	504	1443	-0.05
0.66	483	1448.36	504	1448.44	-0.08
0.76	483	1453.25	504	1453.3	-0.05
0.85	483	1457.81	504	1457.85	-0.04
0.95	483	1463.08	504	1463.12	-0.04
1.04	483	1468.24	504	1468.33	-0.09
1.14	483	1474.58	504	1474.67	-0.09
1.23	483	1481.21	504	1481.27	-0.06
1.33	483	1487.16	504	1487.21	-0.05
1.42	483	1495.04	504	1495.11	-0.07
1.52	483	1501.81	504	1501.86	-0.05
1.61	483	1508.46	504	1508.52	-0.06
1.69	483	1516.13	504	1516.21	-0.08

Comparison of Full Structural Alternative to Non-Structural Alternative

Hydraulic evaluations are conducted for the non-structural alternative and the full structural alternative for Twin Buttes Wash, Caterpillar Tank Wash, West Fork White Peaks Wash, White Peaks Wash, East and West Garambullo. The base HEC-RAS models for study washes characterize the elements of the non-structural alternative. Encroachment stations for the floodway profile developed for the base models are used to set limits of channel improvements proposed for the structural alternative. Should there be a rise in water surface elevation of greater than one foot relative to the base model, encroachment stations are relaxed until the change in water surface elevation is less than one foot. Table 11-27, Table 11-28, Table 11-29, Table 11-30, Table 11-31 and Table 11-32, lists a summary of results for selected hydraulic parameters for the non-structural alternative for Twin Buttes Wash, Caterpillar Tank Wash, West Fork White Peaks Wash, White Peaks Wash, East and West Garambullo respectively. Table 11-33, Table 11-34, Table 11-35, Table 11-36, Table 11-37 and Table 11-38, lists a summary of results for selected hydraulic parameters for the full structural alternative for Twin Buttes Wash, Caterpillar Tank Wash, West Fork White Peaks Wash, White Peaks Wash, East and West Garambullo, respectively.

Results of the hydraulic model for the full structural alternative are compared to results of the hydraulic model for the non-structural alternative to determine the impact of the alternative on the hydraulic properties of the watercourse. Tables 11-39, 11-40, 11-41, 11-42, 11-43 and 11-44 list the results of the comparison of the non-structural model with the full structure alternative for Twin Buttes Wash, Caterpillar Tank Wash, West Fork White Peaks Wash, White Peaks Wash, East and West Garambullo, respectively. Negative values listed in the tables indicate a reduction in the value of the hydraulic parameters relative to the non-structural model. Positive values listed in the table indicate an increase in the value of the hydraulic parameters relative to the non-structural model. Results of the comparison between non-structural and full structural models generally indicate that there is a reduction in floodplain width, at some locations and minor increase in floodplain

width is recorded. Depth of flow and velocity generally decreases. Results are attributed to the fact that the full structural alternative is characterized by a trapezoidal channel with a uniform bottom width consistent with the limits of the floodway (or modified floodway) or the proposed 115th Avenue channel improvements, and 2 to 1 (horizontal to vertical) side slopes. The limit of conveyance is decreased but the overall conveyance area is increased by providing a uniform channel.

Table 11-27

Summary of Hydraulic Parameters

Base HEC-RAS Model (Non-Structural Alternative) Twin Buttes Wash

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
0.19	3775.0	0.0	0.0	10.4	0.0	0.0	5.5	108.5
0.28	3775.0	0.0	0.0	9.1	0.0	0.0	5.6	114.4
0.38	3775.0	0.0	0.0	5.6	0.0	0.0	5.6	276.6
0.47	3775.0	0.0	0.0	9.5	0.0	0.0	4.2	141.1
0.57	3362.0	355.9	57.1	6.6	5.1	1.6	4.3	392.6
0.66	1652.9	2012.5	109.6	4.9	2.7	1.8	5.8	933.9
0.76	2510.3	0.0	1264.7	6.6	0.0	3.5	8.3	471.8
0.85	3731.8	14.2	29.0	9.0	1.2	1.5	8.9	203.2
0.95	3648.3	0.0	126.7	9.1	0.0	2.1	6.6	238.5
1.04	3272.2	360.4	142.3	7.3	2.8	1.7	8.0	402.9
1.14	2556.8	0.0	1218.2	10.1	0.0	5.9	5.9	170.1
1.23	465.0	0.0	3310.0	3.5	0.0	3.4	7.0	555.7
1.33	2738.6	0.0	1036.4	7.0	0.0	4.6	3.8	441.6
1.42	3403.9	371.1	0.0	7.2	2.1	0.0	7.4	379.7
1.52	1821.2	1953.8	0.0	4.1	4.2	0.0	6.8	406.9
1.61	2906.1	305.2	563.7	9.4	3.9	4.6	7.5	214.2
1.7	3775.0	0.0	0.0	4.5	0.0	0.0	8.4	211.4
1.8	3580.6	176.6	17.8	6.5	3.3	1.8	6.0	235.4
1.84	3696.7	78.3	0.0	7.4	2.3	0.0	7.1	198.6
1.91	3775.0	0.0	0.0	4.4	0.0	0.0	7.7	237.0
1.92	3779.0	0.0	0.0	4.6	0.0	0.0	8.0	244.8
1.99	3779.0	0.0	0.0	6.4	0.0	0.0	7.0	234.0
2.08	1750.7	0.0	2028.4	5.8	0.0	4.9	6.9	248.4
2.16	1699.6	439.6	1639.8	6.7	3.8	4.5	4.9	341.9
2.27	3025.5	0.0	753.5	10.1	0.0	4.0	7.1	175.0
2.37	3332.7	0.0	446.3	6.2	0.0	2.4	6.0	321.2
2.46	3779.0	0.0	0.0	7.4	0.0	0.0	7.0	192.3
2.56	3505.5	273.5	0.0	5.5	1.9	0.0	6.5	368.9
2.65	3416.7	362.3	0.0	9.9	3.5	0.0	6.7	166.6
2.75	3727.0	52.0	0.0	7.2	2.5	0.0	6.9	144.5
2.84	3451.6	15.8	311.6	8.9	2.5	3.8	7.5	166.6
2.94	3089.6	689.4	0.0	8.4	3.6	0.0	7.8	164.7
3.03	2283.1	0.0	1496.0	6.3	0.0	4.5	8.1	208.1
3.13	3114.9	664.1	0.0	5.2	4.3	0.0	7.0	232.4
3.22	3337.6	0.0	441.5	8.4	0.0	2.4	7.2	383.0
3.31	2440.8	0.0	1045.2	4.9	0.0	2.7	5.7	396.6
3.41	3486.0	0.0	0.0	10.5	0.0	0.0	7.0	80.9
3.47	1850.4	1635.6	0.0	4.0	4.0	0.0	6.3	409.9
3.5	2312.8	1173.2	0.0	4.7	4.2	0.0	5.9	302.0
3.6	1586.8	1899.2	0.0	7.2	7.7	0.0	5.1	220.7
3.69	2509.0	0.0	0.0	8.9	0.0	0.0	5.0	94.0

Table 11-27 Cont.

Summary of Hydraulic Parameters

Base HEC-RAS Model (Non-Structural Alternative) Twin Buttes Wash

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
3.79	2231.0	278.0	0.0	5.4	2.4	0.0	5.5	247.7
3.88	1548.5	0.0	960.5	8.3	0.0	2.9	5.9	284.7
3.98	1522.4	0.0	986.6	5.6	0.0	3.6	3.7	402.5
4.07	2509.0	0.0	0.0	6.3	0.0	0.0	5.5	216.8
4.17	2509.0	0.0	0.0	4.1	0.0	0.0	4.7	248.7
4.26	2509.0	0.0	0.0	9.0	0.0	0.0	4.4	109.9
4.36	2509.0	0.0	0.0	4.1	0.0	0.0	5.9	284.1
4.45	2448.8	60.3	0.0	7.6	2.2	0.0	4.2	224.6
4.55	2163.3	66.9	278.9	7.2	1.5	3.4	5.5	341.1
4.64	2509.0	0.0	0.0	4.5	0.0	0.0	3.8	339.9
4.73	2509.0	0.0	0.0	6.0	0.0	0.0	4.4	371.7
4.79	1516.8	0.0	992.2	3.7	0.0	3.3	5.0	447.6
4.92	1158.0	0.0	899.0	6.4	0.0	6.7	2.9	239.3
5.02	1217.1	0.0	839.9	5.0	0.0	3.0	4.3	453.4
5.07	1805.7	0.0	251.3	6.9	0.0	2.4	4.6	283.0
5.11	2057.0	0.0	0.0	7.2	0.0	0.0	4.6	115.8
5.21	2057.0	0.0	0.0	7.8	0.0	0.0	6.1	87.5
5.3	2057.0	0.0	0.0	5.6	0.0	0.0	6.5	100.8
5.4	2057.0	0.0	0.0	8.2	0.0	0.0	4.4	121.3
5.49	2057.0	0.0	0.0	6.8	0.0	0.0	4.2	126.5
5.59	2057.0	0.0	0.0	8.5	0.0	0.0	3.1	107.2
5.68	2057.0	0.0	0.0	6.9	0.0	0.0	5.4	135.3
5.78	2057.0	0.0	0.0	4.1	0.0	0.0	6.7	212.5
5.87	1765.7	291.4	0.0	7.1	5.4	0.0	4.8	144.8
5.97	2057.0	0.0	0.0	9.0	0.0	0.0	4.2	88.5
6.06	2056.2	0.6	0.2	7.6	1.3	1.1	4.7	118.0
6.16	2057.0	0.0	0.0	8.3	0.0	0.0	6.9	57.7
6.25	2057.0	0.0	0.0	10.7	0.0	0.0	5.5	54.0
6.34	2057.0	0.0	0.0	7.0	0.0	0.0	7.5	91.7
6.38	2057.0	0.0	0.0	9.3	0.0	0.0	5.8	81.7

Table 11-28

Summary of Hydraulic Parameters

Base HEC-RAS Model (Non-Structural Alternative) Caterpillar Tank Wash

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
0.019	950.3	605.7	0.0	7.5	7.6	0.0	3.4	117.6
0.09	1556.0	0.0	0.0	5.7	0.0	0.0	8.2	61.5
0.19	1556.0	0.0	0.0	7.9	0.0	0.0	3.3	104.0
0.28	1535.2	0.0	20.8	6.4	0.0	1.7	7.6	113.3
0.38	1270.3	285.7	0.0	6.4	2.7	0.0	6.2	263.8
0.47	1340.3	215.7	0.0	6.5	3.5	0.0	3.9	148.7
0.57	1370.1	185.9	0.0	7.1	5.3	0.0	5.2	136.0
0.66	1555.7	0.3	0.0	7.5	1.4	0.0	5.7	73.0
0.76	1556.0	0.0	0.0	5.8	0.0	0.0	4.8	85.2
0.82	1556.0	0.0	0.0	7.1	0.0	0.0	3.4	139.1
0.83	1556.0	0.0	0.0	4.1	0.0	0.0	4.0	217.9
0.95	1572.0	0.0	0.0	7.8	0.0	0.0	6.3	108.9
1.04	1229.0	343.0	0.0	6.8	3.5	0.0	4.7	126.7
1.14	1572.0	0.0	0.0	10.0	0.0	0.0	4.5	51.2
1.23	1572.0	0.0	0.0	6.8	0.0	0.0	4.7	99.5
1.33	1572.0	0.0	0.0	6.9	0.0	0.0	5.3	79.9
1.42	1356.3	0.0	215.7	5.7	0.0	2.7	6.5	150.7
1.52	1572.0	0.0	0.0	9.0	0.0	0.0	5.1	70.7
1.61	1572.0	0.0	0.0	4.8	0.0	0.0	6.3	129.1
1.7	1572.0	0.0	0.0	6.7	0.0	0.0	5.7	76.2
1.8	1386.3	0.0	185.7	9.2	0.0	3.3	5.6	123.7
1.89	780.6	791.4	0.0	6.0	3.5	0.0	4.6	188.1
1.99	1336.1	0.0	235.9	7.3	0.0	4.1	5.4	119.5
2.08	1292.0	0.0	0.0	3.5	0.0	0.0	4.1	126.6
2.18	1292.0	0.0	0.0	6.8	0.0	0.0	3.4	113.4
2.27	1000.1	291.9	0.0	5.0	2.5	0.0	5.3	190.4
2.37	1292.0	0.0	0.0	3.1	0.0	0.0	3.0	328.9
2.46	919.0	261.5	111.5	6.7	2.5	2.0	5.1	257.2
2.56	1292.0	0.0	0.0	4.8	0.0	0.0	4.7	122.6
2.65	718.7	0.9	572.4	6.0	1.3	2.6	5.0	373.7
2.75	1292.0	0.0	0.0	7.0	0.0	0.0	3.9	64.9
2.84	919.5	367.5	5.1	6.3	3.2	1.5	4.1	191.2
2.94	1159.9	132.2	0.0	5.9	2.3	0.0	5.8	114.0
3.03	1153.2	44.9	93.9	6.2	3.9	2.9	4.9	97.0
3.13	1281.5	10.5	0.0	5.9	1.0	0.0	6.3	105.4
3.22	1292.0	0.0	0.0	4.3	0.0	0.0	4.0	127.5
3.31	1292.0	0.0	0.0	7.5	0.0	0.0	6.0	99.1
3.41	913.0	0.0	0.0	3.9	0.0	0.0	6.3	141.4
3.5	913.0	0.0	0.0	7.8	0.0	0.0	4.8	62.1
3.6	913.0	0.0	0.0	4.0	0.0	0.0	8.6	112.6
3.69	817.0	0.0	96.0	5.9	0.0	1.4	9.7	214.5

Table 11-28 Cont.

Summary of Hydraulic Parameters

Base HEC-RAS Model (Non-Structural Alternative) Caterpillar Tank Wash

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
3.73	629.0	0.0	284.0	6.1	0.0	4.1	7.5	108.1
3.79	913.0	0.0	0.0	4.7	0.0	0.0	5.4	99.8
3.88	913.0	0.0	0.0	5.8	0.0	0.0	5.0	63.2
3.98	913.0	0.0	0.0	5.1	0.0	0.0	5.8	76.9
4.07	553.4	0.0	359.6	5.9	0.0	2.7	2.9	163.5
4.17	718.6	0.0	194.4	6.2	0.0	4.6	3.9	79.5
4.26	913.0	0.0	0.0	5.8	0.0	0.0	5.4	60.2
4.36	913.0	0.0	0.0	8.5	0.0	0.0	3.8	48.2
4.45	861.7	50.3	1.0	6.9	2.3	1.4	4.4	81.9
4.55	899.9	0.0	13.1	7.7	0.0	1.7	4.6	56.7
4.64	855.7	57.3	0.0	8.5	2.9	0.0	4.5	59.1
4.73	913.0	0.0	0.0	6.7	0.0	0.0	4.9	54.6
4.92	913.0	0.0	0.0	3.2	0.0	0.0	2.0	208.5
5.02	347.4	563.4	2.3	3.2	4.7	0.8	5.1	106.4
5.04	912.8	0.0	0.2	7.9	0.0	1.3	4.7	58.9

Table 11- 29

Summary of Hydraulic Parameters

Base HEC-RAS Model (Non-Structural Alternative) West Fork Whites Peak Wash

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
0	279	0.0	0.0	3.06	0.0	0.0	3.21	52.87
0.09	279	0.0	0.0	5.55	0.0	0.0	3.31	53.27
0.19	279	0.0	0.0	6.34	0.0	0.0	3.46	23.3
0.28	170.2	108.8	0.0	4.93	3.42	0.0	4.01	62.28
0.38	279	0.0	0.0	6.18	0.0	0.0	2.17	28.24
0.47	279	0.0	0.0	7.77	0.0	0.0	3.32	19.11
0.57	279	0.0	0.0	7.15	0.0	0.0	2.86	23.28
0.66	279	0.0	0.0	7.12	0.0	0.0	2.78	25.32
0.74	279	0.0	0.0	5.84	0.0	0.0	3.57	26.22

Table 11-30

Summary of Hydraulic Parameters

Base HEC-RAS Model (Non-Structural Alternative) Whites Peak Wash

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
0	454.6	0.0	490.4	1.8	0.0	2.0	5.2	241.9
0.09	521.8	5.4	417.8	4.4	1.5	3.4	5.2	215.3
0.19	935.1	9.9	0.0	3.9	1.1	0.0	5.6	125.3
0.28	887.7	57.3	0.0	5.0	2.0	0.0	4.4	87.1
0.38	944.0	0.0	1.0	8.3	0.0	0.9	4.1	58.2
0.47	934.1	0.0	10.9	3.1	0.0	0.8	4.0	172.7
0.57	530.2	0.0	414.8	5.1	0.0	3.1	4.5	229.8
0.66	731.9	0.0	213.2	3.8	0.0	2.6	4.8	176.9
0.76	777.3	0.0	167.7	5.1	0.0	2.5	5.2	180.2
0.85	945.0	0.0	0.0	5.4	0.0	0.0	3.9	75.4
0.95	945.0	0.0	0.0	6.0	0.0	0.0	4.9	52.5
1.04	945.0	0.0	0.0	6.4	0.0	0.0	5.6	53.8
1.14	680.9	264.1	0.0	3.7	2.7	0.0	5.6	138.7
1.23	945.0	0.0	0.0	9.4	0.0	0.0	4.5	36.7
1.33	509.1	406.5	29.4	2.9	2.4	1.0	6.1	254.2
1.42	945.0	0.0	0.0	9.5	0.0	0.0	4.4	34.4
1.48	514.2	430.8	0.0	5.2	2.7	0.0	5.0	128.6
1.52	821.0	120.4	3.6	7.4	3.5	1.0	3.7	90.0
1.61	942.7	2.3	0.0	9.0	1.9	0.0	3.8	43.8
1.7	941.7	3.3	0.0	8.1	1.7	0.0	4.2	43.1
1.8	912.3	32.7	0.0	9.5	2.3	0.0	4.5	47.7
1.89	945.0	0.0	0.0	8.6	0.0	0.0	4.9	41.4
1.97	945.0	0.0	0.0	6.2	0.0	0.0	4.2	74.0
1.99	372.0	0.0	0.0	2.6	0.0	0.0	4.0	63.3
2.08	372.0	0.0	0.0	7.3	0.0	0.0	2.8	30.9
2.18	372.0	0.0	0.0	6.1	0.0	0.0	2.3	38.3
2.27	372.0	0.0	0.0	4.8	0.0	0.0	3.4	45.2
2.37	372.0	0.0	0.0	7.0	0.0	0.0	2.4	34.3
2.46	372.0	0.0	0.0	5.2	0.0	0.0	2.9	37.9
2.56	372.0	0.0	0.0	7.0	0.0	0.0	3.2	36.1
2.65	372.0	0.0	0.0	6.0	0.0	0.0	3.6	27.9
2.75	372.0	0.0	0.0	6.6	0.0	0.0	2.7	32.1
2.84	372.0	0.0	0.0	7.2	0.0	0.0	3.6	31.5
2.94	372.0	0.0	0.0	7.4	0.0	0.0	2.3	28.4
2.95	372.0	0.0	0.0	3.6	0.0	0.0	4.1	35.6

Table 11-31

Summary of Hydraulic Parameters

Base HEC-RAS Model (Non-Structural Alternative) East Garambullo Wash

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
0	876	0.0	0.0	2.15	0.0	0.0	5	447.63
0.09	876	0.0	0.0	8.28	0.0	0.0	2.71	73.62
0.14	567.62	235	73.38	4.18	2.32	1.93	5.1	123.33
0.19	45.42	0.0	326.58	0.92	0.0	2.03	5.9	185.18
0.28	188.04	0.0	183.96	4.71	0.0	3.14	3.21	87.67
0.38	208.43	163.17	0.4	5.45	3.28	0.48	3.1	95.16
0.47	372	0.0	0.0	4.47	0.0	0.0	3	53.81
0.57	372	0.0	0.0	7.61	0.0	0.0	3.37	26.86
0.66	372	0.0	0.0	4.15	0.0	0.0	3.72	51.46
0.76	360.27	0.0	11.73	4.84	0.0	2.27	1.9	68.02
0.85	372	0.0	0.0	3.74	0.0	0.0	1.7	88.78
0.95	372	0.0	0.0	6.88	0.0	0.0	2.66	36
1.04	347.22	0.0	24.78	5.43	0.0	1.9	3.63	62.54
1.14	372	0.0	0.0	8.02	0.0	0.0	3.49	20.34
1.23	372	0.0	0.0	6.59	0.0	0.0	3.03	32
1.33	372	0.0	0.0	6.42	0.0	0.0	1.98	40.05
1.43	372	0.0	0.0	7.03	0.0	0.0	3.45	29.53

Table 11-32

Summary of Hydraulic Parameters

Base HEC-RAS Model (Non-Structural Alternative) West Garambullo Wash

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
0	876	0.0	0.0	2.15	0.0	0.0	5	447.63
0.09	876	0.0	0.0	8.28	0.0	0.0	2.71	73.62
0.14	567.62	235	73.38	4.18	2.32	1.93	5.1	123.33
0.19	504	0.0	0.0	8.2	0.0	0.0	4.05	29.07
0.28	362.16	6.45	135.39	3.62	0.95	1.91	4.13	170.33
0.38	193.62	310.38	0.0	2.66	1.49	0.0	3.8	263.58
0.47	504	0.0	0.0	7.68	0.0	0.0	2.69	86.45
0.57	401.28	27.12	75.61	3.62	1.09	1.92	5.3	139.63
0.66	462.51	0.0	41.49	7.61	0.0	2.31	4.04	53.63
0.76	504	0.0	0.0	4.95	0.0	0.0	4.6	50.18
0.85	251.33	195.23	57.45	5.74	4.05	3.12	2.65	87.83
0.95	490.87	0.0	13.13	7.52	0.0	1.75	4.02	44.18
1.04	504	0.0	0.0	5.5	0.0	0.0	3.03	42.68
1.14	504	0.0	0.0	8.3	0.0	0.0	3.57	27.84
1.23	504	0.0	0.0	6.04	0.0	0.0	3.67	33.72
1.33	504	0.0	0.0	7.99	0.0	0.0	2.71	32.14
1.42	504	0.0	0.0	7	0.0	0.0	4.31	30.46
1.52	504	0.0	0.0	6.26	0.0	0.0	3.96	46.5
1.61	504	0.0	0.0	7.75	0.0	0.2	4.42	25.28
1.69	504	0.0	0.0	8.75	0.0	0.0	4.61	24.52

Table 11-33

Summary of Hydraulic Parameters

Full Structural Alternative HEC-RAS Model Twin Buttes Wash

x-sec	Discharge Channel (cfs)	Discharge Left Over Bank (cfs)	Discharge Right Over Bank (cfs)	Velocity Channel (fps)	Velocity Left Over Bank (fps)	Velocity Right Over Bank (fps)	Channel Depth of Flow (ft)	Top Width (ft)
1	2	3	4	5	6	7	8	9
0.19	3775	0.00	0.00	10.05	0.00	0.00	3.31	120.22
0.28	3775	0.00	0.00	8.95	0.00	0.00	3.54	126.17
0.38	3775.0	0.00	0.00	6.8	0.00	0.00	3.4	171.5
0.47	3775.0	0.00	0.00	10.2	0.00	0.00	3.5	113.8
0.57	3775.0	0.00	0.00	10.2	0.00	0.00	3.5	113.9
0.66	3773.0	0.00	2.0	7.7	0.00	0.7	4.7	135.9
0.76	3775.0	0.00	0.00	6.9	0.00	0.00	5.0	120.0
0.85	3775.0	0.00	0.00	7.5	0.00	0.00	4.6	118.5
0.95	3775.0	0.00	0.00	10.3	0.00	0.00	3.4	113.7
1.04	3775.0	0.00	0.00	6.9	0.00	0.00	5.0	119.9
1.14	3775.0	0.00	0.00	4.8	0.00	0.00	2.1	379.3
1.23	3775.0	0.00	0.00	5.0	0.00	0.00	1.8	412.4
1.33	3775.0	0.00	0.00	4.9	0.00	0.00	2.0	388.1
1.42	3775.0	0.00	0.00	5.3	0.00	0.00	4.6	163.5
1.52	3775.0	0.00	0.00	4.5	0.00	0.00	3.3	263.2
1.61	3775.0	0.00	0.00	11.4	0.00	0.00	4.6	81.3
1.7	3775.0	0.00	0.00	3.8	0.00	0.00	5.8	184.3
1.8	3775.0	0.00	0.00	8.9	0.00	0.00	2.5	171.2
1.84	3775.0	0.00	0.00	5.6	0.00	0.00	4.7	151.8
1.91	3775.0	0.00	0.00	3.9	0.00	0.00	3.9	253.0
1.92	3779.0	0.00	0.00	3.5	0.00	0.00	4.3	262.0
1.99	3779.0	0.00	0.00	6.5	0.00	0.00	2.5	239.9
2.08	3779.0	0.00	0.00	5.8	0.00	0.00	3.6	187.4
2.16	3779.0	0.00	0.00	5.6	0.00	0.00	2.7	260.6
2.27	3779.0	0.00	0.00	9.2	0.00	0.00	5.1	90.5
2.37	3779.0	0.00	0.00	5.8	0.00	0.00	4.0	172.8
2.46	3779.0	0.00	0.00	5.5	0.00	0.00	3.8	190.1
2.56	3779.0	0.00	0.00	8.7	0.00	0.00	3.1	145.5
2.65	3779.0	0.00	0.00	7.9	0.00	0.00	5.7	95.7
2.75	3779.0	0.00	0.00	6.6	0.00	0.00	4.5	136.9
2.84	3779.0	0.00	0.00	8.0	0.00	0.00	4.5	114.9
2.94	3779.0	0.00	0.00	10.3	0.00	0.00	5.1	81.5
3.03	3779.0	0.00	0.00	4.9	0.00	0.00	5.9	143.4
3.13	3779.0	0.00	0.00	4.2	0.00	0.00	3.9	239.6
3.22	3779.0	0.00	0.00	10.9	0.00	0.00	4.1	94.2
3.31	3486.0	0.00	0.00	5.0	0.00	0.00	4.2	173.8
3.41	3486.0	0.00	0.00	6.5	0.00	0.00	5.2	112.9
3.47	3486.0	0.00	0.00	4.1	0.00	0.00	3.4	258.6
3.5	3486.0	0.00	0.00	3.6	0.00	0.00	3.3	302.2
3.6	3486.0	0.00	0.00	8.8	0.00	0.00	2.5	164.0
3.69	2509.0	0.00	0.00	5.9	0.00	0.00	3.0	149.9
3.79	2509.0	0.00	0.00	6.9	0.00	0.00	2.4	156.6
3.88	2509.0	0.00	0.00	5.7	0.00	0.00	3.4	136.7

Table 11-33 Cont.

Summary of Hydraulic Parameters

Full Structural Alternative HEC-RAS Model Twin Buttes Wash

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
3.98	2509	0.0	0.0	8.0	0.0	0.0	2.0	162.0
4.07	2509	0.0	0.0	3.4	0.0	0.0	3.2	236.9
4.17	2509	0.0	0.0	5.6	0.0	0.0	1.8	256.1
4.26	2509	0.0	0.0	8.1	0.0	0.0	2.7	119.9
4.36	2509	0.0	0.0	3.3	0.0	0.0	2.6	294.5
4.45	2509	0.0	0.0	7.6	0.0	0.0	1.9	181.4
4.55	2509	0.0	0.0	4.5	0.0	0.0	4.1	142.6
4.64	2509	0.0	0.0	4.0	0.0	0.0	1.8	351.2
4.73	2509	0.0	0.0	4.7	0.0	0.0	1.4	377.7
4.79	2509	0.0	0.0	6.6	0.0	0.0	1.6	245.3
4.92	2057	0.0	0.0	4.3	0.0	0.0	1.7	276.9
5.02	2057	0.0	0.0	4.6	0.0	0.0	1.7	263.0
5.07	2057	0.0	0.0	6.6	0.0	0.0	2.2	147.7
5.11	2057	0.0	0.0	4.2	0.0	0.0	3.9	135.5
5.21	2057	0.0	0.0	6.1	0.0	0.0	3.5	102.2
5.3	2057	0.0	0.0	5.9	0.0	0.0	3.2	114.9
5.4	2057	0.0	0.0	7.9	0.0	0.0	2.1	130.2
5.49	2057	0.0	0.0	7.0	0.0	0.0	2.2	136.9
5.59	2057	0.0	0.0	8.3	0.0	0.0	2.2	116.9
5.68	2057	0.0	0.0	4.3	0.0	0.0	3.3	150.4
5.78	2057	0.0	0.0	3.8	0.0	0.0	2.5	223.1
5.87	2057	0.0	0.0	8.1	0.0	0.0	2.1	124.5
5.97	2057	0.0	0.0	6.1	0.0	0.0	3.4	105.7
6.06	2057	0.0	0.0	8.1	0.0	0.0	2.1	124.5
6.16	2057	0.0	0.0	6.7	0.0	0.0	4.5	77.9
6.25	2057	0.0	0.0	9.9	0.0	0.0	3.4	68.5
6.34	2057	0.0	0.0	6.5	0.0	0.0	3.2	105.8
6.38	2057	0.0	0.0	9.0	0.0	0.0	2.6	94.3

Table 34

Summary of Hydraulic Parameters

Full Structural Alternative HEC-RAS Model Caterpillar Tank Wash

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
0.019	1556.0	0.0	0.0	8.3	0.0	0.0	2.2	88.0
0.09	1556.0	0.0	0.0	3.6	0.0	0.0	6.0	83.2
0.19	1556.0	0.0	0.0	7.7	0.0	0.0	1.9	110.6
0.28	1556.0	0.0	0.0	5.4	0.0	0.0	4.9	98.6
0.38	1556.0	0.0	0.0	8.3	0.0	0.0	2.3	86.2
0.47	1556.0	0.0	0.0	7.1	0.0	0.0	2.4	94.8
0.57	1556.0	0.0	0.0	5.5	0.0	0.0	2.5	118.0
0.66	1556.0	0.0	0.0	8.5	0.0	0.0	2.4	82.6
0.76	1556.0	0.0	0.0	5.5	0.0	0.0	3.2	95.6
0.82	1556.0	0.0	0.0	7.1	0.0	0.0	1.6	137.5
0.83	1556.0	0.0	0.0	3.5	0.0	0.0	2.1	217.5
0.95	1572.0	0.0	0.0	7.5	0.0	0.0	1.9	116.4
1.04	1572.0	0.0	0.0	8.7	0.0	0.0	2.9	68.5
1.14	1572.0	0.0	0.0	7.5	0.0	0.0	3.6	66.2
1.23	1572.0	0.0	0.0	7.6	0.0	0.0	2.1	104.3
1.33	1572.0	0.0	0.0	6.0	0.0	0.0	3.1	90.5
1.42	1572.0	0.0	0.0	5.4	0.0	0.0	3.3	95.2
1.52	1572.0	0.0	0.0	8.5	0.0	0.0	2.4	81.6
1.61	1572.0	0.0	0.0	4.4	0.0	0.0	2.9	131.4
1.7	1572.0	0.0	0.0	8.4	0.0	0.0	2.4	83.5
1.8	1572.0	0.0	0.0	7.6	0.0	0.0	4.3	56.4
1.89	1572.0	0.0	0.0	6.5	0.0	0.0	2.9	88.7
1.99	1572.0	0.0	0.0	5.6	0.0	0.0	3.7	82.9
2.08	1292.0	0.0	0.0	4.5	0.0	0.0	2.2	135.9
2.18	1292.0	0.0	0.0	4.7	0.0	0.0	2.3	126.0
2.27	1292.0	0.0	0.0	6.1	0.0	0.0	2.6	86.5
2.37	1292.0	0.0	0.0	3.0	0.0	0.0	1.3	342.1
2.46	1292.0	0.0	0.0	6.6	0.0	0.0	2.7	77.9
2.56	1292.0	0.0	0.0	4.8	0.0	0.0	2.6	110.3
2.65	1292.0	0.0	0.0	5.8	0.0	0.0	2.4	97.6
2.75	1292.0	0.0	0.0	7.1	0.0	0.0	2.3	85.0
2.84	1292.0	0.0	0.0	6.4	0.0	0.0	2.9	76.4
2.94	1292.0	0.0	0.0	4.8	0.0	0.0	3.9	75.7
3.03	1292.0	0.0	0.0	6.7	0.0	0.0	2.7	75.9
3.13	1292.0	0.0	0.0	4.4	0.0	0.0	3.8	85.2
3.22	1292.0	0.0	0.0	6.8	0.0	0.0	1.5	133.8
3.31	1292.0	0.0	0.0	3.9	0.0	0.0	3.1	112.4

Table 11-34 Cont.

Summary of Hydraulic Parameters

Full Structural Alternative HEC-RAS Model Caterpillar Tank Wash

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
3.41	913.0	0.0	0.0	4.7	0.0	0.0	1.3	149.3
3.5	913.0	0.0	0.0	5.8	0.0	0.0	2.2	75.8
3.6	913.0	0.0	0.0	4.4	0.0	0.0	5.5	125.8
3.69	913.0	0.0	0.0	6.1	0.0	0.0	8.1	55.2
3.73	913.0	0.0	0.0	4.7	0.0	0.0	6.0	85.6
3.79	913.0	0.0	0.0	3.2	0.0	0.0	2.6	116.3
3.88	913.0	0.0	0.0	7.5	0.0	0.0	1.8	70.4
3.98	913.0	0.0	0.0	3.9	0.0	0.0	2.8	89.3
4.07	913.0	0.0	0.0	8.1	0.0	0.0	2.2	54.9
4.17	913.0	0.0	0.0	3.2	0.0	0.0	2.9	134.8
4.26	913.0	0.0	0.0	5.7	0.0	0.0	2.4	70.7
4.36	913.0	0.0	0.0	8.0	0.0	0.0	2.1	58.5
4.45	913.0	0.0	0.0	6.4	0.0	0.0	2.6	60.4
4.55	913.0	0.0	0.0	6.9	0.0	0.0	2.8	53.1
4.64	913.0	0.0	0.0	8.4	0.0	0.0	2.7	45.8
4.73	913.0	0.0	0.0	5.5	0.0	0.0	2.7	66.8
4.92	913.0	0.0	0.0	4.8	0.0	0.0	0.9	206.7
5.02	913.0	0.0	0.0	4.8	0.0	0.0	3.2	66.2
5.04	913.0	0.0	0.0	7.6	0.0	0.0	1.9	67.5

Table 11-35

Summary of Hydraulic Parameters

Full Structural Alternative HEC-RAS Model

West Fork Whites Peaks Wash

x-sec	Discharge Channel (cfs)	Discharge Left Over Bank (cfs)	Discharge Right Over Bank (cfs)	Velocity Channel (fps)	Velocity Left Over Bank (fps)	Velocity Right Over Bank (fps)	Channel Depth of Flow (ft)	Top Width (ft)
1	2	3	4	5	6	7	8	9
0	279			1.44			3.21	66.84
0.09	279			5.31			1.09	60.58
0.19	279			5.73			1.66	32.64
0.28	279			6.28			1.36	35.43
0.38	279			5.87			1.41	36.62
0.47	279			6.94			1.72	26.86
0.57	279			6.61			1.56	30.23
0.66	279			6.56			1.47	31.88
0.74	279			4.97			1.83	34.33

Table 11-36

Summary of Hydraulic Parameters

Full Structural Alternative HEC-RAS Model Whites Peaks Wash

x-sec	Discharge Channel (cfs)	Discharge Left Over Bank (cfs)	Discharge Right Over Bank (cfs)	Velocity Channel (fps)	Velocity Left Over Bank (fps)	Velocity Right Over Bank (fps)	Channel Depth of Flow (ft)	Top Width (ft)
1	2	3	4	5	6	7	8	9
0	454.63	0.0	490.37	1.8	0.0	1.98	5.16	241.94
0.19	945	0.0	0.0	3.22	0.0	0.0	2.73	112.93
0.28	945	0.0	0.0	7.93	0.0	0.0	2.12	60.47
0.38	945	0.0	0.0	4.99	0.0	0.0	3.57	60.27
0.47	945	0.0	0.0	3.42	0.0	0.0	2.11	135.42
0.57	945	0.0	0.0	9.16	0.0	0.0	3.11	39.43
0.66	945	0.0	0.0	3.37	0.0	0.0	3.44	115.17
0.76	945	0.0	0.0	4.67	0.0	0.0	2.47	86.89
0.85	945	0.0	0.0	6.73	0.0	0.0	1.83	80.33
0.95	945	0.0	0.0	5.06	0.0	0.0	3.58	59.31
1.04	945	0.0	0.0	5.61	0.0	0.0	3.01	62.04
1.14	945	0.0	0.0	4.92	0.0	0.0	2.56	80.22

Table 11-36 Cont.

Summary of Hydraulic Parameters

Full Structural Alternative HEC-RAS Model Whites Peaks Wash

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
1.23	945	0.0	0.0	8.07	0.0	0.0	2.7	48.79
1.33	945	0.0	0.0	2.59	0.0	0.0	2.79	136.17
1.42	945	0.0	0.0	8.56	0.0	0.0	2.51	49.03
1.48	945	0.0	0.0	6.02	0.0	0.0	3.42	59.65
1.52	945	0.0	0.0	4.63	0.0	0.0	2.58	84.33
1.61	945	0.0	0.0	8.59	0.0	0.0	2.55	48.21
1.7	945	0.0	0.0	7.28	0.0	0.0	3.08	48.32
1.8	945	0.0	0.0	9.3	0.0	0.0	3.32	37.27
1.89	945	0.0	0.0	6.63	0.0	0.0	3.27	50.09
1.97	945	0.0	0.0	7.85	0.0	0.0	2.07	62.29
1.99	372	0.0	0.0	2.6	0.0	0.0	2.43	63.74
2.08	372	0.0	0.0	6.81	0.0	0.0	1.55	38.22
2.18	372	0.0	0.0	5.84	0.0	0.0	1.48	45.94
2.27	372	0.0	0.0	4.02	0.0	0.0	1.86	53.44
2.37	372	0.0	0.0	6.64	0.0	0.0	1.48	40.9
2.46	372	0.0	0.0	4.63	0.0	0.0	1.88	46.51
2.56	372	0.0	0.0	6.57	0.0	0.0	1.42	42.68
2.65	372	0.0	0.0	5.47	0.0	0.0	2	38
2.75	372	0.0	0.0	6.31	0.0	0.0	1.59	40.34
2.84	372	0.0	0.0	6.21	0.0	0.0	1.69	38.77
2.94	372	0.0	0.0	6.98	0.0	0.0	1.61	36.42
2.95	372	0.0	0.0	2.75	0.0	0.0	3.19	48.75

Table 11-37

Summary of Hydraulic Parameters

Full Structural Alternative HEC-RAS Model East Garambullo Wash

x-sec	Discharge			Velocity			Channel Depth of Flow	Top Width
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
0	876	0.0	0.0	0.7	0.0	0.0	5	448.49
0.09	876	0.0	0.0	7.98	0.0	0.0	2.18	54.71
0.14	876	0.0	0.0	3.33	0.0	0.0	4.26	70.39
0.19	372	0.0	0.0	4.3	0.0	0.0	0.57	153.28
0.28	372	0.0	0.0	3.75	0.0	0.0	2.48	48.12
0.38	372	0.0	0.0	7.26	0.0	0.0	1.85	31.4
0.47	372	0.0	0.0	3.72	0.0	0.0	2.3	48.18
0.57	372	0.0	0.0	7.27	0.0	0.0	1.85	31.4
0.66	372	0.0	0.0	3.86	0.0	0.0	1.83	56.31
0.76	372	0.0	0.0	6.15	0.0	0.0	1.22	55.21
0.85	372	0.0	0.0	3.21	0.0	0.0	1.27	94.06
0.95	372	0.0	0.0	6.81	0.0	0.0	1.56	38.22
1.04	372	0.0	0.0	4.93	0.0	0.0	2.04	41.15
1.14	372	0.0	0.0	7.54	0.0	0.0	2.05	28.19
1.23	372	0.0	0.0	6.21	0.0	0.0	1.88	35.54
1.33	372	0.0	0.0	6.46	0.0	0.0	1.38	44.52
1.43	372	0.0	0.0	5.95	0.0	0.0	2.02	35.06

Table 11-38

Summary of Hydraulic Parameters

Full Structural Alternative HEC-RAS Model West Garambullo Wash

x-sec	Discharge			Velocity				
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank	Channel Depth of Flow	Top Width
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
0	876	0.0	0.0	0.7	0.0	0.0	5	448.49
0.09	876	0.0	0.0	7.98	0.0	0.0	2.18	54.72
0.14	876	0.0	0.0	3.33	0.0	0.0	4.26	70.39
0.19	504	0.0	0.0	4.21	0.0	0.0	3.35	42.42
0.28	504	0.0	0.0	6.25	0.0	0.0	1.41	63.63
0.38	504	0.0	0.0	4.6	0.0	0.0	1.61	71.42
0.47	504	0.0	0.0	5.89	0.0	0.0	2.13	44.51
0.57	504	0.0	0.0	3.08	0.0	0.0	3.02	60.1
0.66	504	0.0	0.0	8.04	0.0	0.0	2.42	30.7
0.76	504	0.0	0.0	3.65	0.0	0.0	2.39	62.56
0.85	504	0.0	0.0	7.1	0.0	0.0	1.68	45.7
0.95	504	0.0	0.0	5.18	0.0	0.0	3.11	37.45
1.04	504	0.0	0.0	7.06	0.0	0.0	1.65	46.6
1.14	504	0.0	0.0	5.78	0.0	0.0	2.56	39.22
1.23	504	0.0	0.0	7.02	0.0	0.0	1.9	41.6
1.33	504	0.0	0.0	6.11	0.0	0.0	2.2	41.81
1.42	504	0.0	0.0	6.68	0.0	0.0	2.14	39.55
1.52	504	0.0	0.0	5.59	0.0	0.0	1.75	55.01
1.61	504	0.0	0.0	7.54	0.0	0.0	2.33	33.33
1.69	504	0.0	0.0	8.21	0.0	0.0	2.24	29.59

Table 11-39

Comparison of Base HEC-RAS to Full Structural Alternative HEC-RAS

Twin Buttes Wash

x-sec	Difference in Discharge			Difference in Velocity			Difference in Channel Depth of Flow	Top Width Difference
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
0.19	0.0	0.0	0.0	-0.4	0.0	0.0	-2.2	11.7
0.28	0.0	0.0	0.0	-0.1	0.0	0.0	-2.1	11.7
0.38	0.0	0.0	0.0	1.2	0.0	0.0	-2.3	-105.2
0.47	0.0	0.0	0.0	0.7	0.0	0.0	-0.7	-27.3
0.57	413.0	-355.9	-57.1	3.6	-5.1	-1.6	-0.8	-278.8
0.66	2120.1	-2012.5	-107.6	2.8	-2.7	-1.1	-1.1	-798.1
0.76	1264.7	0.0	-1264.7	0.3	0.0	-3.5	-3.3	-351.8
0.85	43.2	-14.2	-29.0	-1.5	-1.2	-1.5	-4.3	-84.7
0.95	126.7	0.0	-126.7	1.3	0.0	-2.1	-3.1	-124.8
1.04	502.8	-360.4	-142.3	-0.4	-2.8	-1.7	-3.0	-283.0
1.14	1218.2	0.0	-1218.2	-5.3	0.0	-5.9	-3.8	209.2
1.23	3310.0	0.0	-3310.0	1.6	0.0	-3.4	-5.2	-143.4
1.33	1036.4	0.0	-1036.4	-2.1	0.0	-4.6	-1.7	-53.5
1.42	371.1	-371.1	0.0	-1.9	-2.1	0.0	-2.8	-216.2
1.52	1953.8	-1953.8	0.0	0.3	-4.2	0.0	-3.5	-143.7
1.61	868.9	-305.2	-563.7	2.0	-3.9	-4.6	-2.9	-132.9
1.7	0.0	0.0	0.0	-0.8	0.0	0.0	-2.5	-27.0
1.8	194.4	-176.6	-17.8	2.5	-3.3	-1.8	-3.4	-64.2
1.84	78.3	-78.3	0.0	-1.7	-2.3	0.0	-2.4	-46.8
1.91	0.0	0.0	0.0	-0.5	0.0	0.0	-3.8	16.0
1.92	0.0	0.0	0.0	-1.1	0.0	0.0	-3.7	17.2
1.99	0.0	0.0	0.0	0.1	0.0	0.0	-4.5	5.9
2.08	2028.4	0.0	-2028.4	0.0	0.0	-4.9	-3.3	-61.1
2.16	2079.4	-439.6	-1639.8	-1.1	-3.8	-4.5	-2.2	-81.3
2.27	753.5	0.0	-753.5	-0.9	0.0	-4.0	-1.9	-84.5
2.37	446.3	0.0	-446.3	-0.4	0.0	-2.4	-2.0	-148.4
2.46	0.0	0.0	0.0	-1.9	0.0	0.0	-3.3	-2.2
2.56	273.5	-273.5	0.0	3.2	-1.9	0.0	-3.4	-223.4
2.65	362.3	-362.3	0.0	-2.0	-3.5	0.0	-1.0	-71.0
2.75	52.0	-52.0	0.0	-0.6	-2.5	0.0	-2.4	-7.6
2.84	327.4	-15.8	-311.6	-0.9	-2.5	-3.8	-3.0	-51.7
2.94	689.4	-689.4	0.0	2.0	-3.6	0.0	-2.7	-83.2
3.03	1496.0	0.0	-1496.0	-1.4	0.0	-4.5	-2.3	-64.7
3.13	664.1	-664.1	0.0	-1.0	-4.3	0.0	-3.1	7.2
3.22	441.5	0.0	-441.5	2.4	0.0	-2.4	-3.2	-288.8

Table 11-39 Cont.

Comparison of Base HEC-RAS to Full Structural Alternative HEC-RAS

Twin Buttes Wash

x-sec	Difference in Discharge			Difference in Velocity			Difference in Channel Depth of Flow	Top Width Difference
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
3.31	1045.2	0.0	-1045.2	0.2	0.0	-2.7	-1.5	-222.8
3.41	0.0	0.0	0.0	-4.0	0.0	0.0	-1.8	32.0
3.47	1635.6	-1635.6	0.0	0.1	-4.0	0.0	-2.9	-151.3
3.5	1173.2	-1173.2	0.0	-1.1	-4.2	0.0	-2.6	0.2
3.6	1899.2	-1899.2	0.0	1.6	-7.7	0.0	-2.6	-56.7
3.69	0.0	0.0	0.0	-3.0	0.0	0.0	-2.0	55.9
3.79	278.0	-278.0	0.0	1.5	-2.4	0.0	-3.1	-91.1
3.88	960.5	0.0	-960.5	-2.6	0.0	-2.9	-2.5	-148.1
3.98	986.6	0.0	-986.6	2.4	0.0	-3.6	-1.7	-240.6
4.07	0.0	0.0	0.0	-2.9	0.0	0.0	-2.3	20.0
4.17	0.0	0.0	0.0	1.5	0.0	0.0	-2.9	7.4
4.26	0.0	0.0	0.0	-1.0	0.0	0.0	-1.7	10.0
4.36	0.0	0.0	0.0	-0.8	0.0	0.0	-3.3	10.4
4.45	60.3	-60.3	0.0	0.0	-2.2	0.0	-2.4	-43.2
4.55	345.7	-66.9	-278.9	-2.7	-1.5	-3.4	-1.4	-198.5
4.64	0.0	0.0	0.0	-0.5	0.0	0.0	-2.0	11.2
4.73	0.0	0.0	0.0	-1.4	0.0	0.0	-3.0	6.0
4.79	992.2	0.0	-992.2	2.9	0.0	-3.3	-3.4	-202.4
4.92	899.0	0.0	-899.0	-2.1	0.0	-6.7	-1.2	37.6
5.02	839.9	0.0	-839.9	-0.5	0.0	-3.0	-2.6	-190.5
5.07	251.3	0.0	-251.3	-0.3	0.0	-2.4	-2.4	-135.3
5.11	0.0	0.0	0.0	-3.1	0.0	0.0	-0.8	19.7
5.21	0.0	0.0	0.0	-1.7	0.0	0.0	-2.5	14.7
5.3	0.0	0.0	0.0	0.3	0.0	0.0	-3.3	14.1
5.4	0.0	0.0	0.0	-0.2	0.0	0.0	-2.4	8.9
5.49	0.0	0.0	0.0	0.2	0.0	0.0	-1.9	10.4
5.59	0.0	0.0	0.0	-0.2	0.0	0.0	-0.9	9.7
5.68	0.0	0.0	0.0	-2.6	0.0	0.0	-2.0	15.1
5.78	0.0	0.0	0.0	-0.4	0.0	0.0	-4.2	10.6
5.87	291.4	-291.4	0.0	1.0	-5.4	0.0	-2.7	-20.3
5.97	0.0	0.0	0.0	-3.0	0.0	0.0	-0.8	17.2
6.06	0.8	-0.6	-0.2	0.5	-1.3	-1.1	-2.6	6.5
6.16	0.0	0.0	0.0	-1.6	0.0	0.0	-2.4	20.1
6.25	0.0	0.0	0.0	-0.8	0.0	0.0	-2.2	14.5
6.34	0.0	0.0	0.0	-0.6	0.0	0.0	-4.3	14.2
6.38	0.0	0.0	0.0	-0.3	0.0	0.0	-3.3	12.6

Table 11-40

Comparison of Base HEC-RAS to Full Structural Alternative HEC-RAS

Caterpillar Tank Wash

x-sec	Difference in Discharge			Difference in Velocity			Difference in Channel Depth of Flow	Top Width Difference
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
0.019	605.73	-605.73	0	0.84	-7.62	0	-1.19	-29.64
0.09	0	0	0	-2.03	0	0	-2.18	21.65
0.19	0	0	0	-0.23	0	0	-1.36	6.56
0.28	20.77	0	-20.77	-1.05	0	-1.69	-2.65	-14.73
0.38	285.73	-285.73	0	1.98	-2.74	0	-3.91	-177.6
0.47	215.73	-215.73	0	0.58	-3.53	0	-1.44	-53.98
0.57	185.91	-185.91	0	-1.54	-5.34	0	-2.74	-18.05
0.66	0.33	-0.33	0	1	-1.42	0	-3.31	9.54
0.76	0	0	0	-0.25	0	0	-1.59	10.38
0.82	0	0	0	-0.01	0	0	-1.74	-1.61
0.83	0	0	0	-0.67	0	0	-1.91	-0.41
0.95	0	0	0	-0.27	0	0	-4.47	7.5
1.04	343.03	-343.03	0	1.93	-3.47	0	-1.82	-58.17
1.14	0	0	0	-2.54	0	0	-0.91	15.01
1.23	0	0	0	0.82	0	0	-2.58	4.75
1.33	0	0	0	-0.97	0	0	-2.2	10.58
1.42	215.69	0	-215.69	-0.28	0	-2.71	-3.21	-55.52
1.52	0	0	0	-0.43	0	0	-2.72	10.93
1.61	0	0	0	-0.42	0	0	-3.49	2.25
1.7	0	0	0	1.74	0	0	-3.28	7.3
1.8	185.66	0	-185.66	-1.61	0	-3.29	-1.25	-67.32
1.89	791.44	-791.44	0	0.48	-3.52	0	-1.68	-99.38
1.99	235.86	0	-235.86	-1.7	0	-4.07	-1.7	-36.64
2.08	0	0	0	0.92	0	0	-1.89	9.39
2.18	0	0	0	-2.12	0	0	-1.13	12.69
2.27	291.93	-291.93	0	1.06	-2.51	0	-2.72	-103.93
2.37	0	0	0	-0.09	0	0	-1.71	13.25
2.46	373	-261.48	-111.52	-0.13	-2.46	-2.04	-2.35	-179.33
2.56	0	0	0	-0.06	0	0	-2.09	-12.3
2.65	573.27	-0.89	-572.38	-0.21	-1.34	-2.56	-2.6	-276.09
2.75	0	0	0	0.05	0	0	-1.63	20.13
2.84	372.55	-367.46	-5.09	0.12	-3.24	-1.48	-1.26	-114.85
2.94	132.15	-132.15	0	-1.01	-2.28	0	-1.82	-38.3
3.03	138.78	-44.91	-93.87	0.56	-3.87	-2.94	-2.19	-21.12
3.13	10.51	-10.51	0	-1.52	-1.04	0	-2.49	-20.13

Table 11-40 Cont.

Comparison of Base HEC-RAS to Full Structural Alternative HEC-RAS

Caterpillar Tank Wash

x-sec	Difference in Discharge			Difference in Velocity			Difference in Channel Depth of Flow	Top Width Difference
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
3.22	0	0	0	2.47	0	0	-2.59	6.33
3.31	0	0	0	-3.53	0	0	-2.89	13.34
3.41	0	0	0	0.78	0	0	-4.95	7.85
3.5	0	0	0	-1.95	0	0	-2.6	13.67
3.6	0	0	0	0.42	0	0	-3.14	13.12
3.69	96.04	0	-96.04	0.23	0	-1.42	-1.6	-159.32
3.73	283.98	0	-283.98	-1.41	0	-4.08	-1.51	-22.49
3.79	0	0	0	-1.48	0	0	-2.81	16.48
3.88	0	0	0	1.66	0	0	-3.12	7.17
3.98	0	0	0	-1.22	0	0	-2.93	12.47
4.07	359.63	0	-359.63	2.19	0	-2.74	-0.67	-108.54
4.17	194.44	0	-194.44	-3.04	0	-4.64	-1.01	55.21
4.26	0	0	0	-0.08	0	0	-2.92	10.58
4.36	0	0	0	-0.5	0	0	-1.7	10.25
4.45	51.35	-50.32	-1.03	-0.51	-2.3	-1.42	-1.83	-21.54
4.55	13.08	0	-13.08	-0.72	0	-1.68	-1.79	-3.58
4.64	57.29	-57.29	0	-0.12	-2.87	0	-1.84	-13.31
4.73	0	0	0	-1.25	0	0	-2.15	12.21
4.92	0	0	0	1.57	0	0	-1.09	-1.83
5.02	565.62	-563.36	-2.26	1.6	-4.66	-0.76	-1.9	-40.18
5.04	0.16	0	-0.16	-0.29	0	-1.29	-2.85	8.6

Table 11-41

Comparison of Base HEC-RAS to Full Structural Alternative HEC-RAS

West Fork Whites Peak Wash

x-sec	Difference in Discharge Channel	Difference in Discharge Left Over Bank	Difference in Discharge Right Over Bank	Difference in Velocity Channel	Difference in Velocity Left Over Bank	Difference in Velocity Right Over Bank	Difference in Channel Depth of Flow	Top Width Difference
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
0	0	0	0	-1.62	0	0	0	13.97
0.09	0	0	0	-0.24	0	0	-2.22	7.31
0.19	0	0	0	-0.61	0	0	-1.8	9.34
0.28	108.8	-108.8	0	1.35	-3.42	0	-2.65	-26.85
0.38	0	0	0	-0.31	0	0	-0.76	8.38
0.47	0	0	0	-0.83	0	0	-1.6	7.75
0.57	0	0	0	-0.54	0	0	-1.3	6.95
0.66	0	0	0	-0.56	0	0	-1.31	6.56
0.74	0	0	0	-0.87	0	0	-1.74	8.11

Table 11-42

Comparison of Base HEC-RAS to Full Structural Alternative HEC-RAS

Whites Peak Wash

x-sec	Difference in Discharge Channel	Difference in Discharge Left Over Bank	Difference in Discharge Right Over Bank	Difference in Velocity Channel	Difference in Velocity Left Over Bank	Difference in Velocity Right Over Bank	Difference in Channel Depth of Flow	Top Width Difference
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.19	423.2	-5.4	-417.8	-1.1	-1.5	-3.4	-2.5	-102.4
0.28	9.9	-9.9	0.0	4.1	-1.1	0.0	-3.5	-64.9
0.38	57.3	-57.3	0.0	0.0	-2.0	0.0	-0.8	-26.9
0.47	1.0	0.0	-1.0	-4.8	0.0	-0.9	-2.0	77.2
0.57	10.9	0.0	-10.9	6.1	0.0	-0.8	-0.9	-133.3
0.66	414.8	0.0	-414.8	-1.7	0.0	-3.1	-1.1	-114.6
0.76	213.2	0.0	-213.2	0.9	0.0	-2.6	-2.3	-90.0
0.85	167.7	0.0	-167.7	1.6	0.0	-2.5	-3.3	-99.9
0.95	0.0	0.0	0.0	-0.4	0.0	0.0	-0.3	-16.1

Table 11-42 Cont.

Comparison of Base HEC-RAS to Full Structural Alternative HEC-RAS

Whites Peak Wash

x-sec	Difference in Discharge			Difference in Velocity			Difference in Channel Depth of Flow	Top Width Difference
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
1.04	0.0	0.0	0.0	-0.4	0.0	0.0	-1.9	9.6
1.14	0.0	0.0	0.0	-1.4	0.0	0.0	-3.0	26.4
1.23	264.1	-264.1	0.0	4.3	-2.7	0.0	-2.9	-89.9
1.33	0.0	0.0	0.0	-6.8	0.0	0.0	-1.7	99.4
1.42	436.0	-406.5	-29.4	5.7	-2.4	-1.0	-3.6	-205.1
1.48	0.0	0.0	0.0	-3.5	0.0	0.0	-1.0	25.3
1.52	430.8	-430.8	0.0	-0.6	-2.7	0.0	-2.4	-44.2
1.61	124.0	-120.4	-3.6	1.2	-3.5	-1.0	-1.2	-41.8
1.7	2.3	-2.3	0.0	-1.7	-1.9	0.0	-0.8	4.5
1.8	3.3	-3.3	0.0	1.2	-1.7	0.0	-0.9	-5.8
1.89	32.7	-32.7	0.0	-2.9	-2.3	0.0	-1.2	2.4
1.97	0.0	0.0	0.0	-0.8	0.0	0.0	-2.8	20.9
1.99	-573.0	0.0	0.0	-3.6	0.0	0.0	-1.8	-10.3
2.08	0.0	0.0	0.0	4.2	0.0	0.0	-2.5	-25.1
2.18	0.0	0.0	0.0	-1.5	0.0	0.0	-1.3	15.1
2.27	0.0	0.0	0.0	-2.1	0.0	0.0	-0.5	15.1
2.37	0.0	0.0	0.0	1.8	0.0	0.0	-2.0	-4.3
2.46	0.0	0.0	0.0	-2.4	0.0	0.0	-0.5	12.2
2.56	0.0	0.0	0.0	1.4	0.0	0.0	-1.5	4.8
2.65	0.0	0.0	0.0	-1.5	0.0	0.0	-1.2	1.9
2.75	0.0	0.0	0.0	0.3	0.0	0.0	-2.0	12.4
2.84	0.0	0.0	0.0	-0.4	0.0	0.0	-1.0	6.7
2.94	0.0	0.0	0.0	-0.3	0.0	0.0	-2.0	4.9
2.95	0.0	0.0	0.0	-4.6	0.0	0.0	0.9	20.4

Table 11-43

Comparison of Base HEC-RAS to Full Structural Alternative HEC-RAS

East GarambulloWash

x-sec	Difference in Discharge			Difference in Velocity			Difference in Channel Depth of Flow	Top Width Difference
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
0	0	0	0	-1.45	0	0	0	0.86
0.09	0	0	0	-0.3	0	0	-0.53	-18.91
0.14	308.38	-235	-73.38	-0.85	-2.32	-1.93	-0.84	-52.94
0.19	326.58	0	-326.58	3.38	0	-2.03	-5.33	-31.9
0.28	183.96	0	-183.96	-0.96	0	-3.14	-0.73	-39.55
0.38	163.57	-163.17	-0.4	1.81	-3.28	-0.48	-1.25	-63.76
0.47	0	0	0	-0.75	0	0	-0.7	-5.63
0.57	0	0	0	-0.34	0	0	-1.52	4.54
0.66	0	0	0	-0.29	0	0	-1.89	4.85
0.76	11.73	0	-11.73	1.31	0	-2.27	-0.68	-12.81
0.85	0	0	0	-0.53	0	0	-0.43	5.28
0.95	0	0	0	-0.07	0	0	-1.1	2.22
1.04	24.78	0	-24.78	-0.5	0	-1.9	-1.59	-21.39
1.14	0	0	0	-0.48	0	0	-1.44	7.85
1.23	0	0	0	-0.38	0	0	-1.15	3.54
1.33	0	0	0	0.04	0	0	-0.6	4.47
1.43	0	0	0	-1.08	0	0	-1.43	5.53

Table 11-44

Comparison of Base HEC-RAS to Full Structural Alternative HEC-RAS

West GarambulloWash

x-sec	Difference in Discharge			Difference in Velocity			Difference in Channel Depth of Flow	Top Width Difference
	Channel	Left Over Bank	Right Over Bank	Channel	Left Over Bank	Right Over Bank		
	(cfs)	(cfs)	(cfs)	(fps)	(fps)	(fps)	(ft)	(ft)
1	2	3	4	5	6	7	8	9
0	0	0	0	-1.45	0	0	0	0.86
0.09	0	0	0	-0.3	0	0	-0.53	-18.9
0.14	308.38	-235	-73.38	-0.85	-2.32	-1.93	-0.84	-52.94
0.19	0	0	0	-3.99	0	0	-0.7	13.35
0.28	141.84	-6.45	-135.39	2.63	-0.95	-1.91	-2.72	-106.7
0.38	310.38	-310.38	0	1.94	-1.49	0	-2.19	-192.16
0.47	0	0	0	-1.79	0	0	-0.56	-41.94
0.57	102.72	-27.12	-75.61	-0.54	-1.09	-1.92	-2.28	-79.53
0.66	41.49	0	-41.49	0.43	0	-2.31	-1.62	-22.93
0.76	0	0	0	-1.3	0	0	-2.21	12.38
0.85	252.67	-195.23	-57.45	1.36	-4.05	-3.12	-0.97	-42.13
0.95	13.13	0	-13.13	-2.34	0	-1.75	-0.91	-6.73
1.04	0	0	0	1.56	0	0	-1.38	3.92
1.14	0	0	0	-2.52	0	0	-1.01	11.38
1.23	0	0	0	0.98	0	0	-1.77	7.88
1.33	0	0	0	-1.88	0	0	-0.51	9.67
1.42	0	0	0	-0.32	0	0	-2.17	9.09
1.52	0	0	0	-0.67	0	0	-2.21	8.51
1.61	0	0	0	-0.21	0	-0.2	-2.09	8.05
1.69	0	0	0	-0.54	0	0	-2.37	5.07

Identification of Flow Break-out Twin Buttes Wash

A potential flow break out that was not identified in the FEMA FIS along Twin Buttes Wash was identified during the HEC-RAS modeling efforts utilizing the base HEC-RAS model. In order to model the flow break-out the HEC-RAS computer program weir subroutine was utilized. Cross-section (0.82) was added to define the start of the break-out and the limits of the weir. A broad crested weir shape was assumed. A weir coefficient of 2.4 was utilized. The flow break-out occurs between

river mile 0.82 and 0.76. Approximately 1900 cfs breaks-out of the main channel during a 100-year event and drains to the east-southeast. The flow breakout returns to Twin Buttes Wash at approximately River Mile 0.38.

Cost Estimate

Purpose

Preliminary estimates of construction cost are prepared for the partial and full structural alternatives. Cost estimates are used as an aid in the selection process of a preferred alternative. Cost estimates developed for each alternative reflect the proposed improvements developed from generalized hydraulic evaluations and are considered approximate. The value of land removed from the floodplain/erosion hazard zone by an alternative is estimated to determine the benefit of the proposed improvement.

Methodology

Quantities are calculated for earthwork (channel excavation and/or fill), volume of bank armoring material required, volume of structural concrete required for box culverts, and for land cost. For the partial structural alternative for the Big Spring Area, volume of fill material was determine by average end area calculations for cross-sections taken through the improvement area. Cut and fill estimates for structural improvements for the Twin Buttes Area was determined from the HEC-RAS channel improvement routine. Bank armoring quantities are determined by applying a typical section along the length of the improvement area. A toe-down nominal depth of 5 feet was assumed for all bank armoring quantities. Fill quantities in the floodway fringe area are based on fill being placed to the calculated freeboard elevation.

Costs for two channel bank options are provided. The first option is rock filled gabion mattress bank protection. A nine-inch thick mattress is utilized for reaches in which the average channel velocity is less than 10 fps. A ten-inch thick mattress is

utilized for reaches in which the average channel velocity is greater than 10 fps. The second option is soil cement bank protection.

The total cost for a structural alternative considers the cost of the structural improvements necessary to implement the proposed alternative (a positive cost), the value of land that is reclaimed from the floodplain/erosion hazard zone by the structural improvements (a negative cost, i.e. benefit). Added together, these costs represent the total net cost of the alternative.

Table 11-45 lists a summary of unit cost utilized to determine cost estimates for each alternative. Given the level of design (conceptual) of the proposed alternatives, a cost contingency is applied to account for design details that is not undertaken at this stage. Contingency cost is estimated at 15 percent of the total construction cost of the proposed improvements.

Table 11-45

Summary of Unit Cost

Item	Unit	Cost
Earth Work	Cubic Yards (cy)	$4.00/cy
Soil Cement	Cubic Yards (cy)	$30.00/cy
Gabion Mattress	Cubic Yards (cy)	$100.00/cy
Structural Concrete	Cubic Yards (cy)	$350.00/cy
Land	Acre	$15,000.00/Acre

Results

Table 11-46 through Table 11-64 provides costs estimates for the partial structural alternatives developed for Unnamed Wash 1, 2 and 3 located in the Big Spring Area, the full structural alternative for Twin Buttes Wash, Caterpillar Tank Wash, West Fork White Peaks Wash, White Peaks Wash, East and West Garambullo located in the Twin Buttes Area and for the full structural alternative for Twin Buttes Wash south of 115th Avenue.

Table 11-46

Cost Estimate Partial Structural Alternative Unnamed Wash 1

9" Thick Gabion Mattress Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	34742	cy	$4.00	$138,968
Gabion	7390	cy	$100.00	$739,000
Misc. Work (15%)				$131,695
Total Construction Cost				$1,009,663
Reclaimed Land Value	9	ac	$15,000	-$128,966
Net Cost				$880,697

Table 11-47

Cost Estimate Partial Structural Alternative Unnamed Wash 1

Soil Cement Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	34742	cy	$4.00	$138,968
Soil Cement	38728	cy	$30.00	$1,161,840
Misc. Work (15%)				$195,121
Total Construction Cost				$1,495,929
Reclaimed Land Value	9	ac	$15,000	-$128,966
Net Cost				$1,366,963

Table 11-48

Cost Estimate Partial Structural Alternative Unnamed Wash 2

12" Thick Gabion Mattress Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	60854	cy	$4.00	$243,415
Gabion	12849	cy	$100.00	$1,284,900
Misc. Work (15%)				$229,247
Total Construction Cost				$1,757,562
Reclaimed Land Value	16	ac	$15,000	-$243,000
Net Cost				$1,514,562

Table 11-49

Cost Estimate Partial Structural Alternative Unnamed Wash 2

Soil Cement Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	60854	cy	$4.00	$243,415
Soil Cement	47205	cy	$30.00	$1,416,150
Misc. Work (15%)				$248,935
Total Construction Cost				$1,908,500
Reclaimed Land Value	16	ac	$15,000	-$243,000
Net Cost				$1,665,500

Table 11-50

Cost Estimate Partial Structural Alternative Unnamed Wash 3

9" Thick Gabion Mattress Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	37005	cy	$4.00	$148,021
Gabion	7585	cy	$100.00	$758,500
Misc. Work (15%)				$135,978
Total Construction Cost				$1,042,499
Reclaimed Land Value	16	ac	$15,000	-$244,500
Net Cost				$797,999

Table 11-51

Cost Estimate Partial Structural Alternative Unnamed Wash 3

Soil Cement Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	37005	cy	$4.00	$148,021
Soil Cement	39647	cy	$30.00	$1,189,410
Misc. Work (15%)				$200,615
Total Construction Cost				$1,538,046
Reclaimed Land Value	16	ac	$15,000	-$244,500
Net Cost				$1,293,546

Table 11-52

Cost Estimate Full Structural Alternative Twin Buttes

9" Thick Gabion Mattress Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	993030	cy	$4.00	$3,972,120
Gabion	40072	cy	$100.00	$4,007,200
Structural Concrete	498	cy	$ 350.00	$174,300
Misc. Work (15%)				$1,196,898
Total Construction Cost				$9,350,518
Reclaimed Land Value	243	ac	$15,000	-$3,641,987.84
Net Cost				$5,708,530

Table 11-53

Cost Estimate Full Structural Alternative Twin Buttes

Soil Cement Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	993030	cy	$4.00	$3,972,120
Soil Cement	207084	cy	$30.00	$6,212,520
Structural Concrete	498	cy	$ 350.00	$174,300
Misc. Work (15%)				$1,527,696
Total Construction Cost				$11,886,636
Reclaimed Land Value	243	ac	$15,000	-$3,641,987.84
Net Cost				$8,244,648

Table 11-54

Cost Estimate Full Structural Alternative Caterpillar Tank

9" Thick Gabion Mattress Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	388961	cy	$4.00	$1,555,844
Gabion	15370	cy	$100.00	$1,537,000
Misc. Work (15%)				$463,927
Total Construction Cost				$3,556,771
Reclaimed Land Value	123	ac	$15,000	-$1,847,792
Net Cost				$1,708,979

Table 11-55

Cost Estimate Full Structural Alternative Caterpillar Tank

Soil Cement Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	388961	cy	$4.00	$1,555,844
Soil Cement	76007	cy	$30.00	$2,280,210
Misc. Work (15%)				$575,408
Total Construction Cost				$4,411,462
Reclaimed Land Value	123	ac	$15,000	-$1,847,792
Net Cost				$2,563,670

Table 11-56

Cost Estimate Full Structural Alternative West Fork Whites Peak

9" Thick Gabion Mattress Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	17438	cy	$4.00	$69,752
Gabion	1825	cy	$100.00	$182,500
Misc. Work (15%)				$37,838
Total Construction Cost				$290,090
Reclaimed Land Value	4	ac	$15,000	-$65,466
Net Cost				$224,624

Table 11-57

Cost Estimate Full Structural Alternative West Fork Whites Peak

Soil Cement Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	17438	cy	$4.00	$69,752
Soil Cement	10627	cy	$30.00	$318,810
Misc. Work (15%)				$58,284
Total Construction Cost				$446,846
Reclaimed Land Value	4	ac	$15,000	-$65,466
Net Cost				$381,381

Table 11-58

Cost Estimate Full Structural Alternative Whites Peak

9" Thick Gabion Mattress Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	112541	cy	$4.00	$450,164
Gabion	17746	cy	$100.00	$1,774,600
Misc. Work (15%)				$333,715
Total Construction Cost				$2,558,479
Reclaimed Land Value	35	ac	$15,000	-$528,367
Net Cost				$2,030,112

Table 11-59

Cost Estimate Full Structural Alternative Whites Peak

Soil Cement Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	112541	cy	$4.00	$450,164
Soil Cement	91504	cy	$30.00	$2,745,120
Misc. Work (15%)				$479,293
Total Construction Cost				$3,674,577
Reclaimed Land Value	35	ac	$15,000	-$528,367
Net Cost				$3,146,210

Table 11-60

Cost Estimate Full Structural Alternative East Garambullo

9" Thick Gabion Mattress Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	63169	cy	$4.00	$252,676
Gabion	4411	cy	$100.00	$441,100
Misc. Work (15%)				$104,066
Total Construction Cost				$797,842
Reclaimed Land Value	14	ac	$15,000	-$211,467
Net Cost				$586,375

Table 11-61

Cost Estimate Full Structural Alternative East Garambullo

Soil Cement Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	63169	cy	$4.00	$252,676
Soil Cement	22632	cy	$30.00	$678,960
Misc. Work (15%)				$139,745
Total Construction Cost				$1,071,381
Reclaimed Land Value	14	ac	$15,000	-$211,467
Net Cost				$859,914

Table 11-62

Cost Estimate Full Structural Alternative West Garambullo

9" Thick Gabion Mattress Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	89126	cy	$4.00	$356,504
Gabion	5123	cy	$100.00	$512,300
Misc. Work (15%)				$130,321
Total Construction Cost				$999,125
Reclaimed Land Value	21	ac	$15,000	-$311,671
Net Cost				$687,454

Table 11-63

Cost Estimate Full Structural Alternative West Garambullo

Soil Cement Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	89126	cy	$4.00	$356,504
Soil Cement	25944	cy	$30.00	$778,320
Misc. Work (15%)				$170,224
Total Construction Cost				$1,305,048
Reclaimed Land Value	21	ac	$15,000	-$311,671
Net Cost				$993,377

Table 11-64

Cost Estimate Full Structural Alternative Twin Buttes South of 115 Ave.

9" Thick Gabion Mattress Option

Item	Quantity	Unit	Unit Cost	Total
Earthwork	92282	cy	$4.00	$369,128
Gabion	6564	cy	$100.00	$656,400
Structural Concrete	2098	cy	$ 350.00	$734,300
Misc. Work (15%)				$263,974
Total Construction Cost				$2,023,802
Reclaimed Land Value	49	ac	$15,000	-$735,000
Net Cost				$1,288,802

11.3.3.2 Storm Water Storage Alternative

Purpose

Both Maricopa County and the City of Peoria require retention/detention for all new developments. The goal of this requirement is to reduce/minimize the impacts of the increased runoff due to development in the watershed. Ideally, this is accomplished by controlling the post-development runoff such that it is equivalent in magnitude, duration and temporal distribution to the pre-development conditions. To achieve this goal both Maricopa County and the City of Peoria (Peoria) use the 100-year, 2-hour storm as the design event for sizing retention/detention facilities.

Traditionally, retention has been accomplished by storing the 100-year, 2-hour runoff volume in below grade basins. These basins typically are drained by percolation into the soil and/or a small outlet structure connected to a watercourse often times via an extensive storm drain system. The effectiveness of this type of facility, both economically and hydraulically, is a function of the soil and terrain characteristics. Shallow soils with low permeability rates and/or soils that occur on steep slopes are not conducive to this particular application.

Inspection of the soil survey for this study area shows that the majority of the study area (38.6 sq. miles) is composed of 5 soil types. These soil types are identified in the Soil Survey of Aguila-Carefree Area, Parts of Maricopa and Pinal Counties, Arizona (NRCS 1986) as map units 31, 51, 52, 109 and 110. The aerial extent and distribution of these soil types within the watershed is shown on Plate 2 of the North Peoria Area Drainage Master Plan, Attachment 2, Hydrology and Hydraulics. According to the soil survey report, these soils are generally characterized by the following:

- Moderate to moderately slow permeability;
- Low to very low available water capacity;
- Shallow depth to bed rock or hard pan, typically less than 2 feet; and

Additionally, these soils typically occur on steep slopes. The steep terrain associated with these soils combined with the shallow depth to bedrock results in physical conditions that are not suitable to the traditional technique for providing retention. As a result, the retention/detention requirement for development sites with these characteristics has, in the past, often been waived. The allowance for a waiver is even stipulated in Peoria's Grading and Drainage ordinance. However, the presence of such physical characteristics does not mean that alternative methods of retention/detention should not be investigated or required. This is particularly true for this study area given the amount of area that meets the stipulations of the retention/detention waiver. Therefore, two alternative methods for reducing or decreasing the effects of increased runoff due to development are proposed for this study area. These methods are in-stream, off-line retention and in-stream, in-line detention.

Methodology

General

Verification of the feasibility of off-line retention and in-line detention basins to reduce the magnitude of post-development runoff to that of pre-development conditions for this study area is tested on the sub-watersheds contributing runoff to

Unnamed Washes 1, 2 and 3. These sub-watersheds are selected because the physical characteristics of the area meet the conditions for obtaining a retention waiver and because of the detailed mapping prepared for these watercourses as part of this study.

Modeling of both the off-line retention and in-line detention basins for these watercourses was accomplished using the unsteady flow module of the Corps of Engineers (COE) HEC-RAS Computer Program, version 3.0, dated January 2001. Initially, 100-year existing condition unsteady flow models for these watercourses were developed from the steady flow hydraulic models developed as part of the floodplain delineation phase of this study. The base unsteady flow models were edited as necessary to improve computational stability and then checked against the floodplain delineation models for reasonableness. The effectiveness of off-line retention and on-line detention basins is tested for post-development conditions for both the 100- and 10-year events. The 10-year event is considered to be an operational lower limit and is used to test the effectiveness of the facilities for multiple storm frequencies. The off-line basin is modeled using the lateral weir and storage basin options. Modeling of percolation in the basin is not an option currently available in the model, therefore the basin is drained via a bleed-off pipe simulated by the hydraulic connection option. The in-line basins are model using the culvert option. Selection of suitable locations for these facilities is based on topography with additional consideration given to site accessibility, proposed roadway crossings and proximity to proposed development boundaries.

Hydrology

Hydrologic data required as input to the unsteady flow module of HEC-RAS consists of upstream and downstream boundary conditions and initial starting conditions. The initial conditions required are flow, stage and storage basin elevations at the beginning of the unsteady flow simulation. The initial stage at each cross-section is computed at run time. Prior to the start of the unsteady flow calculations a backwater analysis is performed for the initial flow to compute water surface elevations at each cross-section at the beginning of the simulation. The initial flow value must be of

sufficient magnitude to produce a stable backwater profile and is a function of the hydraulic characteristics of each watercourse. An initial flow value that is too small will result in computational error. The initial flow values for Unnamed Washes 1, 2 and 3 are 85, 90 and 100 cfs, respectively. The initial storage elevation only applies to the off-line retention basins. This value is set at the minimum elevation of the basin.

HEC-RAS has several options for establishing both the upstream and downstream boundary conditions. For this study, the flow hydrograph option is specified for the upstream boundary condition and the normal depth option is specified for the downstream boundary condition for all three watercourses. The normal depth option requires the input of the friction slope at the downstream boundary. For Unnamed Washes 2 and 3 the values entered are the average slope of the energy grade line used in the floodplain delineation models for these watercourses. Those values are 1.05 and 1.34 percent for Unnamed Washes 2 and 3, respectively. Unnamed Wash 1 is a tributary of Unnamed Wash 2. For the floodplain delineation study, a known water surface elevation is used as the downstream boundary condition. For this analysis, the average bed slope of 0.5 percent at the confluence is entered for the friction slope.

Inflow hydrographs input as the upstream boundary condition for each watercourse are taken from the HEC-1 models developed for this study. Because of the size of the watershed, both the 6- and 24-hour storm durations are modeled. The results of the controlling storm duration are then used as input to the hydraulic models. The controlling storm for Unnamed Washes 1 and 3 is the 6-hour. For Unnamed Wash 2, the controlling storm is the 24-hour. The computational time interval for all the HEC-1 models is 2 minutes. A detailed discussion on the determination of the computational interval for watershed modeling purposes, as well as for all input data to the watershed model and model results is provided in the North Peoria Area Drainage Master Plan Technical Data Notebook, Attachment 2, Hydrology and Hydraulics. For hydraulic modeling purposes, a hydrologic time interval of 10 minutes was selected. A 10-minute time interval was selected to reduce model run time without sacrificing definition of the runoff hydrograph. The starting time

ordinate of this simplified hydrograph was carefully selected in order to reproduce the overall shape of the HEC-1 runoff hydrograph, particularly the definition of the hydrograph peak. Discharge values on the rising and receding limbs of the hydrograph that are less than the initial flow value determined for each watercourse are truncated. The resulting hydrograph input as the upstream boundary condition into HEC-RAS for the 100-year pre-development condition check model along with the corresponding runoff hydrograph from HEC-1 are shown in Figures 11-8 through 11-10 for Unnamed Washes 1, 2 and 3, respectively. Similar hydrographs for the 100- and 10- year post-development condition models are provided in Appendix G.

Figure 11-8

100-Year Pre-development Condition Upstream Boundary Condition for Unnamed Wash 1

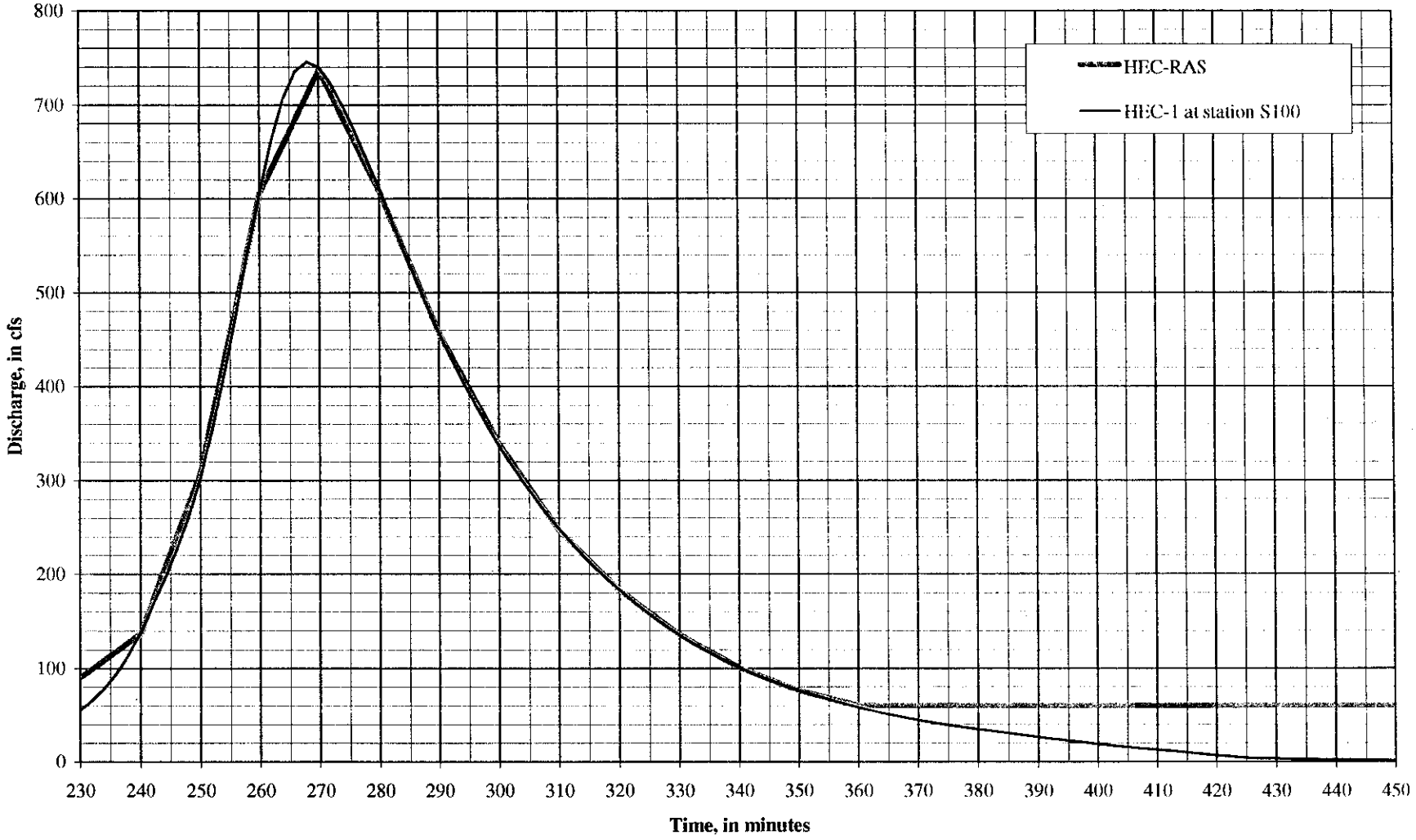


Figure 11-9

100-Year Pre-development Condition Boundary Condition for Unnamed Wash 2

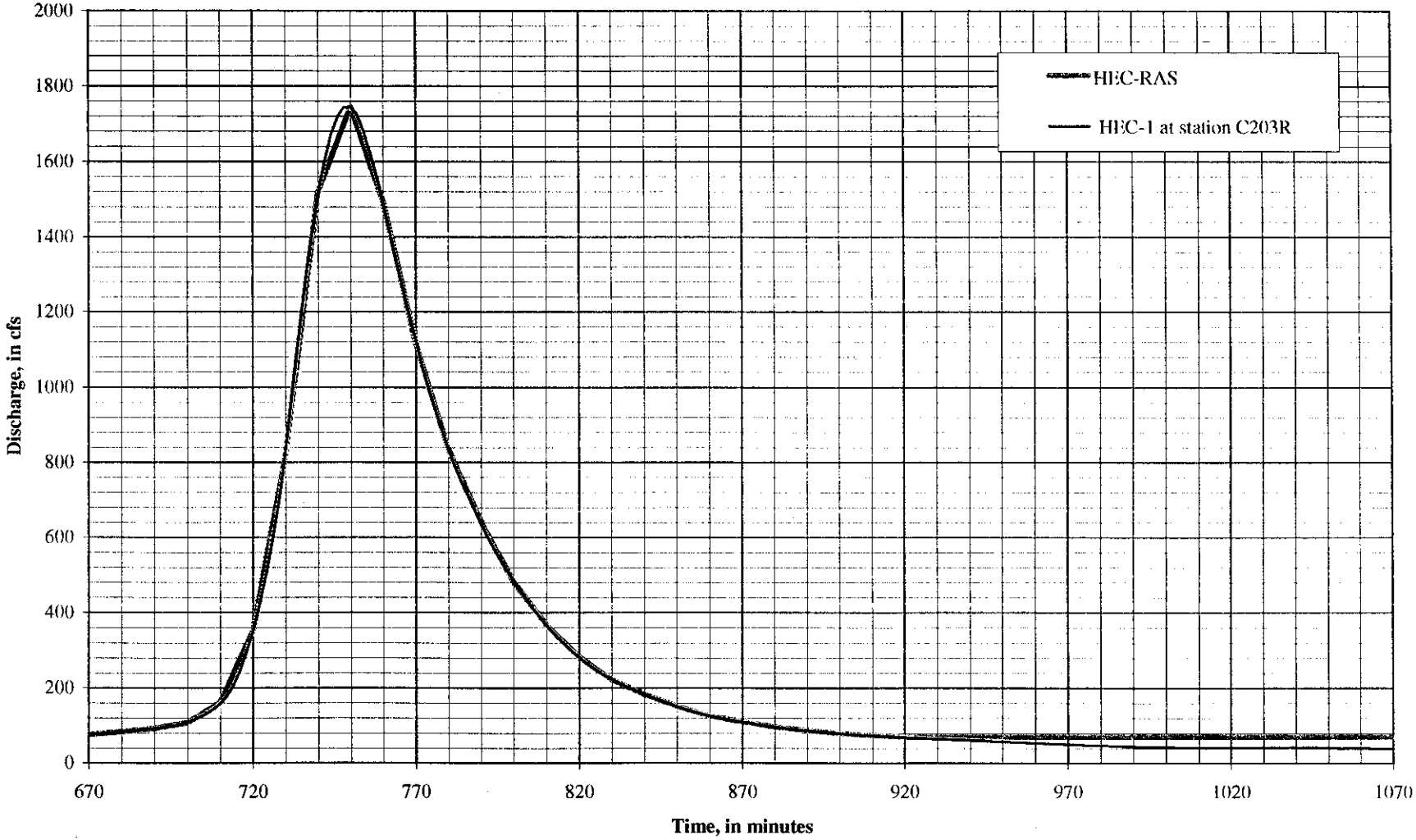
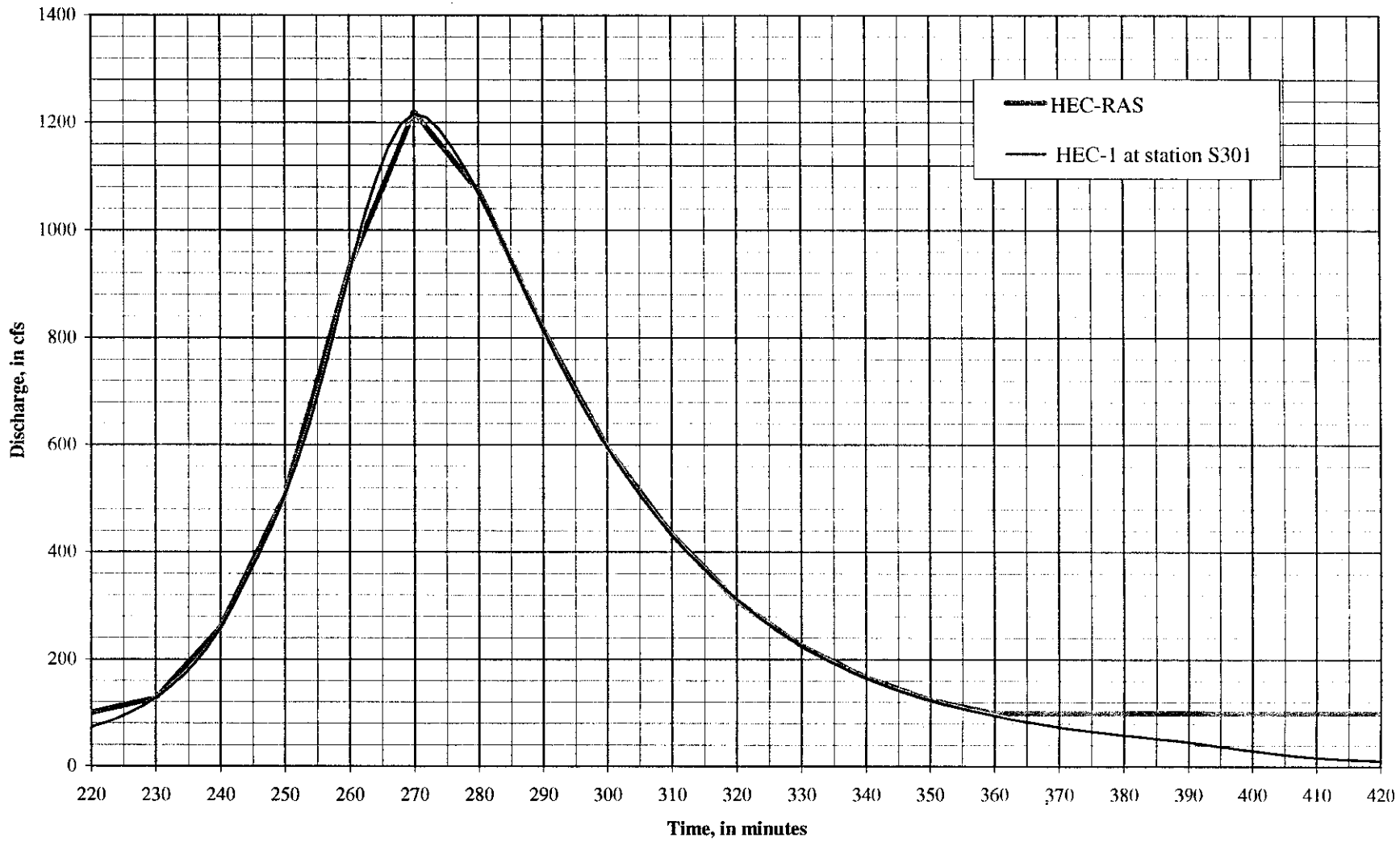


Figure 11-10

100-Year Pre-development Condition Boundary Condition for Unnamed Wash 3



In addition to inflow at the upstream boundary, tributary inflow to each watercourse is input to the model at each flow change location used in the floodplain delineation study. This is accomplished using the lateral inflow option of the unsteady flow module. In HEC-RAS, the lateral inflow hydrograph is input at the first cross-section upstream of the actual flow change location. The lateral inflow hydrograph is then combined with the routed main stem hydrograph from the same cross-section. Because of the use of the area reduction option in the watershed model, and to some degree the differences in routing techniques between HEC-RAS and HEC-1, the lateral inflow hydrograph from the HEC-1 model cannot be directly input to the HEC-RAS model. Reproduction of the actual runoff hydrograph at each flow change location is an iterative process. First, the runoff hydrographs from HEC-1 at each flow change location are simplified to a 10-minute time interval using the same procedure as used for the upstream boundary condition. The lateral inflow hydrograph is initially determined by subtracting the routed main-stem hydrograph at the cross-section immediately upstream of the flow change location from the simplified runoff hydrograph. The subtracted hydrograph is input to the model at the cross-section immediately upstream of the flow change location and the model is executed. The resulting combined hydrograph at the flow change location is then compared to the actual runoff hydrograph. If necessary, the inflow hydrograph is adjusted until the combined hydrograph in HEC-RAS matches the actual runoff hydrograph as closely as possible. The final 100-year pre-development condition input hydrographs and resulting combined main-stem hydrographs are summarized for each flow change location, for each watercourse in Tables 11-65 through 11-67 for Unnamed Washes 1, 2 and 3, respectively. The combined main-stem hydrographs for each of these locations are shown along with the corresponding runoff hydrographs from HEC-1 in Figures 11-11 through 11-13. Similar hydrographs for the 100- and 10- year future condition models are provided in Appendix G.

Table 11-65

Summary of 100-Year, 6-Hour Pre-development Condition Unsteady Flow Modeling Hydrographs for Unnamed Wash 1

HEC-1 Time Ordinate min	HEC-RAS Time Increment min	Input Hydrographs[1] 6.311 cfs	5.917 cfs	4.628 cfs	3.073 cfs	2.047 cfs	Combined Hydrographs[2] 6.311 (S100) cfs	5.862 (C102R) cfs	4.613 (C103R) cfs	3.015 (C104) cfs	1.286 (C105L) cfs
230	0	90	0	0	0	0	90	88	85	85	85
240	10	138	269	234	58	0	137	297	227	148	85
250	20	303	544	436	259	229	309	621	560	353	201
260	30	606	100	824	645	451	606	1075	1209	717	433
270	40	740	525	1250	1116	477	737	1180	1819	1581	835
280	50	611	478	1310	1080	301	608	1144	2227	2464	1498
290	60	457	425	1125	800	444	457	941	2343	2843	2690
300	70	337	550	1064	524	300	339	702	2123	2875	3153
310	80	248	247	908	320	262	247	534	1795	2577	3158
320	90	183	150	740	176	186	183	406	1435	2176	2843
330	100	135	69	566	105	160	136	285	1093	1766	2433
340	110	101	50	462	66	136	101	221	841	1418	2024
350	120	76	35	352	54	115	76	161	627	1115	1663
360	130	60	38	288	60	98	60	124	491	894	1351
370	140	60	20	225	59	90	60	89	387	711	1106
380	150	60	7	186	71	85	60	72	314	579	916
390	160	60	0	138	59	89	60	62	232	468	765
400	170	60	0	87	40	93	60	61	207	387	651

Table 11-65 (Continued)

Summary of 100-Year, 6-Hour Pre-development Condition Unsteady Flow Modeling Hydrographs for Unnamed Wash 1

HEC-1 Time Ordinate min	HEC-RAS Time Increment min	Input Hydrographs[1] 6.311 cfs	5.917 Cfs	4.628 cfs	3.073 cfs	2.047 cfs	Combined Hydrographs[2] 6.311 (S100) cfs	5.862 (C102R) cfs	4.613 (C103R) cfs	3.015 (C104) cfs	1.286 (C105L) cfs
410	180	60	0	123	47	57	60	60	160	308	532
420	190	60	0	18	34	44	60	60	128	250	435
430	200	60	0	42	40	6	60	60	100	231	340
440	210	60	0	20	44	10	60	60	77	163	273
450	220	60	0	10	3	0	60	60	70	123	248

Notes:

1. Input hydrographs at river mile 5.917, 4.628, 3.073 and 2.047 represent the hydrograph that is necessary to produce a combined discharge similar to what is computed in the HEC-1 model for the corresponding concentration points.
2. Total runoff in the watercourse at each location corresponding to HEC-1 concentration points.

Table 11-66

Summary of 100-Year, 24-Hour Pre-development Condition Unsteady Flow Modeling Hydrographs for Unnamed Wash 2

HEC-1 Time Ordinate min	HEC-RAS Time Increment min	Input Hydrographs[1] 6.789 cfs	6.218 cfs	5.974 cfs	4.974 cfs	2.656 cfs	1.677 cfs	0.309 cfs	Combined Hydrographs[2] 6.789 (C203R) cfs	6.161 (C204) cfs	5.927 (C205L) cfs	4.939 (C206) cfs	2.625 (C207R) cfs	1.629 (C105L) cfs	0.252 (C105) cfs
670	400	77	54	15	42	28	1	54	77	123	132	157	163	151	193
680	410	84	60	18	43	29	1	58	84	134	146	167	170	159	202
690	420	93	66	19	40	33	4	63	93	147	160	177	181	169	216
700	430	109	90	18	48	46	12	81	109	181	180	196	201	187	240
710	440	158	154	7	71	83	38	134	162	259	228	231	250	233	304
720	450	354	347	0	99	199	143	307	354	533	403	286	369	376	486
730	460	833	882	0	56	470	517	901	824	1330	1073	397	643	820	1053
740	470	1515	1295	0	0	787	821	1353	1520	2418	2123	1126	996	1436	1911
750	480	1746	1290	251	0	1237	940	1480	1746	2910	3063	2313	1503	1979	2810
760	490	1487	912	739	0	1334	829	1882	1492	2560	3361	3187	2157	2394	3819
770	500	1120	623	756	767	1027	447	3326	1114	1959	2878	3974	3540	3096	5534
780	510	834	475	679	1734	1282	491	3875	834	1480	2282	4405	4591	4421	7112
790	520	637	360	565	1671	480	117	2637	641	1131	1801	3891	4265	4634	7198
800	530	484	281	489	1459	0	0	1734	482	874	1439	3248	4062	4214	6348
810	540	367	201	424	1276	0	0	1013	367	662	1149	2698	3877	4097	5332
820	550	281	169	326	1150	0	0	313	283	522	895	2280	3338	3697	4460
830	560	222	133	247	1020	0	0	27	221	408	695	1922	2751	3130	3717
840	570	183	113	209	922	0	0	0	183	330	563	1630	2299	2611	3114

Table 11-66 (Continued)

Summary of 100-Year, 24-Hour Pre-development Condition Unsteady Flow Modeling Hydrographs for Unnamed Wash 2

HEC-1 Time Ordinate min	HEC-RAS Time Increment min	Input Hydrographs[1]							Combined Hydrographs[2]						
		6.789 cfs	6.218 cfs	5.974 cfs	4.974 cfs	2.656 cfs	1.677 cfs	0.309 cfs	6.789 (C203R) cfs	6.161 (C204) cfs	5.927 (C205L) cfs	4.939 (C206) cfs	2.625 (C207R) cfs	1.629 (C105L) cfs	0.252 (C105) cfs
850	580	151	91	166	662	0	0	0	152	273	464	1273	1959	2199	2624
860	590	126	74	142	457	0	0	0	126	224	389	965	1650	1888	2208
870	600	110	66	119	384	0	0	0	110	192	326	802	1300	1584	1898
880	610	97	52	101	323	0	0	0	97	163	280	677	1008	1263	1602
890	620	87	44	89	281	0	0	0	87	144	244	584	828	986	1290
900	630	80	37	77	239	0	0	0	80	128	212	503	699	822	1045
910	640	74	33	63	203	0	0	0	74	116	186	435	626	704	855
920	650	70	32	55	185	0	0	2	70	108	168	387	552	631	751
930	660	70	30	48	159	0	0	2	70	102	154	343	476	557	661
940	670	70	26	44	136	0	0	0	70	96	143	304	429	483	586
950	680	70	21	39	116	0	0	0	70	91	133	271	388	436	512
960	690	70	16	37	104	0	0	0	70	85	125	246	346	396	461
970	700	70	11	34	97	0	0	0	70	80	117	230	305	360	417
980	710	70	7	29	87	0	0	0	70	76	109	212	271	315	385
990	720	70	2	26	78	0	0	0	70	73	102	196	251	281	345
1000	730	70	0	22	72	0	0	12	70	70	95	181	235	257	316
1010	740	70	0	17	67	0	0	20	70	70	88	169	221	243	294
1020	750	70	0	13	62	0	0	19	70	70	84	157	205	227	273

Table 11-66 (Continued)

Summary of 100-Year, 24-Hour Pre-development Condition Unsteady Flow Modeling Hydrographs for Unnamed Wash 2

HEC-1 Time Ordinate min	HEC-RAS Time Increment min	Input Hydrographs[1] 6.789 cfs	6.218 cfs	5.974 cfs	4.974 cfs	2.656 cfs	1.677 cfs	0.309 cfs	Combined Hydrographs[2] 6.789 (C203R) cfs	6.161 (C204) cfs	5.927 (C205L) cfs	4.939 (C206) cfs	2.625 (C207R) cfs	1.629 (C105L) cfs	0.252 (C105) cfs
1030	760	70	0	13	57	0	0	15	70	70	83	146	191	211	255
1040	770	70	0	13	53	0	0	12	70	70	83	138	174	198	237
1050	780	70	0	13	46	0	0	11	70	70	83	130	161	184	221
1060	790	70	0	9	40	0	0	11	70	70	80	124	146	168	209
1070	800	70	0	9	40	0	0	14	70	70	79	122	141	156	198

Notes:

1. Input hydrographs at river miles 6.218, 5.974, 4.974, 2.656, 1.677 and 0.309 represent the hydrograph that is necessary to produce a combined discharge similar to what is computed in the HEC-1 model for the corresponding concentration points.
2. Total runoff in the watercourse at each location corresponding to HEC-1 concentration points.

Table 11-67

Summary of 100-Year, 6-Hour Pre-development Condition Unsteady Flow Modeling Hydrographs for Unnamed Wash 3

HEC-1 Time Ordinate min	HEC-RAS Time Increment min	Input Hydrographs[1] 4.540 cfs	4.219 cfs	3.193 cfs	1.690 cfs	Combined Hydrographs[2] 4.540 (S301) cfs	4.197 (C301) cfs	3.168 (C302) cfs	1.641 (C303) cfs
210	0	100	100	0	0	100	200	200	200
220	10	100	100	0	0	100	200	200	200
230	20	125	100	0	0	128	211	200	200
240	30	260	150	50	0	260	344	250	200
250	40	510	330	200	150	505	729	472	331
260	50	925	600	320	500	931	1389	981	587
270	60	1220	760	335	1000	1220	1887	1664	1430
280	70	1070	865	170	1125	1073	1976	2078	2204
290	80	820	840	265	750	816	1735	2229	2523
300	90	595	675	400	420	595	1351	2111	2558
310	100	430	540	460	80	433	1040	1814	2331
320	110	310	425	310	0	308	786	1393	2021
330	120	225	325	150	0	225	590	981	1712
340	130	165	255	125	0	166	453	759	1339
350	140	125	200	115	0	125	347	598	909
360	150	100	160	75	0	100	275	450	726
370	160	100	120	60	0	100	221	354	587
380	170	100	100	50	0	100	200	287	430

Table 11-67 (Continued)

Summary of 100-Year, 6-Hour Pre-development Condition Unsteady Flow Modeling Hydrographs for Unnamed Wash 3

HEC-1 Time Ordinate min	HEC-RAS Time Increment min	Input Hydrographs[1] 4.540 cfs	4.219 cfs	3.193 cfs	1.690 cfs	Combined Hydrographs[2] 4.540 (S301) cfs	4.197 (C301) cfs	3.168 (C302) cfs	1.641 (C303) cfs
390	180	100	100	0	0	100	200	210	388
400	190	100	100	0	0	100	200	200	299
410	200	100	100	0	0	100	200	200	237
420	210	100	100	0	0	100	200	200	203
430	220	100	100	0	0	100	200	200	200

Notes:

1. Input hydrographs at river miles 4.219, 3.193 and 1.690 represent the hydrograph that is necessary to produce a combined discharge similar to what is computed in the HEC-1 model at the same location.
2. Total runoff in the watercourse at each location corresponding to HEC-1 concentration points.

Figure 11-11

100-Year Pre-development Condition Main Stem Hydrographs for Unnamed Wash 1

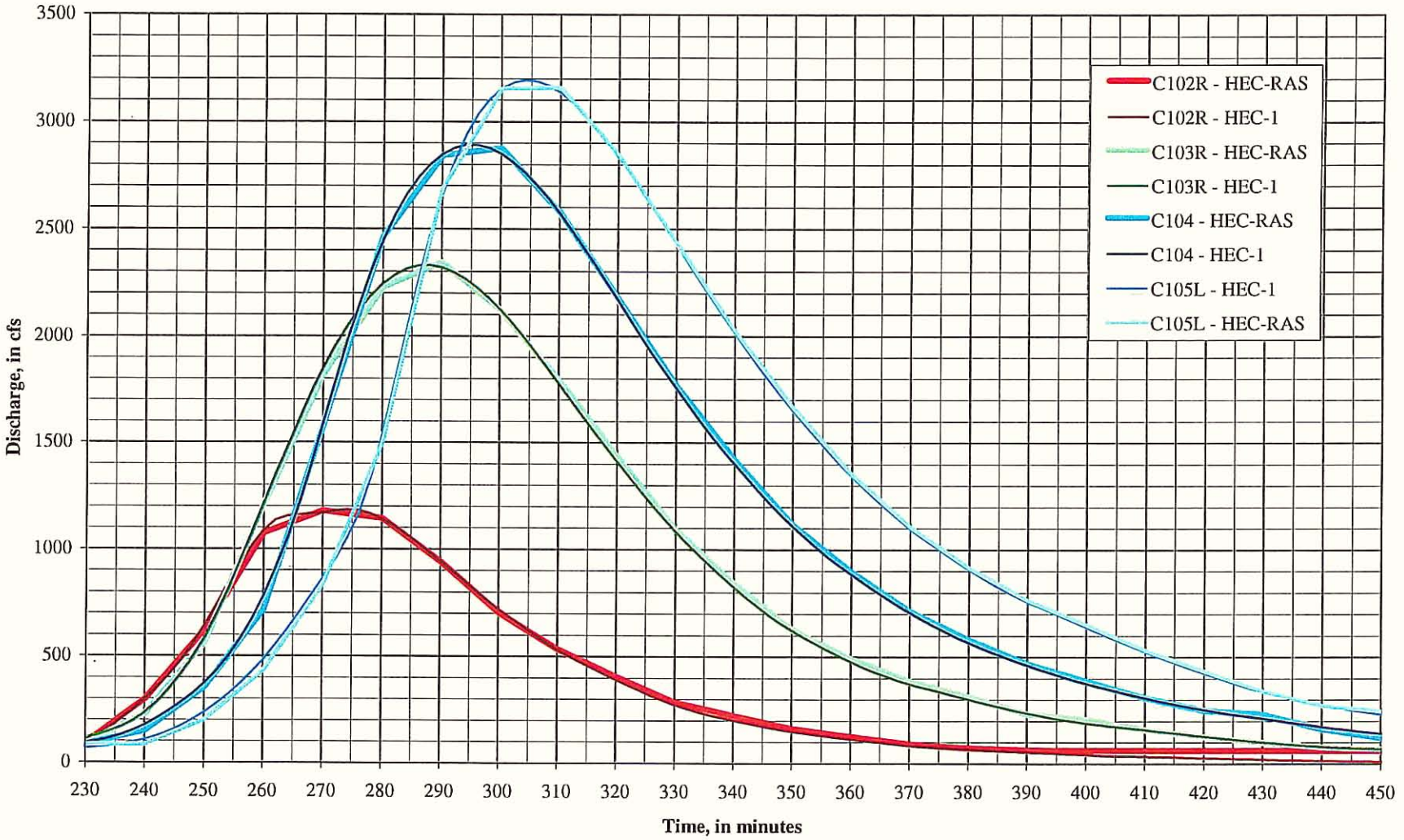


Figure 11-12

100-Year Pre-development Condition Main Stem Hydrographs for Unnamed Wash 2

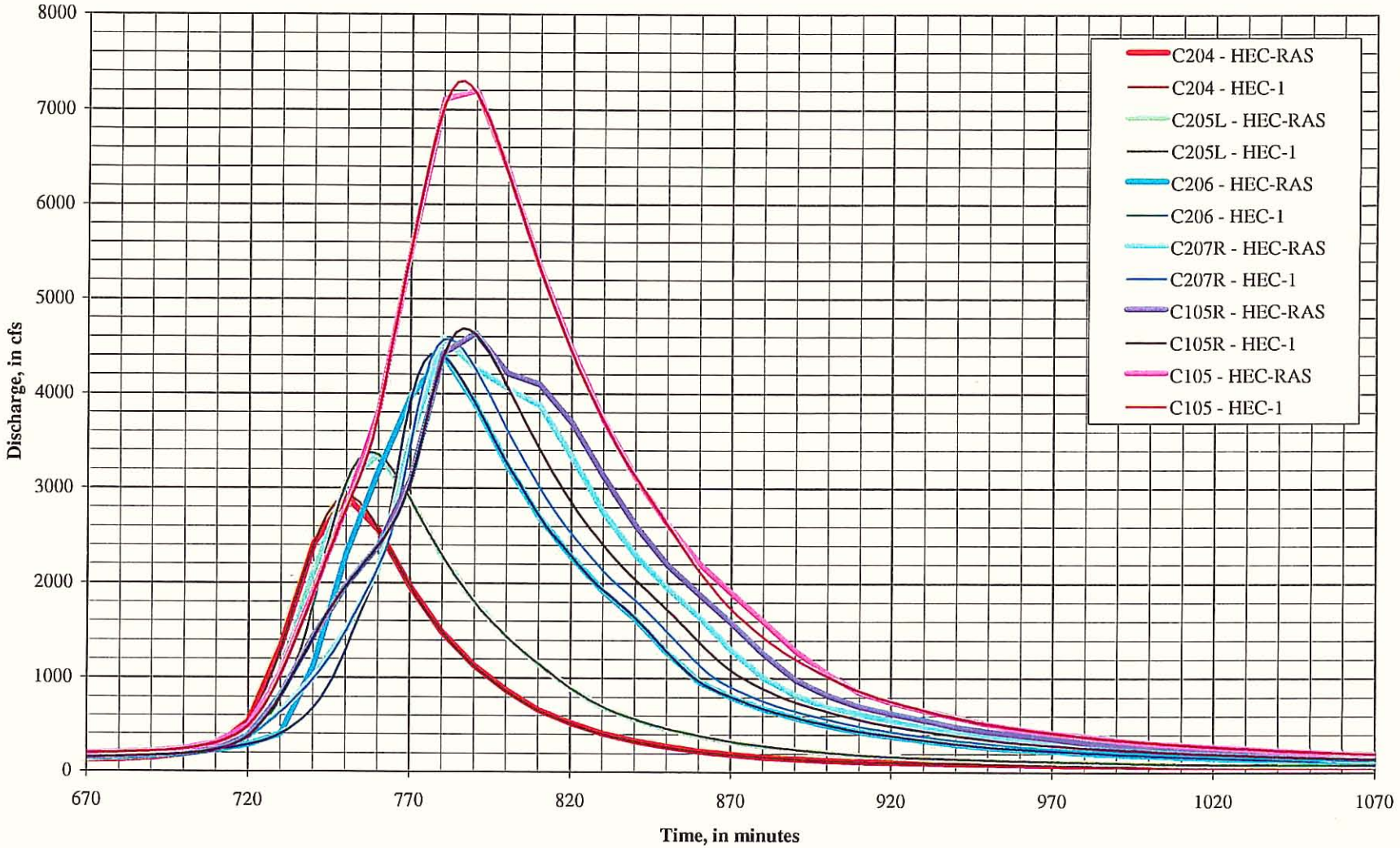
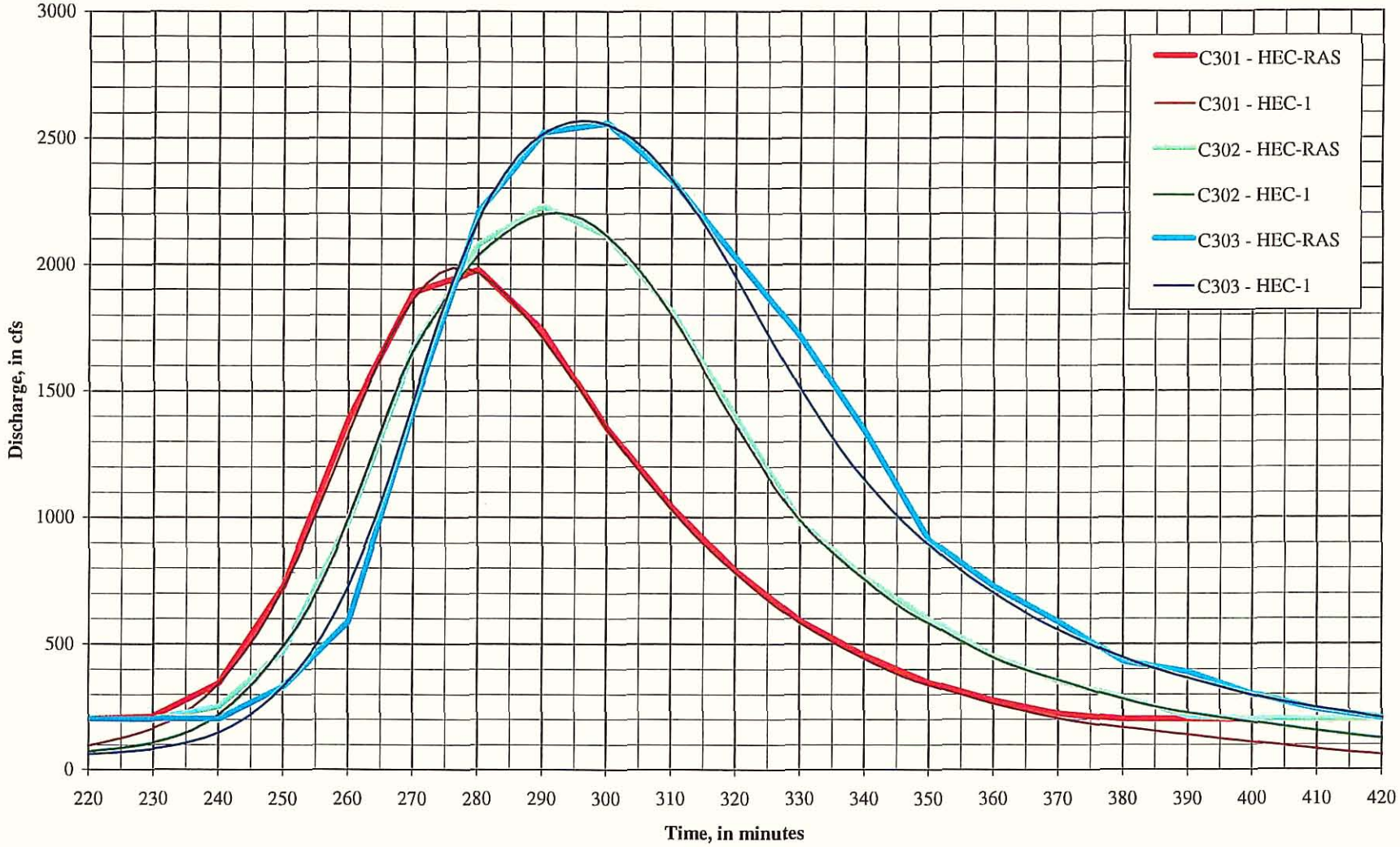


Figure 11-13

100-Year Pre-development Condition Main Stem Hydrographs for Unnamed Wash 3



Geometry

Geometric data for the unsteady flow analysis was taken from the hydraulic models developed for floodplain delineation purposes. That data includes cross-sectional geometry, Manning's roughness estimations and reach lengths. Where necessary this data was modified, with the exception of the Manning's roughness estimates, to improve model stability.

The unsteady flow module of HEC-RAS is designed for gradually varied flow conditions. Rapid changes in cross-sectional area and/or channel bed slope can cause computational instabilities. Additionally, this module is also designed for subcritical flow conditions. All three watercourses have numerous rapid changes in cross-sectional area and channel bed slope. All three watercourses also frequently oscillate between subcritical and supercritical flow conditions. These hydraulic conditions resulted in numerous locations of computational instability and run-time errors. The process of eliminating these errors and computational instabilities involved the addition/deletion of modeling cross-sections, levees and/or ineffective flow areas. This process was to a certain extent iterative as the addition/deletion of modeling cross-sections, in particular, often caused problems at other locations within the reach.

For Unnamed Washes 1 and 2, it was necessary to delete long reaches of modeling cross-sections due to the physical and hydraulic characteristics of the reaches. These reaches can be described as deeply incised trapezoidal channels with steep bed slopes and numerous natural grade control breaks. Consequently, the hydraulic characteristics of these reaches were such that no amount of additional cross-sections would resolve the instability problems. Deletion of the cross-sections in these reaches is, therefore, required and is considered reasonable given that the physical characteristics limited in-stream retention/detention opportunities. Therefore, these reaches serve only as a conduit for routing flows down to the Agua Fria River. For Unnamed Wash 3 a combination of cross-sectional additions and deletions were made to improve model stability.

The addition of levees and ineffective flow was used as a means for improving model stability for all three watercourses. Levees or ineffective flow areas were strategically located at certain cross-sections to eliminate rapid changes in top width, wetted perimeter, and flow area due to changes in discharge with time. Levees, in particular, were used restrict flow to the main channel and out of overbank channels until the flow overtopped the channel banks.

Computational Parameters

The computational settings required are the computation interval, hydrograph output interval, and the detailed output interval. The HEC-RAS models are run with a computation interval of 30 seconds for Unnamed Wash 2 and 20 seconds for Unnamed Washes 1 and 3. These intervals are the maximum time interval for which computational stability could be achieved. The hydrograph output interval and the detailed output interval are both set to 10 minutes.

The only calculation option that is adjusted from the default values is the theta implicit weighting factor. This factor is used in the finite difference solution of the unsteady flow equations and is directly related to the stability and accuracy of the model. The default value of 1.0 provides the most stability in the solution while a value of 0.6 provides the most accurate solution of the equations. This factor is adjusted for each model to the most accurate value that can be obtained without the occurrence of instabilities.

Base Model Comparison

The 100-year existing unsteady flow model for each watercourse is compared to the corresponding floodplain delineation model for reasonableness. The specific results used for the comparison are the water surface elevation and the channel velocity and those values for both the steady and unsteady flow models are summarized in Tables 11-68 through 11-70 for Unnamed Washes 1, 2 and 3, respectively. The results of the unsteady flow model are taken from the maximum water surface profile. The maximum water surface profile is the representation of the hydraulic conditions that

produced the maximum stage at each cross-section during the entire simulation and does not necessarily represent a specific instance in time.

Table 11-68

Pre-development Unsteady Flow Model Comparison for Unnamed Wash 1

River	Water Surface Elevation			Channel Velocity		
Station	Unsteady	Steady	Difference	Unsteady	Steady	Difference
miles	feet	feet	feet	fps	fps	fps
6.311	1797.1	1797.3	-0.2	9.9	9.1	0.8
6.216	1791.7	1789.9	1.8	1.5	6.2	-4.7
6.100	1781.4	1780.4	1.0	8.4	8.4	0.0
6.015	1771.4	1771.0	0.4	11.7	8.5	3.2
5.969	1768.8	1768.4	0.4	4.4	4.4	0.0
5.917	1766.3	1765.2	1.1	5.8	8.4	-2.6
5.862	1759.9	1760.1	-0.2	10.7	9.3	1.4
5.746	1752.7	1751.9	0.8	4.6	6.4	-1.8
5.632	1745.5	1745.9	-0.4	9.8	8.0	1.8
5.505	1739.9	1737.6	2.3	4.6	8.5	-3.9
5.439	1730.7	1731.4	-0.7	12.8	9.5	3.3
5.380	1725.9	1725.7	0.2	5.7	5.8	-0.1
5.310	1720.7	1720.7	0.0	10.2	9.7	0.5
5.227	1716.0	1715.8	0.2	6.6	7.0	-0.4
5.207	1715.5	1715.3	0.2	5.2	5.4	-0.2
5.176	1712.8	1712.9	-0.1	10.7	10.0	0.7
5.096	1707.1	1707.1	0.0	8.5	8.4	0.1
5.007	1702.9	1702.8	0.1	8.2	8.3	-0.1
4.920	1698.2	1698.2	0.0	9.0	9.0	0.0
4.879	1696.7	1696.8	-0.1	6.6	6.0	0.6
4.839	1695.3	1694.8	0.5	6.9	8.1	-1.2
4.725	1687.5	1687.6	-0.1	9.4	8.5	0.9
4.628	1683.2	1681.8	1.4	2.8	3.8	-1.0
4.613	1682.8	1680.8	2.0	5.3	8.1	-2.8
4.536	1675.4	1676.2	-0.8	14.4	11.4	3.0
4.436	---	1669.7	---	---	9.5	---
4.412	1666.7	1666.7	0.0	7.7	7.5	0.2
4.361	1663.7	1663.6	0.1	9.9	10.0	-0.1
4.256	1658.9	1659.0	-0.1	8.2	7.9	0.3
4.170	1654.1	1654.0	0.1	10.8	11.0	-0.2

Table 11-68 (Continued)

Pre-development Unsteady Flow Model Comparison for Unnamed Wash 1

River	Water Surface Elevation			Channel Velocity		
Station	Unsteady	Steady	Difference	Unsteady	Steady	Difference
miles	feet	feet	feet	fps	fps	fps
4.077	1649.6	1649.7	-0.1	9.0	8.3	0.7
3.987	1645.3	1645.1	0.2	9.3	10.0	-0.7
3.895	1642.5	1642.9	-0.4	6.4	5.7	0.7
3.803	1640.9	1642.1	-1.2	5.4	4.3	1.1
3.706	1634.1	1642.1	-8.0	9.2	1.5	7.7
3.671	1632.8	1642.1	-9.3	4.0	0.9	3.1
3.643	1629.4	1642.1	-12.7	8.8	0.7	8.1
3.631			Inline Weir			
3.617	1626.2	1626.2	0.0	7.6	7.6	0.0
3.577	1624.0	1623.6	0.4	7.2	8.1	-0.9
3.515	1619.3	1619.6	-0.3	11.6	10.4	1.2
3.453	1616.6	1616.2	0.4	7.1	7.9	-0.8
3.366	1611.3	1611.3	0.0	10.6	10.6	0.0
3.274	1604.6	1604.7	-0.1	10.7	10.3	0.4
3.186	1601.5	1601.1	0.4	7.5	8.5	-1.0
3.121	1597.8	1597.8	0.0	7.5	7.4	0.1
3.073	1594.2	1594.1	0.1	6.2	6.4	-0.2
3.015	1588.4	1588.4	0.0	9.4	9.4	0.0
2.923	1581.9	1581.8	0.1	8.5	8.7	-0.2
2.880	1577.8	1577.9	-0.1	10.6	10.6	0.0
2.848	1574.8	1574.8	0.0	9.4	9.5	-0.1
2.813	1571.4	1571.4	0.0	10.5	10.5	0.0
2.770	1568.9	1568.7	0.2	8.2	8.5	-0.3
2.674	1561.7	1561.8	-0.1	9.7	9.6	0.1
2.611	1555.7	1555.7	0.0	10.6	10.7	-0.1
2.557	1550.6	1550.6	0.0	10.9	10.9	0.0
2.467	1545.5	1545.4	0.1	7.6	7.9	-0.3
2.390	1540.0	1539.9	0.1	7.9	8.0	-0.1
2.347	1537.1	1537.1	0.0	6.2	6.2	0.0
2.312	1533.6	1533.5	0.1	9.6	9.7	-0.1
2.230	1528.3	1527.8	0.5	5.7	6.4	-0.7
2.134	1520.1	1520.2	-0.1	10.7	10.5	0.2
2.047	1509.9	1509.8	0.1	11.5	11.7	-0.2
1.992	---	1504.0	---	---	7.5	---

Table 11-68 (Continued)

Pre-development Unsteady Flow Model Comparison for Unnamed Wash 1

River	Water Surface Elevation			Channel Velocity		
Station	Unsteady	Steady	Difference	Unsteady	Steady	Difference
miles	feet	feet	feet	fps	fps	fps
1.928	---	1499.2	---	---	10.6	---
1.862	---	1494.4	---	---	9.2	---
1.768	---	1486.7	---	---	10.0	---
1.709	---	1484.0	---	---	7.4	---
1.675	---	1482.4	---	---	8.1	---
1.637	---	1476.8	---	---	14.4	---
1.621	---	1474.6	---	---	10.9	---
1.590	---	1473.3	---	---	8.4	---
1.479	---	1465.7	---	---	10.4	---
1.398	---	1454.0	---	---	15.2	---
1.374	---	1449.4	---	---	13.7	---
1.367	---	1441.2	---	---	14.8	---
1.286	1427.8	1428.4	-0.6	12.1	11.2	0.9
1.208	1420.6	1419.9	0.7	11.3	12.7	-1.4
1.116	---	1414.8	---	---	9.0	---
1.010	---	1405.9	---	---	14.4	---
0.914	---	1399.5	---	---	10.3	---
0.850	---	1396.0	---	---	9.7	---
0.819	1394.6	1394.7	-0.1	8.1	8.1	0.0
0.724	1390.2	1390.2	0.0	7.9	7.9	0.0
0.644	1386.5	1386.5	0.0	8.2	8.2	0.0
0.575	1383.9	1383.8	0.1	8.2	8.4	-0.2
0.547	1381.3	1381.4	-0.1	11.3	11.0	0.3
0.523	1379.8	1379.8	0.0	11.7	11.9	-0.2
0.484	1378.9	1378.9	0.0	8.2	8.1	0.1
0.453	1378.0	1378.0	0.0	8.8	8.8	0.0
0.414	1377.2	1377.3	-0.1	7.7	7.6	0.1
0.356	1375.9	1376.0	-0.1	7.4	7.2	0.2
0.323	1373.1	1373.2	-0.1	12.5	12.2	0.3
0.238	1370.4	1370.2	0.2	5.5	5.8	-0.3
0.190	1369.9	1369.7	0.2	4.5	4.7	-0.2
0.141	1368.8	1368.3	0.5	8.1	9.3	-1.2
0.046	1367.6	1367.6	0.0	4.4	4.4	0.0
		Average:	**-0.2**			**0.2**
		Maximum:	**-12.7**			**8.1**

Table 11-69

Pre-development Unsteady Flow Model Comparison for Unnamed Wash 2

River Station miles	Water Surface Elevation Unsteady feet	Water Surface Elevation Steady feet	Water Surface Elevation Difference feet	Channel Velocity Unsteady fps	Channel Velocity Steady fps	Channel Velocity Difference fps
6.789	1845.5	1845.2	0.3	8.3	9.0	-0.7
6.765	1844.8	1843.6	1.2	7.4	9.3	-1.9
6.714	1838.5	1839.3	-0.8	15.4	13.0	2.4
6.669	1832.4	1833.2	-0.8	15.0	11.6	3.4
6.643	1830.0	1830.5	-0.5	11.3	9.4	1.9
6.595	1826.7	1826.9	-0.2	9.9	9.4	0.5
6.570	1823.8	1824.0	-0.2	11.5	10.9	0.6
6.501	1817.5	1817.8	-0.3	10.6	9.7	0.9
6.451	1813.8	1813.9	-0.1	9.5	8.9	0.6
6.418	1810.3	1810.5	-0.2	9.5	9.1	0.4
6.392	1808.0	1808.1	-0.1	8.4	8.4	0.0
6.318	1803.0	1803.0	0.0	7.2	7.3	-0.1
6.271	1800.6	1800.6	0.0	6.7	6.8	-0.1
6.218	1796.3	1796.4	-0.1	9.9	10.2	-0.3
6.161	1793.1	1792.9	0.2	6.9	7.7	-0.8
6.058	1786.1	1786.3	-0.2	11.8	11.1	0.7
5.974	1782.0	1781.6	0.4	6.5	8.1	-1.6
5.927	1781.1	1778.3	2.8	6.6	11.5	-4.9
5.865	1772.2	1773.6	-1.4	18.1	12.0	6.1
5.845	---	1768.2	---	---	12.9	---
5.759	1758.7	1758.8	-0.1	12.5	12.2	0.3
5.702	1757.4	1756.0	1.4	6.0	8.2	-2.2
5.624	1750.7	1751.3	-0.6	14.4	12.3	2.1
5.551	1746.8	1746.3	0.5	8.4	9.9	-1.5
5.508	1742.5	1743.2	-0.7	13.1	10.8	2.3
5.460	1741.0	1740.4	0.6	7.5	8.8	-1.3
5.364	1734.3	1734.4	-0.1	11.2	10.7	0.5
5.304	1731.9	1731.9	0.0	7.3	7.3	0.0
5.266	1729.0	1729.1	-0.1	12.1	11.9	0.2
5.172	1723.0	1723.1	-0.1	10.8	10.7	0.1
5.114	1721.2	1720.3	0.9	7.8	9.6	-1.8
5.079	1716.9	1717.7	-0.8	14.9	12.1	2.8
4.974	1712.4	1711.3	1.1	3.9	5.9	-2.0
4.939	1708.3	1708.9	-0.6	14.1	11.9	2.2

Table 11-69 (Continued)

Pre-development Unsteady Flow Model Comparison for Unnamed Wash 2

River Station miles	Water Surface Elevation Unsteady feet	Steady feet	Difference feet	Channel Velocity Unsteady fps	Steady fps	Difference fps
4.884	1703.4	1703.9	-0.5	13.3	11.9	1.4
4.784	1695.6	1695.6	0.0	12.8	12.8	0.0
4.692	1688.5	1688.8	-0.3	12.8	12.1	0.7
4.640	1687.2	1686.1	1.1	8.9	11.4	-2.5
4.600	1681.1	1682.7	-1.6	17.9	13.0	4.9
4.502	1673.9	1673.9	0.0	10.2	10.4	-0.2
4.430	1668.6	1668.7	-0.1	10.4	10.3	0.1
4.391	1664.9	1665.0	-0.1	12.1	11.9	0.2
4.365	1663.5	1663.4	0.1	10.0	10.4	-0.4
4.332	1659.9	1660.4	-0.5	14.3	12.9	1.4
4.286	1656.5	1657.0	-0.5	12.6	11.4	1.2
4.199	1652.9	1651.9	1.0	8.7	11.8	-3.1
4.102	1646.0	1646.7	-0.7	12.4	10.1	2.3
4.072	1645.5	1644.9	0.6	7.5	8.9	-1.4
4.013	1640.7	1641.4	-0.7	12.6	10.5	2.1
3.961	1637.7	1637.7	0.0	9.9	10.0	-0.1
3.923	1635.8	1635.8	0.0	7.9	9.6	-1.7
3.874	1634.1	1634.4	-0.3	7.9	7.1	0.8
3.825	1632.4	1630.7	1.7	9.6	12.5	-2.9
3.770	1624.7	1626.0	-1.3	17.4	14.4	3.0
3.725	1623.0	1622.2	0.8	10.1	12.2	-2.1
3.698	1622.6	1621.7	0.9	6.0	7.1	-1.1
3.660	1621.7	1619.2	2.5	6.8	9.4	-2.6
3.643	1621.5	1616.8	4.7	6.9	13.4	-6.5
3.618	1611.6	1614.6	-3.0	24.4	13.4	11.0
3.590	1612.2	1611.3	0.9	7.8	9.2	-1.4
3.523	1606.4	1606.9	-0.5	14.0	12.8	1.2
3.426	1603.3	1600.4	2.9	5.3	8.7	-3.4
3.311	1591.5	1592.8	-1.3	17.2	13.8	3.4
3.211	1584.9	1584.8	0.1	10.2	10.6	-0.4
3.122	1581.5	1582.7	-1.2	10.3	8.6	1.7
3.053	1580.9	1582.7	-1.8	6.2	5.1	1.1
3.033	1575.0	1577.1	-2.1	20.6	15.4	5.2
3.007	1576.8	1577.2	-0.4	9.2	8.9	0.3

Table 11-69 (Continued)

Pre-development Unsteady Flow Model Comparison for Unnamed Wash 2

River	Water Surface Elevation			Channel Velocity		
Station	Unsteady	Steady	Difference	Unsteady	Steady	Difference
miles	feet	feet	feet	fps	fps	fps
2.976	1573.2	1572.9	0.3	15.1	16.3	-1.2
2.934	1573.8	1569.3	4.5	8.0	14.4	-6.4
2.903	1564.1	1566.7	-2.6	22.2	13.7	8.5
2.892	---	1564.1	---	---	13.8	---
2.856	---	1558.0	---	---	14.4	---
2.813	1553.9	1553.8	0.1	10.5	11.5	-1.0
2.718	1552.3	1549.0	3.3	6.7	11.7	-5.0
2.683	1552.4	1548.7	3.7	4.0	7.0	-3.0
2.656	1542.3	1545.2	-2.9	18.6	13.4	5.2
2.625	1540.4	1540.5	-0.1	8.4	8.3	0.1
2.603	1538.5	1538.7	-0.2	12.1	11.7	0.4
2.521	1533.3	1533.2	0.1	12.5	12.9	-0.4
2.424	1527.8	1527.9	-0.1	10.1	10.0	0.1
2.401	1526.5	1526.4	0.1	10.7	10.8	-0.1
2.319	1521.9	1522.0	-0.1	11.4	11.1	0.3
2.225	1516.3	1516.2	0.1	12.3	12.5	-0.2
2.131	1509.3	1509.8	-0.5	14.5	13.3	1.2
2.034	1503.9	1503.9	0.0	11.3	11.5	-0.2
1.940	1497.9	1497.9	0.0	12.0	12.1	-0.1
1.846	1493.9	1493.4	0.5	9.5	10.3	-0.8
1.818	1490.8	1491.2	-0.4	13.4	12.4	1.0
1.781	1488.1	1488.3	-0.2	12.5	12.0	0.5
1.742	1485.3	1485.5	-0.2	11.8	11.5	0.3
1.677	1481.9	1481.7	0.2	8.6	9.2	-0.6
1.629	1478.2	1478.2	0.0	11.8	11.4	0.4
1.535	1471.5	1471.5	0.0	12.2	12.0	0.2
1.481	1470.5	1466.2	4.3	7.5	13.3	-5.8
1.438	1461.8	1463.1	-1.3	17.4	11.9	5.5
1.419	---	1458.4	---	---	14.6	---
1.363	---	1451.4	---	---	13.6	---
1.261	1441.1	1439.0	2.1	7.8	11.4	-3.6
1.168	1432.1	1433.3	-1.2	15.9	12.6	3.3
1.092	---	1433.2	---	---	4.4	---
1.052	---	1428.2	---	---	16.1	---

Table 11-69 (Continued)

Pre-development Unsteady Flow Model Comparison for Unnamed Wash 2

River Station miles	Water Surface Elevation Unsteady feet	Steady feet	Difference feet	Channel Velocity Unsteady fps	Steady fps	Difference fps
0.995	1417.5	1417.7	-0.2	12.7	12.3	0.4
0.957	1416.6	1414.3	2.3	10.4	14.3	-3.9
0.916	1409.8	1411.1	-1.3	17.2	13.7	3.5
0.864	1405.8	1405.7	0.1	12.8	13.2	-0.4
0.769	1403.6	1400.6	3.0	7.8	11.7	-3.9
0.745	1403.7	1401.0	2.7	5.1	6.4	-1.3
0.734	1392.7	1397.0	-4.3	31.8	16.2	15.6
0.703	1389.9	1394.0	-4.1	14.7	7.9	6.8
0.650	---	1389.9	---	---	13.9	---
0.625	---	1389.5	---	---	11.7	---
0.610	---	1386.4	---	---	16.5	---
0.589	1379.4	1379.7	-0.3	13.7	13.0	0.7
0.537	1376.9	1377.3	-0.4	11.0	10.6	0.4
0.441	1372.1	1371.8	0.3	11.3	12.5	-1.2
0.348	1370.0	1368.6	1.4	4.8	8.0	-3.2
0.309	1369.7	1367.0	2.7	4.6	9.3	-4.7
0.252	1363.1	1363.9	-0.8	15.2	11.3	3.9
0.205	1360.4	1360.4	0.0	8.0	7.9	0.1
		Average:	**0.1**			**0.3**
		Maximum:	**4.7**			**15.6**

Table 11-70

Pre-development Unsteady Flow Model Comparison for Unnamed Wash 3

River Station miles	Water Surface Elevation Unsteady feet	Steady feet	Difference feet	Channel Velocity Unsteady fps	Steady fps	Difference fps
4.540	1641.0	1641.1	-0.1	8.7	8.5	0.2
4.464	1636.7	1636.6	0.1	7.4	7.7	-0.3
4.442	1635.8	---	---	6.2	---	---
4.428	1635.6	1635.3	0.3	4.9	5.5	-0.6
4.417	1633.7	1634.1	-0.4	10.2	8.3	1.9
4.399	1632.0	1631.8	0.2	8.2	8.7	-0.5
4.379	1629.5	1629.6	-0.1	9.9	9.4	0.5
4.338	1626.8	1626.1	0.7	7.0	8.7	-1.7
4.289	1621.8	1622.4	-0.6	10.6	8.9	1.7
4.245	1619.4	---	---	6.3	---	---
4.229	1618.4	1618.2	0.2	7.5	8.2	-0.7
4.219	1618.3	---	---	4.9	---	---
4.197	1616.9	1616.8	0.1	6.9	7.1	-0.2
4.188	1616.6	---	---	6.0	---	---
4.177	1616.2	1615.8	0.4	7.1	7.9	-0.8
4.161	1616.0	---	---	6.0	---	---
4.145	1611.2	1612.4	-1.2	16.0	11.5	4.5
4.127	1609.5	---	---	11.8	---	---
4.111	---	1608.1	---	---	10.9	---
4.101	1607.2	---	---	10.9	---	---
4.084	1605.6	---	---	10.9	---	---
4.038	1601.7	---	---	9.5	---	---
4.013	1599.2	1599.3	-0.1	10.3	10.2	0.1
3.921	1591.2	1591.1	0.1	10.6	10.8	-0.2
3.875	1589.8	---	---	7.0	---	---
3.847	1586.0	---	---	13.6	---	---
3.826	1585.4	1585.3	0.1	8.4	8.7	-0.3
3.777	1581.6	---	---	9.8	---	---
3.731	1579.8	1579.0	0.8	6.7	9.5	-2.8
3.689	1576.7	---	---	10.5	---	---
3.649	1574.8	1574.8	0.0	7.1	7.1	0.0
3.605	1572.8	---	---	8.2	---	---
3.561	1570.6	1570.5	0.1	8.7	9.0	-0.3
3.520	1568.8	1569.3	-0.5	6.8	5.8	1.0

Table 11-70 (Continued)

Pre-development Unsteady Flow Model Comparison for Unnamed Wash 3

River Station miles	Water Surface Elevation Unsteady feet	Steady feet	Difference feet	Channel Velocity Unsteady fps	Steady fps	Difference fps
3.509	1568.7	1569.1	-0.4	5.2	5.1	0.1
3.497	1567.1	1567.6	-0.5	10.7	9.2	1.5
3.487	1567.0	1567.4	-0.4	7.1	6.5	0.6
3.460	1564.9	1565.0	-0.1	10.1	10.0	0.1
3.426	1564.1	1563.9	0.2	7.0	7.3	-0.3
3.412	1563.9	1562.6	1.3	6.6	9.6	-3.0
3.386	1560.4	---	---	10.6	---	---
3.370	1559.4	1559.4	0.0	7.1	7.2	-0.1
3.351	1559.1	1559.1	0.0	5.4	5.4	0.0
3.319	1558.3	1558.2	0.1	6.6	6.9	-0.3
3.309	1555.7	1556.5	-0.8	13.2	10.7	2.5
3.287	1554.3	---	---	10.4	---	---
3.257	1553.4	1553.0	0.4	7.5	8.7	-1.2
3.228	1551.5	---	---	10.3	---	---
3.193	1550.0	---	---	7.5	---	---
3.168	1548.6	1548.4	0.2	7.9	8.3	-0.4
3.144	1547.2	1547.4	-0.2	8.9	7.6	1.3
3.114	1545.7	1545.2	0.5	8.0	9.4	-1.4
3.097	1544.6	---	---	9.8	---	---
3.061	1543.2	1543.4	-0.2	6.3	5.9	0.4
3.042	1542.3	1542.9	-0.6	6.4	5.1	1.3
3.015	1541.6	1542.6	-1.0	5.4	4.9	0.5
2.992	1540.7	---	---	7.0	---	---
2.984	1539.5	1539.1	0.4	10.3	11.2	-0.9
2.973	1539.8	---	---	7.4	---	---
2.961	1540.0	---	---	4.8	---	---
2.934	1535.6	---	---	14.4	---	---
2.916	1535.4	1535.1	0.3	7.5	8.4	-0.9
2.883	1534.4	---	---	6.7	---	---
2.850	1533.9	1532.5	1.4	5.5	7.7	-2.2
2.779	1528.3	1529.1	-0.8	12.8	9.7	3.1
2.726	1526.2	---	---	7.1	---	---
2.703	1524.9	---	---	9.2	---	---
2.677	1523.6	1523.7	-0.1	9.1	8.7	0.4

Table 11-70 (Continued)

Pre-development Unsteady Flow Model Comparison for Unnamed Wash 3

River Station miles	Water Surface Elevation Unsteady feet	Steady feet	Difference feet	Channel Velocity Unsteady fps	Steady fps	Difference fps
2.659	1522.8	---	---	9.0	---	---
2.631	1522.1	---	---	7.1	---	---
2.605	1519.9	---	---	10.4	---	---
2.581	1519.2	1519.1	0.1	8.1	9.2	-1.1
2.541	1517.3	---	---	8.3	---	---
2.522	1516.7	1516.4	0.3	6.9	7.6	-0.7
2.471	1513.4	1513.6	-0.2	9.8	8.9	0.9
2.421	1510.5	1510.9	-0.4	8.7	7.3	1.4
2.376	1508.9	---	---	7.4	---	---
2.350	1508.3	---	---	5.9	---	---
2.333	1508.1	---	---	6.4	---	---
2.315	1504.9	1506.0	-1.1	14.6	9.8	4.8
2.282	1503.5	---	---	7.8	---	---
2.255	1502.5	---	---	8.2	---	---
2.233	1501.8	1501.2	0.6	7.4	9.0	-1.6
2.200	1501.5	---	---	5.4	---	---
2.169	1496.7	---	---	14.6	---	---
2.154	1496.8	---	---	6.9	---	---
2.140	1496.5	---	---	6.4	---	---
2.118	1495.3	1495.3	0.0	9.0	8.9	0.1
2.097	1494.6	---	---	8.1	---	---
2.080	1492.9	---	---	10.3	---	---
2.050	1491.6	1491.8	-0.2	7.4	7.8	-0.4
2.022	1489.9	---	---	7.7	---	---
2.011	1488.9	1488.8	0.1	9.5	9.6	-0.1
1.973	1487.7	1487.2	0.5	7.0	7.8	-0.8
1.944	1484.4	1484.7	-0.3	11.8	10.5	1.3
1.915	1482.9	---	---	8.8	---	---
1.872	1480.8	1480.9	-0.1	8.7	8.5	0.2
1.784	1476	1475.9	0.1	9.4	9.6	-0.2
1.690	1473.3	1472.4	0.9	3.6	7.8	-4.2
1.641	1470.3	1469.6	0.7	7.4	10.6	-3.2
1.600	1470.1	1467.2	2.9	2.9	8.0	-5.1
1.563	1466.5	1464.3	2.2	4.6	10.4	-5.8

Table 11-70 (Continued)

Pre-development Unsteady Flow Model Comparison for Unnamed Wash 3

River	Water Surface Elevation			Channel Velocity		
Station	Unsteady	Steady	Difference	Unsteady	Steady	Difference
miles	feet	feet	feet	fps	fps	fps
1.546	1466.6	---	---	4.4	---	---
1.537	1457.9	1460.3	-2.4	25.8	12.0	13.8
1.519	1457.6	1457.7	-0.1	13.0	12.5	0.5
1.497	1458.2	1456.4	1.8	8.7	10.4	-1.7
1.481	1454.0	1454.8	-0.8	15.4	12.3	3.1
1.425	1450.9	1449.1	1.8	7.2	9.7	-2.5
1.399	1445.4	---	---	14.3	---	---
1.385	1441.0	1441.7	-0.7	15.4	13.1	2.3
1.356	1437.9	1437.5	0.4	6.9	7.4	-0.5
1.331	1437.1	1436.0	1.1	6.1	7.5	-1.4
1.316	1436.1	---	---	7.7	---	---
1.304	1436.1	1433.1	3.0	6.1	9.6	-3.5
1.288	1436.2	---	---	3.8	---	---
1.259	1436.2	1426.8	9.4	3.5	12.7	-9.2
1.248	1436.2	---	---	2.7	---	---
1.237	1421.4	---	---	32.0	---	---
1.222	1416.5	1416.3	0.2	12.4	13.2	-0.8
1.171	1414.0	1413.3	0.7	5.6	6.3	-0.7
1.152	1413.0	1411.4	1.6	7.8	9.9	-2.1
1.088	1405.9	1407.2	-1.3	13.5	10.2	3.3
1.032	1403.7	---	---	7.0	---	---
1.008	1401.8	1401.4	0.4	10.0	10.8	-0.8
0.986	1401.3	1400.3	1.0	7.1	8.6	-1.5
0.960	1396.5	1397.2	-0.7	14.3	12.2	2.1
0.928	1394.8	1394.4	0.4	7.3	7.9	-0.6
0.852	1389.8	1389.8	0.0	11.6	11.7	-0.1
0.761	1384.7	1384.8	-0.1	9.0	8.9	0.1
0.734	1383.2	1382.8	0.4	9.4	10.2	-0.8
0.716	1383.0	1382.3	0.7	7.1	8.2	-1.1
0.695	1378.2	1379.2	-1.0	16.1	13.4	2.7
0.658	1376.7	1376.2	0.5	8.0	10.0	-2.0
0.625	1373.5	1373.8	-0.3	12.3	11.4	0.9
0.598	1372.7	1372.1	0.6	6.7	7.6	-0.9
0.583	1372.6	1371.7	0.9	5.5	6.5	-1.0

Table 11-70 (Continued)

Pre-development Unsteady Flow Model Comparison for Unnamed Wash 3

River Station miles	Water Surface Elevation Unsteady feet	Water Surface Elevation Steady feet	Water Surface Elevation Difference feet	Channel Velocity Unsteady fps	Channel Velocity Steady fps	Channel Velocity Difference fps
0.565	1368.0	1369.2	-1.2	16.2	12.0	4.2
0.544	1368.0	---	---	9.2	---	---
0.520	1365.2	1365.5	-0.3	12.3	11.5	0.8
0.481	1363.5	1363.6	-0.1	8.8	8.8	0.0
0.454	1363.1	---	---	8.4	---	---
0.386	1357.4	1358.1	-0.7	13.2	11.2	2.0
0.337	1355.4	---	---	7.8	---	---
0.306	1353.2	1353.4	-0.2	10.5	9.8	0.7
0.275	1352.5	---	---	5.9	---	---
0.240	1348.6	1349.3	-0.7	11.4	6.8	4.6
0.214	1346.2	---	---	9.0	---	---
0.194	1345.6	---	---	7.0	---	---
0.185	1344.1	1344.2	-0.1	10.6	10.4	0.2
0.144	1340.7	1340.7	0.0	11.0	11.1	-0.1
		Average:	**0.2**			**0.0**
		Maximum:	**9.4**			**13.8**

As can be seen from these tables the water surface elevation and channel velocity results for the unsteady flow model at the maximum stage is, in general, very similar to the steady flow, floodplain delineation model results.

The maximum water surface and channel velocity differentials for Unnamed Wash 1 occur immediately upstream of an existing stock tank, River Mile (RM) 3.643. The structural integrity of the stock tank embankment is unknown and therefore the hydrologic attenuation that the ponding area would provide is not considered in the hydrologic analysis. This is a conservative, yet realistic assumption. Conversely, the structure is included in the floodplain delineation modeling since mapping of the ponding area results in the most conservative delineation. This structure is not modeled in the unsteady flow analysis and as a result the water surface elevations and channel velocities immediately upstream of this structure are significantly different.

This structure is removed from the unsteady flow model because of the attenuation that would occur from routing the hydrograph through the structure. The next largest difference in water surface elevation is an increase of 2.3 feet at RM 5.505. The next largest difference in channel velocity is a decrease of 4.7 fps at RM 6.216. These differences are most likely due to rapid changes in the physical characteristics of the watercourse at these locations.

The maximum water surface differential for Unnamed Wash 2 occurs upstream of a natural constriction in the watercourse. The unsteady flow model computes a water surface elevation at RM 3.643 that is 4.7 feet higher than what is computed in the steady flow model. This constriction causes a backwater condition and as a consequence there is a drop in discharge due to the storage. Thus the hydraulic conditions at this location are significantly different than in the steady flow model. A similar situation occurs at RM 0.734. At this location, the maximum channel velocity computed in the unsteady flow model increases by 15.6 fps over what is computed in the steady flow model. Here the flow is accelerating rapidly through the constriction. This rapid change in hydraulic conditions may also be causing instabilities in the calculations.

Like Unnamed Wash 2, the maximum water surface and channel velocity differentials for Unnamed Wash 3 also occur at natural constrictions in the watercourse. The maximum differential in water surface elevation is an increase of 9.4 feet and occurs at RM 1.259. The maximum differential in channel velocity is an increase of 13.6 fps and occurs at RM 1.537.

In general, the water surface elevation and channel velocity results for the maximum stage profile of the unsteady flow model compare favorably to those of steady flow model. The mathematical average differential for all three watercourses for both the water surface elevation and the channel velocity is less than 0.3 feet and 0.3 fps, respectively. In consideration of the hydraulic characteristics of these watercourses in relation to the limitations and differences of the two modules the results of the base unsteady flow models seem very reasonable.

Off-line Retention Basins

Post-development peak discharge and runoff volume is reduced to that of pre-development conditions by diverting the necessary amount of flow via a lateral weir into a basin that is adjacent to the main channel of the watercourse. The diverted runoff can then be allowed to percolate into the soil or can be slowly released back into the watercourse. Verification of the functionality of this method of retention is only tested in the Unnamed Wash 3 sub-watershed. Testing of the off-line basin is limited to Unnamed Wash 3 because of the topographic conditions and the nature of the land use proposed for the sub-watersheds for Unnamed Washes 1 and 2. The topographic conditions along these watercourses are such that off-line basins are practical only in the upper reaches. However, the proposed land use in the upper portions of these watercourses is primarily low-density residential or open space. The resulting difference in pre- and post-development runoff volumes does not warrant this particular application.

The off-line basin for Unnamed Wash 3 is located approximately at RM 2.750 which is a short distance upstream of the hydrologic concentration point C302 as shown in relation to the watershed in Figure 11-14. This location was selected based on the following.

- Topography,
- Accessibility,
- Proximity to proposed development limits, and
- Relative location within the sub-watershed.

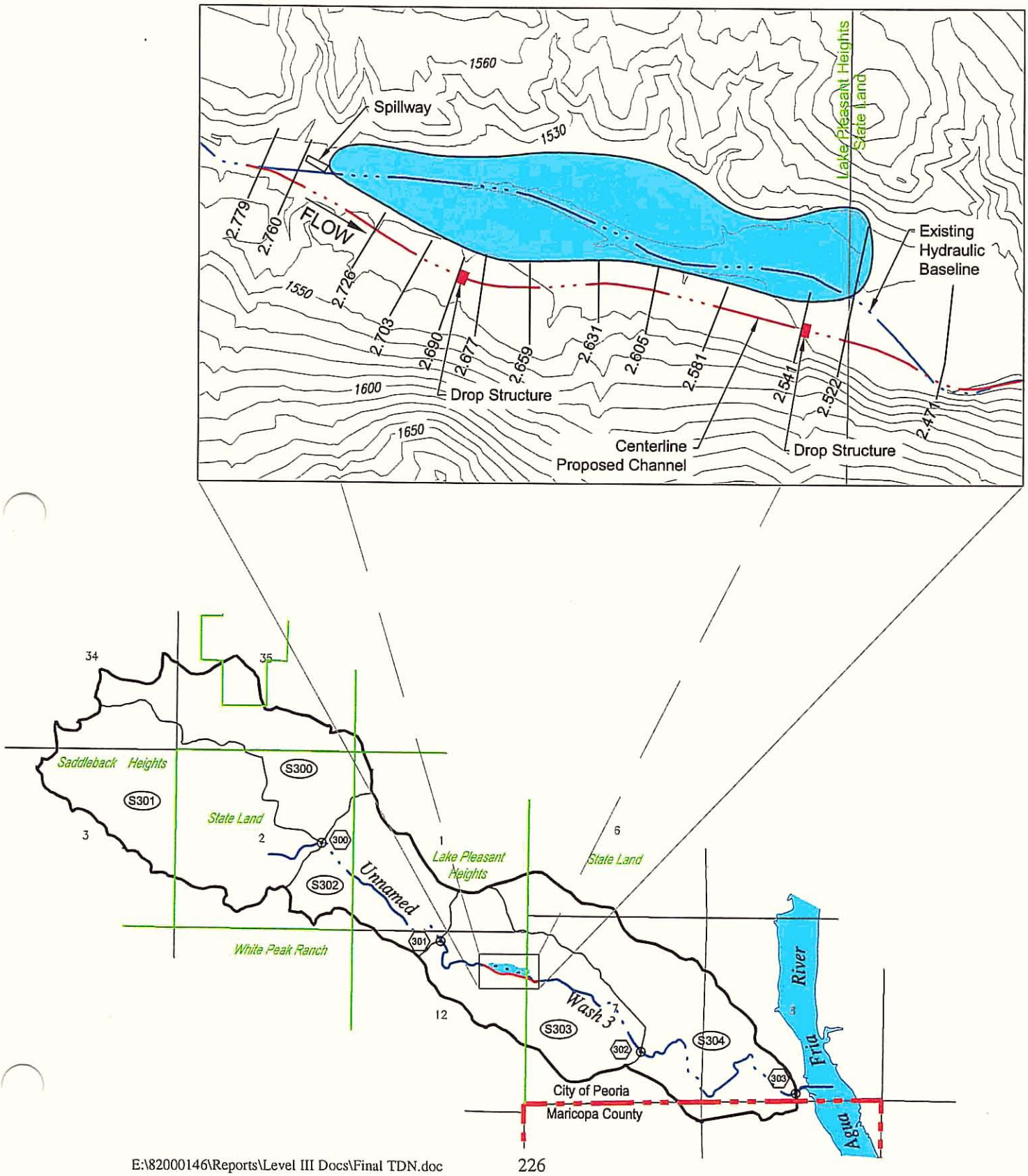
Ideally, the watercourse would be flowing in a subcritical regime in the reach that the diversion is to take place. This is not the case for the selected reach, therefore this reach of the watercourse is channelized and drop structures are added to force the flow into a subcritical regime. Realignment of the channel is also necessary at this particular location in order to provide sufficient space for storage of the required volume of runoff. The location of the basin and proposed channel alignment is

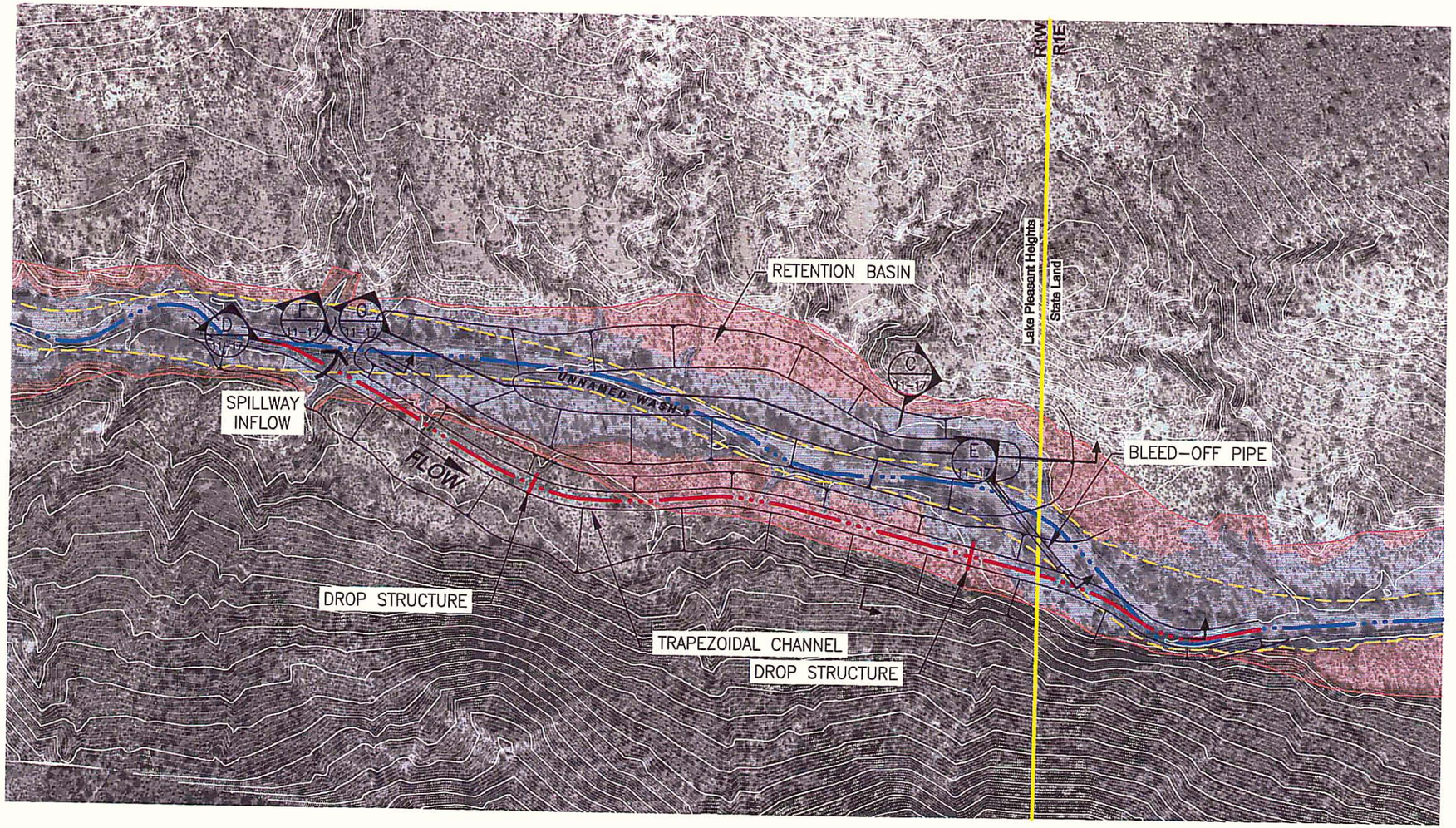
shown in relation to the topography of the selected site in Figure 11-15. Conceptual details of the various elements are shown in Figure 11-19.

The 100-year pre-development peak discharge and runoff volume at this location (HEC-1 Id C302) is approximately 2,200 cfs and 250 acre-feet, respectively. The 100-year post-development peak discharge and runoff volume at this location is approximately 3,130 cfs and 270 acre-feet, respectively. Initially, the lateral weir, basin volume and outlet pipe dimensions are sized simultaneously to reduce the 100-year post-development peak discharge and runoff volume downstream of the basin to those of pre-development conditions. The weir dimensions are then modified, to the extent possible, to be effective during the 10-year event without altering the operations for the 100-year event. The basin stage-storage relation input to the model is based on the available surface area and an assumption of 4:1 side slopes. The basin depth is then varied until the right combination of weir length, storage volume and outlet size is achieved. The weir coefficient used in the analysis is 2.6. The current version of HEC-RAS does not allow varying the lateral weir coefficient with discharge or depth over the weir, therefore, the value selected must be appropriate for the range of flows and hydraulic conditions to be modeled during the entire simulation. A coefficient of 2.6 is considered to be the minimum value that is expected for the specific conditions.

Figure 11-14

Retention/Detention Alternative Location Map for Unnamed Wash 3





AERIAL PHOTOGRAPHY BASE PROVIDED BY FLOOD CONTROL DISTRICT OF MARICOPA COUNTY.
AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

N

100' 0' 100' 200'

LEGEND

- EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY
- EROSION HAZARD SETBACK
- FLOODWAY BOUNDARY
- PONDING LIMITS
- RIGHT OF WAY
- CENTERLINE EXISTING CHANNEL
- CENTERLINE PROPOSED CHANNEL
- RANGE LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.

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2			
1			

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Figure 11-15
Off-Line Retention Basin
Alternative for Unnamed Wash 3

Stantec Consulting Inc.
5211 South 48th Street
Phoenix AZ 85044-5355 U.S.A.
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

	BY	DATE
DESIGN	—	—
DESIGN CHK.	—	—
PLANS	HAR	07.07.01
PLANS CHK.	PJE	07.07.01

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In-line Detention Basins

Reduction of post-development peak discharge is accomplished by storing the entire runoff volume behind an embankment. The basin is drained by an outlet structure that is sized for a peak discharge equal to that of the pre-development conditions. A common application of this approach would be at a roadway crossing of the watercourse. In-line detention basins are located using the same criteria as for the off-line basins with additional consideration for proposed roadway crossings. Roadway crossings proposed for the study area are taken from a draft copy of the Northwest Valley Transportation Study (BRW, Inc. Feb. 2000) and preliminary development plans for Lake Pleasant Heights and Lake Pleasant Estates. The in-line basin location selected for Unnamed Wash 3 is the same location as for the off-line basin and is also near a proposed roadway alignment. The selected location for Unnamed Wash 1 is at an existing stock tank at approximately RM 3.631 which is a short distance upstream of the hydrologic concentration point C103R as shown in Figure 11-16. The selected location for Unnamed Wash 2 is at a proposed roadway crossing at approximately RM 3.872 which is a short distance upstream of the hydrologic concentration point C206 as shown on Figure 11-17.

The 100-year pre-development peak discharge at these locations (HEC-1 Id C103R, C206 and C302) are approximately 2,330 cfs, 4,420 cfs and 2,200 cfs for Unnamed Washes 1, 2 and 3, respectively. The 100-year post-development peak discharges are approximately 2,630 cfs, 4,700 cfs and 3,130 cfs, respectively. A concrete box culvert is used as the outlet structure for each basin. The culvert dimensions are determined by first setting the width equal to the channel bottom width. The culvert height is then varied such that the outflow is equivalent to the pre-development peak discharge. The length of the culvert is a function of the maximum water surface elevation, embankment top width and side slope. The minimum embankment side slope used for all three locations is 3:1. The embankment top width used for Unnamed Washes 2 and 3 is 60 feet, which is the City of Peoria minor collector roadway right-of–way width. The embankment height is then set just above the maximum water surface elevation. For Unnamed Wash 1, only minor changes are

made to the existing stock tank embankment. The culvert dimensions are then balanced with an overflow spillway. Figure 11-18 shows the culvert and embankment in relation to the existing topography the Unnamed Wash 3 location. Conceptual details for the culvert are shown in Figure 11-19.

Figure 11-16

Retention/Detention Alternative Location Map for Unnamed Wash 1

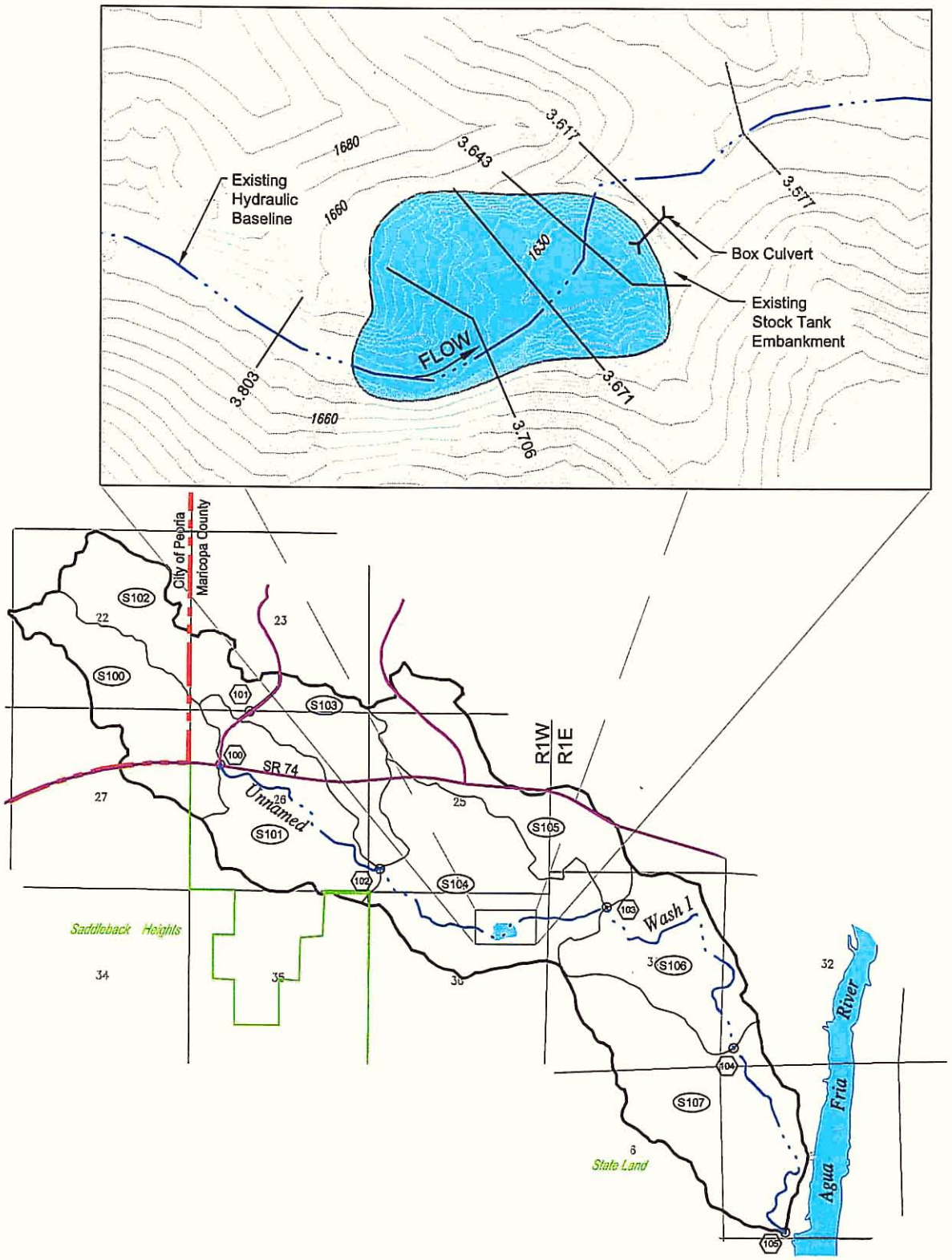
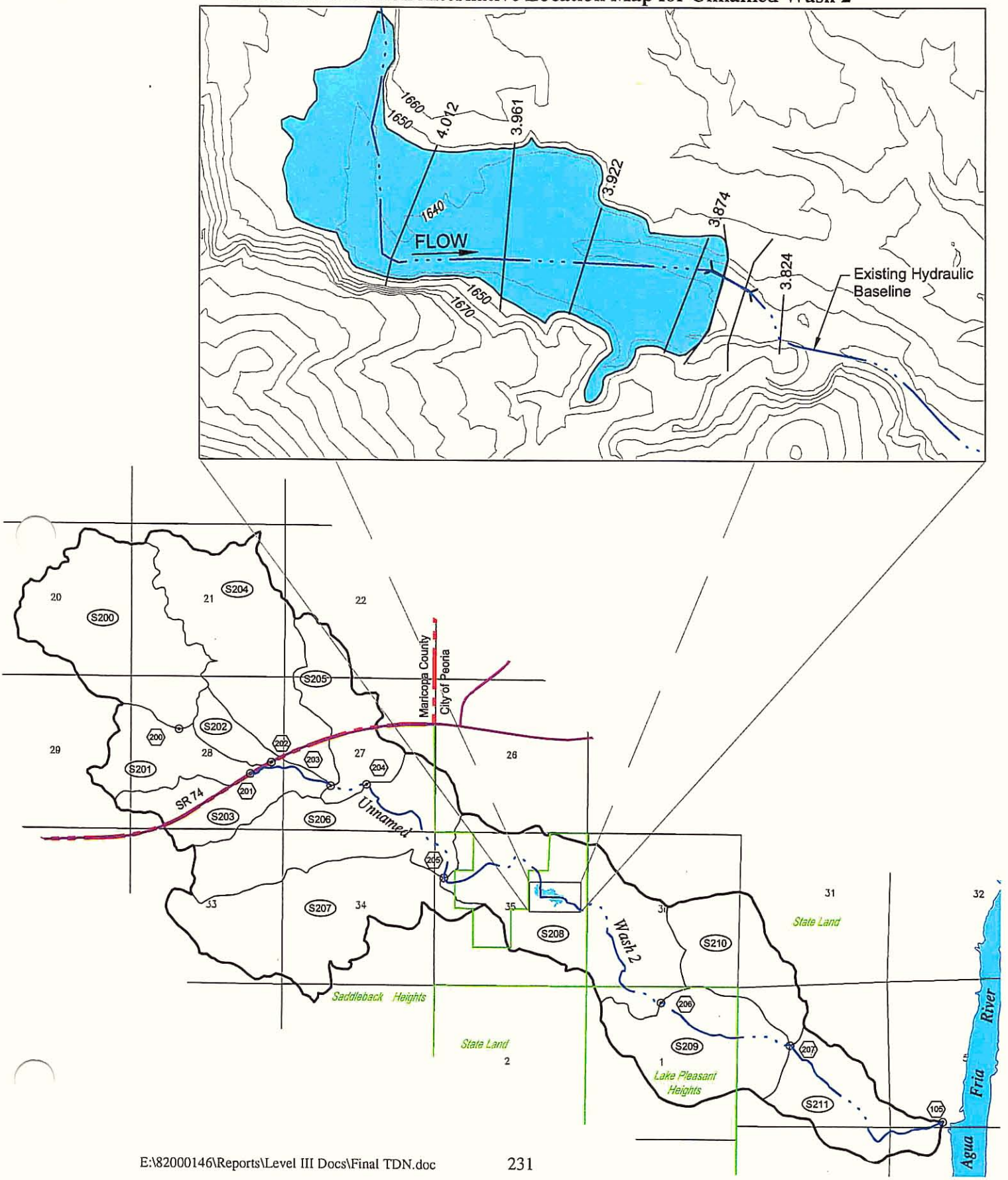
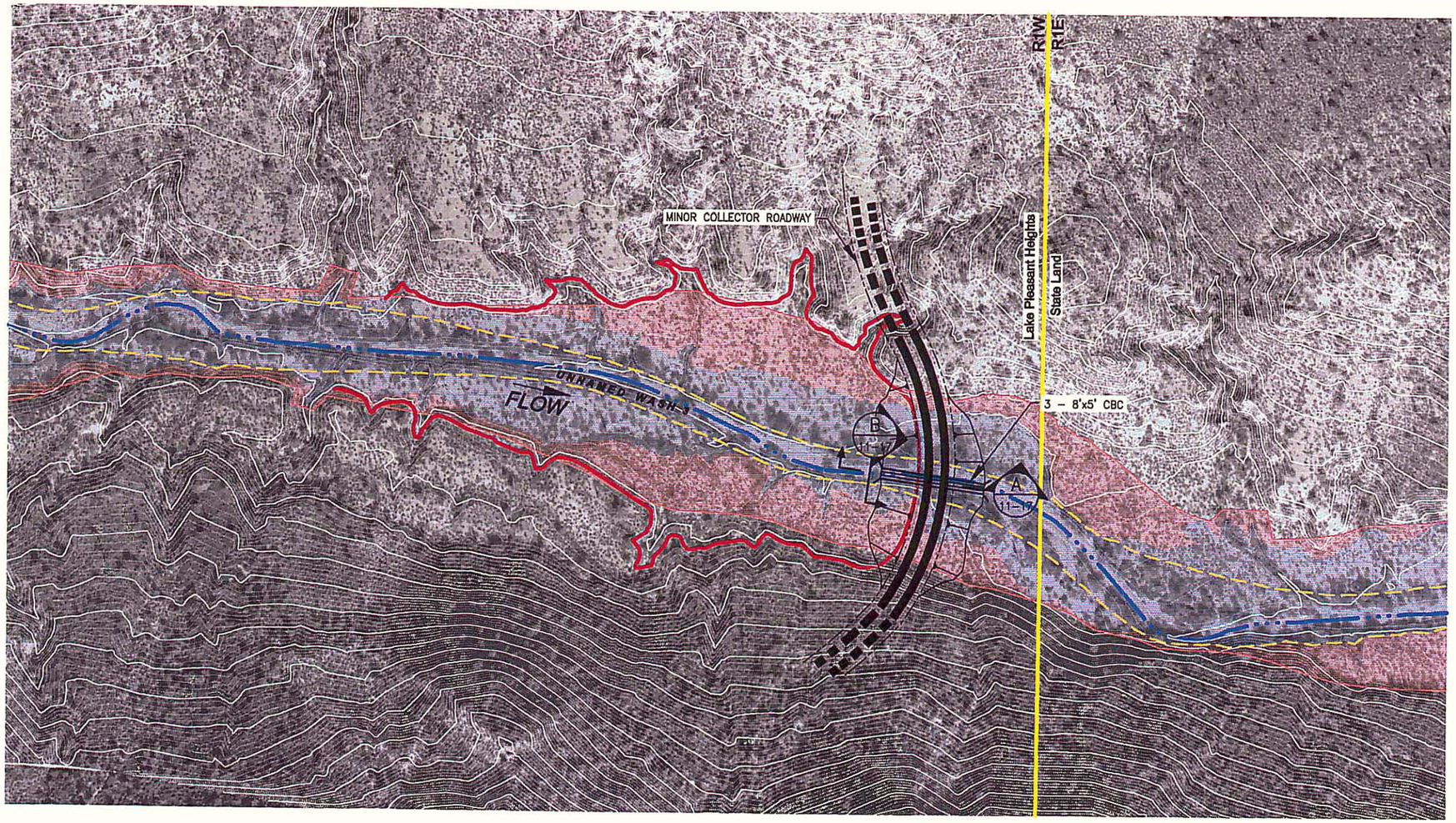


Figure 11-17

Retention/Detention Alternative Location Map for Unnamed Wash 2





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AERIAL PHOTOGRAPHY DATE: DECEMBER 2000

N

100' 0' 100' 200'

LEGEND

- EFFECTIVE FEMA 100-YR FLOODPLAIN BOUNDARY
- EROSION HAZARD SETBACK
- FLOODWAY BOUNDARY
- PONDING LIMITS
- RIGHT OF WAY
- CENTERLINE EXISTING CHANNEL
- CENTERLINE PROPOSED CHANNEL
- RANGE LINE

NOTES

1. ALL SECTION LINES AND CORPORATE LIMITS ARE APPROXIMATE.
2. EROSION HAZARD BOUNDARIES DELINEATED BY JE FULLER HYDROLOGY AND GEOMORPHOLOGY, INC.

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Figure 11-18
In-Line Detention Basin Alternative for Unnamed Wash 3

Stantec Consulting Inc.
6211 South 48th Street
Phoenix AZ 85044-5355 U.S.A.
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

	BY	DATE
DESIGN	–	–
DESIGN CHK.	–	–
PLANS	HAR	07.07.01
PLANS CHK.	PJE	07.07.01

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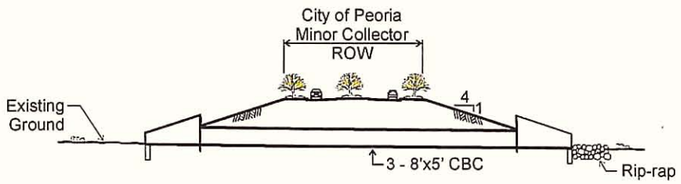
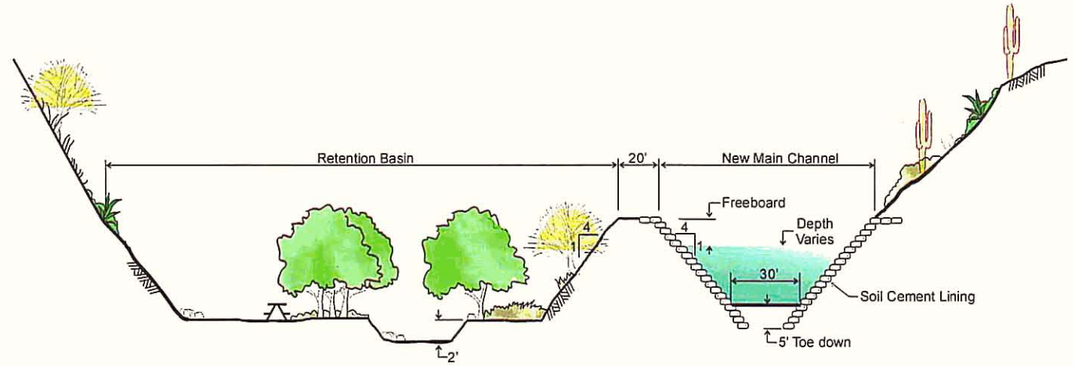
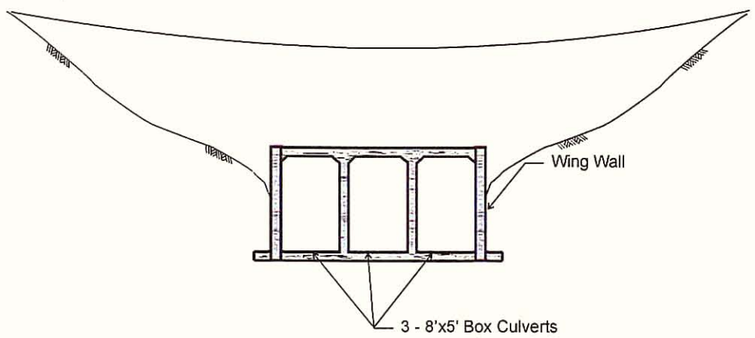
2001 August 30, 7:42 a.m.



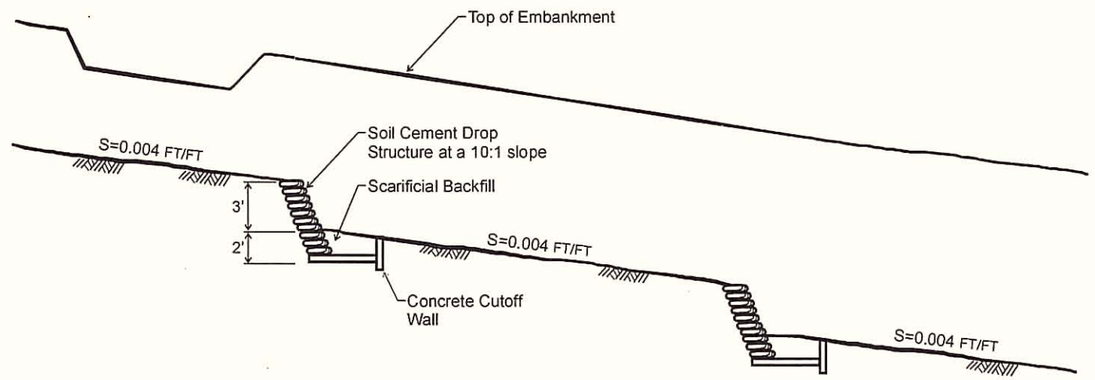
A 11-17 Culvert Profile
nts



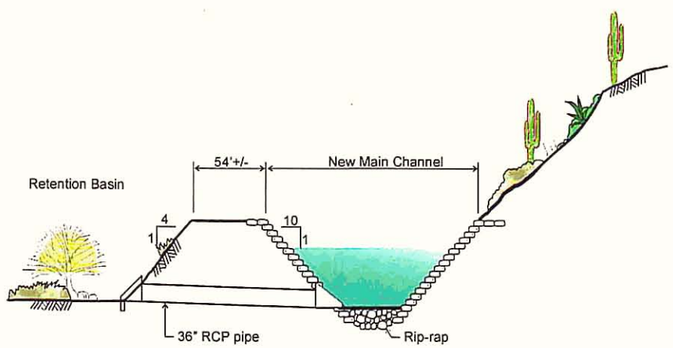
C 11-17 Channel and Basin Section
nts



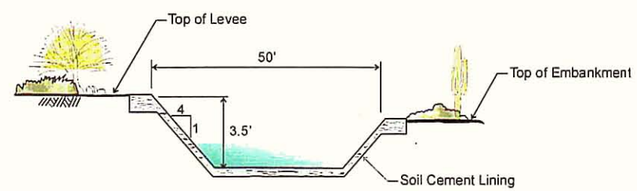
B 11-17 Box Culverts
nts



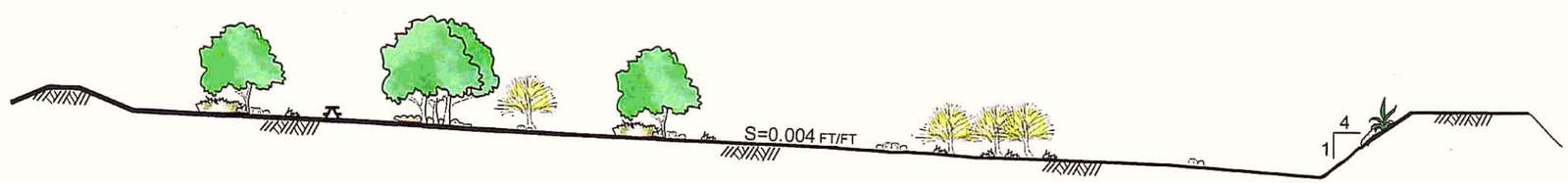
D 11-17 Channel Profile
nts



E 11-17 Bleedout Pipe Section
nts



F 11-17 Spillway Section
nts



G 11-17 Basin Section
nts

NO.	REVISION	BY	DATE
2			
1			

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

Figure 11–19
Retention / Detention
Conceptual Details

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ 85044-5355 U.S.A.
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

	BY	DATE
DESIGN	MCG	07.17.01
DESIGN CHK.	—	—
PLANS	HAR	08.13.01
PLANS CHK.	PJE	08.13.01

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2001 August 30, 7:34 a.m.

Modeling Results

The effectiveness of retention/detention facilities at reducing/minimizing the effects of increased runoff due to development in the watershed can be measured in many ways, some of which are difficult to quantify. As an alternative to quantifying potential impacts, the effectiveness of these facilities can be checked by the successfulness of the facilities at reproducing the pre-development runoff conditions, specifically the magnitude, duration and temporal distribution of the runoff hydrograph. If the pre-development runoff hydrograph is successfully reproduced, it can be assumed that the impacts of the resulting runoff are minimal. Runoff hydrographs for each alternative (off-line, in-line and 100-year, 2-hour) for Unnamed Washes 1, 2 and 3 are shown in relation to the corresponding pre-development runoff hydrographs in Figures 11-20 through 11-22 for the 100-year event and Figures 11-23 through 11-25 for the 10-year event. Runoff hydrographs for pre-development, post-development without retention and post-development with 100-year, 2-hour retention are taken from the HEC-1 models at concentration points C103R, C206 and C302 for Unnamed Washes 1, 2 and 3, respectively. Tables 11-71 and 11-72 summarize the 100-year peak discharge and volume, respectively, for each alternative for each watercourse. Tables 11-73 and 11-74 summarize the 10-year peak discharge and runoff volume, respectively, for each alternative for each watercourse. Model output for each watercourse is provided in Appendix H. Digital input and output files are provided on CD as Appendix F.

Table 11-71

Summary of Retention/Detention Alternative 100-Year Peak Discharges

	100-Year Peak Discharge, in cfs				
	Pre-Devel.	**Post-Devel. w/o Ret.**	**In-Line Detention**	**Off-Line Retention**	**100-Yr, 2-Hr Retention**
Unnamed Wash 1	2,330	2,630	2,380	---	2,480
Unnamed Wash 2	4,420	4,700	4,190	---	4,440
Unnamed Wash 3	2,200	3,130	2,300	2,210	2,650

Table 11-72

Summary of Retention/Detention Alternative 100-Year Runoff Volumes

	100-Year Runoff Volume, in acre-feet				
	Pre-Devel.	Post-Devel. w/o Ret.	In-Line Detention	Off-Line Retention	100-Yr, 2-Hr Retention
Unnamed Wash 1	270	280	280	---	240
Unnamed Wash 2	640	670	630	---	560
Unnamed Wash 3	250	270	270	210	190

Table 11-73

Summary of Retention/Detention Alternative 10-Year Peak Discharges

	10-Year Peak Discharge, in cfs				
	Pre-Devel.	Post-Devel. w/o Ret.	In-Line Detention	Off-Line Retention	100-Yr, 2-Hr Retention
Unnamed Wash 1	860	1,020	920	---	710
Unnamed Wash 2	1,730	1,860	1,840	---	1,480
Unnamed Wash 3	810	1,350	1,210	1,010	610

Table 11-74

Summary of Retention/Detention Alternative 10-Year Runoff Volumes

	10-Year Runoff Volume, in acre-feet				
	Pre-Devel.	Post-Devel. w/o Ret.	In-Line Detention	Off-Line Retention	100-Yr, 2-Hr Retention
Unnamed Wash 1	130	140	130	---	100
Unnamed Wash 2	350	380	360	---	270
Unnamed Wash 3	120	140	150	130	60

In general, in-line basins are very effective at reducing the post-development peak discharges for a specific design event, in this case the 100-year event, to pre-development magnitudes. However, for more frequent events, the in-line basin is relatively ineffective. In-line basins also do not provide any reduction in runoff volume, despite what is shown in Tables 11-72 and 11-74. Runoff volumes reported

in these tables for in-line, as well as off-line, basins are based on simplified hydrologic data as discussed previously. As such, these results should be considered approximate. Runoff volumes are shown for general comparative purpose, but also to demonstrate that the model results are relatively reasonable. Given the fact that in-line basins reduce the peak discharge but not the runoff volume, it follows that the duration of runoff must increase. This results in duration that is more consistent with the pre-development conditions.

The off-line basin alternative was developed for Unnamed Wash 3 only for reasons discussed previously. Downstream of the basin the post-development 100-year peak discharge and runoff volume is 2,210 cfs and 210 acre-feet, respectively. This is compared to the pre-development 100-year peak discharge and runoff volume of 2,200 cfs and 250 acre-feet, respectively. Similarly, the 10-year post-development peak discharge and runoff volume downstream of the basin is 1,010 cfs and 130 acre-feet, respectively as compared to 810 cfs and 120 acre-feet, respectively for pre-development conditions. The off-line basin is also somewhat effective for other storm frequencies. Unlike in-line basins, off-line basins would generally have the effect of shortening the duration of runoff as can be seen from Figures 11-22 and 11-25.

Following the standard 100-year, 2-hour retention approach will produce similar results as the off-line basins. However the results of this analysis shows that the volume of runoff retained is, for every case, greater than what is required resulting in less volume in the runoff hydrograph than what is estimated for pre-development conditions. Furthermore, in the case of Unnamed Wash 3 for the 100-year event this volume is not sufficient to capture the peak.

Figure 11-20

Comparison of Retention/Detention Alternatives for Unnamed Wash 1 for the 100-Year Event

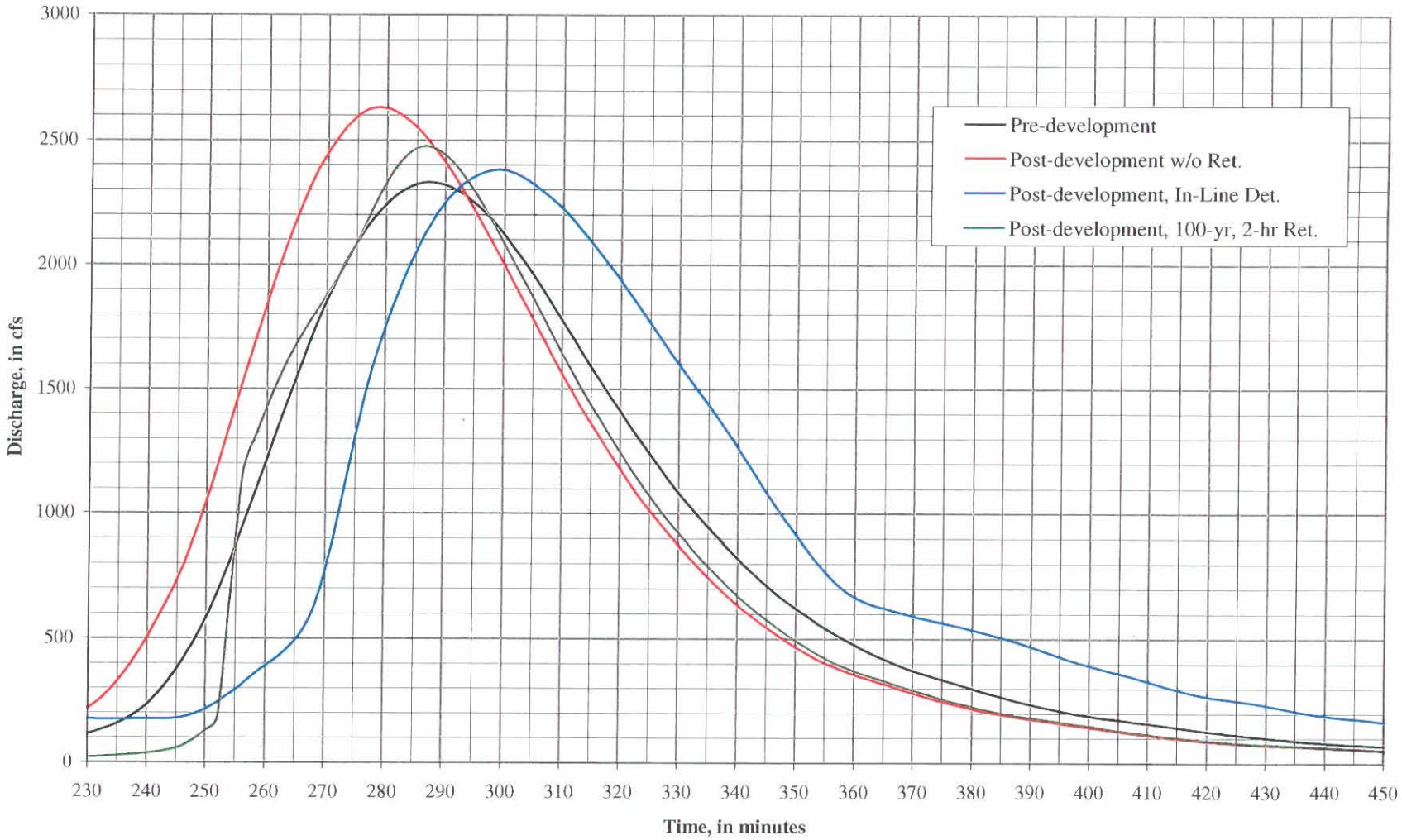


Figure 11-21

Comparison of Retention/Detention Alternatives for Unnamed Wash 2 for the 100-Year Event

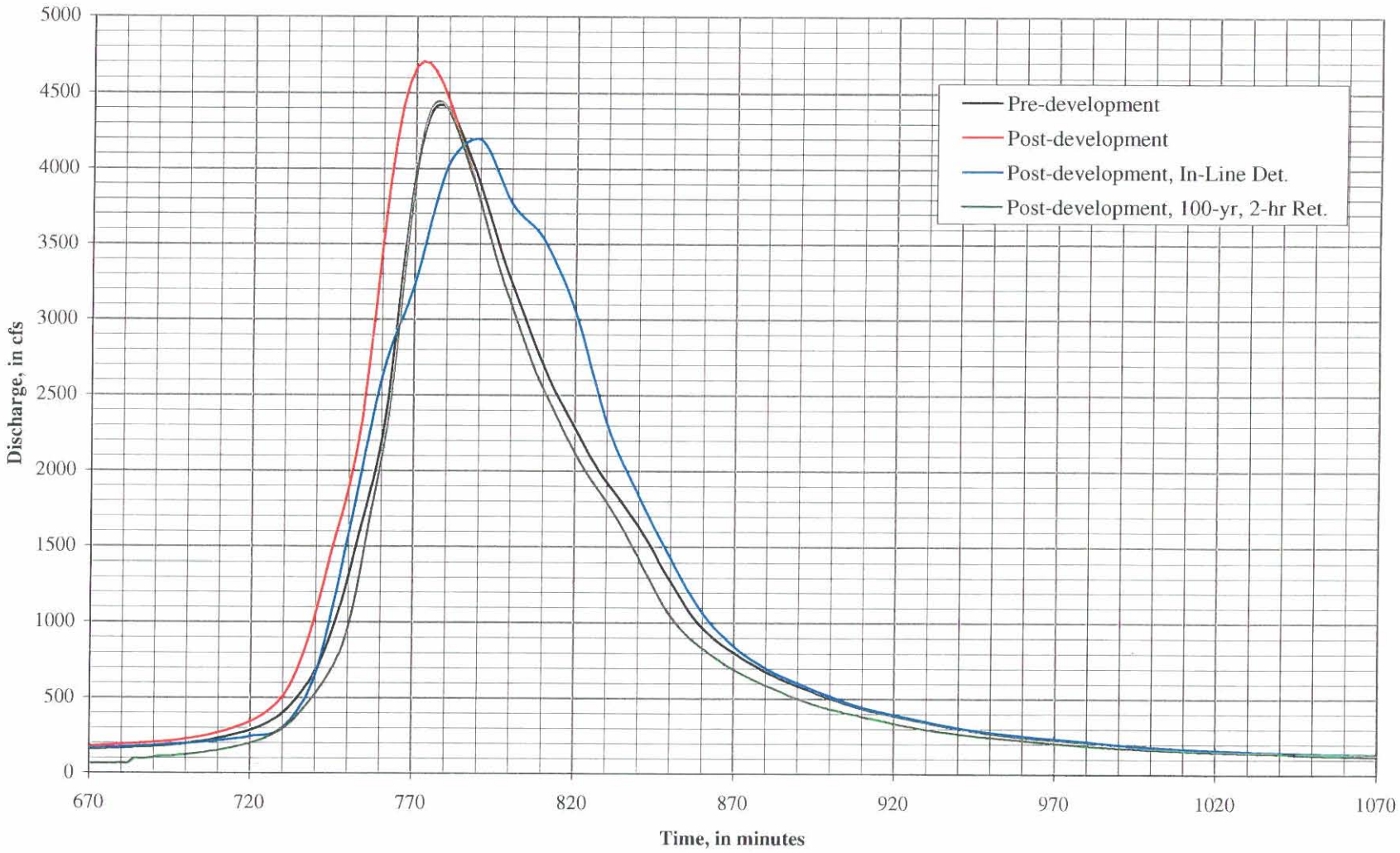


Figure 11-22

Comparison of Retention/Detention Alternatives for Unnamed Wash 3 for the 100-Year Event

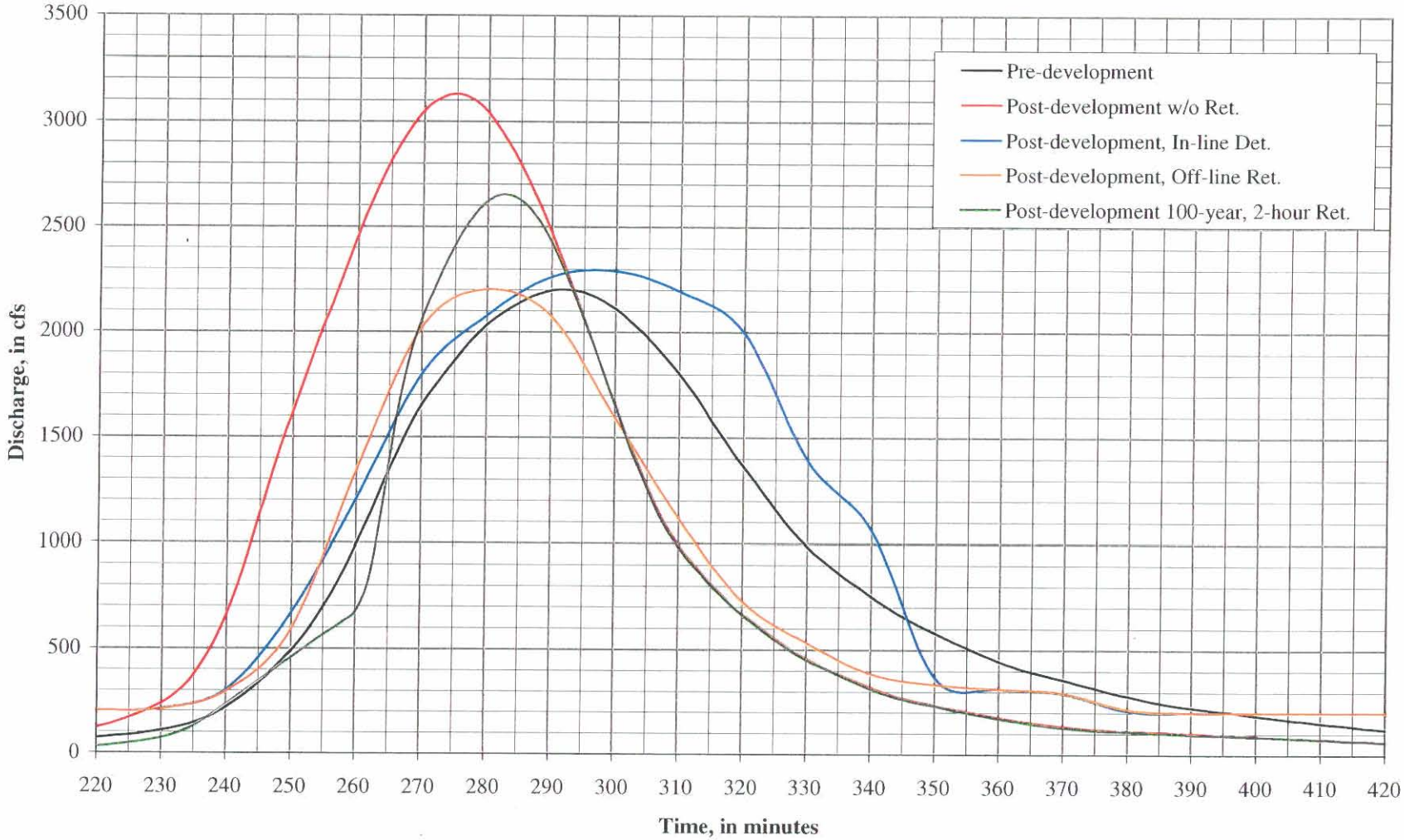


Figure 11-23

Comparison of Retention/Detention Alternatives for Unnamed Wash 1 for the 10-Year Event

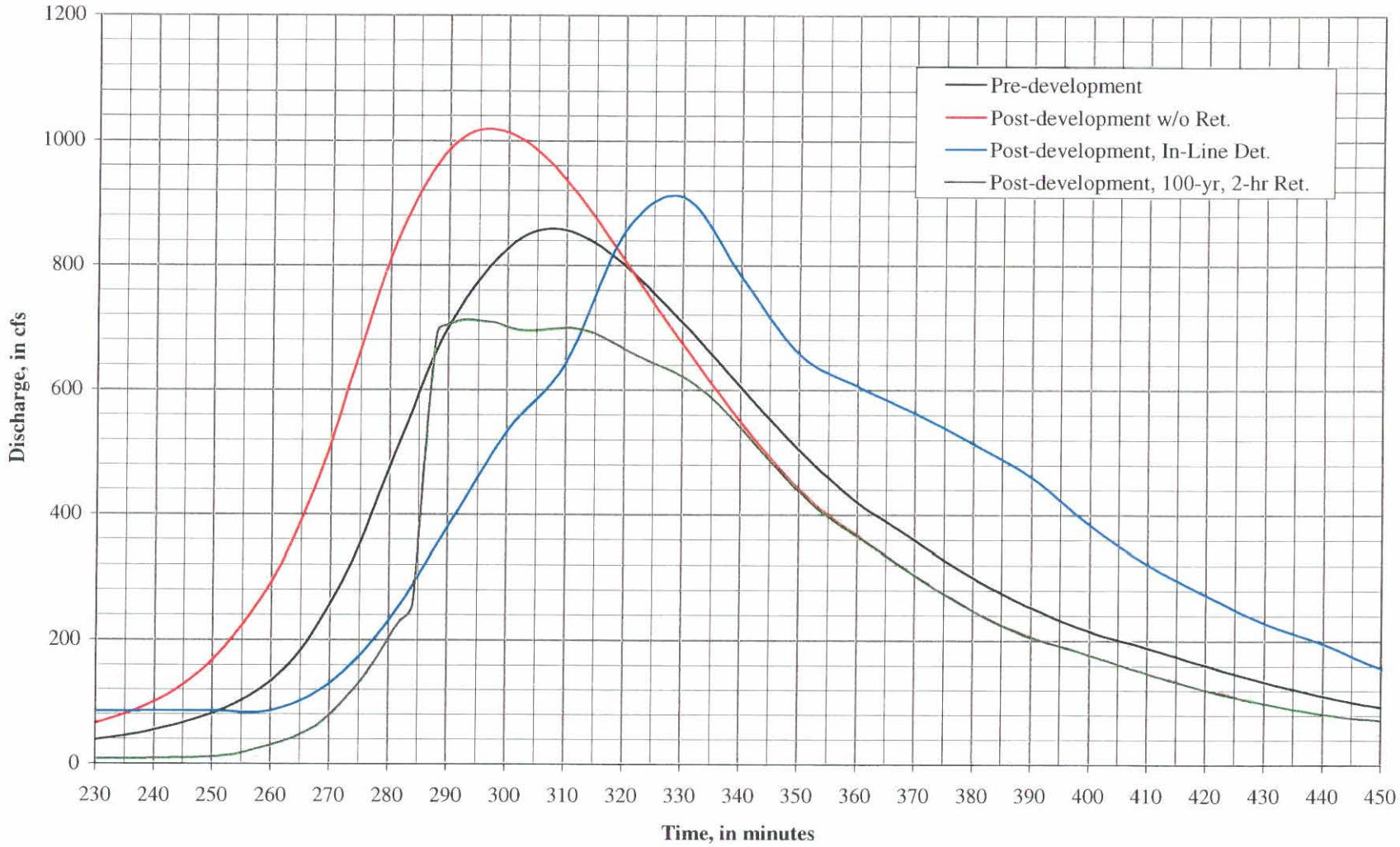


Figure 11-24

Comparison of Retention/Detention Alternatives for Unnamed Wash 2 for the 10-Year Event

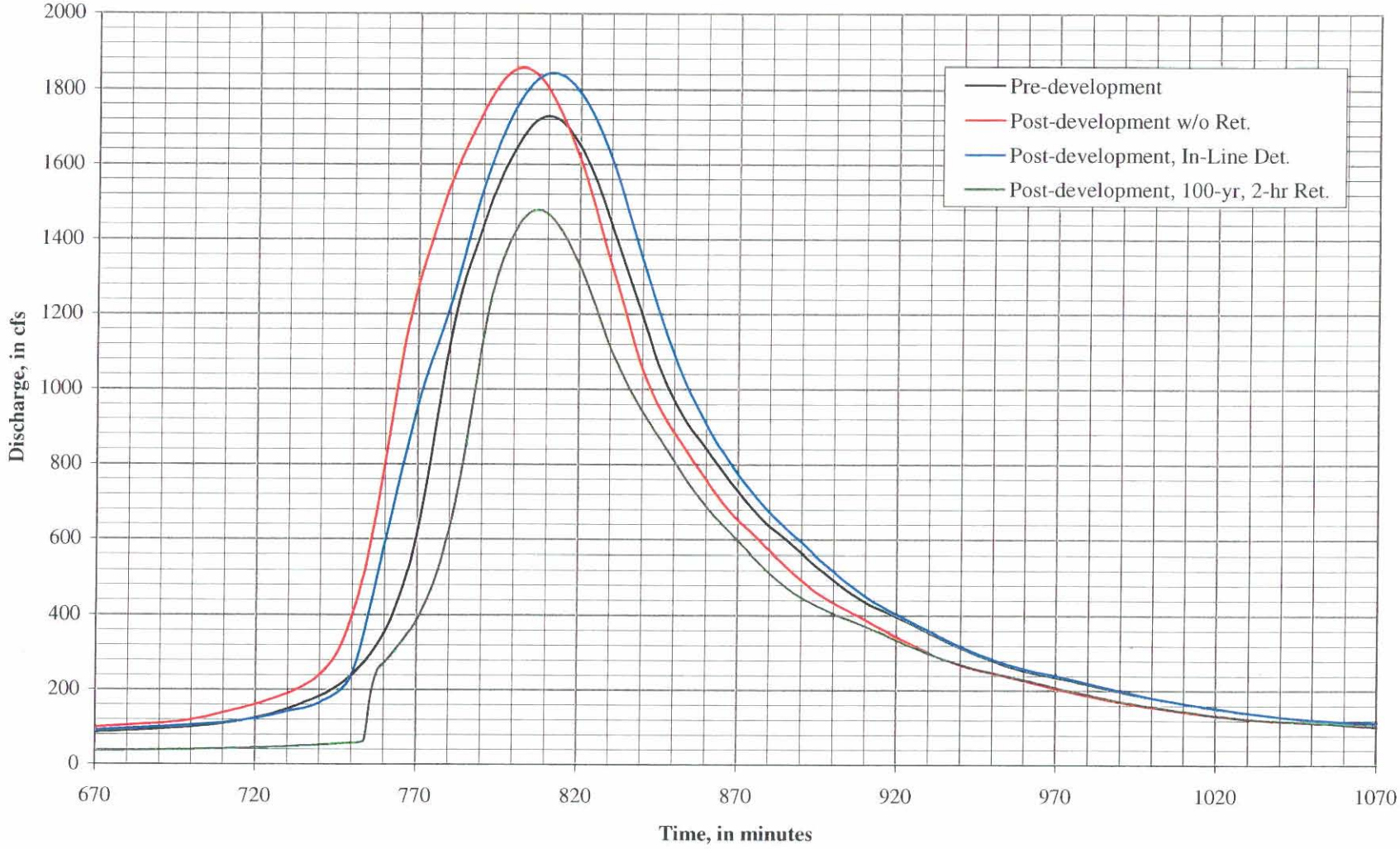
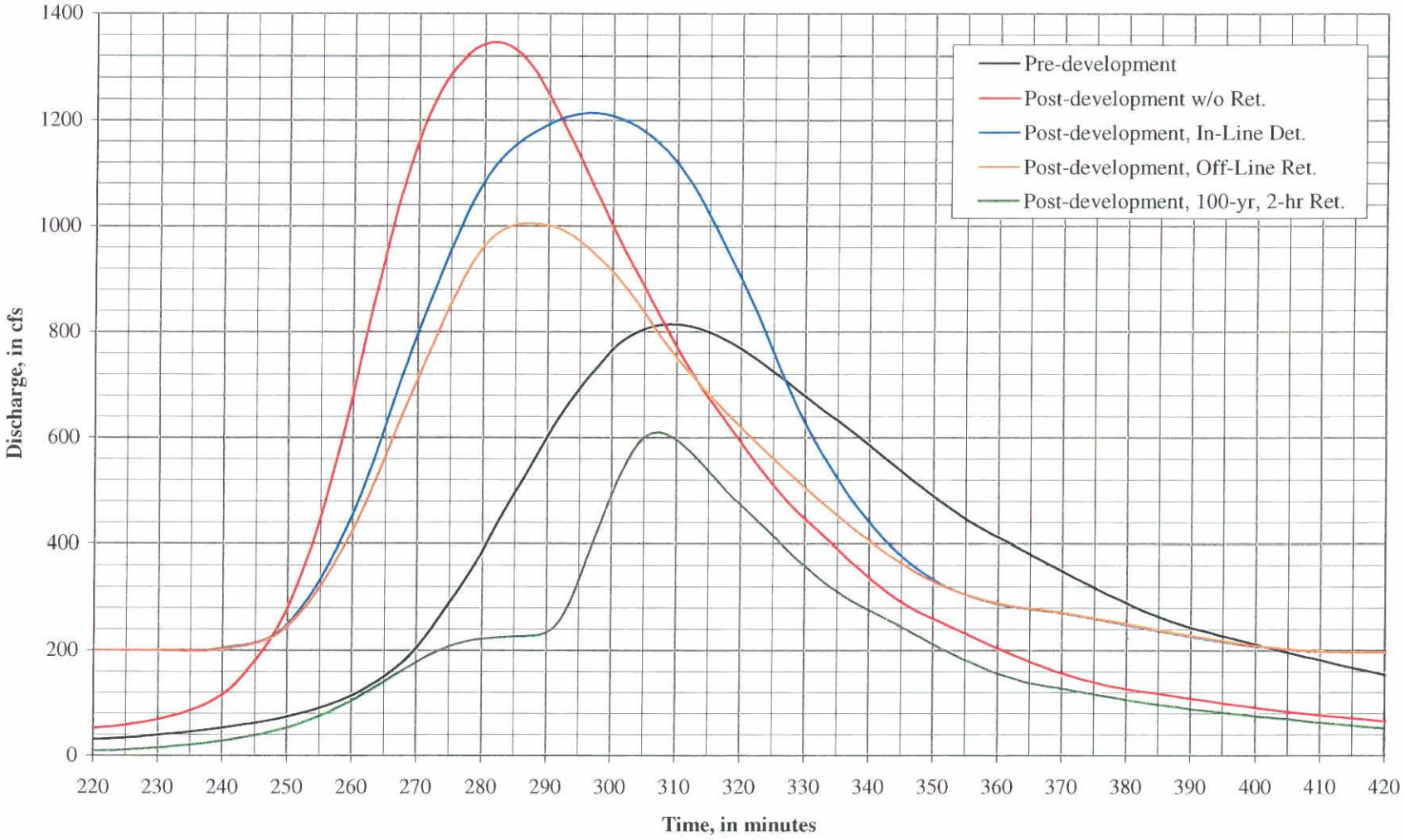


Figure 11-25

Comparison of Retention/Detention Alternatives for Unnamed Wash 3 for the 10-Year Event



Cost Estimate

Purpose

Preliminary estimates of probable construction costs are prepared for both the in-line and off-line alternatives as developed for Unnamed Wash 3. These cost estimates are used as an aid in the selection process of a preferred alternative. Cost estimates developed for each alternative reflect the proposed improvements developed from generalized hydraulic evaluations and are considered approximate. A cost estimate is not estimated for the 100-year, 2-hour retention basin as this is the current standard policy.

Methodology

Quantities are calculated for earthwork (excavation and/or fill), bank armoring, structural concrete for box culverts, concrete pipe and for riprap. For both the in-line and off-line basin alternatives, the volume of earthwork was determined by average end area calculations for cross-sections taken through the improvement area. Bank armoring quantities were determined by applying a typical section along the length of the improvement area. A nominal toe down depth of 5 feet was assumed for all bank-armoring quantities.

Table 11-75 lists a summary of unit cost utilized to determine cost estimates for each alternative. Given that these are conceptual designs of the proposed alternatives, a cost contingency is applied to account for design details that cannot be for seen at this stage. Contingency cost is estimated at 15 percent of the total construction cost of the proposed improvements.

Table 11-75

Summary of Unit Costs

Item	Unit	Cost
Earthwork	Cubic Yards (cy)	$4.00
Soil Cement	Cubic Yards (cy)	$30.00
Structural Concrete	Cubic Yards (cy)	$350.00
36" rcp	Linear Foot	$150.00
Riprap	Cubic Yards (cy)	$80.00

Results

Tables 11-76 and 11-77 are listing of the costs for the in-line and off-line alternatives, respectively. The total cost, including 15% contingency is $332,800 for the in-line basin and $727,300 for the off-line basin as development for Unnamed Wash 3

Table 11-76

In-line Detention Basin Cost Estimate

Item	**Quantity**	**Unit**	**Unit Cost**	**Total**
Earthwork	17,300	cy	$4.00	$69,200
Structural Concrete	650	cy	$350	$227,500
Riprap (dumped)	125	cy	$80	$10,000
Net Cost				$306,700
Contingency (15%)				$46,005
Total				$352,705

Table 11-77

Off-line Detention Basin Cost Estimate

Item	Quantity	Unit	Unit Cost	Total
Earthwork	97,300	cy	$4	$389,200
Soil Cement	10,200	cy	$30	$306,000
Structural Concrete	10	cy	$350	$3,500
36" rcp	180	lf	$150	$27,000
Riprap (dumped)	50	cy	$80	$4,000
Net Cost				$729,700
Contingency (15%)				$109,455
Total				$839,155

11.3.3.2 Wash Vegetation Buffer Evaluation

Purpose

Objective A-5 of the City of Peoria's Peoria Desert Lands Conservation Master Plan recommends that appropriate or sufficient buffers between areas dominated by human activities and environmentally sensitive areas be established (open space buffers must be at least 25 feet). Policy A-5.2 developed for the objective states "Encourage the location of project open space areas in close proximity to dedicated or reserved open space areas to provide a transition between developed and undeveloped areas and to provide a buffer between natural and developed open space areas". Riparian areas and wash corridors and vegetation along wash corridors are presented as environmentally sensitive lands in the plan and are recommended to be protected.

Some management approaches to defining the buffer have been to set the limits of the buffer from the sandy bottom or banks of a wash. Taking into consideration, 100-year floodplain and erosion hazard zone widths measuring the width of the buffer from the sandy bottom or bank of a wash may not provide adequate set back for development.

The purpose of this evaluation is to develop a management approach to defining the buffer taking into consideration 100-year floodplain, erosion hazard zones and the minimum 25-foot buffer.

Methodology

The following assumptions, procedures, and methodologies were employed in while evaluating a management scheme for wash vegetation buffer zones:

- Floodplain, erosion hazard zone and vegetation corridor widths are determined at a number of locations.
- Vegetation corridor is defined as the extent of vegetation along a wash. The width of the corridor is the width of the vegetation from one wash edge to the other plus the 25-foot minimum buffer (both edges of the wash).
- Vegetation widths are measured from digital aerial photographs.
- Floodplain and erosion hazard zones widths are measured at the same location as the vegetation corridor widths from digital delineation files.
- Floodplain, erosion hazard zone and vegetation corridor widths are compared to determine the difference between each zone.

Results

Results of the comparison of vegetation corridor buffer widths to floodplain and erosion hazard zone widths are presented in Table 11-78.

Table 78

Summary of Floodplain, Erosion Hazard, Vegetation Corridor Widths

Watercourse Id	River Mile Sta. (mile)	Floodplain Width (ft)	Erosion Hazard Width (ft)	Vegetation Corridor Width Plus 50' Buffer (ft)	Difference Between Vegetation Corridor Buffer And Floodplain Width (ft)	Difference Between Vegetation Corridor Buffer And Erosion Hazard Width (ft)
1	2	3	4	5	6	7
Morgan City	0.00	160.2	225.5	186.0	-25.8	39.5
Morgan City	1.00	154.6	219.1	172.0	-17.4	47.1
Morgan City	2.00	172.0	260.3	217.0	-45.0	43.3
Morgan City	3.00	454.3	608.6	435.0	19.3	173.6
Morgan City	4.00	269.5	348.2	319.0	-49.5	29.2
Morgan City	5.10	269.0	331.5	408.1	-139.1	-76.6
Morgan City	6.00	207.5	339.9	266.0	-58.5	73.9
Morgan City	6.80	356.8	357.0	320.8	36.0	36.2
Morgan City	8.00	345.4	379.1	367.0	-21.6	12.1
Morgan City	9.00	211.6	241.9	285.0	-73.4	-43.1
Morgan City	10.00	115.7	116.0	139.0	-23.3	-23.0
Twin Buttes	1.00	435.8	878.8	129.2	306.6	749.6
Twin Buttes	2.10	150.0	370.2	174.6	-24.6	195.6
Twin Buttes	3.00	191.1	659.3	114.5	76.6	544.8
Twin Buttes	4.00	253.3	331.5	162.8	90.5	168.7
Twin Buttes	5.00	66.3	261.2	118.0	-51.7	143.2
Twin Buttes	6.00	88.3	208.7	150.3	-62.0	58.4
Twin Buttes	7.00	69.0	142.4	149.3	-80.3	-6.9
Twin Buttes	8.00	85.3	126.9	150.5	-65.2	-23.6
Unnamed 2	1.00	74.6	77.9	128.1	-53.5	-50.2
Unnamed 2	2.00	93.5	153.8	166.0	-72.5	-12.3
Unnamed 2	3.00	65.9	105.4	75.5	-9.6	29.9
Unnamed 2	4.10	272.2	376.7	153.9	118.3	222.8
Unnamed 2	5.00	114.9	305.0	187.4	-72.5	117.6
Unnamed 2	6.00	128.1	148.0	137.2	-9.1	10.8
Unnamed 2	7.00	39.7	84.1	141.7	-102.0	-57.7
Unnamed 2	8.00	48.4	108.3	161.0	-112.6	-52.7

The following conclusions are developed from the comparison of floodplain, erosion hazard and vegetation corridor widths:

- The dimension of the vegetation corridor plus the minimum buffer width as compared to floodplain and erosion hazard widths indicate that the buffer as measured from the edge of wash

vegetation would lie at some location within the limits of the floodplain and erosion hazard zones and at other locations outside.

- A management practice of determining a wash buffer of a minimum setback of 25 feet from the edge of vegetation or the limits of the erosion hazard zone which ever is greater is proposed as a method for determining the buffer area.

11.3.3.3 Roadway Drainage Structures at Wash Crossings Evaluation

Purpose

During the steering committee meeting, a proposal was made that all roadway crossings of washes shall span the 100-year floodplain to minimize the impact of the crossing on the natural function of the watercourse. Spanning the 100-year floodplain with a bridge at roadway crossings of washes relative to the standard practice of some degree of encroachment into the floodplain with a culvert drainage structure could be costly. An evaluation of different types of roadway/wash crossing structures is conducted to determine the following:

- Cost of a bridge structure to span the 100-year floodplain.
- Cost of two different culvert structures scenarios.
- Identification of relative changes to depth and velocity due to an encroachment in the 100-year floodplain.
- Cost estimate for increasing the height of a structure to 8 feet to provide enhanced pedestrian/wildlife access.

Methodology

Two different encroachment scenarios are evaluated at a number of potential roadway/wash crossings through out the study area. The different encroachment scenarios are:

- Scenario 1: Encroach into the floodplain to the discernable bottom (sandy bottom width or bank limits) or until a 0.5 foot rise in depth of flow is realized upstream of a culvert.

- Scenario 2: Encroach into the floodplain until a 1-foot rise in water surface elevation is realized or to the floodway limit (if defined).

The following assumptions, procedures, and methodologies were employed while evaluating and estimating cost for the different encroachment scenarios:

- The 100-year peak discharge is utilized as the design peak discharge. Peak discharges are determined from the hydrology models conducted for this study. Area unit discharges relationships are developed to estimate peak discharges for locations where concentration points were not developed in the study hydrology model.

- Structures are designed to pass the 100-year event with no over-topping.

- The dimension of the natural bottom width assumes that the bottom width represents the geomorphic dimensions necessary to maintain natural sediment transport conditions.

- It is assumed that box culverts offer the least impact to the natural function of the watercourse over circular or elliptical culverts. Only box culverts are considered in the evaluation.

- Encroachment limits are relaxed should results indicated a greater rise in the depth of flow then what is set by the scenario criteria.

- Wash cross-section geometric data are determined from topographic maps available for the study area.

- A Manning's roughness coefficient of 0.015 was utilized to estimate the roughness of box culverts. Manning's roughness coefficients utilized in the routing routine of the hydrologic models for the study area are used to estimate wash roughness.

- The FWHA culvert analysis HY-8 computer program (Version 6.1) is utilized to perform culvert evaluations.

- Arizona Department of Transportation standard drawings B-02.00 through B-02.70 for box culverts are utilized in the evaluation. Entrance loss coefficients are based on a 1:1 bevel and 45° wing walls.

- The lengths of box culverts are based on a 70-foot roadway right of way.

- Minimum box culvert height is set at 4 feet.

- Culvert slope is set to be consistent with wash slope.

- Cost estimates are determined utilizing $350.00 per cubic yard for structural concrete and $65.00 per square foot for a bridge. Cost estimates only include the cost of the structure no other cost associated with the structure such as right of way cost and roadway construction are estimated.

Results

Results of the evaluation of different roadway/wash crossing for each structure scenario are listed in Table 11-79 and Table 11-80 for Scenario 1 and Scenario 2, respectively. Table 11-81 lists, cost estimated for a bridge crossing, Scenario 1 and Scenario 2 culvert structures and the cost of a Scenario 2 structure increased to a height of 7 or 8 feet. HY8 calculation sheets are provided in Appendix I.

Table 11-79

Wash/Culvert Evaluation Summary-Scenario 1

Wash ID (1)	oncentration Point (2)	100-year Peak Discharge (cfs) (3)	Culvert Size (4)	Culvert HW Depth (ft) (5)	Outlet Velocity (fps) (6)	Bottom Width (ft) (7)	Downstream Velocity (fps) (8)	Downstream Depth (ft) (9)
Morgan City Wash	C611R	10241	30 RCB 10'x8'	6.62	4.94	235	9.06	6.91
Unnamed Wash 2	S206	304	4 RCB 10'x4'	1.80	9.08	10	4.21	1.31
Unnamed Wash 3	S301	295	1 RCB 8'x4' and 1 RCB 6'x4'	3.70	12.59	10	6.23	3.19
Unnamed Wash 3	S300	710	3 RCB 10'x4'	4.05	12.48	15	7.05	3.99
Caterpillar Tank Wash	S400	335	2 RCB 10'x4'	3.15	10.43	10	4.43	2.65
Twin Buttes Wash	C501	1,250	5 RCB 10'x4' and 1 RCB 6'x4'	3.87	12.8	10	9.64	3.41
Twin Buttes Wash	C512	3,775	12 RCB 10'x4' and 1 RCB 8'x4'	5.28	7.42	40	5.07	5.17
Unnamed Wash 7	S724	817	20 RCB 10'x4'	1.19	8.09	200	2.70	1.53
Unnamed Wash 8	S725	586	21 RCB 10'x4'	0.92	6.58	210	2.33	0.99

Table 11-80

Wash/Culvert Evaluation Summary-Scenario 2

Wash ID (1)	Concentration Point (2)	100-year Peak Discharge (cfs) (3)	Culvert Size (4)	Culvert HW Depth (ft) (5)	Outlet Velocity (fps) (6)	Bottom Width (ft) (7)	Downstream Velocity (fps) (8)	Downstream Depth (ft) (9)
Morgan City Wash	C611R	10241	12 RCB 12'x8' and 2 RCB 8'x8'	7.83	15.95	235	9.06	6.91
Unnamed Wash 2	S206	304	2 RCB 10'x4' and 1 RCB 8'x4'	2.29	10.08	10	4.21	1.31
Unnamed Wash 3	S301	295	2 RCB 6'x4'	4.17	12.87	10	6.24	3.20
Unnamed Wash 3	S300	710	3 RCB 8'x4'	4.85	13.01	15	7.05	3.99
Caterpillar Tank Wash	S400	335	1 RCB 8'x4' and 1 RCB 10'x4'	3.38	10.66	10	4.43	2.65
Twin Buttes Wash	C501	1,250	4 RCB 10'x4' and 1 RCB 8'x4'	4.37	13.35	10	9.64	3.41
Twin Buttes Wash	C512	3,775	11 RCB 10'x4'	5.82	8.58	40	5.07	5.17
Unnamed Wash 7	S724	817	6 RCB 10'x4' and 1 RCB 6'x4'	2.53	9.46	200	2.70	1.53
Unnamed Wash 8	S725	586	6 RCB 8'x4' and 1	1.97	8.31	210	2.33	0.99

Table 11-81

Cost Summary for Wash/Roadway Crossing Structures

Wash Name ID (1)	CP/SB ID (2)	Bridge Cost $ (3)	Scenario 1 Structure (4)	Scenario 1 Cost $ (5)	Scenario 2 Structure (6)	Scenario 2 Cost $ (7)	Scenario 2 with 8' high cbc's Structure (8)	Scenario 2 with 8' high cbc's Cost $ (9)
Morgan City Wash	C611R	1,382,654	30 RCB 10'x8'	919,575	12 RCB 12'x8' and 2 RCB 8'x8'	542,368	12 RCB 12'x8' and 2 RCB 8'x8'	542,368
Unnamed Wash 2	S206	369,278	4 RCB 10'x4'	104,926	2 RCB 10'x4' and 1 RCB 8'x4'	84,157	2 RCB 10'x8' and 1 RCB 8'x8'	116,575
Unnamed Wash 3	S301	130,539	1 RCB 8'x4' and 1 RCB 6'x4'	48,493	2 RCB 6'x4'	35,886	2 RCB 6'x7' *	45,329
Unnamed Wash 3	S300	194,876	3 RCB 10'x4'	81,018	3 RCB 8'x4'	62,034	3 RCB 8'x8'	80,798
Caterpillar Tank Wash	S400	264,628	2 RCB 10'x4'	57,109	1 RCB 8'x4' and 1 RCB 10'x4'	59,146	1 RCB 8'x8' and 1 RCB 10'x8'	89,457
Twin Buttes Wash	C501	256,028	5 RCB 10'x4' and 1 RCB 6'x4'	150,280	4 RCB 10'x4' and 1 RCB 8'x4'	131,975	4 RCB 10'x8' and 1 RCB 8'x8'	171,056
Twin Buttes Wash	C512	2,731,670	12 RCB 10'x4' and 1 RCB 8'x4'	863,996	11 RCB 10'x4'	734,143	11 RCB 10'x8'	872,302
Unnamed Wash 7	S724	2,223,312	20 RCB 10'x4'	515,341	6 RCB 10'x4' and 1 RCB 6'x4'	174,189	6 RCB 10'x8' and 1 RCB 6'x7' *	213,455
Unnamed Wash 8	S725	1,684,592	21 RCB 10'x4'	539,250	6 RCB 10'x4' and 1 RCB 8'x4'	179,792	6 RCB 10'x8' and 1 RCB 8'x8'	225,513

Notes: * ADOT Standard No.'s B-02.10 through B-02.70 with a span of 6 ft, have a maximum height of 7 ft.

The following conclusions are developed form the roadway drainage structures at wash crossing evaluation:

- By comparing bottom width (assumes that the bottom width represents the geomorphic dimensions necessary to maintain natural sediment transport conditions) to box culvert width, encroachment into the 100-year floodplain limit to the discernable bottom width is not obtainable unless the rise in water surface upstream of the culvert structure is allowed to be greater than 1 foot.

- At locations the structure width required to pass the 100-year peak discharge is twice to three times the bottom width of the channel. At these locations should a structure be sized to pass the 100-year flow with the constraints of a maximum rise in water surface elevation of 1 foot, the natural channel would be greatly expanded resulting in an increase potential for deposition to occur upstream and within the culvert during more frequent events (2-, 10-, 25-year). Without proper maintenance the structure will become clogged with sediment.

- The greater the degree of encroachment into the floodplain by a culvert structure results in greater changes in outlet velocity downstream of the structure relative to natural conditions (up to a 100 percent increase). The greater the change in velocity the greater the chances of scour downstream.

- Unnamed Wash 7 and 8 at the location where structures were evaluated are characterized by wide shallow floodplains. Structure sizes for these washes, given minimum design constraints (minimum height of 4 feet) and encroachment limits resulted in very large and costly structures. The area either lends it self to a structure consisting of many small culverts (24" or 36" CMP or

RCP) which would present maintenance issues, or to a structure where the flow has been concentrated into a channel to optimize the size and cost of the structure. Another option would be to select a different location for a roadway crossing.

- For the drainage structure/wash crossings evaluated (with the exception of for Unnamed Wash 7 and 8), the cost of a bridge spanning the 100-year floodplain is typically 1.5 to 4.5 times more than a culvert structure in which encroachment is allowed.

- Typically, the greater the amount of encroachment into the floodplain by a culvert structure results in less cost.

- Maintenance cost and log term function should be taken into consideration when selecting a drainage structure at a wash crossing. If the natural sediment transport capacity of the wash is disrupted by increasing the dimensions of the channel to accommodate a structures based on cost for an infrequent event (50-, 100-year event) the structure, over time may become clogged with sediment from frequent events increasing maintenance cost and decreasing the function of the structure.

- Increasing a box culvert height from 4 feet to 7 or 8 feet increases the cost of the structure by 20 to 50 percent.

11.3.3.4 Development of Policies

Goals, Objectives, and Policies developed for the North Peoria ADMP are under review by the District, Arizona State Land Department, City of Peoria and private landowners. Policies will be presented in the final document.

11.3.3.5 Alternatives Evaluation/Selection

Criteria and Procedure

Evaluation criteria and procedures developed for the North Peoria Area Drainage Master Plan are adapted in part from evaluation criteria and procedures developed for the Cave Creek Watercourse Master Plan. The evaluations of the alternatives are based on weighted elements of four criteria. The criteria are Public Safety Impacts, Social Impacts, Environmental Impacts and Economic Impacts. A weighting factor was developed by the steering committee that represents the "relative importance" of each element in the evaluation process. The weighting factors were measured on a scale of 1 to 10, where a factor of 10 represented highest importance.

A rating system is used to measure the effectiveness of each alternative at meeting the elements of each criterion. The rating system ranges from 1 to 5. A value of 1 represents a "very low" rating at meeting the criteria, a value of 2 represents a "low" rating, a value of 3 represents a "moderate" rating, a value of 4 represents a "high" rating, and a value of 5 represents a "very high" rating. Rated values for each element are averaged to obtain an average value for the criterion. The evaluation criteria and weights of importance are listed in Table 11-82.

TABLE 11-82

CRITERIA & WEIGHTING FACTORS FOR EVALUATION OF ALTERNATIVES

Evaluation Criteria	Weighting Factor Range 0-10	Maximum Possible Score*
Public Safety		
Protect Life and Property	10	50
Water Quality	10	50
Social		
Community Acceptance	3	15
Multi-use Opportunities	3	15
Compatibility with other Existing Plans	3	15
Environmental		
Complexity of Environmental Permitting, Impact on Biological Resources,	6	30
Impact on Cultural Resources	6	30
Visual Resources and Aesthetic Compatibility	6	30
Economic		
Implementation Cost	4	20
Maintenance Cost	4	20

*Maximum Possible Score = Weighting Factor x Rating Factor of 5

Public Safety Criterion

The public safety criterion is based on evaluating the threat for loss of human life, possible damage to structures and property and impacts to water quality resulting from implementation of a given alternative. This criterion is an indicator of how well the proposed alternative will succeed in reducing or eliminating life threatening, or potentially life threatening, flood and erosion related hazards, as well as reducing the potential for flood and erosion related damage to public and private properties.

The evaluation of the public safety criterion is based on the effectiveness of each alternative in satisfying the two elements described below. The elements account for various types of risk, hazards, and impacts associated with development encroaching into natural watercourses.

Protect Life and Property.

Historically, society has experienced loss of life and property due to flooding and erosion that is associated with a storm water runoff event. This element rates the function of the alternative to keep the public out of harms way during a 100-year storm event while minimizing potential downstream impacts to life, property and structures. An element rating value of 5 is assigned to an alternative that functions to protect life, property and structures without increasing potential damages downstream. An element rating of 3 is assigned to an alternative that functions to protect life, property and structures, however, there is a potential for downstream impacts because of the alternative. An element rating of 1 is assigned to an alternative that does not function to protect life, property and structures.

Water Quality

Federal guidelines mandate that communities develop Best Management Practices (BMP's) to promote water quality. This element accounts for the impacts of an alternative on water quality. An alternative that provides opportunity for a BMP's would be rated a 5, while an alternative that does not provide an opportunity for a BMP's would be rated a 1.

Social Criterion

The evaluation of the social impact criterion is based on the effectiveness of each alternative in satisfying the three elements described below.

Community Acceptance

This element accounts for the input received from the public involvement process. There is a nationwide trend towards promoting non-structural approaches and ecosystem preservation, as witnessed by the removal of flood control structures in many parts of the country. Federal agencies such as the U.S. Army Corps of

Engineers and the U.S. Bureau of Reclamation have, in recent years, significantly changed their focus from hard engineering solutions to include non-structural alternatives, preservation of natural hydrologic functions, and ecosystem restoration. The specific input from the public involvement process was that the preservation of watercourses and their associated habitat is more important than maximizing developable land by destroying the natural hydrologic processes, which results from encroaching into watercourses.

The effectiveness of an alternative in meeting community acceptance is measured by the amount of land preserved in its natural state within in the 100-year floodplain and erosion hazard zone. An alternative that preserves this entire zone would be rated a 5, while an alternative that includes the maximum encroachment in to the floodplain would be rated a 1.

Multi-use Opportunities

This element is an indicator of the multi-use opportunities of an alternative. Examples of such uses included passive and active recreation, trails, and open space. The effectiveness of the criterion is based on the extent of multi-use opportunities that result from implementing a given alternative.

The alternatives were assessed on their ability to accommodate multi-use trails/pathways, their compatibility with other potential recreation facilities in terms of access, and user's experience on the trail/pathway. The standard used to evaluate the alternatives is a combination of channel type and available access. Multi-use opportunities associated with a wide, rectangular, concrete channel with limited access points would be rated as a 1 due to the limitations in accommodating equestrian use, the restriction on potential connections to other recreation facilities, and the less than desirable user experience. Alternatives that permit unlimited access to a natural channel environment would be rated a 5.

Compatibility with Other Existing Plans

This element is an indicator of the compatibility of the proposed alternative with planning policies cited in other existing planning documents. Planning document reviewed are, Maricopa County Comprehensive Plan 2020 Eye to the Future, Maricopa County Whit Tank/Grand Avenue Area Plan, City of Peoria's General Plan, City of Peoria's Desert Lands Conservation Plan, City of Peoria's Lake Pleasant/North Peoria Area Plan and the City of Peoria's Trails Master Plan. An alternative that is compatible with other plans would be rated a 5, while an alternative that is not would be rated a 1.

Environmental Criterion

The evaluation of the Environmental Impact Criterion is based on the effectiveness of each alternative in satisfying the three elements described below.

Environmental

This element consists of two sub elements, complexity of environmental permitting and impacts on biological resources.

Complexity of Environmental Permitting focuses on the acquisition of the US Army Corps of Engineers 404 Permits and 401 Water Quality Certifications. The alternatives are measured based on the potential for needing a 404 Permit, the level of 404 Permit required (Nationwide vs. Individual), and the level of mitigation necessary to gain federal approval to construct the alternative. To evaluate this element, it is assumed that alternatives with structural features will cause disturbance to the land within the Waters of the United States. The more extensive the structural features, the lower the rating. As an example, constructing a wide, rectangular, concrete channel would place fill within the Waters of the United States, require an Individual 404 Permit and 401 Water Quality Certification, and require extensive mitigation measures to replace the relatively high-value habitat and vegetation associated with the undisturbed desert riparian wash.

Impacts on biological resources accounts for the potential impact on biological resources by the proposed alternatives and how well the proposed management alternative will succeed in preserving or restoring the natural riparian environment found along the study watercourses. The most important indicator of this is the ability of a given alternative to preserve wildlife habitat or minimize disruption to existing habitat.

An alternative where no environmental permitting is required and there are no biological resource impacts would be rated as a 5. Alternatives where extensive environmental permitting is required and there are extensive biological resource impacts would be rated as a 1.

Visual Resource and Aesthetic Compatibility

This element evaluates the relative degree of contrast between the various components of the alternatives and their setting in the landscape. Visual contrast is based on spatial dominance, visual compatibility, color, line, and form. The standard used to measure the compatibility of a given alternative is the construction of a wide, rectangular, concrete channel. Such a channel would spatially dominate the setting, have a high degree of contrast in terms of color, line, and form, and would not be visually compatible with the surrounding natural desert vegetation and landforms. A structure of this type would be rated as a 1. Alternatives that do not include structural features would be rated a 5.

Impact on Cultural Resources

This element accounts for the potential impact on cultural resources by a given alternative. It is also an indicator of how well the alternatives will succeed in preserving cultural resources. An alternative that impacts all of the known cultural resources would be rated a one 1, while an alternative that impacts none of the known cultural resources would be rated a 5.

Economic Criterion

The evaluation of the economic criterion is based on the effectiveness of each alternative in satisfying two elements that are described below.

Implementation Cost

This element represents the estimated cost of the proposed alternative to the public, either through increased development costs passed on to future residents of the area who will directly benefit from the improvements (local public) or the costs to the general public.

The cost for a structural alternative considers the cost of the structural improvements necessary to implement the proposed alternative (a positive cost), the value of land that is reclaimed from the floodplain/erosion hazard zone by the structural improvements (a negative cost, i.e., benefit). Added together, these costs represent the total net cost of the alternative.

The effectiveness of a given alternative is measured by using the total net cost. The lower the net cost, the higher the rating for the alternative. Negative net cost is rated a five, while positive net cost is rated a 1.

Maintenance Cost

This element accounts for the potential maintenance costs associated with the structural components of an alternative. It has been assumed that such costs are proportional to the length of bank protection proposed for a given alternative. The greater the bank protection length, the higher the potential maintenance cost and the lower the rating. A full-structural alternative would be rated a 1. An alternative with no bank protection would be rated a 5.

Summary of Results

The results of ranking each alternative are summarized in Tables 11-83 through 11-94.

Unnamed Wash 1, 2 and 3 have similar physical characteristics and are evaluated collectively. Results for Unnamed Wash 1, 2 and 3 are presented under the heading of Big Spring Area.

Twin Buttes Wash, Caterpillar Tank, West Fork Whites Peak Wash, Whites Peak Wash and West and East Garambullo washes located in the Twin Buttes Area have similar physical characteristics and are evaluated collectively. Results for washes located in the Twin Buttes Area are presented under the heading of Twin Buttes Area.

Results of ranking the Standard Retention Alternative, Inline Detention Alternative, and the Side Weir Retention Alternative are presented in Table 11-92, Table 11-93, and Table 11-94 respectively. Ranking results for the Low Impact Structural Alternative are listed in Table 11-91.

Table 11-83

Ranking Summary for the Non-Structural Alternative

Morgan City Area

Evaluation Criteria	Weighting Factor	Rating (1 to 5)	Score
Public Safety	-	-	-
Protect Life and Property	10	4.5	45
Water Quality	10	3.5	35
Social	-	-	-
Community Acceptance	3	4.0	12
Multi-use Opportunities	3	3.0	9
Compatibility with other Existing Plans	3	4.0	12
Environmental	-	-	-
Complexity of Environmental Permitting and Impact on Biological Resources,	6	5.0	30
Impact on Cultural Resources	6	4.5	27
Visual Resources and Aesthetic Compatibility	6	4.5	27
Economic	-	-	-
Implementation Cost	4	3.0	12
Maintenance Cost	4	3.0	12
		Total =	**221**

Table 11-84

Ranking Summary for the Do Nothing Alternative

Morgan City Area

Evaluation Criteria	Weighting Factor	Rating (1 to 5)	Score
Public Safety	-	-	-
Protect Life and Property	10	3	30
Water Quality	10	3	30
Social	-	-	-
Community Acceptance	3	3.5	10.5
Multi-use Opportunities	3	2	6
Compatibility with other Existing Plans	3	2	6
Environmental	-	-	-
Complexity of Environmental Permitting and Impact on Biological Resources,	6	2	12
Impact on Cultural Resources	6	2	12
Visual Resources and Aesthetic Compatibility	6	1	6
Economic	-	-	-
Implementation Cost	4	1	4
Maintenance Cost	4	1	4
		Total =	**121**

Table 11-85

Ranking Summary for the Non-Structural Alternative

Big Spring Area

Evaluation Criteria	Weighting Factor	Rating (1 to 5)	Score
Public Safety	-	-	-
Protect Life and Property	10	4	40
Water Quality	10	4	40
Social	-	-	-
Community Acceptance	3	4	12
Multi-use Opportunities	3	2	6
Compatibility with other Existing Plans	3	4	12
Environmental	-	-	-
Complexity of Environmental Permitting and Impact on Biological Resources,	6	5	30
Impact on Cultural Resources	6	5	30
Visual Resources and Aesthetic Compatibility	6	5	30
Economic	-	-	-
Implementation Cost	4	3	12
Maintenance Cost	4	3	12
		Total =	**224**

Table 11-86

Ranking Summary for the Do Nothing Alternative

Big Spring Area

Evaluation Criteria	Weighting Factor	Rating (1 to 5)	Score
Public Safety	-	-	-
Protect Life and Property	10	3	30
Water Quality	10	3	30
Social	-	-	-
Community Acceptance	3	3	9
Multi-use Opportunities	3	2	6
Compatibility with other Existing Plans	3	2	6
Environmental	-	-	-
Complexity of Environmental Permitting and Impact on Biological Resources,	6	2	12
Impact on Cultural Resources	6	2	6
Visual Resources and Aesthetic Compatibility	6	1	6
Economic	-	-	-
Implementation Cost	4	1	4
Maintenance Cost	4	1	4
		Total =	**119**

Table 11-87

Ranking Summary for the Partial Structural Alternative

Big Springs Area

Evaluation Criteria	Weighting Factor	Rating (1 to 5)	Score
Public Safety	-	-	-
Protect Life and Property	10	4.3	43
Water Quality	10	3.2	32
Social	-	-	-
Community Acceptance	3	2.9	8.7
Multi-use Opportunities	3	3.1	9.3
Compatibility with other Existing Plans	3	3	9.0
Environmental	-	-	-
Complexity of Environmental Permitting and Impact on Biological Resources,	6	2.5	15
Impact on Cultural Resources	6	2.9	17.4
Visual Resources and Aesthetic Compatibility	6	2.4	14.4
Economic	-	-	-
Implementation Cost	4	2.0	8
Maintenance Cost	4	2.4	9.6
		Total =	**166**

Table 11-88

Ranking Summary for the Non-Structural Alternative

Twin Buttes Area

Evaluation Criteria	Weighting Factor	Rating (1 to 5)	Score
Public Safety	-	-	-
Protect Life and Property	10	4	40
Water Quality	10	3.9	39
Social	-	-	-
Community Acceptance	3	3.8	11.4
Multi-use Opportunities	3	3	9
Compatibility with other Existing Plans	3	4.1	12.3
Environmental	-	-	-
Complexity of Environmental Permitting and Impact on Biological Resources,	6	4.9	29.4
Impact on Cultural Resources	6	4.8	28.8
Visual Resources and Aesthetic Compatibility	6	4.8	28.8
Economic	-	-	
Implementation Cost	4	3	12
Maintenance Cost	4	3	12
		Total =	**223**

Table 11-89

Ranking Summary for the Do Nothing Alternative

Twin Buttes Area

Evaluation Criteria	Weighting Factor	Rating (1 to 5)	Score
Public Safety	-	-	-
Protect Life and Property	10	3	30
Water Quality	10	3	30
Social	-	-	-
Community Acceptance	3	2	6
Multi-use Opportunities	3	2	6
Compatibility with other Existing Plans	3	3	9
Environmental	-	-	-
Complexity of Environmental Permitting and Impact on Biological Resources,	6	2	12
Impact on Cultural Resources	6	2	12
Visual Resources and Aesthetic Compatibility	6	1	6
Economic	-	-	-
Implementation Cost	4	1	4
Maintenance Cost	4	1	4
		Total =	**119**

Table 11-90

Ranking Summary for the Full Structural Alternative

Twin Buttes Area

Evaluation Criteria	Weighting Factor	Rating (1 to 5)	Score
Public Safety	-	-	-
Protect Life and Property	10	4.8	48
Water Quality	10	1.9	19
Social	-	-	-
Community Acceptance	3	2.1	6.3
Multi-use Opportunities	3	2.3	6.9
Compatibility with other Existing Plans	3	2.8	8.4
Environmental	-	-	-
Complexity of Environmental Permitting and Impact on Biological Resources,	6	1.4	8.4
Impact on Cultural Resources	6	1.8	10.8
Visual Resources and Aesthetic Compatibility	6	1.4	8.4
Economic	-	-	-
Implementation Cost	4	1.7	6.8
Maintenance Cost	4	2.3	9.2
		Total =	**132**

Table 11-91

Ranking Summary for the Low Impact Structural Alternative

Twin Buttes Area

Evaluation Criteria	Weighting Factor	Rating (1 to 5)	Score
Public Safety	-	-	-
Protect Life and Property	10	4.7	47
Water Quality	10	3.6	36
Social	-	-	-
Community Acceptance	3	3.6	10.8
Multi-use Opportunities	3	3.4	10.2
Compatibility with other Existing Plans	3	2.8	8.4
Environmental	-	-	-
Complexity of Environmental Permitting and Impact on Biological Resources,	6	3.7	22.2
Impact on Cultural Resources	6	3.8	22.8
Visual Resources and Aesthetic Compatibility	6	3.3	19.8
Economic	-	-	-
Implementation Cost	4	3.1	12.4
Maintenance Cost	4	3.5	14
		Total =	**204**

Table 11-92

Ranking Summary for the Standard Retention Alternative

Big Springs Area

Evaluation Criteria	Weighting Factor	Rating (1 to 5)	Score
Public Safety	-	-	-
Protect Life and Property	10	4.2	42
Water Quality	10	4	40
Social	-	-	-
Community Acceptance	3	3.7	11.1
Multi-use Opportunities	3	3.7	11.1
Compatibility with other Existing Plans	3	4.4	13.2
Environmental	-	-	-
Complexity of Environmental Permitting and Impact on Biological Resources,	6	3.9	23.4
Impact on Cultural Resources	6	3.4	20.4
Visual Resources and Aesthetic Compatibility	6	3	18
Economic	-	-	-
Implementation Cost	4	3.3	13.2
Maintenance Cost	4	2.7	10.8
		Total =	**203**

Table 11-93

Ranking Summary for the In-Line Detention Alternative

Big Spring Area

Evaluation Criteria	Weighting Factor	Rating (1 to 5)	Score
Public Safety	-	-	-
Protect Life and Property	10	4.3	43
Water Quality	10	2.1	21
Social	-	-	-
Community Acceptance	3	3.3	9.9
Multi-use Opportunities	3	3.2	9.6
Compatibility with other Existing Plans	3	3.8	11.4
Environmental	-	-	-
Complexity of Environmental Permitting and Impact on Biological Resources,	6	2.7	16.2
Impact on Cultural Resources	6	3.3	19.8
Visual Resources and Aesthetic Compatibility	6	2.8	16.8
Economic	-	-	-
Implementation Cost	4	2.7	14.8
Maintenance Cost	4	2.3	9.32
		Total =	**172**

Table 11-94

Ranking Summary for the Side Weir Retention Alternative

Big Spring Area

Evaluation Criteria	Weighting Factor	Rating (1 to 5)	Score
Public Safety	-	-	-
Protect Life and Property	10	4.3	43
Water Quality	10	3.2	32
Social	-	-	-
Community Acceptance	3	2.9	8.7
Multi-use Opportunities	3	3.1	9.3
Compatibility with other Existing Plans	3	3	9
Environmental	-	-	-
Complexity of Environmental Permitting and Impact on Biological Resources,	6	2.5	15
Impact on Cultural Resources	6	2.9	17.4
Visual Resources and Aesthetic Compatibility	6	2.4	14.4
Economic	-	-	-
Implementation Cost	4	2	8
Maintenance Cost	4	2.4	9.6
		Total =	**186**

11.3.4 Level III Evaluation

11.3.4.1 Introduction

Based on the evaluation and rankings of the alternatives the preferred watercourse based flood control management alternative is the non-structural alternative. The non-structural alternative defines a corridor that allows the watercourse to function naturally and is defined by the 100-year floodplain, erosion hazard zone and a buffer if applicable between human activity and a wash corridor. The plan recognizes that there may be situations in which development activities may be required or desired within the erosion hazard zone, for this situation the plan presents a low impact structural alternative. Channelization is not a preferred flood control management alternative, however the plan also recognizes that there may be situations in which channelization may be required.

The preferred storm water storage alternative is the standard practice of retaining the volume from the 2-hour, 100-year rainfall event, however this practice may not be practical for certain portions of the study area. The standard retention practices if implemented within in an entire watershed would have negative impacts in regards to sustaining native vegetation along watercourses. The plan offers two alternatives to the standard practice, they are, the in-stream, off-line retention and in-stream, in-line detention. These storm water storage alternatives are based on reducing post-development peak discharges to pre-development magnitudes. Of the two detention/retention alternatives offered, the in-stream, off-line retention alternative is the preferred alternative of the two because the facility functions to allow the majority of the flow and sediment to pass through and only captures the peak of the hydrograph thus minimizing disruptions to the sediment transport capacity of the wash.

Level III evaluation includes development of Implementation and Maintenance plans for the preferred alternatives. The primary objective of the Implementation Plan is too establish a set of regulatory criteria (Rules of Development) and guidelines by which communities can manage the preferred alternatives. The objective of the

Maintenance Plan is to address monitoring, inspection, and maintenance activities that must be under taken for both non-structural goals as well as the specific elements of potential structural and low-impact structural measures that may be employed as part of the plan.

11.3.4.2 Implementation

Rules of Development

Communities develop drainage ordinances, policies and standards with the intent to mitigate/minimize flooding impacts due to urbanization of a watershed. The purpose of these regulations are to minimize the occurrence of losses, hazards and conditions adversely affecting the public health, safety and general welfare which might result from flooding caused by surface runoff of rainfall. Potential rainfall runoff relation impacts to a watershed due to urbanization are:

- Decrease of storm water infiltration capacity within a watershed due to urbanization increases peak discharge from a watershed unless measures are undertaken to reduce post development peak discharges.

- An increase of peak discharge, frequency and runoff volume due to urbanization in a watershed increases the potential for erosion and sedimentation within watercourses.

- An increase in erosion potential can result in loss of property and riparian habitat.

- Due to an increase in peak discharge, existing drainage structures downstream of newly urbanized areas will be undersized.

- Increase in peak discharge increases the amount of property within floodplain. Existing structures within or adjacent to the predevelopment floodplain are at risk of a greater flood impact.

- Disruption of natural flow paths can disrupt the natural system equilibrium and induce bank erosion and long-term degradation of the channel bed.

- An increase in bank erosion and long-term channel bed degradation can result in the need of grade control structures and bank stabilization.

- Increased erosion and deposition will result in greater costs for future structures, higher potential damage and likelihood of failure of existing structures, and increased maintenance cost.

- Increased deposition results in loss of channel capacity and increased flood levels.

The North Peoria ADMP is one of the many tools that have been developed to guide growth and development in the study area, so that impacts of urbanization on the environment are minimized. The focus of the North Peoria ADMP is on flood and erosion control management, however the plan takes into consideration the impacts of different flood control management alternatives on environmental, cultural, and visual resources and looks at multi-use opportunities. The intent of this plan is to work in conjunction with other planning documents and ordinances developed by the City of Peoria and Maricopa County. The plan is to be used by policy makers in the City of Peoria and Maricopa County, future residents, and developers when making decisions concerning development in the area.

Implementation of and guidance provide by the plan is based on a set of management goals, objectives, and policies for each of the four elements of the plan. The elements are Environmental Hazard Identification, Development and Planning Considerations, Environmental and Multiple-Use Opportunities. Management goals, objectives, and policies for each of the four elements are presented in the North Peoria Area Drainage Master Plan document under the Rules of Development Section. In addition too management goals, objectives and policies the plan presents design guidelines for the development of flood control management facilities within the study area.

The plan area for the North Peoria ADMP lies within two jurisdictional areas, Maricopa County and the City of Peoria. The specific guidance that is offered by each of the governmental bodies within in their adopted planning programs vary depending on their needs and their vision for managing growth. The goals objectives and policies developed for the North Peoria ADMP are applicable to both jurisdictions, however, reference is made to other planning documents that offer development guidance. The user of the North Peoria ADMP document should also take into consideration specific goals, objectives and policies developed for the area by both jurisdictions.

11.3.4.3 Maintenance Plan

General

The North Peoria Area Drainage Master Plan presents watercourse and storm water storage flood control management alternatives. Watercourse flood control alternatives consists of, in order of preference, a nonstructural alternative, a low impact alternative and a partial structural alternative. Channelization is not a preferred flood control management alternative, however the plan also recognizes that there may be situations in which channelization may be required. The preferred storm water storage alternative is the standard practice of retaining the volume from the 2-hour, 100-year rainfall event, however this practice may not be practical for certain portions of the study area. The standard retention practices if implemented within in an entire watershed would have negative impacts in regards to sustaining native vegetation along watercourses. The plan offers two alternatives to the standard practice, they are, the in-stream, off-line retention and in-stream, in-line detention. The in-stream, off-line retention is the preferred alternative of the two.

The non-structural alternative involves the definition of a corridor that will allow the watercourse to function naturally. That corridor is defined by the 100-year floodplain, an erosion hazard zone and/or a buffer, if applicable. Although, the non-structural alternative is the preferred alternative selected for the study area, it is recognized that there may be situations in which development activities are required or desired within

this corridor, such as roadway crossings and in-stream retention/detention facilities. For these situations, the plan presents specific design guidelines in an effort to minimize the potential impacts of these structures on the natural processes of the watercourse. Additionally, a low impact structural alternative is presented for the situations where development within the erosion hazard zone is required or desired.

For this plan to be successful, a monitoring and maintenance plan is required that addresses the overall non-structural goals as well as the specific elements of potential structural and low-impact structural measures. In the following sections recommendations for monitoring and maintenance criteria and activities are made for each specific element of the plan. Recommendations may be chosen to be adopted by the Flood Control District of Maricopa County, the City of Peoria, or the owner/owners of the facility or watercourse.

Monitoring Schedule

Monitoring schedule is dependent on the frequency of runoff events and the potential risk to structures, facilities and life. The greater the number of runoff events the more frequent the monitoring activities should be. All facilities should be inspected after significant runoff events. Suggested frequency for significant runoff events are events equal to or greater than the 25-year runoff event (3.31 inches of rainfall). Should a facility or a component of the facility be designed for an event that is less than the significant runoff event the facility should be inspected after the design event has occurred. At minimum biannual inspections are recommended. Time between inspection and monitoring activities could be extended should there be no development adjacent to the erosion hazard zones or facilities (flood control or transportation) within or immediately adjacent to the erosion hazard zone. Should conclusions from monitoring efforts indicate that significant changes to the watercourse have taken place in events lesser than the significant events, the criteria defining the significant event should be establish to an event less the 25-year event.

Non-Structural Alternative

Over time, erosive forces and other natural processes will cause changes to the form and function of the watercourses. Changes to the watercourse as they relate to the non-structural management approach will likely occur in the form of lateral migration, aggradation and degradation of the channel bed. It is also likely that these changes will be accelerated due to urbanization of the watershed. Urbanization within the watershed may further impact the form and function of the watercourse by altering the riparian vegetation. The width of the management corridor for the watercourses is established to allow the changes to occur however, regularly monitoring and inspection activities should be conducted regularly. The following is a list of recommended monitoring activities that could be implemented:

- Field monitoring should include documentation of evidence that would indicate lateral instability or a potential for lateral instability. Observation should include the condition of the riparian vegetation (loss of vegetation), areas of significant aggradation, degradation and head cutting. Monitoring stations located in a wash that consist of a graduated staff could be used to monitor aggradation and degradation trends. Location of monitoring stations should be in reaches of consistent slope and at locations where average reach slopes change significantly. Should monitoring indicate aggradation or degradation trends the extent of the trend could be determined by conducting field surveys of the wash longitudinal profile between subject monitoring stations and comparing the field survey to an establish base.

- Evidence of aggradation, degradation, head cutting and the loss of bank protection could indicate a trend to channel widening or later migration. Should evidence suggest a trend towards lateral migration aerial photography should be used to define the extent of lateral migration.

- Another method for motoring lateral migration is field surveys of control sections along a reach. The locations of control sections should be at

location where there are changes in the dimensions of the erosion hazard zone. Control section locations should include both straight reaches and channel bends sites.

- Identify locations where channel lateral migration has occurred outside of the identified erosion hazard zones. The identification of lateral migration outside of the erosion hazard zone triggers a maintenance activity to mitigate the hazard. Maintenance activity includes, redefining the erosion hazard zone (should there be no structures or facilities at risk) placement of compacted backfill and re-vegetation to reconstruct the bank lines to the original grades and alignment or construction of permanent erosion protection measures.

Structural Alternatives

It is recognized that construction of specific structural features will occur within the watercourse management corridor. The structural features that are included in the plan are roadway crossings and in-stream storm water storage facilities. To the extent possible, these structures are to be designed such that the impacts to the natural form and function of the watercourse are minimized. To address the effectiveness and function of the facility to meet the goals of the plan will require long term monitoring and maintenance activities to be preformed on a regular basis. Recommended monitoring and maintenance activities for each structure are listed below.

Roadway Crossings

Roadway crossings can be at-grade (with permission from the reviewing agency), culvert or bridge crossings. These structures should be inspected for the following:

- Development of scour holes on the downstream side of the structure.
- Long term degradation downstream of the structure.
- Long term aggradation upstream, downstream and within the structure.

- Evidence of lateral migration upstream and downstream of the structure.
- Increase in the vegetation growth immediately upstream of the structure (possible contributor to capacity loss of structure).
- Evidence of abrasion and fracturing or cracking of the roadway crossing structure and associated structures.

Maintenance activities should be conducted biannually, after major flood events or as needed based on the results of the inspections. Recommended maintenance activities are as follows:

- Backfill scour holes with native material or an erosion resistant material.
- Removal of sediment buildup in and/or upstream of the structure.
- Replacement of eroded bank material with native material and/or bank stabilization using native vegetation.
- Removal of vegetation and debris that collects immediately upstream of the structure.
- Repair or replacement of structural bank protection measures or grade control structures associated with the roadway crossing structure.
- Repair or replace roadway crossing structure.

In-stream, In-line Detention Basins

In-stream, in-line detention basins have the same characteristics of a culvert roadway crossing. Therefore, refer to the roadway crossing section above for recommended monitoring and maintenance activities.

In-stream, Off-line Retention Basins

In-stream, off-line retention basins may involve significant, but localized, modifications to the natural watercourse. Those modifications can include, but are not limited to, basin excavation, channelization and bank protection, and construction of grade control structures within the channel and basin inlet and outlet structures. Inspection activities should include those elements listed for roadway crossings in addition to the identification of the following:

- Scouring at the toe of bank protection, grade control structures and the lateral weir.
- Cracks or separations in joints of channel linings.
- Vegetation growth through channel lining.
- Abrasion and/or delamination of bank protection, lateral weir and grade control structures.
- Loss of supporting soil behind engineered embankments.
- Sediment accumulation within the basin.
- Blockage of inlet and outlet works.

Maintenance activities should be conducted biannually, after major flood events or as needed based on the results of the inspections. Recommended maintenance should include those items listed for roadway crossings. Repair of soil cement and roller compacted concrete structures showing signs of abrasion and/or delamination would require reconstruction of the structure to restore it to the original dimensions.

Low Impact Structural

- The low impact structural alternative involves the placement of an erosion barrier at a location within the limits of the erosion hazard zone such that

the natural form and function of the watercourse is not disturbed. Typically, the barrier is some form of engineered bank protection and/or vegetative stabilization measure. Engineered bank protection measures are typically buried with earthen material and revegetated with native plant species. Monitoring activities include the identification of the following:

- Flow scours below the designed toe-down depth, around leading or tail edge or along the channel edge that could lead to undermining the bank protection measure through the subject reach.
- Evidence of long term degradation or aggradation along the improvement reach.
- Evidence of lateral migration upstream and downstream of the structure.
- Condition of vegetated areas to determine survival and the need to revegetate.
- Loss of supporting soil behind engineered embankments.
- Loss of soil, covering engineered bank measures (head cut and rill erosion).

Maintenance activities should be conducted biannually, after major flood events or as needed based on the results of the inspections. Recommended maintenance activities are as follows:

- Backfill scour holes with native material or an erosion resistant material.
- Backfill exposed bank protection measures to limits indicated on design drawings.
- Backfill behind erosion protection measures in areas that have lost supporting soil.

- Revegetate areas that have experienced a vegetation loss.
- Reconstruction or repair of erosion protection measures that have failed or no longer meet design specifications presented on engineering drawings.
- Extend erosion protection measures in response to lateral migration that could undermine upstream edge of the facility.

Permits

At a minimum, any construction occurring as a result of the maintenance activity will require the following permits:

NPDES Storm Water Permit. The Clean Water Act Amendments of 1987 require that certain types of storm water discharges be permitted under the National Pollutant Discharge Elimination System (NPDES). Construction activities that disturb more than five acres (one acre after March 2003-Phase II Regulations) are included in this program. Submittal of a Notice of Intent (NOI) as well as development of a Storm Water Pollution Prevention Plan (SWPPP) is necessary.

Section 404 Permit. This section of the Clean Water Act requires the issuance of a permit for the discharge of dredged or fill material into waters of the United States. Specific categories of activity may qualify for Nationwide permits, however, the maximum impact allowable under Nationwide permits is usually one-tenth of an acre. Projects causing more than this level of impact will require an Individual Permit.

Inspection Report

An accurate and detailed description of conditions observed during each inspection allows meaningful comparison of conditions observed at different times. All measurements and details should be recorded. Photographs or videotapes are recommended. The location of photos should be recorded and subsequent photos taken from the same location for comparison. The location and extent of any questionable or suspected problem areas or conditions must be accurately described

so that the area or condition can be evaluated for changes over time or reexamined by experts. A detailed description of the items inspected should be given. A dated report should be filled out for each inspection and should be filed along with photographs, videotapes or other data collected. In addition to inspection observations, monitoring measurements should also be included in the inspection report. The report should also include comparisons with the results of previous monitoring activities as well as with historical information if available.

11.4 REFERENCES

DFD Architecture, 2001, *Attachment 4, Landscape Character and Visual Assessment Report.*

DFD Architecture, 2001, Attachment 5, *Multi-Use Opportunities Assessment Report.*

Johnson & Associates, EEI, Inc., 2001, *Attachment 6 Plant Communities and Biological Resources.*

12.0 PUBLIC INVOLMENT

12.1 GENERAL

An integral part of the preparation of the North Peoria ADMP was public and community participation and input. Ninety-eight percent of the property in the study area is held by federal, state and private interest with the majority of the private interest (approximately 31% of the area) held by a few individuals or partnerships that are planning on developing their property. Typically private lands are undeveloped and owners are absentee owners. The nature and distribution of land ownership does not lend it self to a typical public involvement process of conducting a series of public information meetings. A public out reach program consisting of questionnaires, newsletters, individual meetings with landowners and federal, state and local agencies and a public meeting was initiated to obtain public and community participation.

Landowners in the area where notified of the development, goals and progress of the plan through individual mailings of newsletters, questionnaires and public announcements in local newspapers. A public workshop was held to present data collection results, policy development, alternative storm water management approaches developed for the plan and to obtain comments and suggestions from participants.

Through out the term of the project individual meeting were held with engineers and/or planners representing the interest of ongoing development projects. Development projects within the plan area include Lake Pleasant Vistas, Saddleback Heights, White Peaks Ranch, Lake Pleasant Heights, Lakeland Village, Upco and the ground water recharge project conducted by the Central Arizona Project.

Copies of completed questionnaires returned by landowners are provided in Appendix J.

13.0 CONSIDERATIONS FOR STRUCTURES IN FLOOD HAZARD AREAS

13.1 GENERAL

Within the North Peoria ADMP study area, one permanent residential structure was identified within a flood and erosion hazard zone. The structure is located within Unincorporated Maricopa County, approximately 0.6 miles north of Happy Valley Road along 115th Avenue alignment in the Twin Buttes Wash floodway. Flood Insurance Study work maps [*Flood Insurance Study for Caterpillar Tank and Twin Buttes Washes From Agua Fria River to C.A.P. Canal Maricopa County, Arizona*, (1991)] indicate that the structure was built prior to the original floodplain delineation of Twin Buttes Wash.

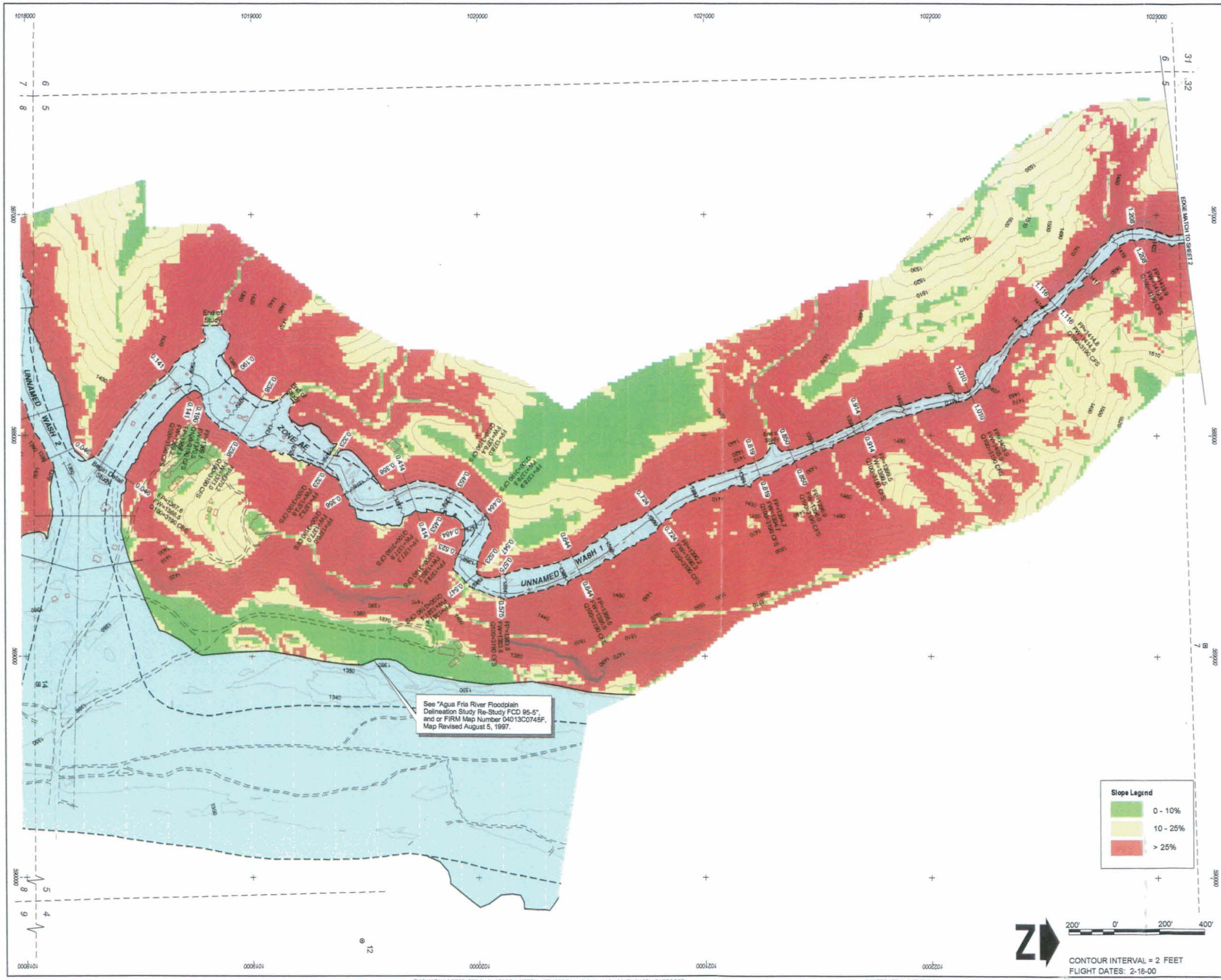
As part of the North Peoria ADMP, channel improvements that would mitigate impacts to the alignment of 115th Avenue and to the residential structure from a 100-year runoff event were evaluated. Improvements evaluated consist of a channel, side slope protection consisting of rock-filled wire-tied baskets and an 11 cell 10 foot by 4 foot' concrete box culvert. The cost estimate for construction of the channel improvements (not including land costs) is estimated at $1,299,137.

Currently Maricopa County has no capital improvement plans to provide roadway/channel improvements along the 115th alignment between Happy Valley and Jomax Roads. City of Peoria personal related that should the City of Peoria annex the area, any improvements would be funded through an improvement district. There are plans being developed for the Estrella Roadway, which will cross the alignment of 115th Avenue, and Twin Buttes Wash approximately 1000 feet downstream of the subject structure, however there are no improvements proposed that would mitigate flooding to the structure or to the alignment of 115th Avenue.

13.2 OPTIONS

Under current Maricopa County floodplain regulations the existing structure could not be rebuild if, due to flooding, fire, or some other catastrophic event, the structure

suffered damages of greater than 50 percent of its appraised value. In addition, the current or future owners could not obtain building permits for new structures. A possible option to address the problem is to recommend the property be considered for a voluntary acquisition or on-site relocation program managed by the Flood Control District. If the home qualifies for the program the homeowner would have the option of selling their parcel to the Flood Control District and having the structure removed from the site so that the land could return to its natural or near natural state or, if there are areas of the parcel outside the floodway and erosion hazard zone, and the homeowner wishes to move their home, the homeowner would have the option of relocating the residence on-site, but outside the high hazard areas.



THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 200' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS.

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.

LEGEND

100-YR FLOODPLAIN BOUNDARY	
FLOODWAY BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
CROSS SECTION	0.100 (CROSS SECTION HYDRAULIC DESIGNATION) — FP= 1888.74 (FLOODPLAIN WATER SURFACE ELEVATION); FW= 1889.54 (ENCROACHED WATER SURFACE ELEVATION); Q100 = CFS (100 YEAR DISCHARGE)
BASE FLOOD ELEVATIONS	1221
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
COUNTY, PARISH, STATE OR INTERNATIONAL BOUNDARY	County Boundary
SECTION LINES	

ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

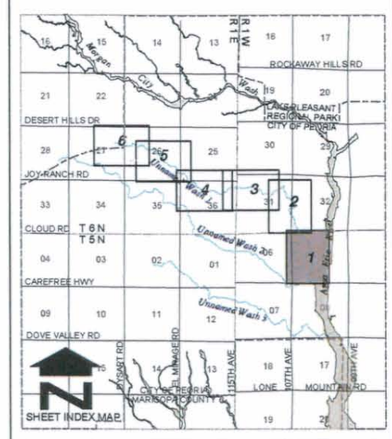
I.D. NUMBER	ELEVATION (FT)	DESCRIPTION/LOCATION
7 ⊞	1499.825	GLO BRASS CAP 1/4 CORNER SECTIONS 5 & 32 T 6 N, R 1 E, N: 1023210.001 E: 588949.105
12 ⊙	1440.888	CHISLED "+" ON STRUCTURE, VALCO TBM 65 - NORTHEAST CORNER OF CONCRETE BARRIER ON BRIDGE OVER BEARDSLEY CANAL +-1.6 MILES WEST OF LAKE PLEASANT ROAD AND WEST CAREFREE HIGHWAY. N: 1019452.853 E: 593568.029

NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1996 VALUES.

3- ALL SECTION LINES ARE APPROXIMATE.



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FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA AREA DRAINAGE MASTER PLAN DETAIL TERRAIN SLOPE MAP UNNAMED WASH 1 F.C.D. CONTRACT NO. 99-45

Stantec Consulting Inc.
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	BY	DATE
DESIGN	MCG	04/01
DESIGN CHK.	PJE	04/01
PLANS	NKD	04/01
PLANS CHK.	PJE	04/01

PLATE 2 SHEET 1 OF 6

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THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 200' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS.

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.

LEGEND

100-YR FLOODPLAIN BOUNDARY	
FLOODWAY BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
CROSS SECTION	0.100 — FP= 1888.74 (FLOODPLAIN WATER SURFACE ELEVATION); FW= 1889.54 (ENCROACHED WATER SURFACE ELEVATION); Q100 = CFS (100 YEAR DISCHARGE); CROSS SECTION RIVERMILE DESIGNATION
BASE FLOOD ELEVATIONS	1221
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
COUNTY, PARISH, STATE OR INTERNATIONAL BOUNDARY	County Boundary
SECTION LINES	

ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

I.D. NUMBER	ELEVATION (FT)	DESCRIPTION/LOCATION

NOTES

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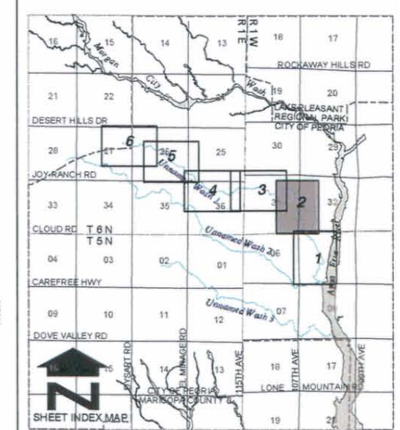
3- ALL SECTION LINES ARE APPROXIMATE.



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FLOOD CONTROL DISTRICT
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PLANS	NKD	04/01
PLANS CHK.	PJE	04/01

PLATE 2 SHEET 2 OF 6

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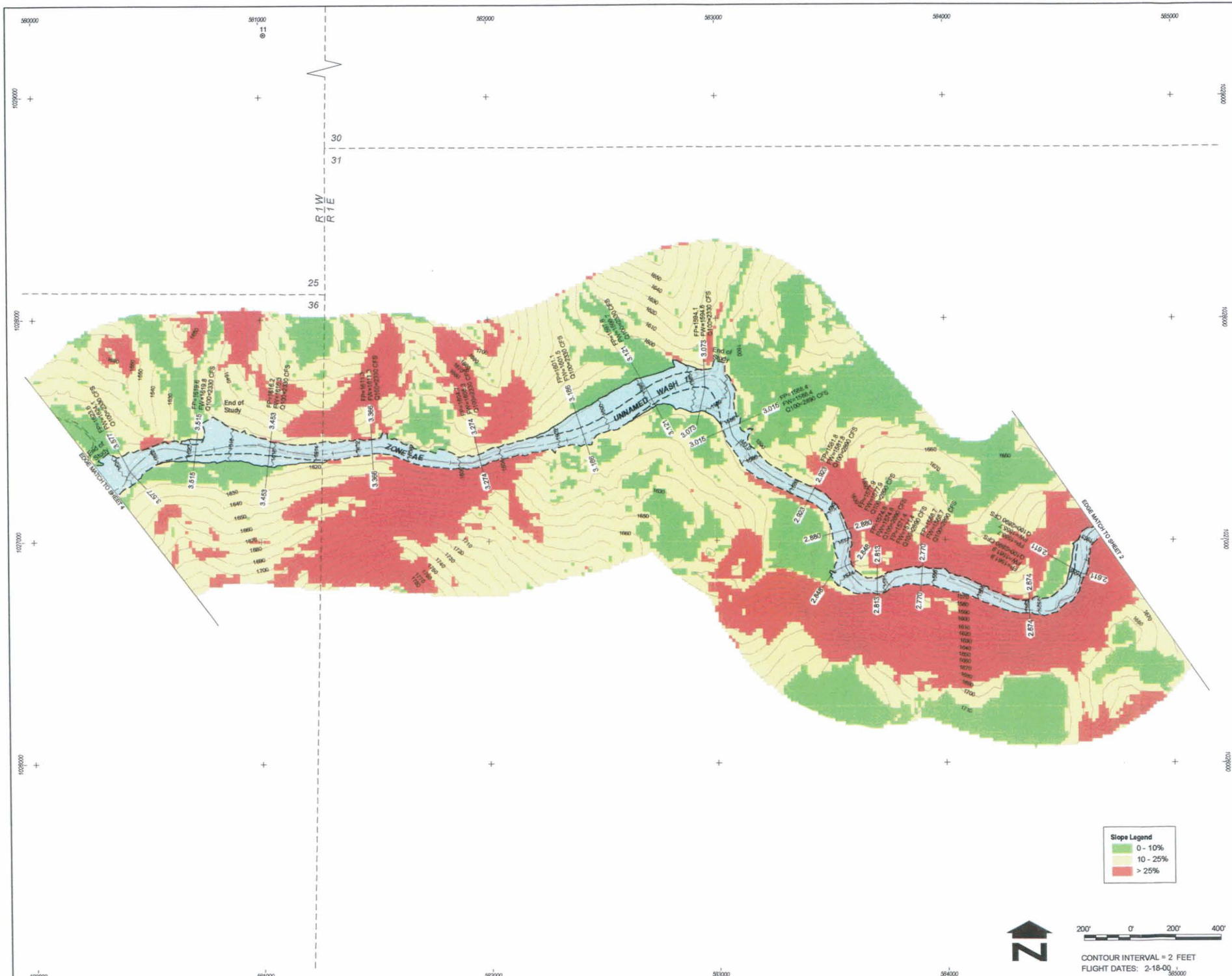

LEGEND

100-YR FLOODPLAIN BOUNDARY	
FLOODWAY BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
CROSS SECTION	0.100 — FP= 1888.74 (FLOODPLAIN WATER SURFACE ELEVATION); FW= 1889.54 (FLOODWAY WATER SURFACE ELEVATION); Q100 = CFS (100 YEAR DISCHARGE); CROSS SECTION RIVER MILE DESIGNATION
BASE FLOOD ELEVATIONS	1221
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
COUNTY, PARISH, STATE OR INTERNATIONAL BOUNDARY	County Boundary
SECTION LINES	

ELEVATION REFERENCE MARKS

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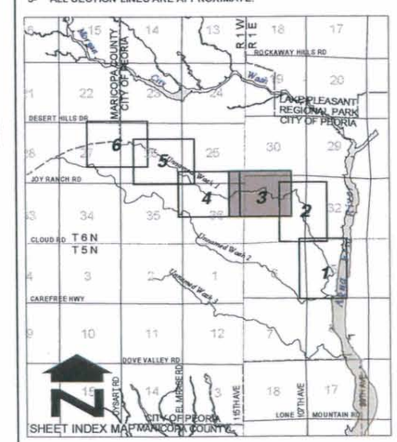
I.D. NUMBER	ELEVATION (FT)	DESCRIPTION/LOCATION
11 ⊙	1731.577	ADOT DISK STAMPED "LAKE" IN ROCK OUTCROP, LAKE - IN SOUTH R/W SR 74, 1 MILE SW OF LAKE PLEASANT AT MILEPOST 19.20. THE STATION IS 3 FEET INSIDE THE SOUTH R/W FENCE AND MARKED BY A WITNESS POST & SIGN. N: 1031113.905 E: 581053.811

NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1998 VALUES.

3- ALL SECTION LINES ARE APPROXIMATE.



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FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
DETAIL TERRAIN SLOPE MAP
UNNAMED WASH 1
F.C.D. CONTRACT NO. 99-45

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PLANS CHK.	PJE	04/01

PLATE 2 SHEET 3 OF 6

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GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.

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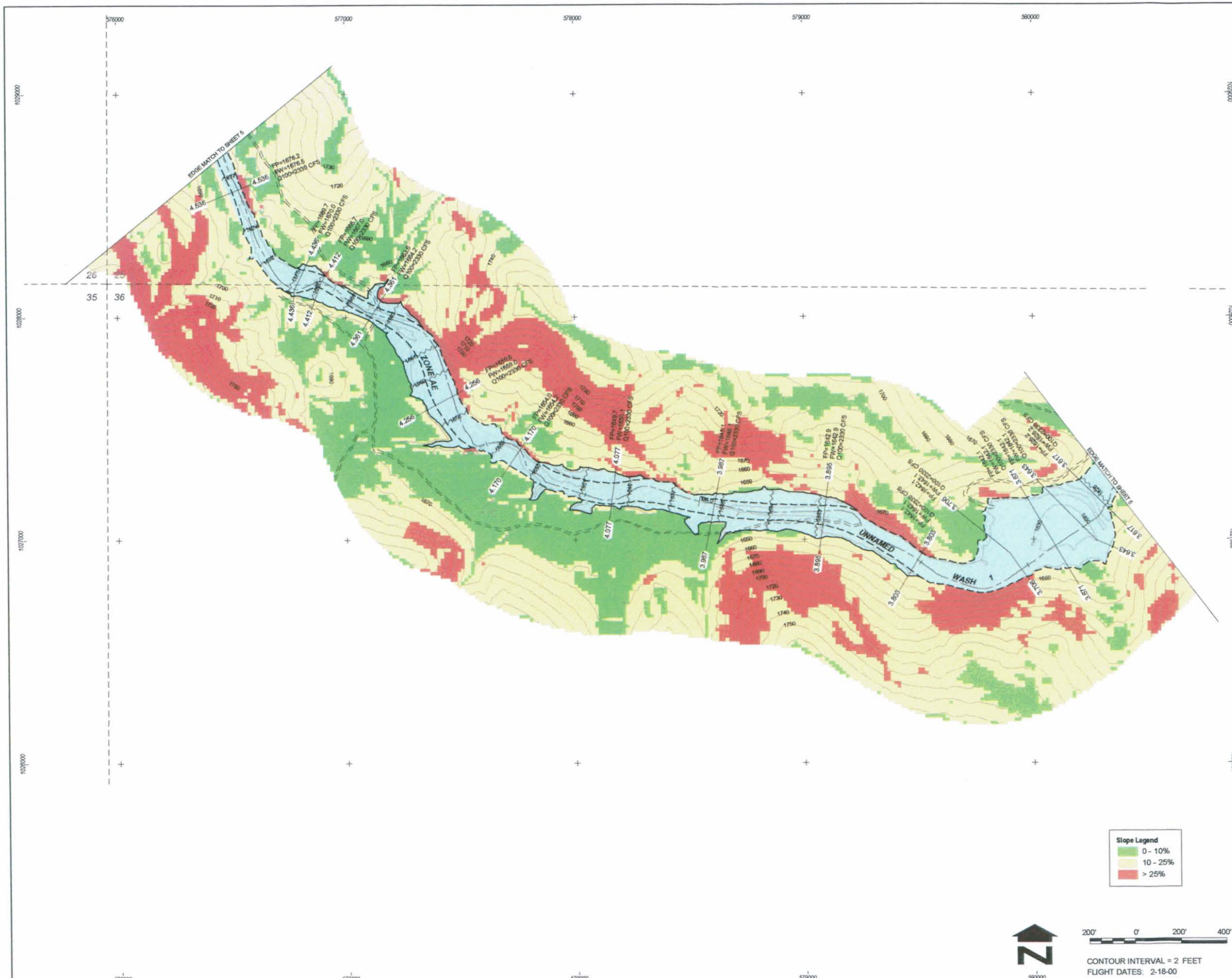

LEGEND

100-YR FLOODPLAIN BOUNDARY	
FLOODWAY BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 M13.0
CROSS SECTION	0.100 FP= 1888.74 FW= 1889.54 Q100 = CFS
BASE FLOOD ELEVATIONS	1221
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
COUNTY, PARISH, STATE OR INTERNATIONAL BOUNDARY	County Boundary
SECTION LINES	

ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

I.D. NUMBER	ELEVATION (FT)	DESCRIPTION/LOCATION

NOTES

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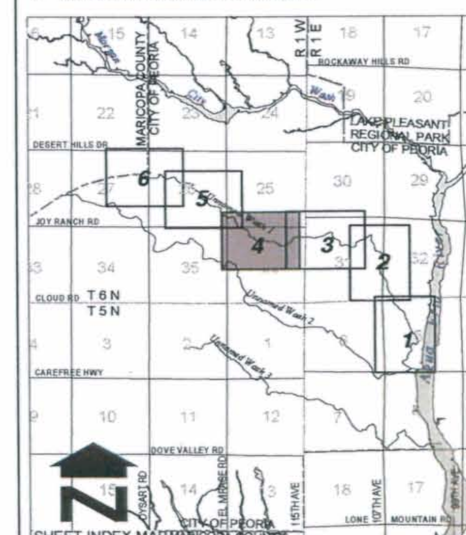

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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

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PLANS CHK.	PJE	04/01

PLATE 2 SHEET 4 OF 6

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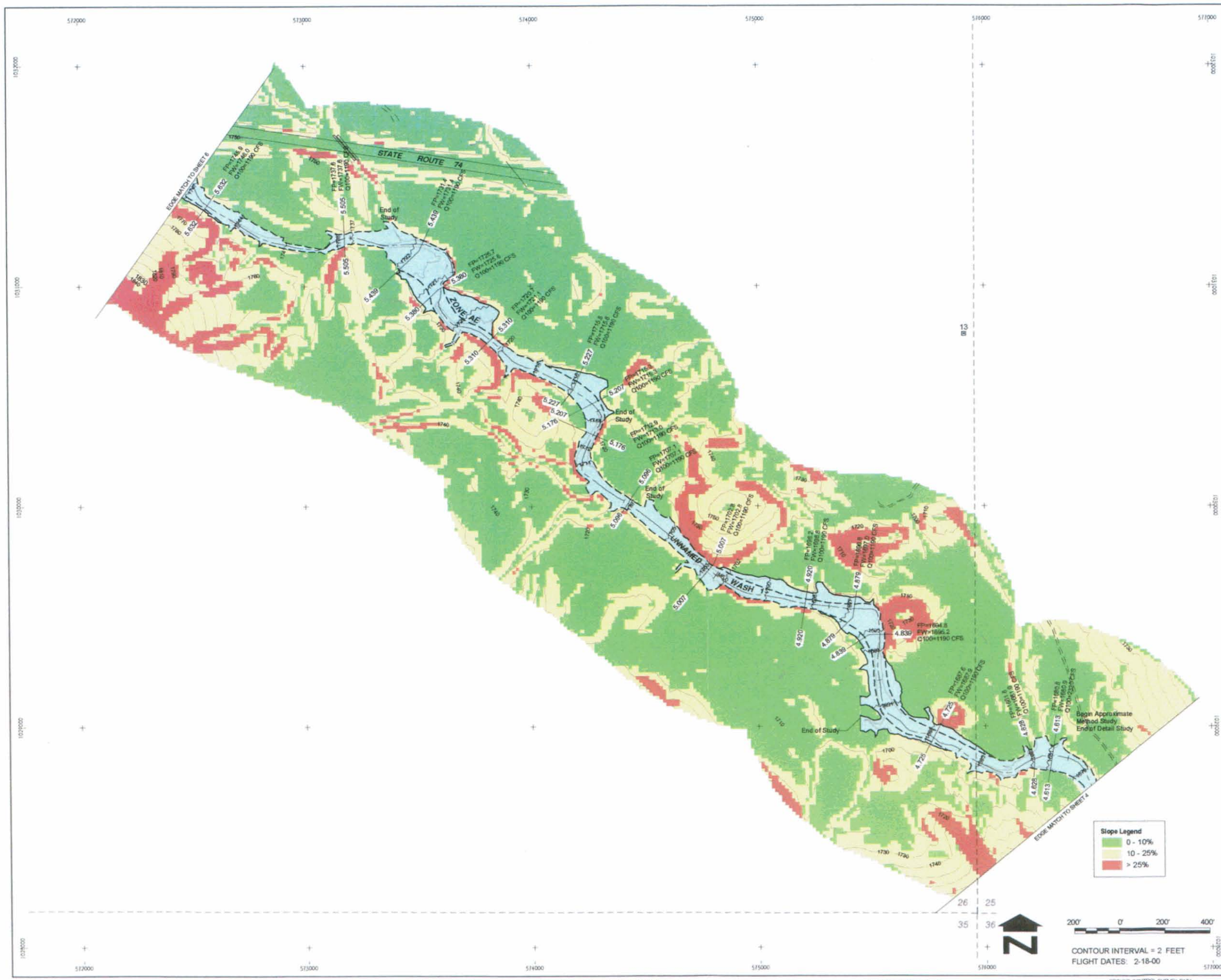

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GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP

LEGEND

100-YR FLOODPLAIN BOUNDARY	
FLOODWAY BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 M13.0
CROSS SECTION	0.100 FP= 1888.74 FW= 1889.54 Q100 = CFS
BASE FLOOD ELEVATIONS	1221
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
COUNTY, PARISH, STATE OR INTERNATIONAL BOUNDARY	County Boundary
SECTION LINES	

ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

I.D. NUMBER	ELEVATION (FT)	DESCRIPTION/LOCATION
13	1747.520	GLO BRASS CAP, 1/4 CORNER SECTION 26 AND 25, T 6 N, R 1 W N: 1030780.041 E: 575913.787

NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

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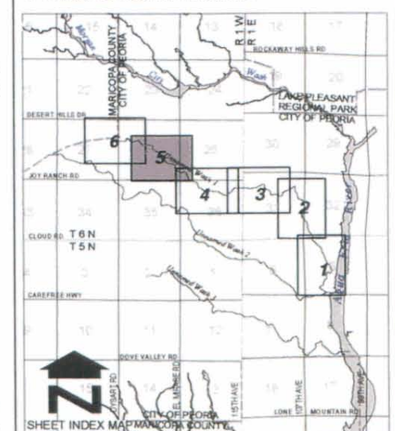

NO	REVISION	BY	DATE
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1			

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
DETAIL TERRAIN SLOPE MAP
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DESIGN	MCG	01/01
DESIGN CHK	PJE	01/01
PLANS	NKD	01/01
PLANS CHK	PJE	01/01

PLATE 2 SHEET 5 OF 6

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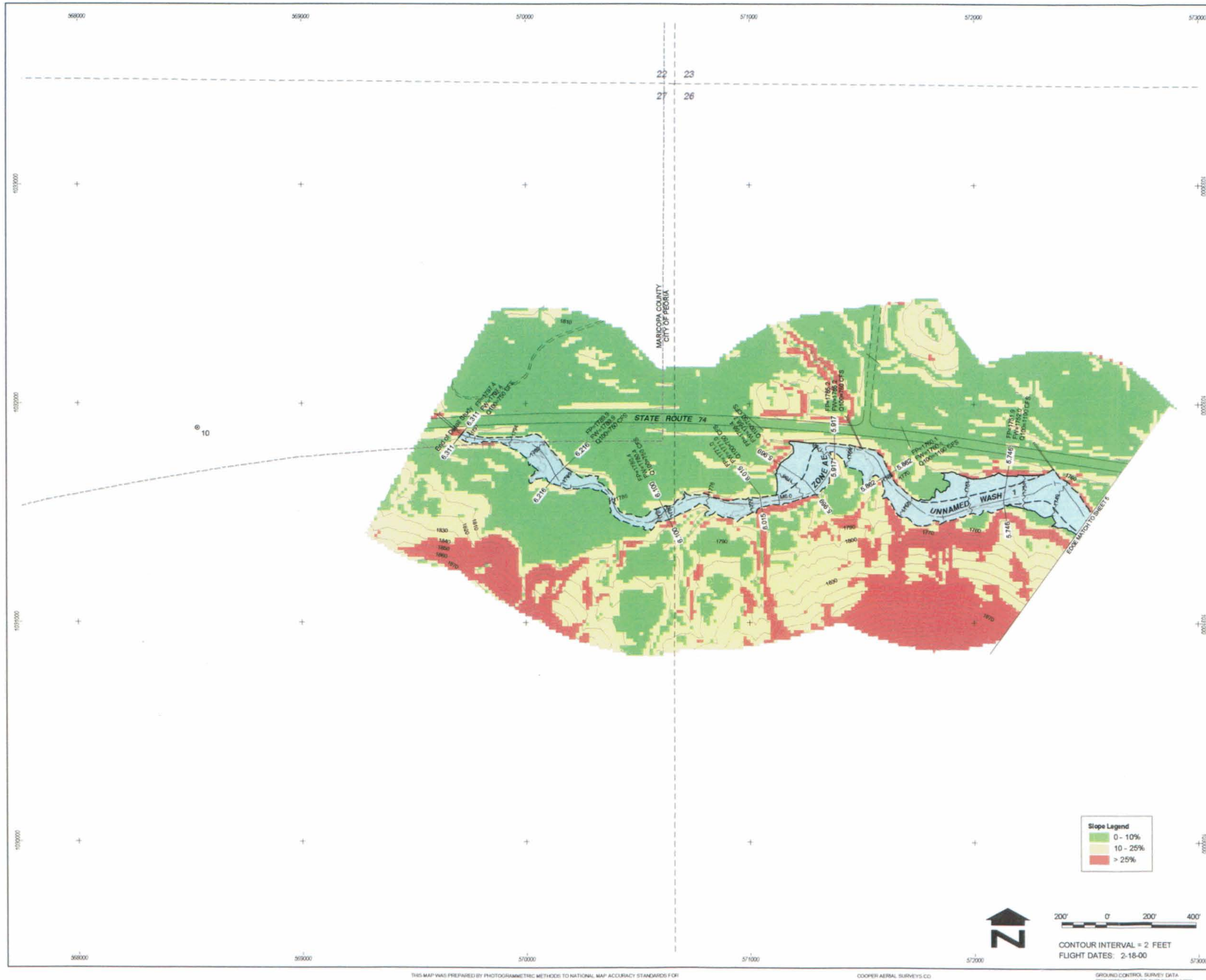

LEGEND

100-YR FLOODPLAIN BOUNDARY	
FLOODWAY BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
CROSS SECTION	0.100 — FP= 1888.74 / FW= 1889.54 / Q100 = CFS
BASE FLOOD ELEVATIONS	1221
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
COUNTY, PARISH, STATE OR INTERNATIONAL BOUNDARY	County Boundary
SECTION LINES	

ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

I.D. NUMBER	ELEVATION (FT)	DESCRIPTION/LOCATION
10 ⊕	1856.402	ADOT DISK STAMPED "CUT" IN 10" CONC. MONUMENT, CUT- IN NORTH R/W SR74, 5 MI WSW OF LAKE PLEASANT AT MILEPOST 16.99. THE MARK IS 3.5 FEET SOUTH OF THE NORTH R/W FENCE ON TOP OF A 15 FOOT CUTBANK. N: 1031888.332 E: 568536.274

NOTES

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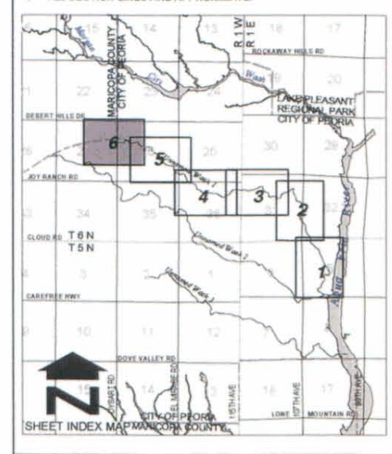
2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1998 VALUES.

3- ALL SECTION LINES ARE APPROXIMATE.



NO	REVISION	BY	DATE
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FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
DETAIL TERRAIN SLOPE MAP
UNNAMED WASH 1
F.C.D. CONTRACT NO. 99-45

Stantec Consulting Inc.
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Phoenix, AZ 85044-5355 U.S.A.
Tel.: (602) 438-7200
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	BY	DATE
DESIGN	MCG	04/01
DESIGN CHK.	PJE	04/01
PLANS	NKD	04/01
PLANS CHK.	PJE	04/01

PLATE 2 SHEET 6 OF 6

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 200' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.

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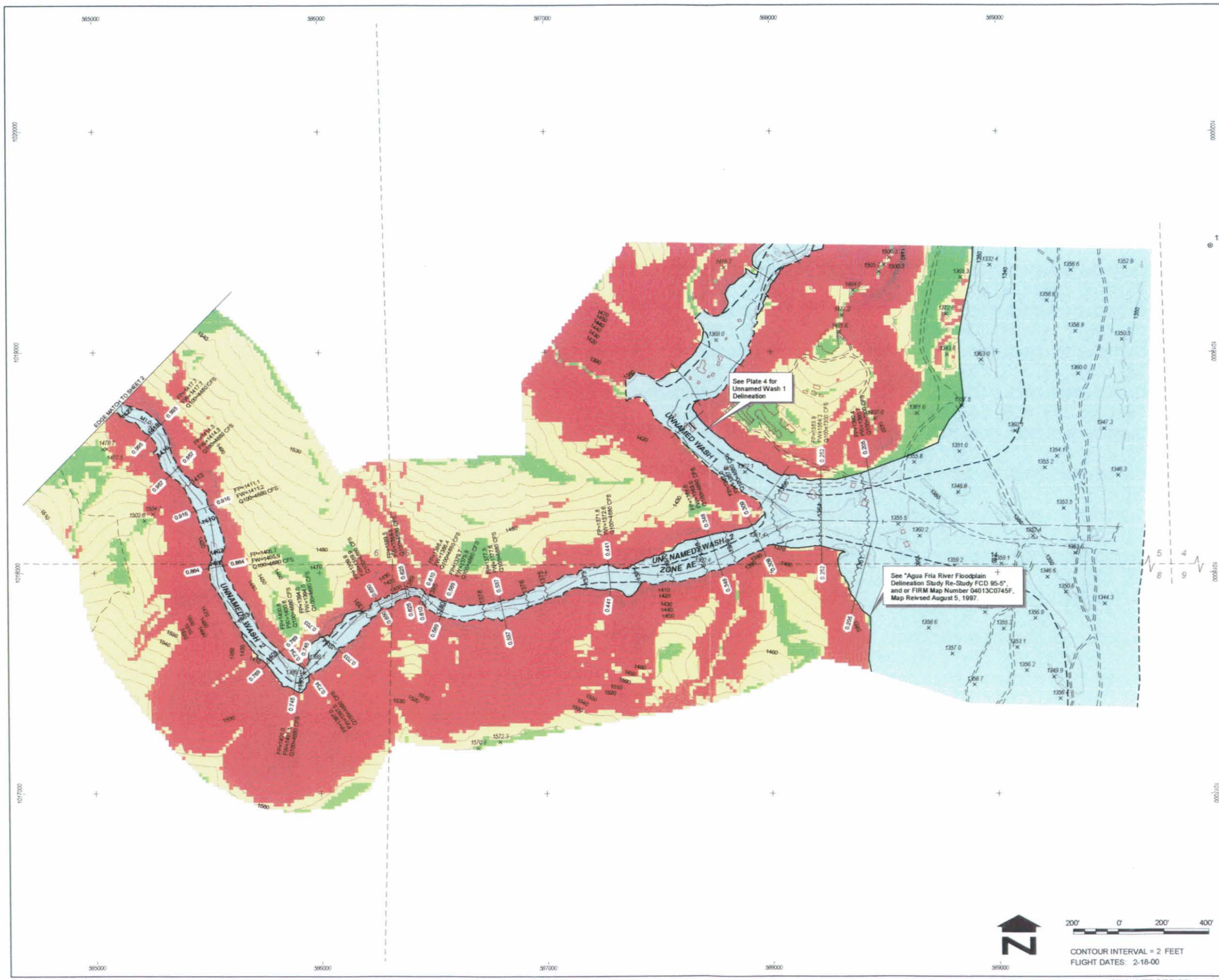


LEGEND

100-YR FLOODPLAIN BOUNDARY	
FLOODWAY BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 M13.0
CROSS SECTION	0.100 FP= 1888.74 FW= 1889.54 Q100 = CFS
BASE FLOOD ELEVATIONS	1221
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
COUNTY, PARISH, STATE OR INTERNATIONAL BOUNDARY	County Boundary
SECTION LINES	

ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

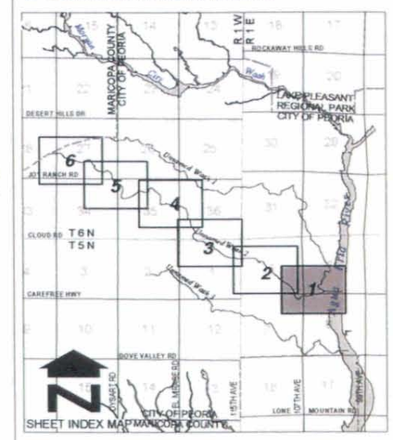
I.D. NUMBER	ELEVATION (FT)	DESCRIPTION/LOCATION
14 ⊠	1356.700	DEPT. OF INTERIOR ALUM. CAP, 1/4 CORNER SECTIONS 5 & 6 T5N, R1E N: 1018052.383 E: 589126.608
12 ⊕	1440.688	CHISLED "+" ON STRUCTURE, VALCO TBM 65 - NORTHEAST CORNER OF CONCRETE BARRIER ON BRIDGE OVER BEARDSLEY CANAL +-1.6 MILES WEST OF LAKE PLEASANT ROAD AND WEST CAREFREE HIGHWAY. N: 1019462.853 E: 593588.029

NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1998 VALUES.

3- ALL SECTION CORNERS ARE APPROXIMATE.



SHEET INDEX MAP MARICOPA COUNTY

NO	REVISION	BY	DATE
2			
1			

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
DETAIL TERRAIN SLOPE MAP
UNNAMED WASH 2
F.C.D. CONTRACT NO. 99-45

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DESIGN	MCG	04/01
DESIGN CHK	PJE	04/01
PLANS	NKD	04/01
PLANS CHK	PJE	04/01

PLATE 3 SHEET 1 OF 6

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 200' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS

COOPER AERIAL SURVEYS CO

GROUND CONTROL SURVEY DATA PROVIDED BY: VALCO SURVEYING CORP

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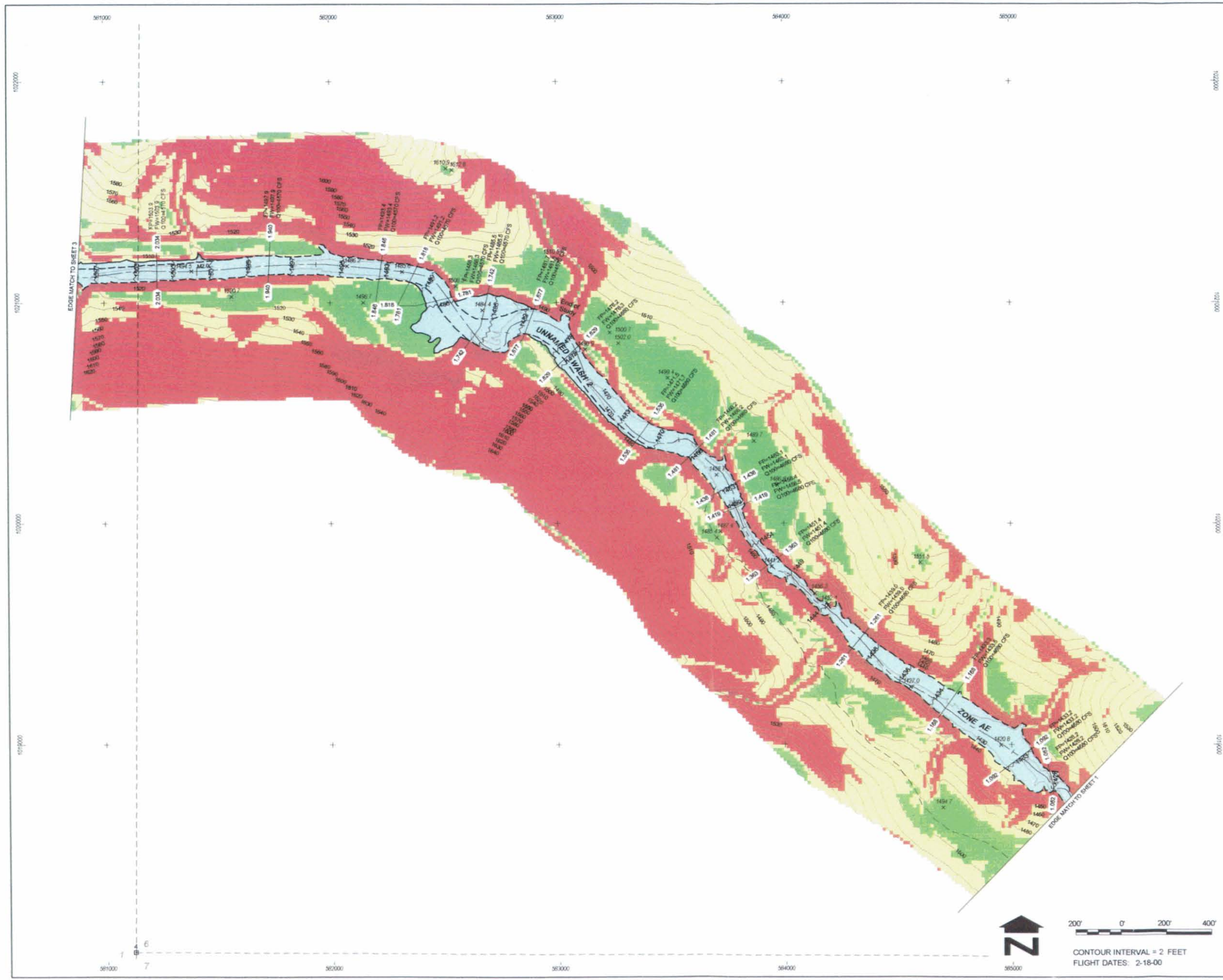


LEGEND

100-YR FLOODPLAIN BOUNDARY	
FLOODWAY BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 M13.0
CROSS SECTION	0.100 FP= 1888.74 FW= 1889.54 Q100 = CFS
BASE FLOOD ELEVATIONS	1221
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
COUNTY, PARISH, STATE OR INTERNATIONAL BOUNDARY	County Boundary
SECTION LINES	

ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

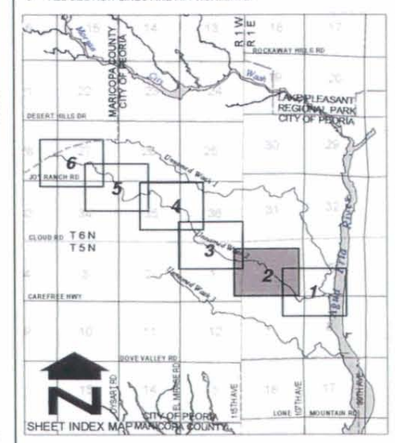
I.D. NUMBER	ELEVATION (FT)	DESCRIPTION/LOCATION
4 ⊞	1744.668	GLO BRASS CAP SECTION CORNER, SECTIONS 1, 6, 7, T5N, R1W & R1E N: 1018061.909 E: 581123.399

NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1988 VALUES.

3- ALL SECTION LINES ARE APPROXIMATE.



NO.	REVISION	BY	DATE
2			
1			

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
DETAIL TERRAIN SLOPE MAP
UNNAMED WASH 2
F.C.D. CONTRACT NO. 99-45

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DESIGN	MCG	04/01
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PLANS	NKD	04/01
PLANS CHK.	PJE	04/01

PLATE 3 SHEET 2 OF 6

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 200' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS

COOPER AERIAL SURVEYS CO

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP

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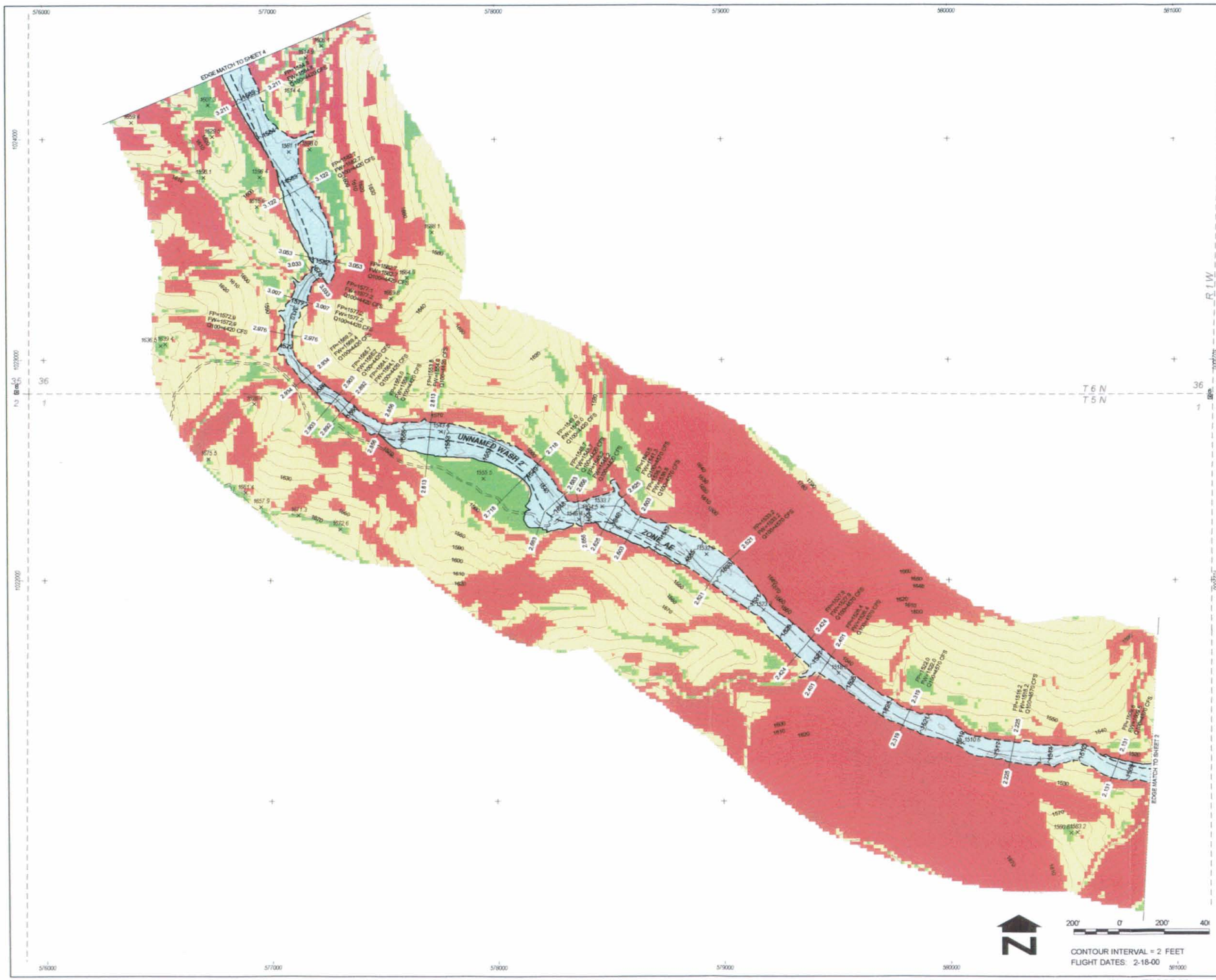


LEGEND

100-YR FLOODPLAIN BOUNDARY	
FLOODWAY BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
CROSS SECTION	0.100 — FP= 1888.74, FW= 1889.54, Q100 = CFS
BASE FLOOD ELEVATIONS	1221
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
COUNTY, PARISH, STATE OR INTERNATIONAL BOUNDARY	County Boundary
SECTION LINES	

ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

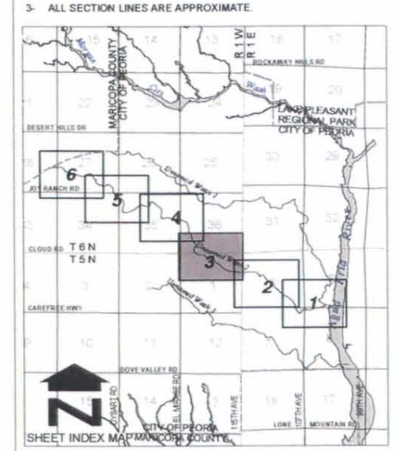
I.D. NUMBER	ELEVATION (FT)	DESCRIPTION/LOCATION
6	1743.227	GLO BRASS CAP SECTION CORNER, SECTIONS 31, 36, 1, 6 T5N, T6N, R1E, R1W N: 1022840.322 E: 581157.608
8	1713.615	GLO BRASS CAP SECTION CORNER, SECTIONS 31, 36, 1, 2 T5N, T6N, R1W N: 1022868.043 E: 575881.369

NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1998 VALUES.

3- ALL SECTION LINES ARE APPROXIMATE.



SHEET INDEX MAP

NO	REVISION	BY	DATE
2			
1			

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
DETAIL TERRAIN SLOPE MAP
UNNAMED WASH 2
F.C.D. CONTRACT NO. 99-45

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PLANS	NKD	04/01
PLANS CHK.	PJE	04/01

PLATE 3 SHEET 3 OF 6

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 200' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS.

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.

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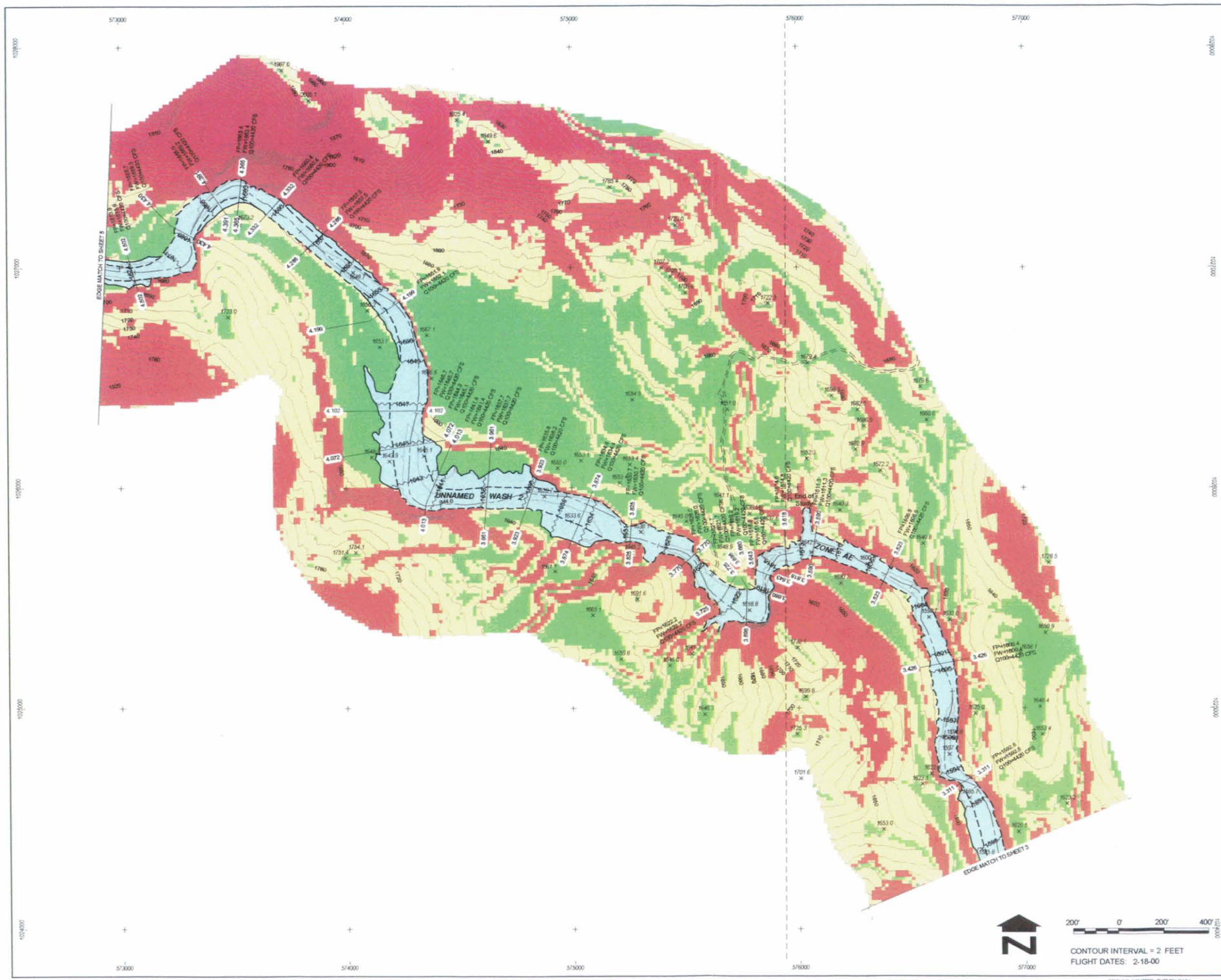


LEGEND

100-YR FLOODPLAIN BOUNDARY	
FLOODWAY BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 M13.0
CROSS SECTION	0.100 FP= 1888.74 FW= 1889.54 Q100 = CFS
BASE FLOOD ELEVATIONS	1221
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
COUNTY, PARISH, STATE OR INTERNATIONAL BOUNDARY	County Boundary
SECTION LINES	

ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

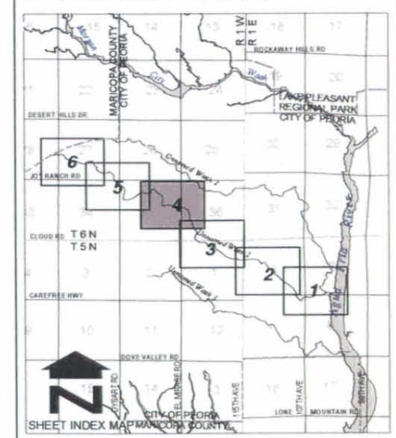
I.D. NUMBER	ELEVATION (FT)	DESCRIPTION/LOCATION

NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1988 VALUES.

3- ALL SECTION CORNERS ARE APPROXIMATE.



SHEET INDEX MAP

NO	REVISION	BY	DATE
2			
1			

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
DETAIL TERRAIN SLOPE MAP
UNNAMED WASH 2
F.C.D. CONTRACT NO. 99-45

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DESIGN	MCG	04/01
DESIGN CHK.	PJE	04/01
PLANS	NKD	04/01
PLANS CHK.	PJE	04/01

PLATE 3 SHEET 4 OF 6

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1" = 200' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.

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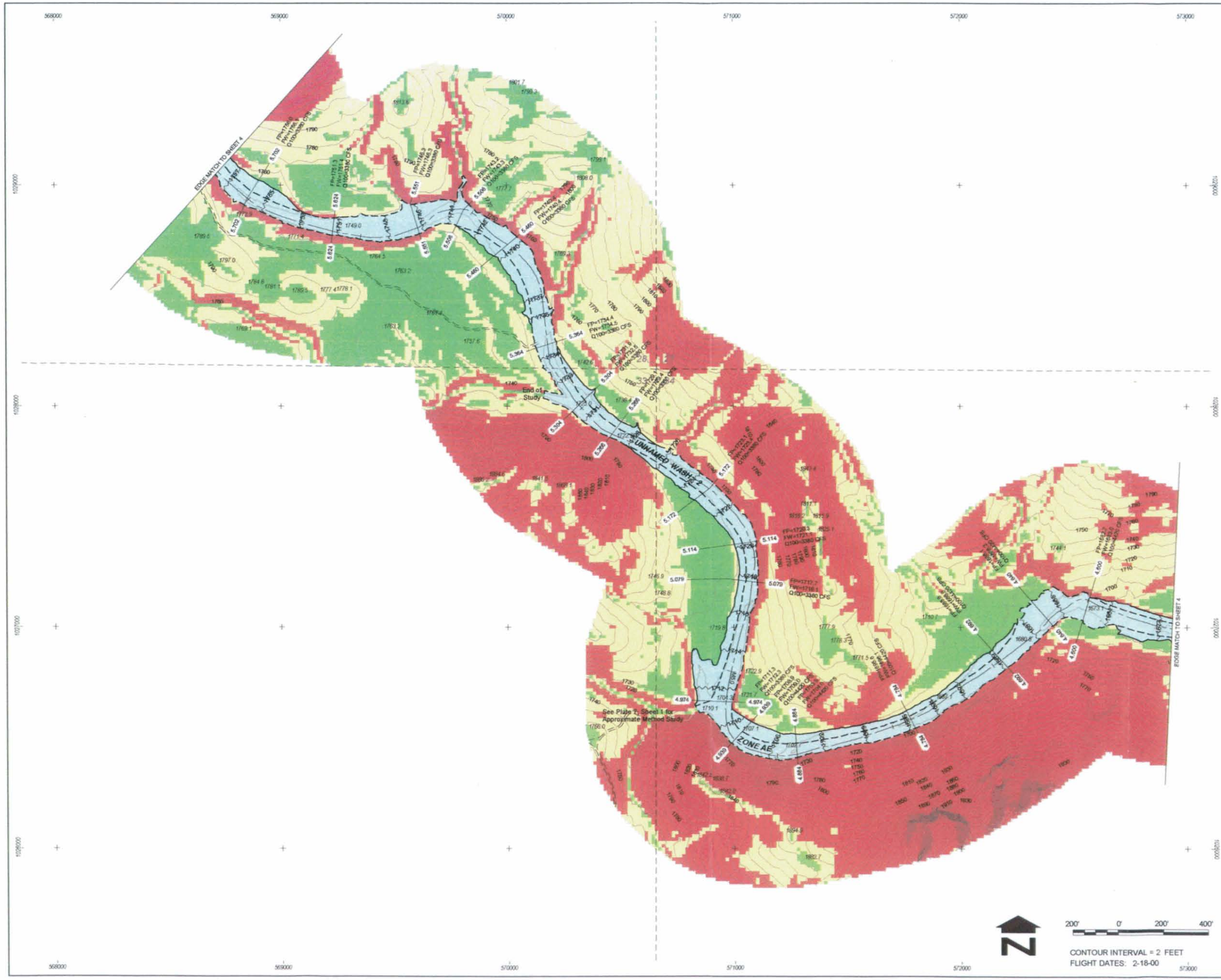


LEGEND

100-YR FLOODPLAIN BOUNDARY	
FLOODWAY BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 M13.0
CROSS SECTION	0.100 FP= 1888.74 FW= 1889.54 Q100 = CFS
BASE FLOOD ELEVATIONS	1221
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
COUNTY, PARISH, STATE OR INTERNATIONAL BOUNDARY	County Boundary
SECTION LINES	

ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

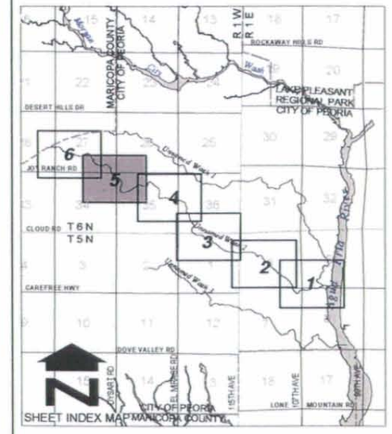
I.D. NUMBER	ELEVATION (FT)	DESCRIPTION/LOCATION

NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1998 VALUES.

3- ALL SECTION LINES ARE APPROXIMATE.



NO	REVISION	BY	DATE
2			
1			

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
DETAIL TERRAIN SLOPE MAP
UNNAMED WASH 2
F.C.D. CONTRACT NO. 99-45

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DESIGN	MCG	04/01
DESIGN CHK.	PJE	04/01
PLANS	NKD	04/01
PLANS CHK.	PJE	04/01

PLATE 3 SHEET 5 OF 6

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 200' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.

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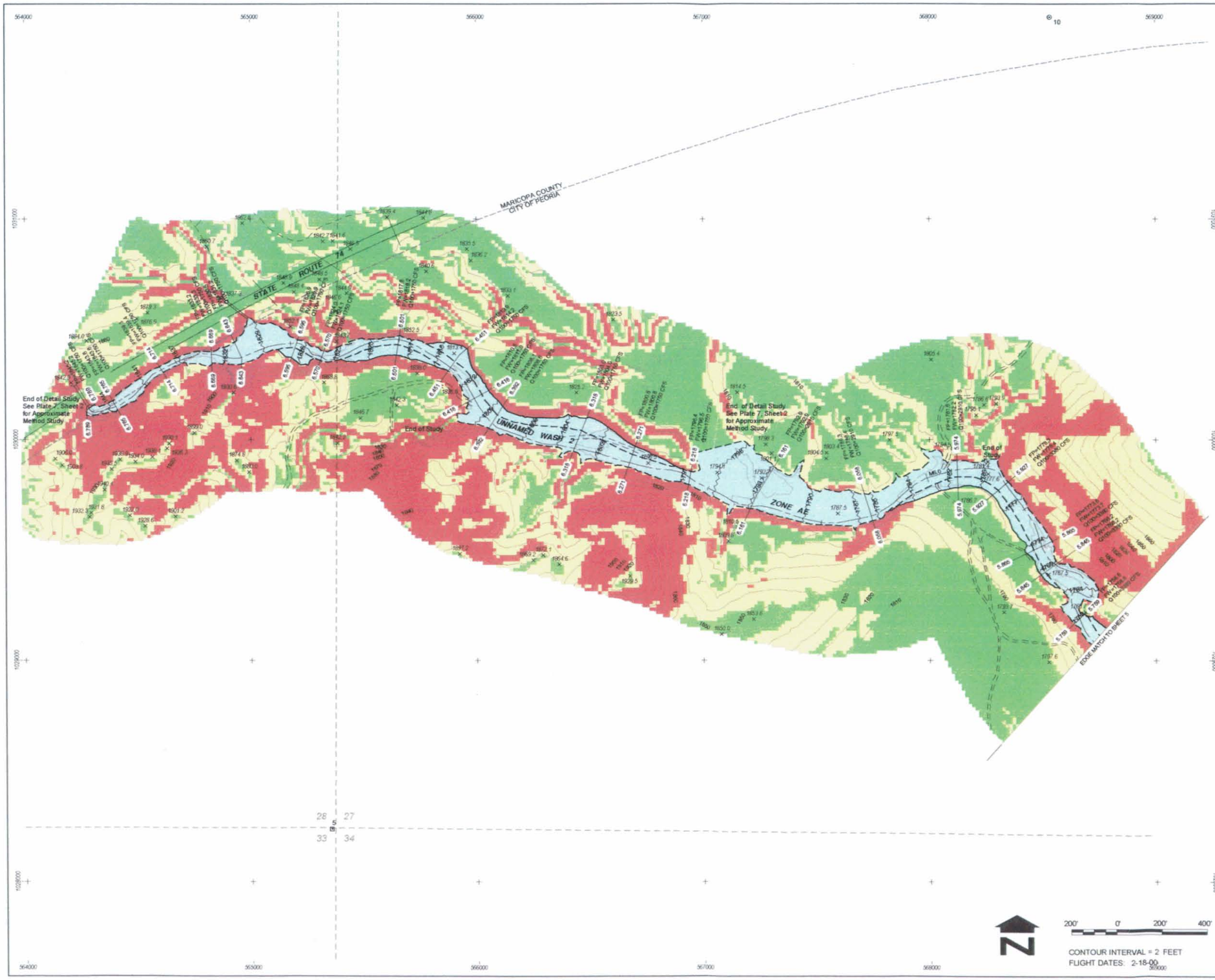


LEGEND

100-YR FLOODPLAIN BOUNDARY	
FLOODWAY BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 M13.0
CROSS SECTION	0.100 FP= 1888.74 FW= 1889.54 Q100 = CFS
BASE FLOOD ELEVATIONS	1221
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
COUNTY, PARISH, STATE OR INTERNATIONAL BOUNDARY	County Boundary
SECTION LINES	

ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

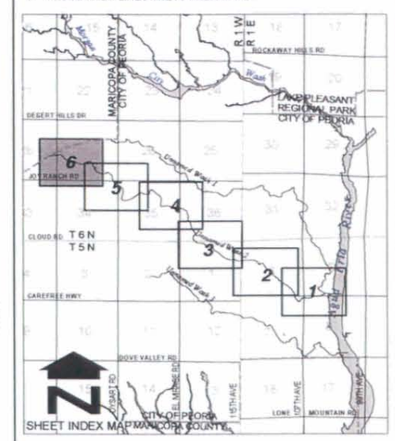
I.D. NUMBER	ELEVATION (FT)	DESCRIPTION/LOCATION
10 ⊗	1856.402	ADOT DISK STAMPED "CUT" IN 10" CONC. MONUMENT, CUT- IN NORTH R/W SR74, 5 MI WSW OF LAKE PLEASANT AT MILEPOST 16.99. THE MARK IS 3.5 FEET SOUTH OF THE NORTH R/W FENCE ON TOP OF A 15 FOOT CUTBANK. N: 1031888.332 E: 568536.274
5 ⊠	1868.563	GLO BRASS CAP, SECTION CORNER, SECTIONS 27, 28, 33, 34, T6N, R1W N: 1028211.900 E: 565351.762

NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1998 VALUES.

3- ALL SECTION LINES ARE APPROXIMATE.



NO	REVISION	BY	DATE
2			
1			

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
DETAIL TERRAIN SLOPE MAP
UNNAMED WASH 2
F.C.D. CONTRACT NO. 99-45

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PLANS	NKD	04/01
PLANS CHK.	PJE	04/01

PLATE 3 SHEET 6 OF 6

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1": 200' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS

COOPER AERIAL SURVEYS CO

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP

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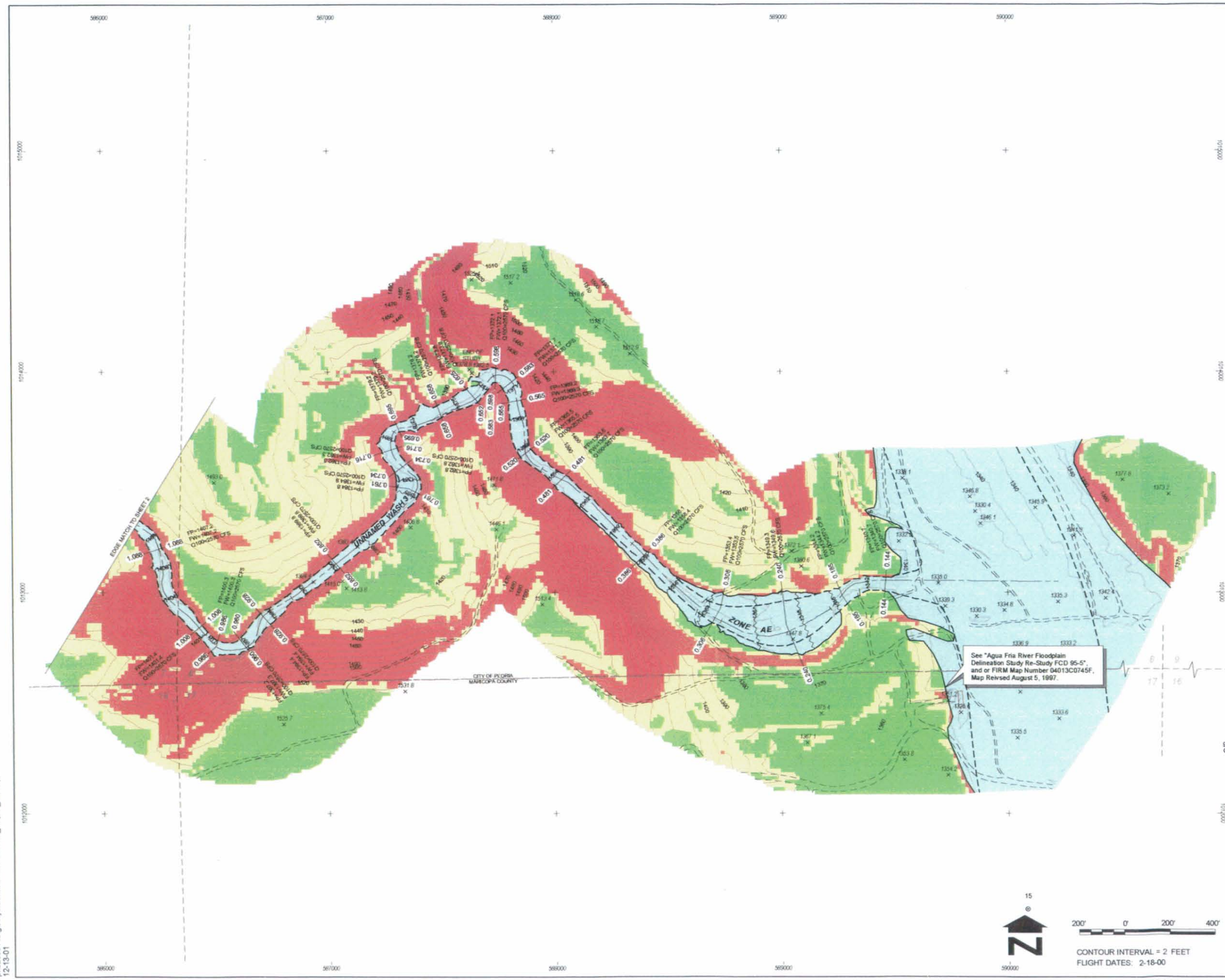

LEGEND

100-YR FLOODPLAIN BOUNDARY	
FLOODWAY BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 M13.0
CROSS SECTION	0.100 FP= 1888.74 FW= 1889.54 Q100 = CFS
ELEVATION REFERENCE MARK	ERM XXX
BASE FLOOD ELEVATIONS	1221
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
COUNTY, PARISH, STATE OR INTERNATIONAL BOUNDARY	County Boundary
SECTION LINES	

ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

I.D. NUMBER	ELEVATION (FT)	DESCRIPTION/LOCATION
15 ⊗	1353.720	+" TOP BOLT IN SW CORNER CONCRETE ABUTTMENT AT WEST END OF FLUME, WEST END BEARDSLEY CANAL FLUME CROSSING AGUA FRIA RIVER N: 1011568.327 E: 590082.699
9 ⊗	1434.830	CHISLED "+" NW COR. CONC. HEADWALL, CHUTE - SOUTH OF BEARDSLEY CANAL AND NORTH OF CAP SERVICE ROAD. +- 1.0 MILES WEST OF LAKE PLEASANT ROAD AND CAP BRIDGE. N: 1012280.198 E: 594087.160

NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

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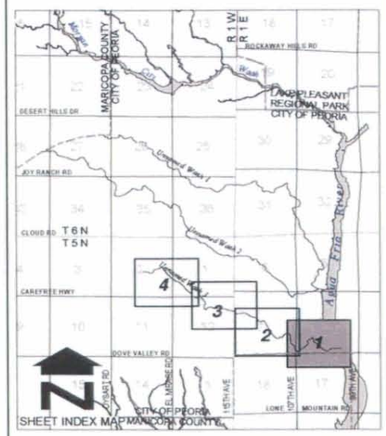
3- ALL SECTION LINES ARE APPROXIMATE.



NO	REVISION	BY	DATE
2			
1			

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODWAY AND FLOODPLAIN MAP
UNNAMED WASH 3
F.C.D. CONTRACT NO. 99-45

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DESIGN CHK.	PJE	04/01
PLANS	NKD	04/01
PLANS CHK.	PJE	04/01

PLATE 4 SHEET 1 OF 4

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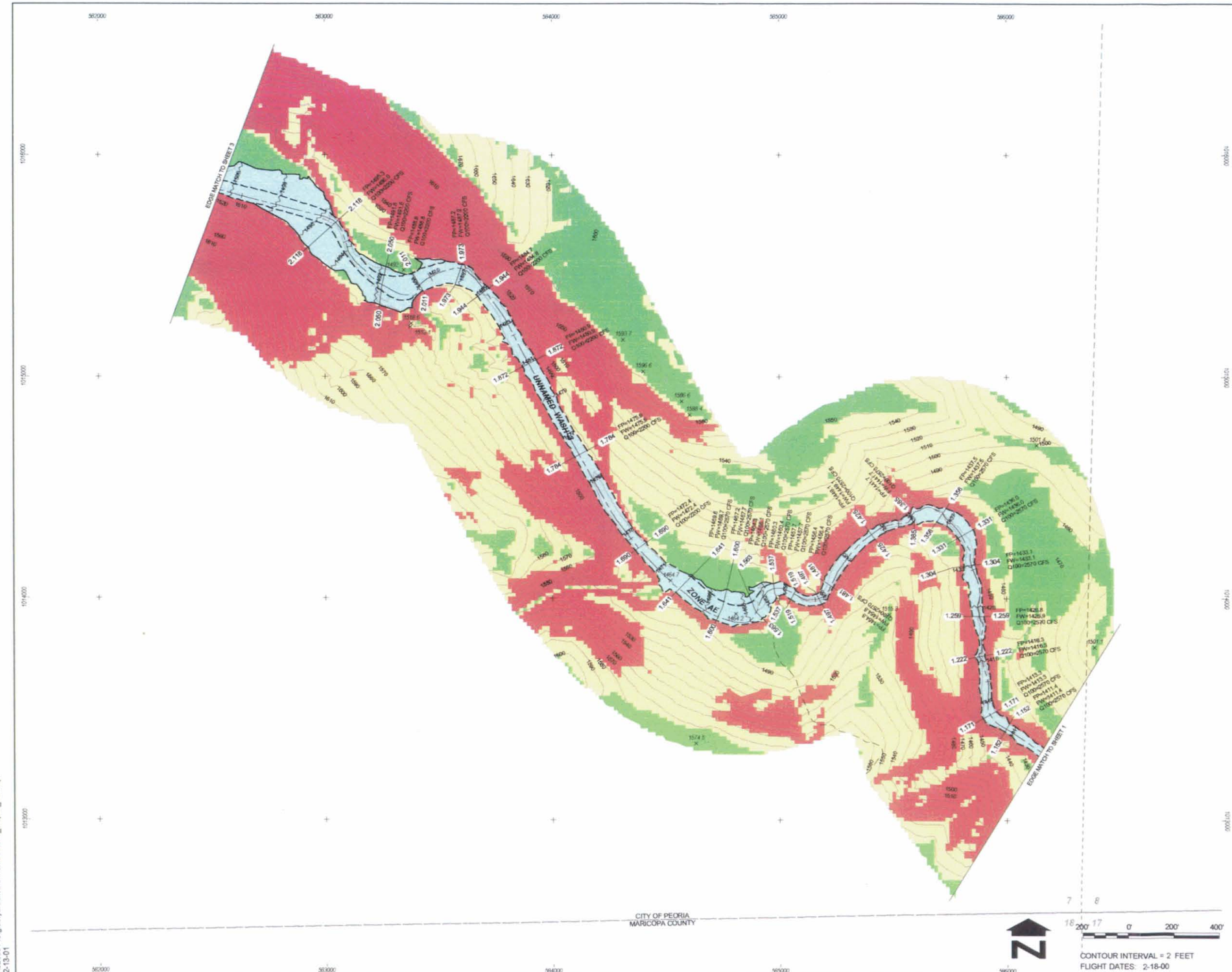
12-13-01

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 200' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.



LEGEND

100-YR FLOODPLAIN BOUNDARY	
FLOODWAY BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
CROSS SECTION	0.100 — FP= 1888.74, FW= 1889.54, Q100 = CFS
ELEVATION REFERENCE MARK	ERM XXX
BASE FLOOD ELEVATIONS	1221
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
COUNTY, PARISH, STATE OR INTERNATIONAL BOUNDARY	County Boundary
SECTION LINES	

ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

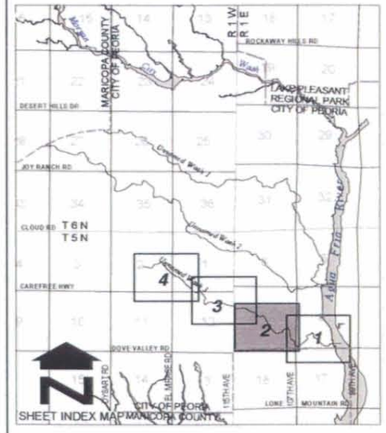
I.D. NUMBER	ELEVATION (FT)	DESCRIPTION/LOCATION

NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1998 VALUES.

3- ALL SECTION LINES ARE APPROXIMATE.



NO	REVISION	BY	DATE
2			
1			

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODWAY AND FLOODPLAIN MAP
UNNAMED WASH 3
F.C.D. CONTRACT NO. 99-45

Stantec Consulting Inc.
8211 South 48th Street
Phoenix, Az 85044-5355 U.S.A.
Tel: (602) 436-2260
Fax: (602) 431-8662
www.stantec.com

	BY	DATE
DESIGN	MCG	04/01
DESIGN CHK.	PJE	04/01
PLANS	NKD	04/01
PLANS CHK.	PJE	04/01

PLATE 4 SHEET 2 OF 4

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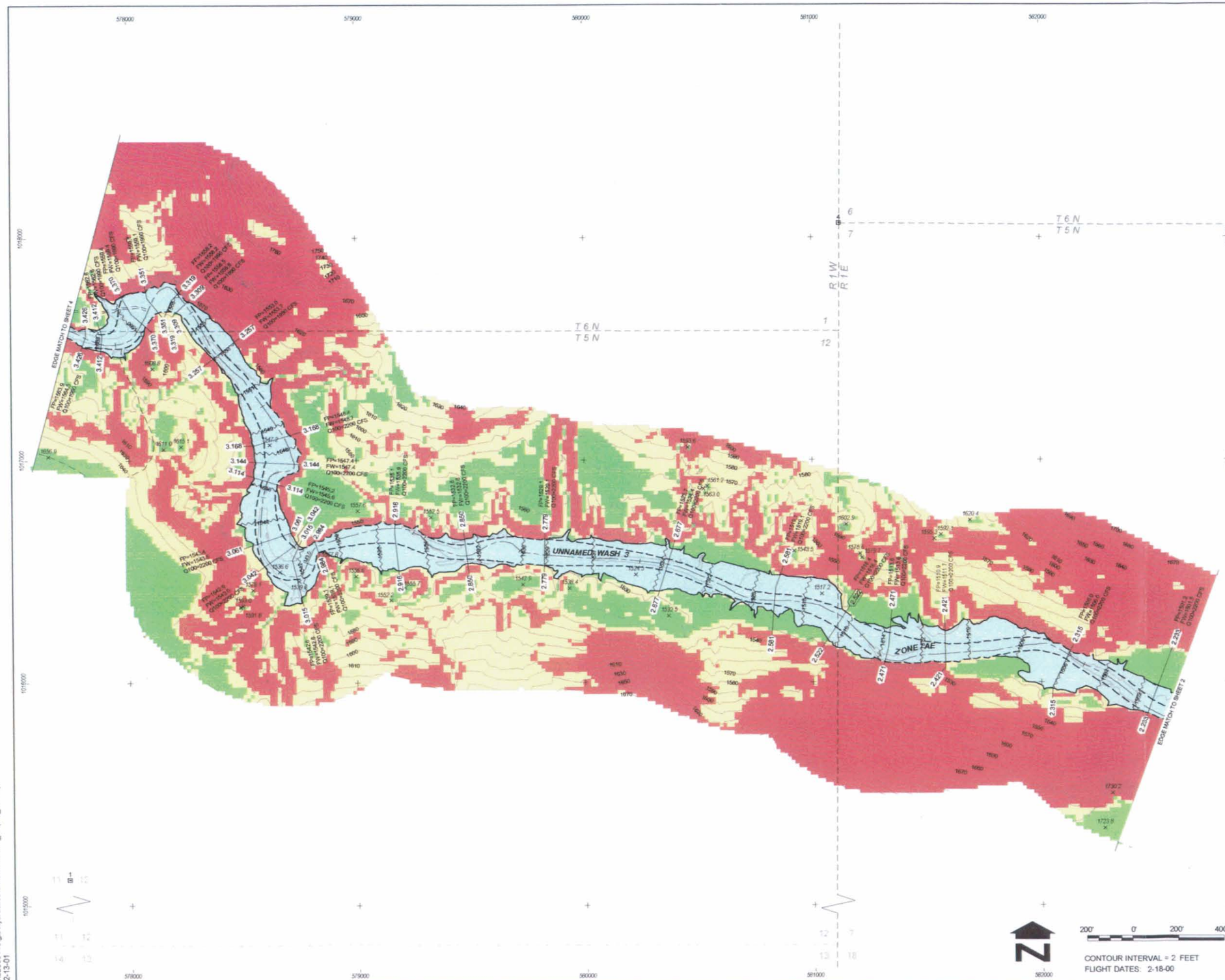
12-13-01

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1" = 200' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.



LEGEND

100-YR FLOODPLAIN BOUNDARY	
FLOODWAY BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 — M13.0
CROSS SECTION	0.100 — FP= 1888.74 (FLOODPLAIN WATER SURFACE ELEVATION) FW= 1889.54 (FLOODWAY WATER SURFACE ELEVATION) Q100 = CFS (100 YEAR DISCHARGE) (CROSS SECTION WITH RIVER MILE DESIGNATION)
ELEVATION REFERENCE MARK	ERM XXX
BASE FLOOD ELEVATIONS	1221
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
COUNTY, PARISH, STATE OR INTERNATIONAL BOUNDARY	County Boundary
SECTION LINES	

ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

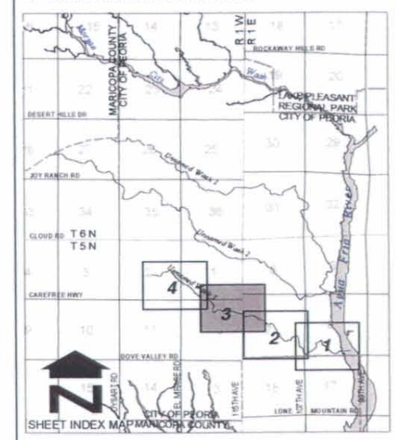
I.D. NUMBER	ELEVATION (FT)	DESCRIPTION/LOCATION
4 ⊠	1744.668	GLO BRASS CAP SECTION CORNER, SECTIONS 1, 6, 7, T5N, R1W & R1E N: 1018061.909 E: 581123.399
1 ⊠	1611.931	GLO BRASS CAP 1/4 CORNER, SECTIONS 11 & 12 T5N, R1W N: 1014953.756 E: 575853.309

NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

2- COORDINATES ARE IN NAD 1983 HORIZONTAL AND NGVD 1929 VERTICAL. COORDINATES ARE GRID AND IN INTERNATIONAL FEET. NGVD 1929 ELEVATIONS WERE DERIVED BY SUBTRACTING THE PUBLISHED DIFFERENCE OF 2.07 FEET AT BM S-366 FROM THE ADJUSTED NAVD 1998 VALUES.

3- ALL SECTION LINES ARE APPROXIMATE.



NO	REVISION	BY	DATE
2			
1			

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NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODWAY AND FLOODPLAIN MAP
UNNAMED WASH 3
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DESIGN	MCG	04/01
DESIGN CHK.	PJE	04/01
PLANS	NKD	04/01
PLANS CHK.	PJE	04/01

PLATE 4 SHEET 3 OF 4

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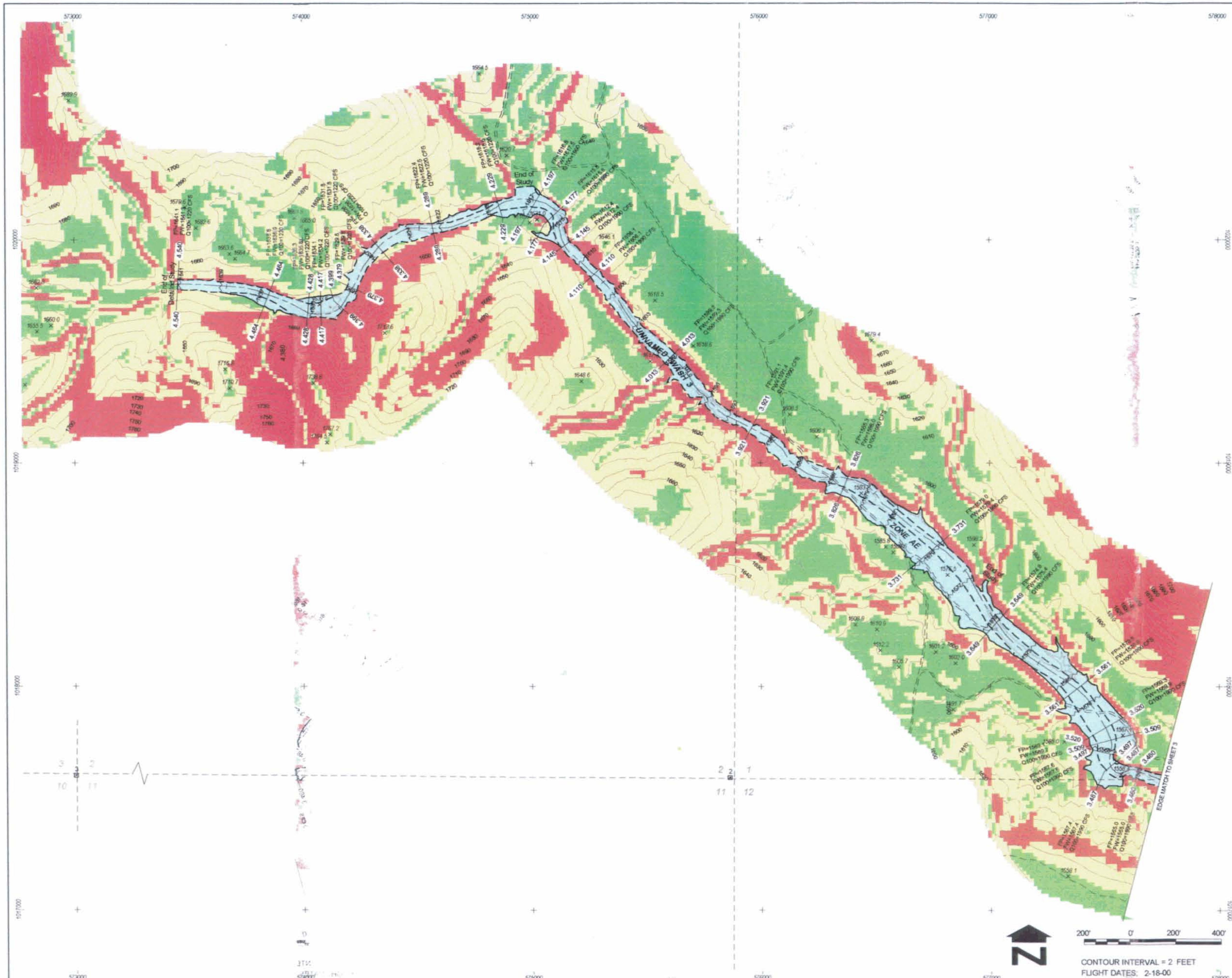
12-13-01

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1": 200' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY: VALCO SURVEYING CORP.



LEGEND

100-YR FLOODPLAIN BOUNDARY	
FLOODWAY BOUNDARY	
HYDRAULIC BASE LINE WITH RIVER MILE	M12.0 M13.0
CROSS SECTION	0.100 FP= 1888.74 FW= 1889.54 Q100 = CFS
ELEVATION REFERENCE MARK	ERM XXX
BASE FLOOD ELEVATIONS	1221
ZONE DESIGNATIONS	ZONE AE
CORPORATE LIMITS	Corporate Limits
COUNTY, PARISH, STATE OR INTERNATIONAL BOUNDARY	County Boundary
SECTION LINES	

ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

I.D. NUMBER	ELEVATION (FT)	DESCRIPTION/LOCATION
2	1624.244	GLO BRASS CAP SECTION CORNER, SECTIONS 1, 2, 11, 12 T5N, R1W N: 1017591.572 E: 575862.942
3	1646.762	GLO BRASS CAP SECTION CORNER, SECTIONS 2, 3, 10, 11 T5N, R1W N: 1017617.764 E: 570584.939

NOTES

1- THE HYDRAULIC BASE LINE IS CROSS SECTION STATION 10,000 UNLESS NOTED OTHERWISE.

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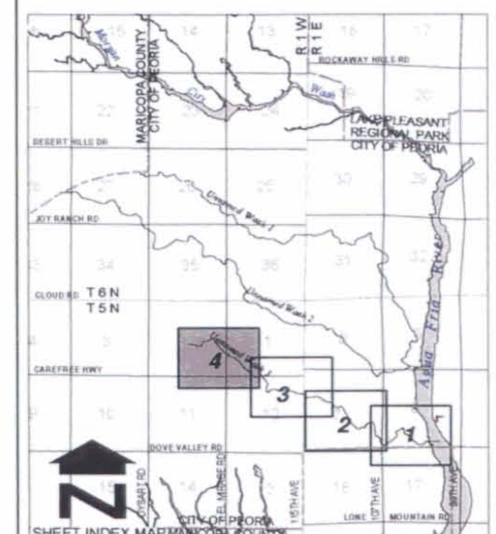
3- ALL SECTION LINES ARE APPROXIMATE.



SHEET INDEX MAP

NO	REVISION	BY	DATE
2			
1			

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FLOODWAY AND FLOODPLAIN MAP
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	BY	DATE
DESIGN	MCG	04/01
DESIGN CHK.	PJE	04/01
PLANS	NKD	04/01
PLANS CHK.	PJE	04/01

PLATE 4 SHEET 4 OF 4

THIS MAP WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 1"= 200' HORIZONTAL SCALE AND 2' CONTOUR INTERVALS

COOPER AERIAL SURVEYS CO.

GROUND CONTROL SURVEY DATA PROVIDED BY VALCO SURVEYING CORP.

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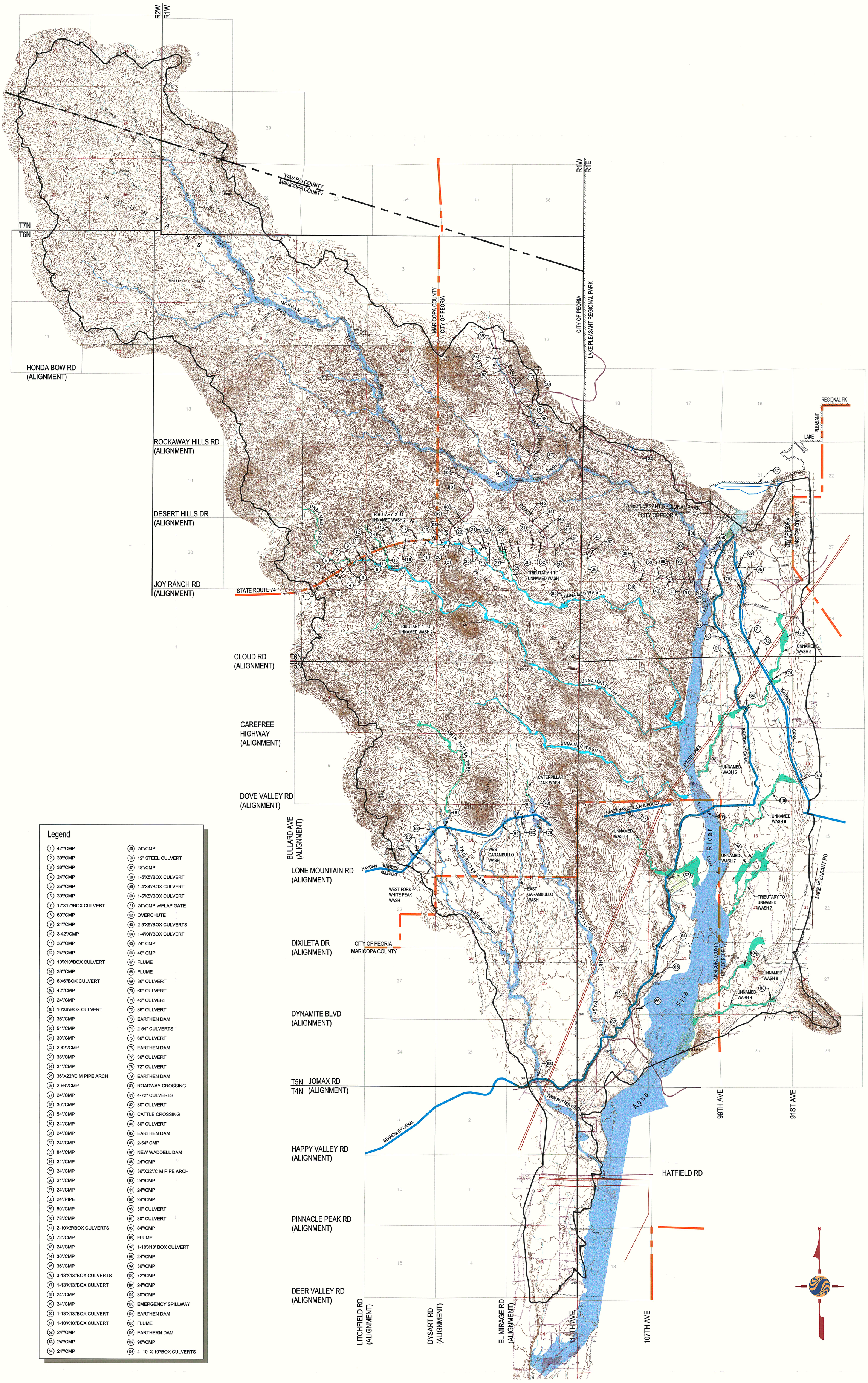

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2002 March 13, 10:39 a.m.

Stantec

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File Name: 01efm146.dwg	HAR	MCG	MCG	08.30.01
	Dwn.	Chkd.	Dsgn.	Date

Legend

- Canal
- Existing Road
- Corporate Limits
- Park Boundary
- Power Lines
- Project Boundary
- Effective FEMA Floodplain
- Zone A Floodplain (New FEMA Submittal)
- Detainled Delineation Floodplain (New FEMA Submittal)

Prepared for:

FLOOD CONTROL DISTRICT of MARICOPA COUNTY

In conjunction with:

CITY OF PEORIA

Client/Project

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
NORTH PEORIA

AREA DRAINAGE MASTER PLAN
FCD NO. 99-45

Peoria, Arizona

Title

PLATE 1
EXISTING FACILITIES MAP

Project No. 82000146

Scale 1"=2000' (0, 2000', 3000', 4000')

Drawing No.

Sheet 1 of 1