Supporting Narrative for Establishing Base Flood Elevations For Lots 3-16 and 19-27 In Association with the Recorded CORONADO HILLS SUBDIVISION

T23S, R28E, Section 32,
G&SRB&M, Cochise County, Arizona

Prepared for:

CITY OF DOUGLAS

City of Douglas
425 E 10th St
Douglas, Arizona 85607

Prepared by:
CMG DRAINAGE ENGINEERING, INC.
CMG Drainage Engineering, Inc.
3555 North Mountain Avenue
Tucson, AZ 85719
520-882-4244
saltherr@cmgdrainage.com

Registered Professional Engineer (Civil)
CERTIFICATE NO.
43795
SCOTT J.
ALTHERR
Date Signed 11-16-17
ARIZONA, U.S.A.
Expires 3/31/2018

CMG Project No. 17-029
November 16, 2017

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

SECTION 1: INTRODUCTION

1.1 Purpose

This technical narrative has been prepared to document existing floodplain conditions and establish base flood elevation (BFE) data, where none exists, to effectively make a determination on whether the Coronado Hills Subdivision can be removed from the Special Flood Hazard Area (SFHA). The flooding source is an Un-Named Wash which is currently designated as an un-numbered A-Zone, in the City of Douglas corporate limits, on Flood Insurance Rate Map (FIRM) Panel No. 040003C2595F.

1.2 Location of Study

The site is located within Section 32 Township 23 South, Range 28 East, G&SRB&M, Cochise County, Arizona. The total length of the study reach is approximately 3,300 feet which extends upstream and downstream sufficient to establish BFEs adjacent to the project. A location and vicinity map for the study area are shown on Figure C-1, Appendix C.

1.3 Hydrologic and Hydraulic Methodology

The Effective Flood Insurance Study (FIS) reports no discharge rates for the Un-Named Wash. The City of Douglas also did not have a regulatory discharge for the Un-Named Wash so a 1% chance event discharge was required to be calculated. The United States Geological Survey (USGS) software program entitled National Stream Statistics (NSS) Version 6.1 was utilized to generate a peak discharge using regional regression equations and a hydrograph. Results are provided in Appendix A.

The U.S. Army Corps of Engineers' river system modeling software, HEC-RAS version 5.0.1, April 2016, was used to model the unnamed wash and determine BFEs.

SECTION 2: FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA) FORMS

FEMA Forms

- No forms will be submitted at this time as the results indicate structures in the subdivision, that are presently within the Zone A, have lowest adjacent grades (LAGs) that are not above the base flood elevations.

SECTION 3: SURVEY AND MAPPING INFORMATION

3.1 Digital Projection Information

The Shape files prepared for this project were all constructed on the State Plane Coordinate system. Digital projection for these shape files are shown as follows:

- Horizontal Datum: NAD83(HARN)
- Projection: Arizona State Plane, East Zone
- Units: International Feet
- Vertical Datum: NAVD88

3.2 Field Survey Information

Field Surveys were performed by Alta Land Surveying and delivered on the above referenced datums. Surveys were tied to control points on the state plane coordinate system and collected point elevation data on 23 residences in the Coronado Hill Subdivision. Survey shots were collected on lowest floor, lowest adjacent grade (LAG), highest adjacent grade (HAG), and the finished floor (FFE). These are shown on Figure C-6.

3.3 Mapping

Topographic mapping and aerial photography used in the preparation of this study were acquired from the United States Geological Survey (USGS) National Elevation Dataset and United States Department of Agriculture (USDA) National Agriculture Imagery Program (NAIP) 2015 aerial photography project. The topographic mapping was generated by utilizing a USGS 1/9 arc-second digital elevation model (DEM) which was generated in 2012, which were used to create 2-foot interval contours.

SECTION 4: HYDROLOGY

4.1 Method Description

As noted in Section 1.3 above, the hydrology for the 1% annual chance storm occurring over the contributing watershed was developed using USGS NSS 6.1. This method was chosen as it is can provide a 1% annual exceedance probability (AEP) discharge as well as hydrograph. PC-Hydro 6.0, developed for Pima County, was also used for verification purposes and as a comparison.

4.2 Parameter Estimation

4.2.1 Drainage Area Boundaries

The study stream watershed has a drainage area of 5.5 square miles along the study reach which originates in the Perilla Mountains to the northeast of the project reach. See Figure C-2, Watershed Map. The watershed has changed over the last 21 years. An aerial photo review shows that in 1996 flow upstream of Hwy 80 was draining to a different concentration point. This is consistent with the USGS Quadrangle Map “College Peaks” published in 1986 which shows flow from the Perilla Mountains going across Hwy 80 between mileposts 372 and 373. Due to geomorphic changes on the alluvial fan, the flow of runoff has changed course and now crosses Hwy 80 just south of milepost 372.

4.2.2 Precipitation

Precipitation data is not required for the NSS 6.1 program which uses regional regression equations.

4.2.3 Physical Parameters

Land use in the watershed is consistent with rural range land as the predominant use. There are no significant structures or impoundments in the watershed that would require a rainfall-runoff model approach. Slope, Area and longest watercourse were necessary to calculate a time of concentration which in-turn was converted to lag time. Lag time is the only parameter required in NSS 6.1 for generation of a hydrograph.

4.3 Final Results

The project falls within Region 5 (Southeast Basin and Range) and calculations in NSS 6.1 use the regression equations developed and updated by USGS in 2014. The regulatory discharge for the unnamed study stream is 3,190 cubic feet per second (cfs) and the lag time is 1.48 hr. The hydrograph is shown on Figure C-2.

SECTION 5: HYDRAULICS

5.1 Method Description

The study reach is primarily an incised natural channel watercourse with an abrupt turn that empties into a dry pond. The channel is a sandy bottom ephemeral wash with banks vegetated moderately through the site. Channel overbanks are characterized as fairly densely vegetated mesquite acacia scrubland.

On the effective FIRM (Figure C-3), the study reach is shown as FEMA flood Zone A. As a first step, a manning's normal depth rating was performed on the channel upstream of the Coronado Hills Subdivision. The rating showed that the channel was severely under-capacity for the flow arriving there. Using a 1-D steady state model to analyze the breakout and abrupt change in direction would not be appropriate.

It was determined that the best option for modeling the flood hazard would be a 2-Dimensional model. HEC-RAS, Version 5.0.3 (September 2016, U.S. Army Corps of Engineers) was used in a 2-D-only Diffusive Wave capacity with an un-steady state flow to determine the max flow depths and water surface elevations for the 100-year discharge. The downstream boundary condition for the HEC-RAS model was normal depth. The upstream boundary condition for the 2-D unsteady flow area was the inflow hydrograph. Each of these boundary condition locations was graphically selected from the 2-D mesh.

The source for selecting the Manning's roughness coefficients was *Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona (Dec 1989)*. A Land Cover was created for HEC-RAS which covered the channel, pond, streets and houses. Table 1, Manning's "n" Values lists the values used for each land-use.

Table 1, Manning's "n" Values

Land-Use	"n" value
default	0.05
channel	0.03
pond	0.03
building	10.0
walled yards	10.0

The 2-D Flow area (aka mesh) was delineated to provide sufficient room for distributary flow and breakout. The mesh was ended along the north south road Coronado Drive and the east west road Golf Course Road. The mesh contains approximately 22,000 cells over 109 acres. Figure C-4 Hydraulic Work Map shows the 2-D mesh, the land cover, contours, boundary conditions lines and breaklines.

Because the analysis was designated to be run in unsteady state, several program settings were adjusted from default in order to achieve stability in the model: Maximum iterations in 2D Flow Options was adjusted to 40, initial conditions time was set to 20 hrs, initial conditions ramp-up fraction was increased from 0.1 to 0.5, and time slices were increased from 1 to 10. Additionally, the computation interval was set at 1-minute. With these adjustments, the model achieves stability.

5.2 Hydraulic Analysis Results

As suspected with the initial channel rating described in Section 5.1, that the flood inundation from the watercourse breaks over the south edge of the channel and inundates the Coronado Hills Subdivision. The subdivision streets are conveying flows ranging from 1-2 feet in depth. Most homes have some level of inundation with the exception of Lot 19, which is above the base flood elevation. This Lot 19 residence was not in the FEMA floodplain to begin with. The analysis shows that there is actually more homes susceptible to flooding than the Zone A FEMA floodplain depicts. Lots 3-5 have significant flood depths greater than 18". Most of the homes are inundated with depths > 1 feet. Approximately 8 of the homes are inundated with shallow depths < 0.5 feet.

The HEC-RAS model (Filename: wash1_17029.prj) results are displayed on Figures D-5 and D-6. A printout of the HEC-RAS Computation Log File (CLF) and the Boundary Condition hydrographs have been provided in Appendix B. The CLF shows the volume conservation accuracy, storage volume, and the stability of the model. Figure C-6 displays a table of surveyed LAG, FFE, and BFE for each structure.

Electronic copies of the HEC-RAS models are included on a compact disc, which is provided in Appendix D.

5.4 Proposed Recommendations

There is a significant flood hazard impacting this subdivision as the results show. This stems from a changing geomorphology in the upstream watershed as stated in Section 4.2.1 and also from the lack of sufficient infrastructure to collect and safely convey the runoff away from the subdivision.

We recommend that the City of Douglas (City) acquire some of the land upstream of the subdivision, predicated by a design study that suggests the size and dimensions of a collector channel that is adequate to collect and convey flows without overtopping into the subdivision.

We also recommend that the City evaluate the required outfall from the pond to the west of the subdivision and optimize it to function with the increased flow that it will be receiving.

Both recommendations can be evaluated using the 2-D model from this study and modifying it for design conditions, once the improvements are conceptually designed.

SECTION 6: REFERENCES

1. Paretti, N.V., Kennedy, J.R., Turney, L.A., and Veilleux, A.G., 2014, Methods for estimating magnitude and frequency of floods in Arizona, developed with unregulated and rural peak-flow data through water year 2010: U.S. Geological Survey Scientific Investigations Report 2014-5211, 61 p., http://dx.doi.org/10.3133/sir20145211
2. United States Geological Survey (USGS), Scientific Investigations Report 2006-5108, *Selection of Manning's Roughness Coefficient for Natural and Constructed Vegetated and Non-Vegetated Channels, and Vegetation Maintenance Plan Guidelines for Vegetated Channels in Central Arizona*, 2007;
3. USGS, Open File Report 93-419, *Methods for Estimating Magnitude and Frequency of Floods in the Southwestern United States,* pg. 59, 1994;
4. FEMA, *Guidelines & Specifications for Flood Hazard Mapping Partners, Appendix C, Guidance for Riverine Flooding Analyses and Mapping*, November 2009;
5. U.S. Army Corps of Engineers *HEC-RAS River Analysis System User Manual*, Version 5.0.3, April 2016;
6. FEMA, *Flood Insurance Study (FIS) for Cochise County and Incorporated Areas*, October 20, 2016;
7. City of Tucson, *Standards Manual for Drainage Design & Floodplain Management,* December 1989, Revised July 1998.
8. USGS. The National Streamflow Statistics Program, Version 6.1: A Computer Program For Estimating Streamflow Statistics For Ungaged Sites 2016.

APPENDIX A

HYDROLOGIC ANALYSIS SUPPORTING DOCUMENTATION

Time of Concentration
Douglas, AZ

ADOT Eq. 4-1

desert/mountain

$$T_c = 2.4\ A^{.1}\ L^{.25}\ L_{ca}^{.25}\ S^{-.2}$$

A =	5.5	sq mi
L =	7.4	mi
Lca =	4.67	mi
S =	171	ft/mi
Tc =	2.47	hr
T_L =	1.48	hr

National Streamflow Statistics Program
Version 6.1
Based on Techniques and Methods Book 4-A6
Equations from database C:\Program Files (x86)\NSS\data\NSS_v6_2016-04-25.mdb
Updated by KGR 4/4/2016 2:24:42 PM Added 8 new low-flow StatLabels for MT

Site: unnamed, Arizona
User:
Date: Thursday, November 16, 2017 02:53 PM

Equations for Arizona developed using English units

Rural Estimate: Rural 4
Basin Drainage Area: 5.5 square miles
1 Region

Region: Peak_Region_5_SE_Basin_Range_2014_5211 (Paretti, N.V., Kennedy, J.R., Turney, L.A., and Veilleux, A.G., 2014, Methods for estimating magnitude and frequency of floods in Arizona, developed with unregulated and rural peak-flow data through water year 2010: U.S. Geological Survey Scientific Investigations Report 2014-5211, 61 p., http://dx.doi.org/10.3133/sir20145211.)
Contributing_Drainage_Area = 5.5 square miles

Results for: Rural 4

Equations used:
PK2 = 10^(6.363 - 4.386*CONTDA^(-0.060))
PK5 = 10^(5.868 - 3.506*CONTDA^(-0.080))
PK10 = 10^(5.778 - 3.218*CONTDA^(-0.090))
PK25 = 10^(5.757 - 2.99*CONTDA^(-0.100))
PK50 = 10^(5.696 - 2.795*CONTDA^(-0.110))
PK100 = 10^(5.651 - 2.634*CONTDA^(-0.120))
PK200 = 10^(5.761 - 2.638*CONTDA^(-0.120))
PK500 = 10^(5.750 - 2.502*CONTDA^(-0.130))

Statistic	Value, ft3/s	Pred. Intervals Low	Pred. Intervals High	Prediction Error, %
PK2	253	73	878	87
PK5	644	252	1640	62
PK10	1040	462	2350	52
PK25	1720	838	3530	46
PK50	2390	1210	4750	44
PK100	3190	1630	6260	43
PK200	4080	2090	7980	42
PK500	5560	2840	10900	43

Rural Estimate: Cor Hills Watershed
Basin Drainage Area: 5.5 square miles
1 Region

Region: Peak_Region_5_SE_Basin_Range_2014_5211 (Paretti, N.V., Kennedy, J.R., Turney, L.A., and Veilleux, A.G., 2014, Methods for estimating magnitude and frequency of floods in Arizona, developed with unregulated and rural peak-flow data through water year 2010: U.S. Geological Survey Scientific Investigations Report 2014-5211, 61 p., http://dx.doi.org/10.3133/sir20145211.)
Contributing_Drainage_Area = 5.5 square miles

Results for: Cor Hills Watershed

Equations used:
PK2 = 10^(6.363 - 4.386*CONTDA^(-0.060))
PK5 = 10^(5.868 - 3.506*CONTDA^(-0.080))
PK10 = 10^(5.778 - 3.218*CONTDA^(-0.090))
PK25 = 10^(5.757 - 2.99*CONTDA^(-0.100))
PK50 = 10^(5.696 - 2.795*CONTDA^(-0.110))
PK100 = 10^(5.651 - 2.634*CONTDA^(-0.120))
PK200 = 10^(5.761 - 2.638*CONTDA^(-0.120))
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PK2	253	73	878	87
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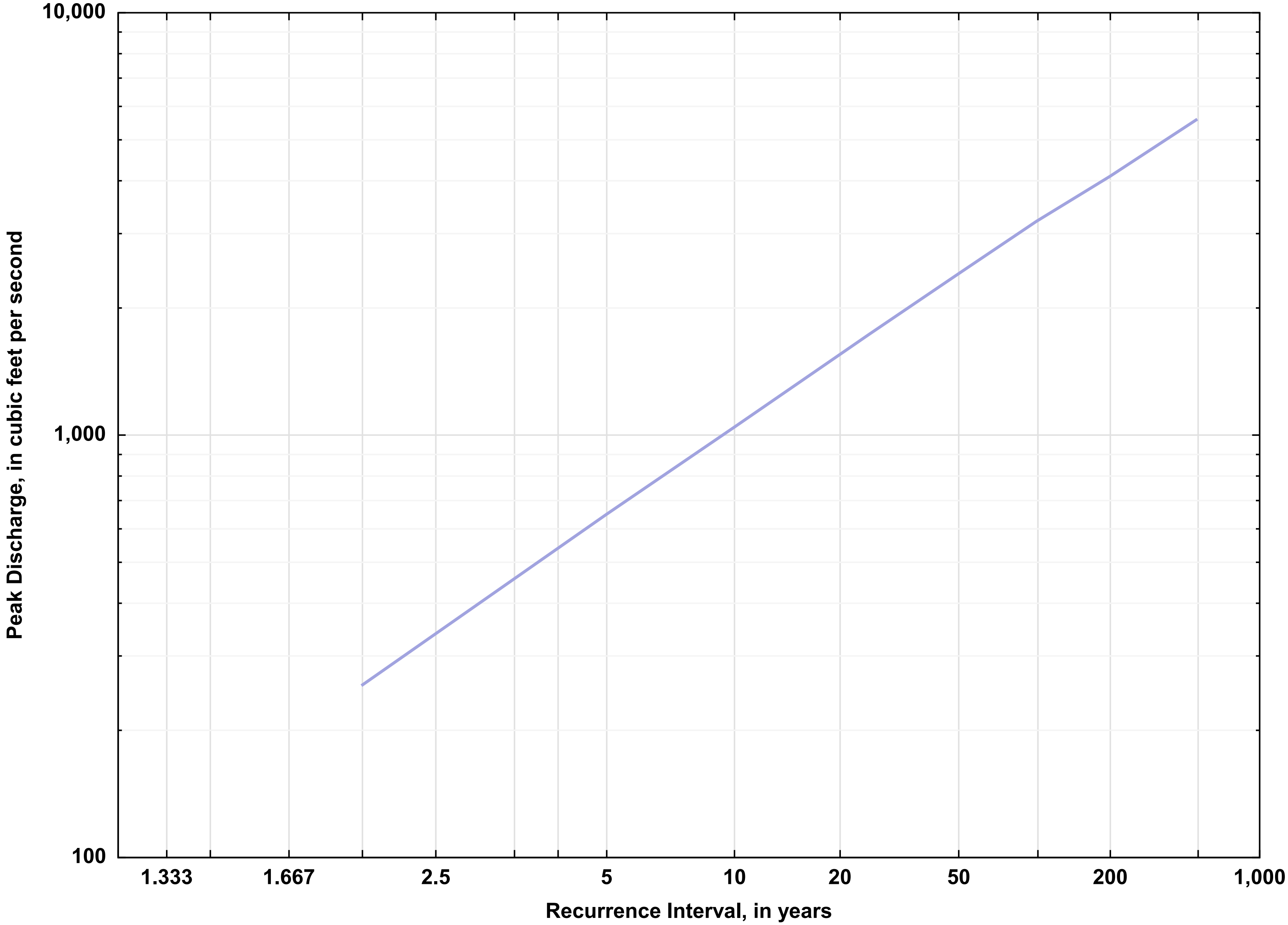
PK50	2390	1210	4750	44
PK100	3190	1630	6260	43
PK200	4080	2090	7980	42
PK500	5560	2840	10900	43



Flood Frequency Plot

APPENDIX B

HYDRAULIC ANALYSIS SUPPORTING DOCUMENTATION

B.1 – Computation Log File (Volume Conservation)
B.2 – Boundary Condition Hydrographs

B.1 – COMPUTATION LOG FILE

```
                                              HEC-RAS - River Analysis System

Project File:  Z:\PROJECTS\2017\17-029_Douglas_Coronado_Hills\GIS\HEC-RAS\wash1_17029.prj

Project Name:  wash1


Plan Name:     Unsteady 01

Short ID:      Unsteady 1


Starting Time:   11Jul2017 1200

Ending Time:     11Jul2017 1538

                ################################################
                #                                              #
                #                                              #
                #       1D and 2D Unsteady Flow Module         #
                #                                              #
                #                                              #
                #          HEC-RAS 5.0.1 April 2016            #
                #                                              #
                #             03AUG17 at 14:47:59              #
                #                                              #
                ################################################




                 Volume Accounting in Acre Feet

                           External Boundary Flux of Water

         US Inflow       Lat Hydro      DS Outflow        SA Hydro     Groundwater       2D Inflow      2D Outflow
Diversions
         *********       *********      **********        ********     ***********       *********      **********
**********
                                                                                             414.4           383.4

                      River Reaches, Storage Areas, and 2D Areas

    Start 1D Reach   Starting SA's     Starting 2D  Final 1D Reach      Final SA's  Final 2D Areas
    **************   *************     ***********  **************      **********  **************
                                                                                             30.98

                             Error   Percent Error

                             *****   *************
                          0.003235        0.000781




                 Volume Accounting for 2D Flow Area in Acre Feet

           2D Area    Starting Vol      Ending Vol      Cum Inflow     Cum Outflow           Error   Percent Error
           *******    ************      **********      **********     ***********           *****    ************


          CorHills                           30.98           414.4           383.4        0.003235        0.000781



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 º                                             º
 º                                             º
 º              DSS-Writer                     º
 º                                             º
 º         For Unsteady Flow Module            º
 º                                             º
 º         HEC-RAS 5.0.1 April 2016            º
 º                                             º
 º           03AUG17 at 14:52:17               º
 º                                             º
 ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ¼



Output file:  Z:\PROJECTS\2017\17-029_Douglas_Coronado_Hills\GIS\HEC-RAS\wash1_17029.bco02
```
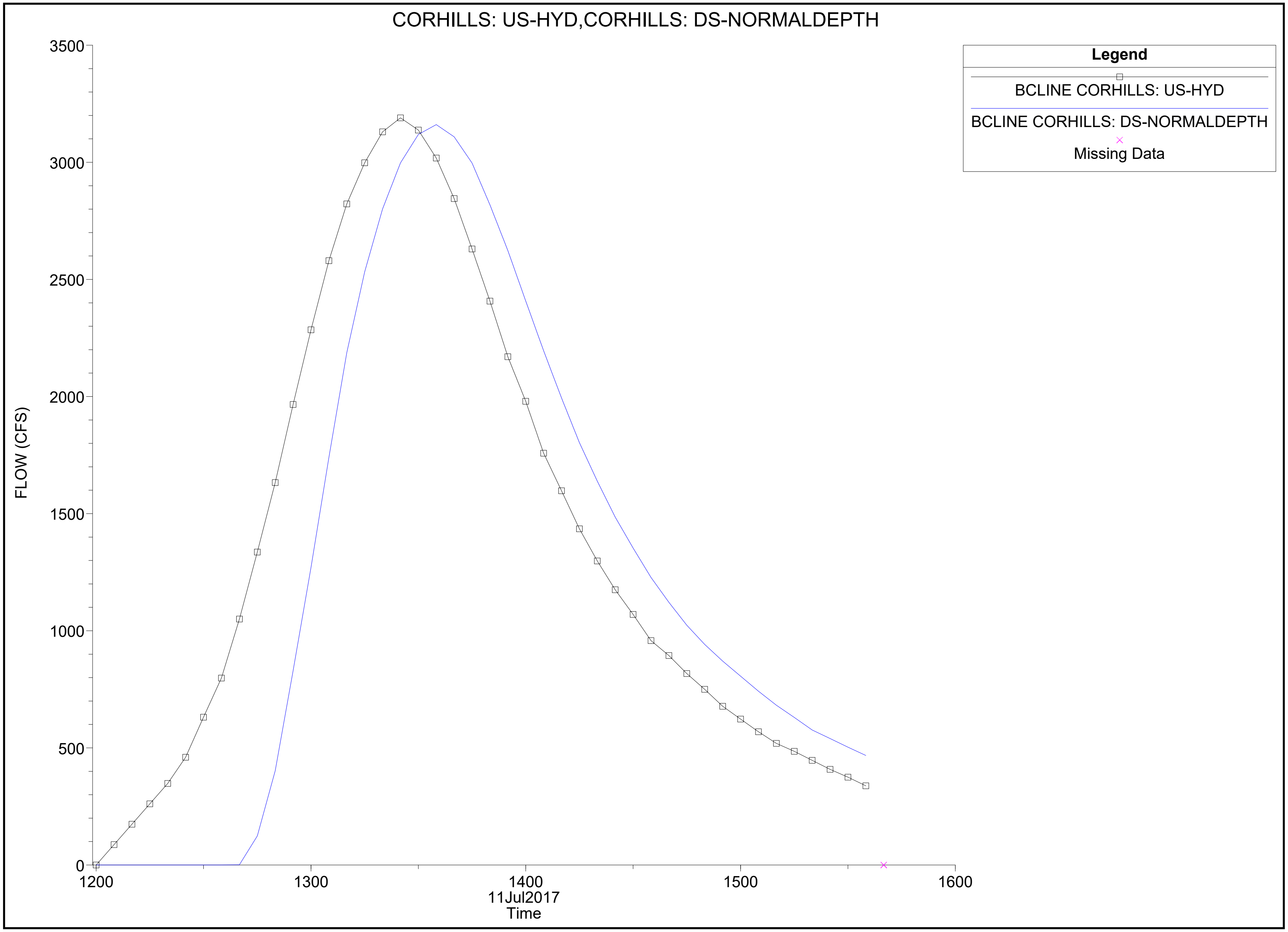

B.2 – BOUNDARY CONDITION HYDROGRAPHS



CORHILLS: US-HYD,CORHILLS: DS-NORMALDEPTH
Legend
BCLINE CORHILLS: US-HYD
BCLINE CORHILLS: DS-NORMALDEPTH
Missing Data
FLOW (CFS)
3500
3000
2500
2000
1500
1000
500
0
1200
1300
1400
1500
1600
11Jul2017
Time

APPENDIX C

EXHIBIT MAPS

PORTION OF SECTIONS 32, TOWNSHIP 23 SOUTH, RANGE 28 EAST, G&S.R.S.M. COCHISE COUNTY, ARIZONA

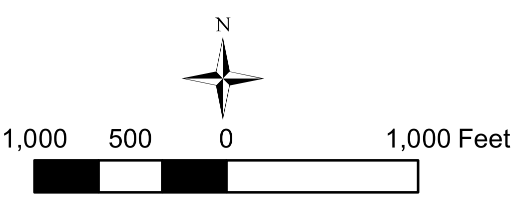
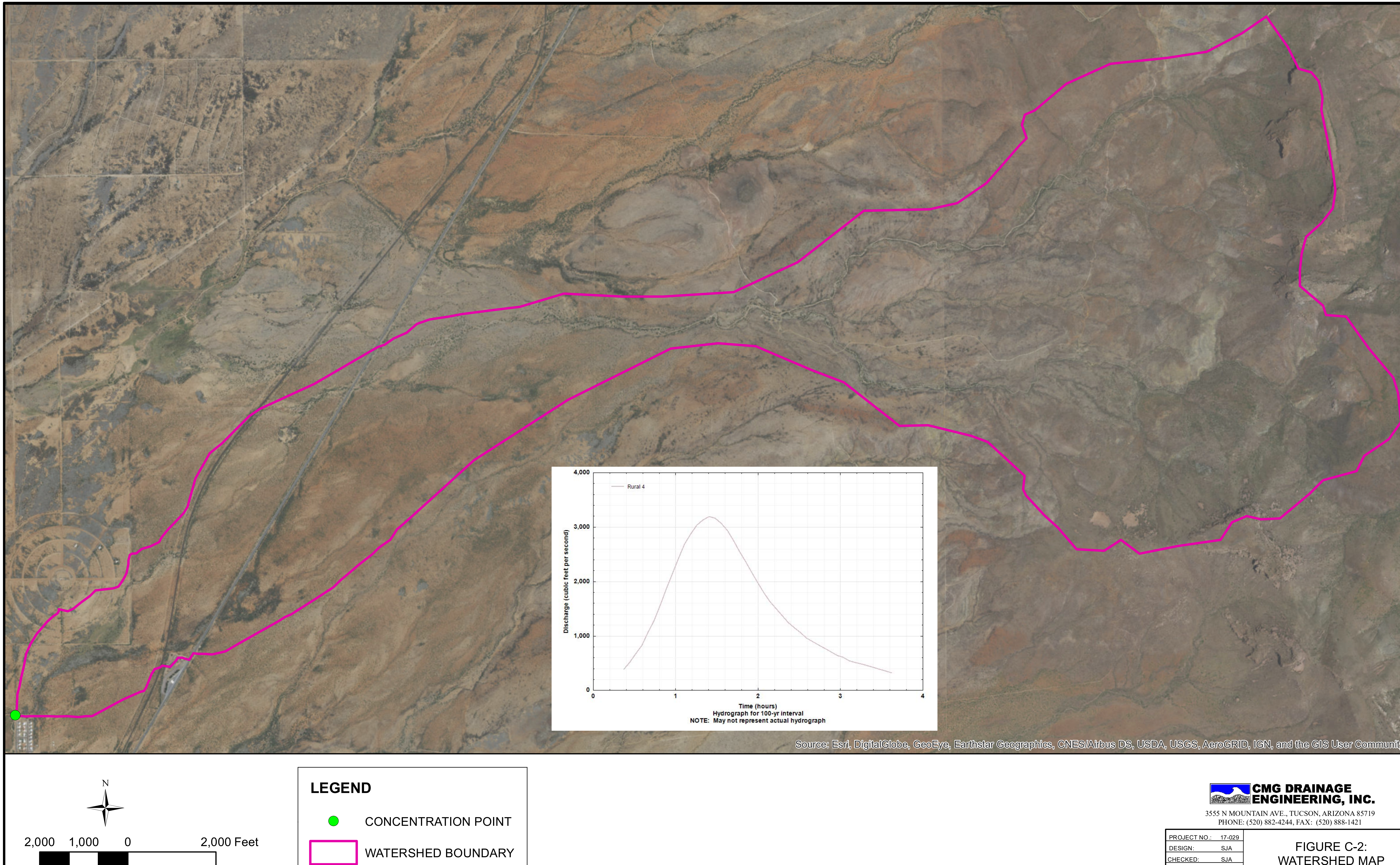


FIGURE C-1:

LOCATION MAP

PROJECT NO.: 17-029

CMG DRAINAGE ENGINEERING, INC.
3555 N MOUNTAIN AVE., TUCSON, ARIZONA 85719
PHONE: (520) 882-4244, FAX: (520) 888-1421



LEGEND

- CONCENTRATION POINT
- WATERSHED BOUNDARY

CMG DRAINAGE ENGINEERING, INC.
3555 N MOUNTAIN AVE., TUCSON, ARIZONA 85719
PHONE: (520) 882-4244, FAX: (520) 888-1421

PROJECT NO.:	17-029
DESIGN:	SJA
CHECKED:	SJA
DRAWN:	BJK
DATE:	07/06/2017

FIGURE C-2:
WATERSHED MAP

PORTION OF SECTIONS 32, TOWNSHIP 23 SOUTH, RANGE 28 EAST, G&S.R.S.M. COCHISE COUNTY, ARIZONA

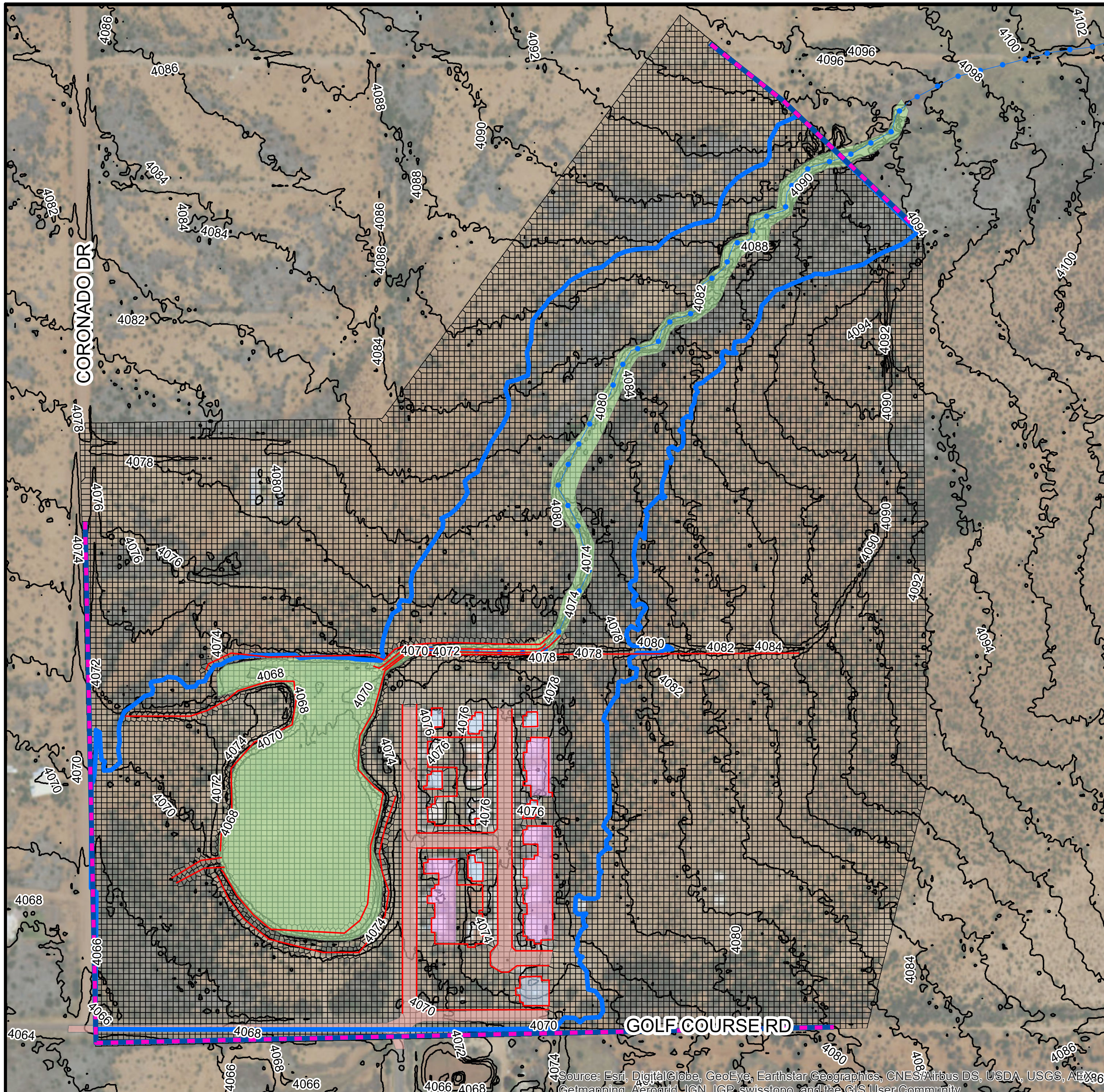
N

FIGURE C-3:
FLOOD INSURANCE RATE MAP

1,000 500 0 1,000 Feet

PROJECT NO.: 17-029

CMG DRAINAGE ENGINEERING, INC.
3555 N MOUNTAIN AVE., TUCSON, ARIZONA 85719
PHONE: (520) 882-4244, FAX: (520) 888-1421



LEGEND

- boundary_Condition_Lines
- Breaklines
- Streamline
- 100-YR Inundation Limits

Land_Class

- Building
- Earthen Channel Banks with brush
- Pavement
- Perimter Walls
- 2D Mesh
- 2ft Contours

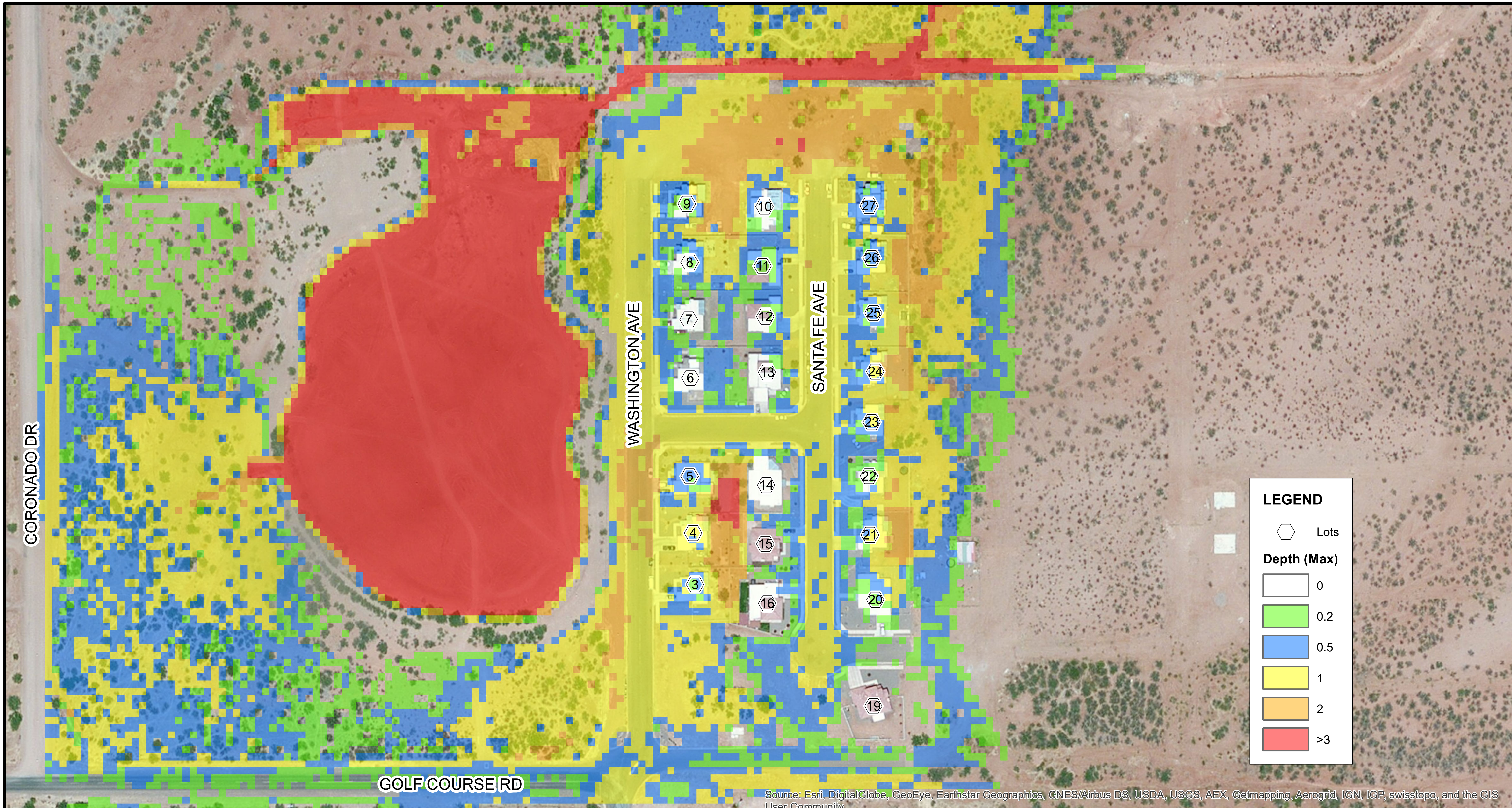
N

300 150 0 300 Feet

CMG DRAINAGE ENGINEERING, INC.
3555 N MOUNTAIN AVE., TUCSON, ARIZONA 85719
PHONE: (520) 882-4244, FAX: (520) 888-1421

PROJECT NO.:	17-029
DESIGN:	SJA
CHECKED:	SJA
DRAWN:	BJK
DATE:	07/06/2017

FIGURE C-4:
HYDRAULIC WORK MAP



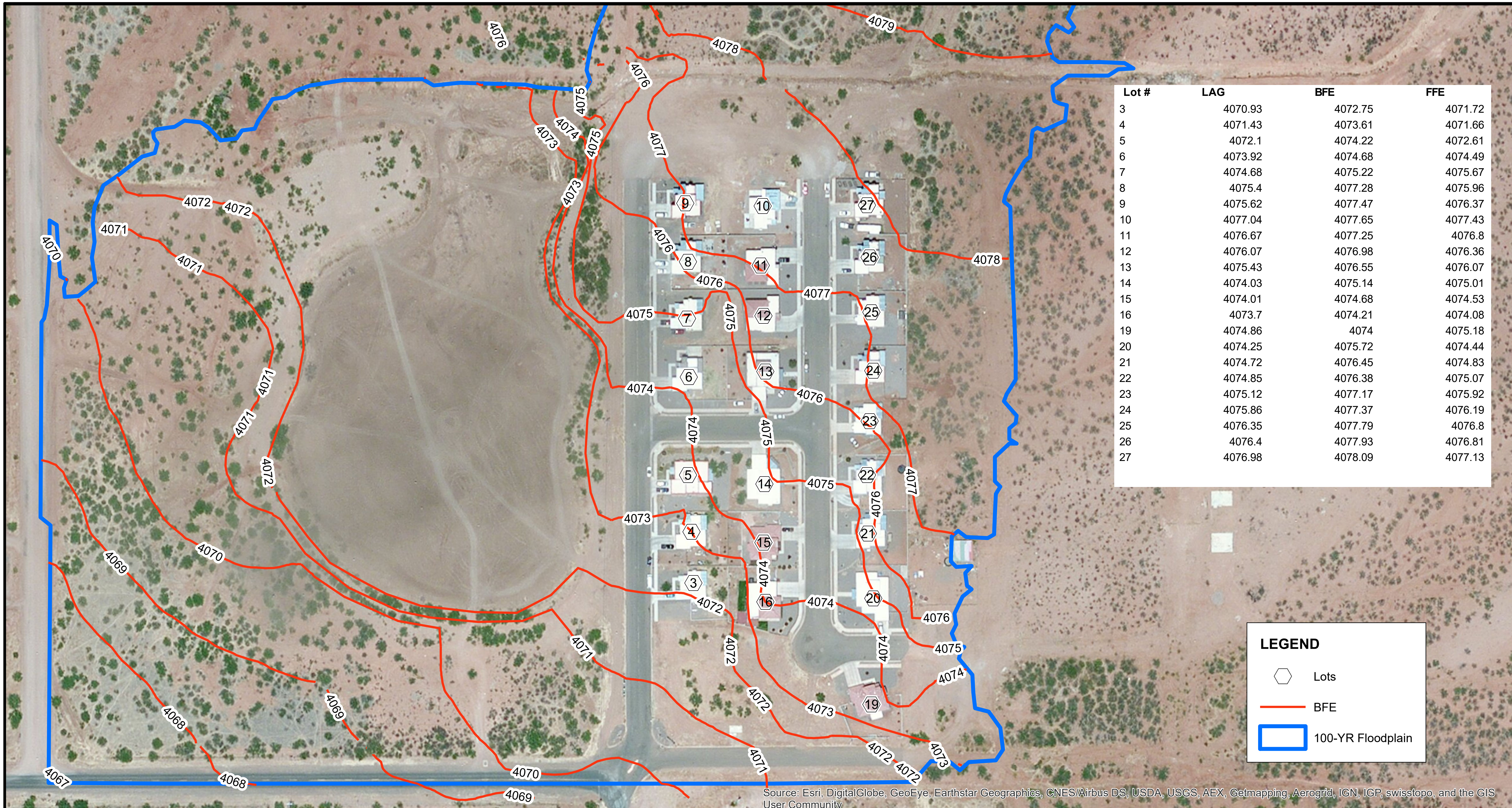
N

150 75 0 150 Feet

CMG DRAINAGE ENGINEERING, INC.
3555 N MOUNTAIN AVE., TUCSON, ARIZONA 85719
PHONE: (520) 882-4244, FAX: (520) 888-1421

PROJECT NO.:	17-029
DESIGN:	SJA
CHECKED:	SJA
DRAWN:	BJK
DATE:	07/06/2017

FIGURE C-5:
MAX FLOW DEPTHS
(100-Year)



Lot #	LAG	BFE	FFE
3	4070.93	4072.75	4071.72
4	4071.43	4073.61	4071.66
5	4072.1	4074.22	4072.61
6	4073.92	4074.68	4074.49
7	4074.68	4075.22	4075.67
8	4075.4	4077.28	4075.96
9	4075.62	4077.47	4076.37
10	4077.04	4077.65	4077.43
11	4076.67	4077.25	4076.8
12	4076.07	4076.98	4076.36
13	4075.43	4076.55	4076.07
14	4074.03	4075.14	4075.01
15	4074.01	4074.68	4074.53
16	4073.7	4074.21	4074.08
19	4074.86	4074	4075.18
20	4074.25	4075.72	4074.44
21	4074.72	4076.45	4074.83
22	4074.85	4076.38	4075.07
23	4075.12	4077.17	4075.92
24	4075.86	4077.37	4076.19
25	4076.35	4077.79	4076.8
26	4076.4	4077.93	4076.81
27	4076.98	4078.09	4077.13

CMG DRAINAGE ENGINEERING, INC.
3555 N MOUNTAIN AVE., TUCSON, ARIZONA 85719
PHONE: (520) 882-4244, FAX: (520) 888-1421

PROJECT NO.:	17-029
DESIGN:	SJA
CHECKED:	SJA
DRAWN:	BJK
DATE:	07/06/2017

FIGURE C-6:
BFE MAP (100-Year)

APPENDIX D

ELECTRONIC FILES ON COMPACT DISC

HEC-RAS Model –

File name: wash1_17029.prj