DRAFT Drainage Design Report
(60% Submittal) for the

Beardsley Connector
Agua Fria Freeway - SR 101L

Prepared for:

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and

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October 22, 2007
J2 Project No. 03.3045

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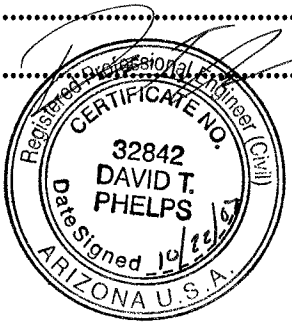

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1 INTRODUCTION

1.1 Background and Scope

This project is a joint project between the City of Peoria, Arizona Department of Transportation (ADOT), and the City of Glendale. The project entails the extension of Beardsley Road from 81st Avenue to extend across New River with a new bridge and connect to the Loop 101 Freeway. Additionally, Beardsley Road will be widened between 83rd Avenue and 81st Avenue. Maintenance agreements between the three agencies are currently being worked on. Generally speaking, each entity will be responsible to maintain the portion of this projects roadway that falls within its respective right of way. Glendale will maintain Beardsley Road extension from the western side of the new bridge to the east. The City of Peoria will maintain Beardsley Road from the western limits of the new bridge to the west. ADOT will maintain the ADOT ramps and frontage road. Specific maintenance details will be formalized when the inter-governmental agreement (IGA) is completed.

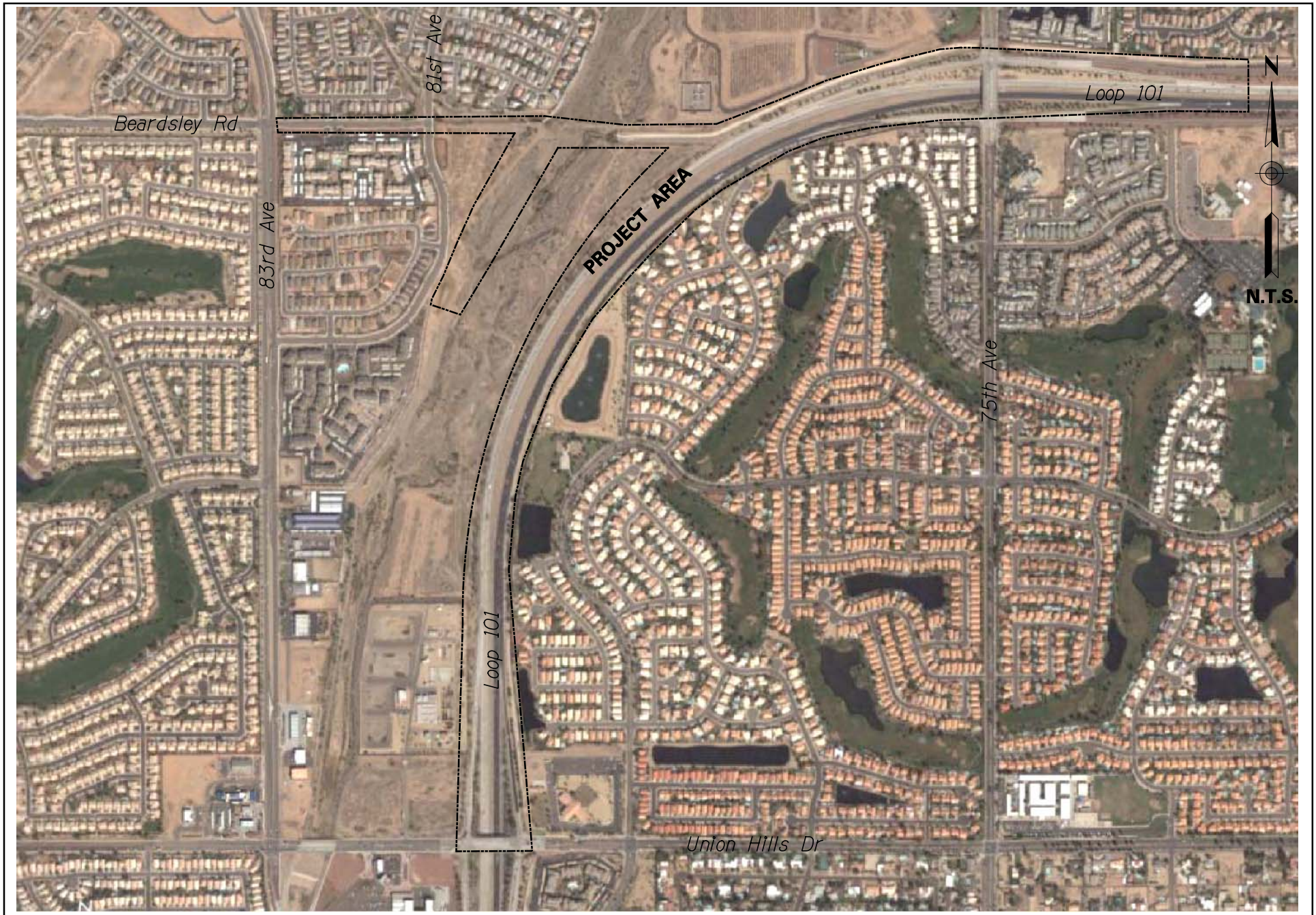
This project is located within Maricopa County Arizona. Specifically, within the Cities of Peoria and Glendale, along the Loop 101, from Union Hills Road and 75th Avenue, and as shown on Figure 1.

This project has been divided into several submittal Phases. Phase I currently consists of Beardsley Road widening from 81st Ave to the west, across a new bridge over New River to the Beardsley Road / Frontage Road Traffic Interchange (TI). Phase II currently consists of the Beardsley Frontage Road, U-Turn, and 101L access ramps. Project phasing is shown on Figure 2. This report documents the roadway drainage design associated with Phase II.

Drainage computations supporting the new bridge across New River and bank protection along New River will be issued in an upcoming separate report.

1.2 Previous Studies

The drainage design for the Loop 101 freeway drainage system is documented in the *Final Drainage Report, Outer Loop Highway, Design Section 5A, Bell Road to 75th Avenue*, as prepared for ADOT by Creegan + D'Angelo Engineers-Planners-Surveyors, November 1, 1988. Several drainage reports have been issued for the New River, however the governing report is the *Middle New River Watercourse Master Plan, Final Report,* as prepared for the Flood Control District of Maricopa County (FCDMC) and revised in May 2000 by Stantec Consulting, Inc. Both reports were utilized to establish the basis of drainage design for this project.



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VICINITY MAP

FIGURE 1

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PROJECT MAP

FIGURE 2

1.3 FEMA Studies

The Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) for this area is panel 1190 of 4350 (04013C 1190H) for Maricopa County, Arizona and Incorporated Areas. The current FIRM of record is dated September 30, 2005, portions of which are reproduced on Figure 3.

The FEMA flood hazard assigned to this reach of the New River is zone AE. FEMA flood hazard zone AE is defined as a special flood hazard zone with base flood elevations determined for the floodplain. The floodway in zone AE is defined as "the channel or stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 0.1% annual chance flood can be carried without substantial increases in flood height". The proposed Beardsley Road Bridge span is being designed to span the Zone AE floodway with minimal rise due to encroachment.

The majority of the proposed roadway improvements for this project are outside of the New River floodplain regulated by FEMA. The proposed frontage road encroaches into FEMA flood hazard zone AE from mainline STA 894+00 to STA 903+00. The majority of this area is located in the ineffective flow area of the New River (due to a severe downstream constriction). The water surface elevation will not be significantly impacted by the frontage road roadway prism. Future bank protection along this reach will move the FEMA flood hazard zone further to the west (Middle New River Watercourse Master Plan) and away from the proposed Frontage Road. Team members had discussions with private developers along the east side of the New River on several occasions. ADOT stated that they could construct the eastern bank protection (to be reimbursed by the development) as part of this project. The developers stated that they could construct the bank protection more economically than ADOT. It was determined that the developers would construct the eastern bank protection as part of their project. It was assumed that the proposed development would closely follow the freeway improvements.

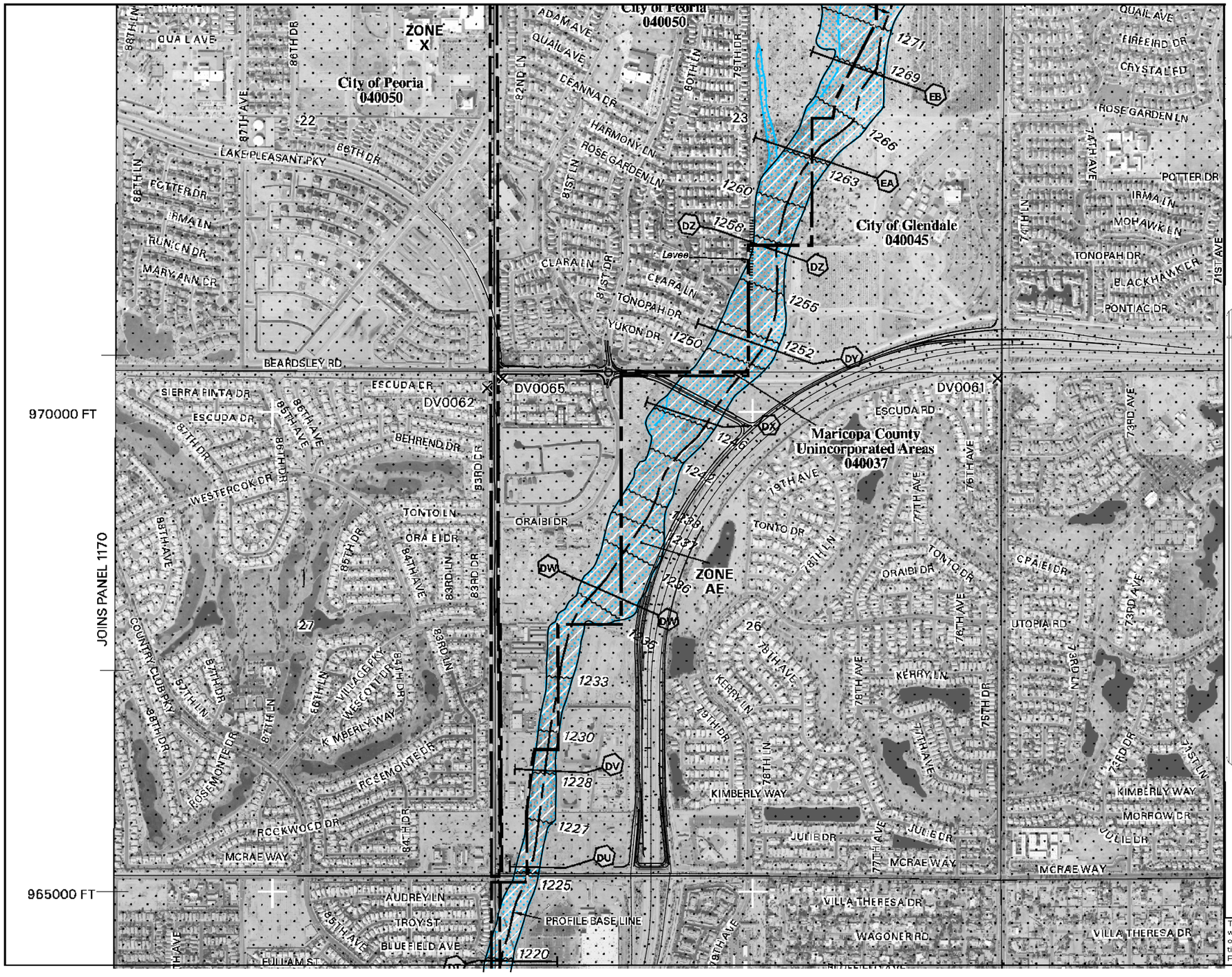
The remainder of the roadway improvements lie within the FEMA flood hazard zone X. Flood hazard zone X is defined as "Areas of 0.2% annual chance flood; areas of 0.1% chance flood with an average depth of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 0.1% annual chance flood".

It is the design team's opinion that the modifications to the FIRM are not significant. If the floodplain administrator requests that ADOT prepare a Conditional Letter of Map Revision (CLOMR) submittal for FEMA, then the design team members can prepare a technical data notebook. The CLOMR, if filed, would start the process with FEMA to revise the New River floodplain shown on Figure 3 to reflect the floodplain after the proposed channel improvements and bank protection and the Beardsley Road Bridge proposed for this project are constructed.

1.4 Purpose of Report

This report presents the hydrologic and hydraulic design calculations utilized within Phase II of the project limits for the 60% submittal. The purpose of this report is to document the engineering analyses and assumptions utilized for this project.

The hydrologic and hydraulic analyses followed procedures and methodologies presented in the Arizona Department of Transportation (ADOT) *Highway Drainage Design Manual – Hydrology* (Hydrology Manual) and *Roadway Design Guidelines* (RDG). Roadway drainage peak discharge values were calculated using the Rational Method as documented within the ADOT manual. All plans and reports for this project are presented utilizing English Units.



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NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 1190H

FIRM
FLOOD INSURANCE RATE MAP
MARICOPA COUNTY, ARIZONA
AND INCORPORATED AREAS

PANEL 1190 OF 4350

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
GLENDALE, CITY OF	040045	1190	H
MARICOPA COUNTY	040037	1190	H
PEORIA, CITY OF	040050	1190	H

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
04013C1190H

MAP REVISED
SEPTEMBER 30, 2005

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

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FEMA FIS MAP

FIGURE 3

$FILE%

2 SURVEY AND MAPPING

The one foot contour mapping developed for the project area was provided by Cooper Aerial of Phoenix Arizona. The mapping was produced from aerial photography taken in 2004.

Survey control for the project and aerial photography was performed by Carter Burgess of Phoenix, Arizona in 2004. Mapping data as reported by Carter Burgess follow:

COORDINATE SYSTEM:
State Plane Coordinate system using NAD27 (ADOT)

VERTICAL CONTROL:
Vertical datum is NAVD29.

BASIS of BEARINGS:
Grid north was used for the basis of bearing.

The following vertical datum conversions were used to convert as-built information to this project's datum:

ADOT as-built plans - add 1.88 ft

Fletcher Heights as-built plans (by CMX) – add 1.946 ft

3 HYDROLOGY

3.1 Precipitation

Rainfall data for the onsite analysis was determined using procedures found in Appendix B of the ADOT *Highway Drainage Design Manual, Hydrology*. Point rainfall depths were obtained from NOAA Atlas 14 maps. Rainfall depths were calculated for the 2-, 10-, 25-, 50-, 100-, and 500-year storm events. The precipitation data used for this project is provided in Appendix A.

3.2 Offsite Hydrology

There are two existing concrete channels along this reach of Loop 101. At the northern end of the project (101L mainline STA 920+00 to 75th Avenue), the existing concrete lined trapezoidal channel will remain in place. This channel intercepts and conveys the 100-yr offsite drainage from the north to New River. As part of Phase I, the terminus of the existing channel will be adjusted to match the proposed new bridge and bank protection. Portions of existing ADOT onsite roadway drain to this channel. Portions of the proposed frontage road will drain to this channel.

At the south end of the project, the existing concrete lined channel from about STA 880+00 to Union Hills does not intercept offsite drainage from the east. The subdivision to the east (Arrowhead Ranch) retains its 100-yr 2-hr runoff volume. Runoff in excess of the 100-yr 2-hr volume will spill into the ADOT right-of-way from Arrowhead Ranch. There is an overflow structure located near mainline STA 874+25. It is assumed that rainfall runoff in excess of the 100-yr 2-hr volume will be discharged from Arrowhead Ranch at this location. Additionally, the elevation of the existing channel is too high to drain existing 101L pavement drainage. Pavement drainage drains to the existing 84" storm drain below the Loop 101. For these reasons, the removal of the upper portion of this channel (approx STA 847+50 to STA 880+00) to allow the proposed Union Hill Ramp D construction will not adversely affect drainage.

3.3 Onsite Hydrology

Onsite hydrology or roadway drainage peak discharge values were determined utilizing the Rational method as documented in the ADOT Hydrology Manual. Magnitudes of flow for each drainage sub area are provided in Table 2 at the end of this section.

3.3.1 Onsite Drainage Criteria

Drainage areas were determined utilizing the proposed roadway improvement plans for this project. At the time of the drainage analysis, the roadway data was generally at a 60% level of completion. Assumptions to establish drainage areas were based on the best available information. Drainage areas are documented in Appendix B. Currently the drainage facilities

for the roadway improvements are being designed with the following drainage criteria for each public agency:

Drainage systems within the City of Peoria and City of Glendale (Beardsley Road):

- Catch basin locations are placed such that flow depths in the gutter do not overtop the curb and/or are not allowed to pond more than one lane (spread ≤ 14'), while maintaining at least one dry lane in each direction for the 10-year storm, whichever controls. Roadway sag areas utilize flanker inlets placed per FHWA criteria.
- Standard City of Phoenix (COP) catch basin P1569 and construction details will be used.
- Catch basin openings (curb type) will be sized using a clogging factor of 0.8. Grated type openings are not utilized.

Drainage systems within ADOT right-of-way:

- Catch basin locations are placed such that flow depths in the gutter do not overtop the curb and/or are not allowed to pond more than the allowable spread (Table 603.2C, ADOT 2007 RDG), whichever controls. Roadway sag areas utilize flanker inlets placed per FHWA criteria.
- Catch basin openings are sized using clogging factors of 0.8 for curb openings and 0.5 for grate openings.
- Bicycle safe grates will be utilized along the Frontage Road, and all ramps according to ADOT RDG Figures 606.2A and 606.2B.
- Standard ADOT catch basins and construction details will be utilized, where possible.

All drainage systems (City and ADOT) will be designed with the following criteria:

- Super elevation rollover locations or gore areas shall not release more than 0.2 cfs of sheet flow across the rollover or gore.
- Storm drain lateral connector pipes shall be 18-inches or greater.
- Storm drain trunk lines shall be 24-inches or greater.
- Manhole spacing shall be: 330-ft or less for 24-in pipe, and utilized at bends.
  500-ft or less for 30 to 36-in pipe, and utilized at bends.
  650-ft or less for 42 to 72-in pipe, and utilized at bends.

In addition to the above criteria, any storm drain systems within the City of Peoria that discharge roadway drainage directly to the New River shall include a first flush basin or an oil/water separator structure to treat the first flush (1/2 inch of rain). This is mandated by the City of Peoria to comply with the Arizona Department of Environmental Quality's (ADEQ) general permit which dictates pre determined Best Management Practices (BMP's). It is recommended by J2 that oil/water separator structures contain a "bypass" system to allow storm water flows in

excess of the first flush to pass through the separator structure without causing excessive backwater.

3.3.2 Rational Equation

The Rational runoff method calculates the peak discharge using the algebraic formula:

$$Q = CiA$$

Where Q = peak discharge, in cfs,

C = the runoff coefficient,

i = average rainfall intensity, in inches/hour, and,

A = the contributing drainage area, in acres.

Printouts of the Rational equation calculations can be found in Appendix C. Each of the rational equation components are discussed below.

3.3.2.1 Rational Runoff: C

The value of the C coefficient is a function of the one-hour precipitation depth, vegetative cover, percent of effective impervious area and the hydrologic soil group (HSG).

The "C" coefficients for each soil type and landuse are determined using the appropriate Figures in the ADOT *Highway Drainage Design Manual – Hydrology*. Composite coefficients are determined for each sub-basin.

3.3.2.2 Rational Runoff: i

The intensity (i) in the Rational Runoff equation is the average rainfall intensity for a selected return period with a rainfall duration that is equal to the time of concentration. The time of concentration is the travel time, during the corresponding period of most intense rainfall excess, for a flood wave to travel from the hydraulically most distant point in the watershed to the point of interest.

For the rational runoff method, the rainfall depths were converted to rainfall intensities. An iterative process is utilized to determine the relationship between the rainfall intensity and the time of concentration of the basin. Refer to Appendix A for the Intensity–Duration–Frequency (I-D-F) curves for 0 to 60 minutes utilized in the Rational equation. The minimum T_c used for the project was 10 minutes, per ADOT criteria.

The time of concentration was developed from the following iterative equation (ADOT 2-2):

$$Tc = 11.4\, L^{0.5}\, K_b^{0.52}\, S^{-0.31}\, i^{-0.38}$$

Where: T_c= Time of concentration (hours)

L= Length of the longest flow path (miles)

K_b= Watershed resistance coefficient

S= Slope of the longest flow path (ft/mile)

i= Average rainfall intensity (in/hr)

Equation 2-4 in the ADOT *Highway Drainage Design Manual - Hydrology* was utilized to determine composite slopes for sub-basins with non-uniform grades or slope breaks. The resistance coefficient (Kb) was determined from Table 2-1 in the ADOT *Highway Drainage Design Manual - Hydrology*. Roadway drainage areas within the project limits are best described as paved (overland flow only). This category yields a Kb factor of 0.02.

4 HYDRAULIC ANALYSIS

Procedures and design criteria outlined in the ADOT publication entitled *Roadway Design Guidelines* (ADOT RDG) are utilized for hydraulic design and analysis for this project.

The onsite roadway drainage collection system is analyzed and designed following industry standard practice by utilization of various Federal Highway Administration (FHWA) equations and practices.

The proposed roadway profile and super elevation data affect the 60% drainage analysis, and as a result the proposed inlet locations and culvert sizes documented herein are subject to revision as the design of this project continues. Catch basin locations and expected storm drain alignments based on the 60% roadway design are provided on the drainage sheets included in Appendix B.

4.1 Catch Basins

Roadway improvements within the ADOT maintenance areas for this project consist of a local arterial street (Beardsley Road), frontage road, freeway on and off ramps and mainline freeway widening in the ramp transition areas. For the ADOT C-05.10, type D gutter, this project shall use the ADOT C-15.20 catch basin. When the ADOT roadways drain to a concrete barrier or ADOT C-05.10 type B or C curb is used, the ADOT C-15.91 or C-15.92 catch basins are recommended.

In areas where infield freeway side slopes drain towards the freeway and proposed retaining walls or concrete barrier, it is recommended that a drainage collection system be utilized behind the wall, rather than allow the drainage to sheet flow over the wall and on to the freeway. Standard ADOT C-15-81 catch basins are recommended at these locations. ADOT infield drainage areas will typically be collected by an ADOT C15.80 (median) catch basin.

The Beardsley road extension and widening fall within the Cities of Peoria and Glendale. Both Cities prefer catch basins built to the City of Phoenix standard detail P-1569. Appendix C contains a summary Table with catch basin locations and recommended types for this project.

4.2 Storm Drains

Storm drain hydraulics were estimated using Manning's equation and applying loss coefficients to the velocity head at structures. Haestad Methods StormCAD v5.5 software is used to model the 60% storm drain hydraulics. Haestad allows each structure to be assigned a loss coefficient. Head loss coefficients for manholes and catch basins are assigned values using the FHWA HEC-22 values associated with the software (typically 0.15 and 1, respectively). At minor bends and/or pipe collars, the loss coefficient was input directly and estimated to be about 0.02.

Hydraulic summary printouts for storm drains are provided in Appendix D. Electronic copies of the StormCAD files are available upon request.

Portions of the ADOT roadway system are depressed (101L mainline under Union Hills and 75th Avenue). The majority of the ADOT improvements drain to the existing 84" main trunk line.

As such, storm drain hydraulics are analyzed using the 50-yr storm event. As an additional conservative measure, intercepted flow as determined on each catch basin computation sheet is entered into Storm CAD as additional flow. This method does not account for hydrograph timing and usually overestimates the magnitude of flow in a storm drain main trunk line.

4.3 Utilities

There are no known utility conflicts with drainage at this time. Existing utilities will be protected in place. The following information is a record of current known utility information.

4.3.1 Sanitary Sewer

An existing 21-in vitrified clay sanitary sewer line runs north-south beneath the Frontage Road alignment. The Frontage Road alignment diverges away from the sanitary sewer alignment at STA 58+00 (101L ML STA 923+00). At that location, the sewer crosses beneath the existing ADOT concrete channel and heads north. The 21" sanitary sewer is deep. Invert elevations resulting from survey (dip shots at manholes) at various locations are:

- Invert elev. = 1218 near 101L Mainline STA 879+00 (north of Union Hills Drive),
- Invert elev. = 1222 near 101L mainline STA 895+00 (under existing 48" storm drain),
- Invert elev. = 1232 near 101L mainline STA 908+25 (under existing 48" storm drain),
- Invert elev. = 1238.1 near 101L mainline STA 915+50 (under CB 104)

A trunk line of the sanitary sewer crosses beneath Loop 101 at STA 875+10. It is assumed that the trunk line is deep (invert near 1218), but needs to be verified.

4.3.2 Existing Drainage Structures

There is an existing 48" reinforced concrete pipe storm drain crossing beneath 101L at STA 895+00. An existing manhole is located near Beardsley Road Ramp A STA 13+35, 16' Lt, which is located at the proposed gutter, about 45-ft behind the gore from the Frontage Road. This manhole will be required to remain in place. It is recommended that the manhole access be adjusted to gutter grade and rotated to be outside of the wheel path (same type of adjustment used for existing sanitary sewer manholes in the Frontage Road).

Another 48" reinforced concrete pipe storm drain crosses beneath 101L at STA 908+25. There appears to be an existing drain manhole on this 48" line located near the Frontage Road STA 42+60, 6' Rt. It is recommended that ADOT Drainage allow this manhole to be capped instead

of extending it to the surface of the proposed Frontage Road. A new manhole (MH 78) is proposed to be constructed about 35' upstream of the existing manhole.

Elevations of existing storm drain systems reported within this report and on the construction plans were taken from the ADOT as-built plans. The vertical adjustment factor of 1.88-ft, as provided by Carter Burgess, is added to all ADOT as-built elevations.

4.3.3 Proposed Retaining Wall Foundations

As the vertical design of the proposed retaining wall foundations are developed, the Structural Engineer will need to use the storm drain profiles included with the 60% submittal. The majority of the new pipes drain to existing storm drain systems. As such, proposed storm drain profiles have limited vertical adjustment capabilities. J2 will work with the Structural Engineer to resolve potential conflicts.

7 SUMMARY AND CONCLUSIONS

The onsite collection system documented herein is designed to collect the 10-yr runoff before it overtops the roadway curb and/or spreads onto the roadway more than the allowable spread. Catch basin locations and sizes have been determined based on the 60% roadway plan and profile layout provided by Carter Burgess. Storm drain pipe sizes and outfall locations have been analyzed with respect to hydraulic performance and vertical geometry. Where possible, ADOT Loop 101 infield area collection systems are proposed to drain away from the main collection system (84" storm drain). This is an effort to minimize the amount of new drainage being added to the existing ADOT main storm drain.

As mentioned previously, portions of the 101L mainline are depressed. As such, the storm drain profiles shown herein reflect the 50-yr event. The profiles show that the 50-yr storm does not surcharge the 84" main storm drain. Additionally the 50-yr computed water surface elevation in all catch basins is 1-ft or more below the catch basin grate.

The construction items expected for this project are documented in the ADOT, *Project Plans, State Highway, Agua Fria Freeway, SR 101L, Beardsley Connector, Stage III, 60% Submittal, (project no. 101 MA 015 H707601C NON-FA)*, construction plans, dated October 2, 2007, and submitted under separate cover. A quantity count and corresponding opinion of probable cost for the drainage items is provided in Appendix E. The $1.44 million estimate should only be used for drainage related capital cost budgetary purposes. It does not include fees for engineering design, survey, construction observation, traffic control or utility relocations.

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