PRELIMINARY DRAINAGE REPORT

El Mirage Facility Expansion

San Bernardino County, California

PREPARED FOR

General Atomics
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1 INTRODUCTION

1.1 PROJECT BACKGROUND

Kimley-Horn was retained by General Atomics Aeronautics to conduct a hydrologic analysis for the proposed El Mirage Facility Expansion, located in unincorporated San Bernardino County (SBC), California (Figure 1). The site is located just outside the El Mirage dry lake bed (Figure 2). The existing airport area is approximately 644 acres, and the expansion facility spans an additional 42 acres. The site is at the toe of an alluvial fan supplied by Sheep Creek in the San Gabriel Mountains (Figure 3).

The purpose of this report is to provide the results of the on-site and off-site drainage analysis to evaluate the potential impacts to the site, and provide recommendations, as necessary, associated with storm water runoff for the 100-year design storm event.

1.2 SITE DESCRIPTION

The site is located in an undeveloped area of California, located approximately 24 miles north of Mount San Antonio, 16.5 miles west of Victorville, at Latitude 34°37'23" N and Longitude 117°35'24" W. The site resides within an unincorporated area of San Bernardino County. The proposed expansion facility spans approximately 42 acres, located in Section 11 of Township 6N, Range 7W. The site resides near the El Mirage Lake Bed, and is generally flat.

The entire site lies within a Federal Emergency Management Agency (FEMA) Special Hazard Flood Zone D as depicted on Flood Insurance Rate Map (FIRM) panel 06071C5775H (Appendix D). FEMA Flood Zone D is defined as areas with possible but undetermined flood hazards; therefore, a FEMA flood analysis has not been conducted for the project area.

2 HYDROLOGY

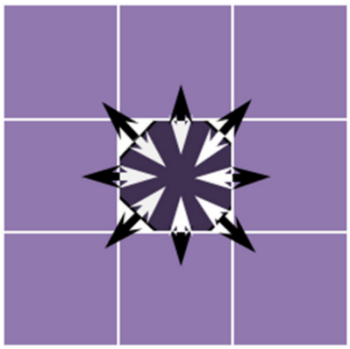
2.1 OFF-SITE DRAINAGE AREA

2.1.1 METHODOLOGY

As illustrated in Figure 1 and 3, the project is located just outside the El Mirage dry lake bed, within the Sheep Creek alluvial fan floodplain. An alluvial fan is a triangle-shaped deposit of alluvium, which consists of gravel, sand, and smaller materials deposited by flowing water. Flooding occurring on the surface of an alluvial fan or similar landform are characterized by high-velocity flows, erosion, active sediment transport, and unpredictable flow paths. Due to the lack of the defined channels, unpredictable flow paths, and relatively flat plain, a two-dimensional hydrologic model was created to complete the off-site hydrology.

The hydrology for off-site areas were modeled using FLO-2D Pro (FLO-2D Software, Inc). FLO-2D is a finite difference, finite element model using uniform square grid elements. FLO-2D is essentially a finite volume model that tracks the volume distribution to represent the floodwave movement. USGS Digital Elevation Model (DEM) topography data and the Grid Developer System (GDS) was used to create a gridded network of the floodplain, streets, and other obstruction data, as well as interpolate ground elevation values for each grid. The DEM consists of a 1/3 arc second ASCII Grid format with 10-meter grid spacing. The model computes the discharge flux and velocity

in eight (8) directions for each cell; the model was comprised of 100-ft x 100-ft grid elements (146,178 total grid elements). An illustration of the FLO-2D grid is shown below.



FLO-2D Grid Elements

The FLO-2D model computational limits are shown on Figure 1. The model includes the alluvial fan portion of Sheep Creek, as well as the tributary watershed within the San Gabriel Mountains. The model extents within the alluvial fan were drawn such that all areas of the alluvial fan that could potentially contribute run-off towards the project site were included. Review of aerial photos and topographic data showed that not all areas within the fan will concentrate onto the site. The FLO-2D model will allow runoff to leave the model computational domain if existing topography dictates that the runoff will flow away from the site.

FLO-2D calculates runoff for each grid element, based on a given rainfall depth and rainfall distribution. The flow direction, depth, and velocity are based on several factors, including topography, surface roughness (Manning's "n"), and infiltration characteristics (SCS Runoff Curve Numbers). There were a few key features within the watershed that influence the floodplain limits. These features included Sheep Creek Bridge (Bridge No. 54-0810) and concrete dikes at State Route 138 (SR 138), and the California Aqueduct passing east-west through the center of the model boundary extents.

The dikes at SR 138 were modeled in FLO-2D as levees. The dikes and bridge concentrated flood flows along the west side of the alluvial fan. The bridge and dikes are located near the apex of the fan, and as a result flooding within the fan no longer has an unpredictable nature. This can be seen in our flood analysis (Figure 7), as well as in a visual inspection of the geology as defined by color variance in soil along the concentrated flow path. As a result, runoff from the mountain watershed will circumvent the proposed expansion facility, resulting in lower flows than might otherwise exist.

The California Aqueduct passing east to west across our watershed was not modelled in our analysis. Our model assumes any flows within the alluvial fan will pass through the aqueduct without interception, resulting in more conservative flood depths.

2.1.2 RAINFALL

The off-site hydrologic analysis was conducted for the 100-year, 24-hour design storm event. Rainfall depths for the design storm were obtained using NOAA Atlas 14 grids within ArcGIS. Rainfall depths were applied through the FLO-2D model across the watershed to each FLO-2D

grid element, on a spatially variable basis. Rainfall depths varied from approximately 3.4-inches within the flat plains to 16.2-inches within the mountain range. The use of NOAA Atlas 14 rainfall was in accordance with the 2010 *County of San Bernardino Hydrology Addendum for Arid Regions* (SBCDPW, April 2010). The off-site hydrology analysis was summarized in Appendix A. Supporting hydrologic data is provided in Appendix D.

2.1.3 EXISTING CONDITIONS AND MODEL LOSSES

Watershed losses were calculated using the SCS Runoff Curve Number (CN) method per San Bernardino County curve number values. Soils data was obtained from the NRCS Web Soil Survey to assign hydrologic soil groupings (Figure 4) in accordance with the 2010 Hydrology Manual Addendum. Where soil data was incomplete or missing, a conservative Hydrologic Soil group of "D" was assigned. Runoff curve numbers were determined using the San Bernardino County Hydrology Manual. Curve numbers were scaled up from values in Hydrology Manual Figure C-3 from Antecedent Moisture Condition (AMC) of II to AMC III. This assumption accounts for the potential loss of infiltration capacity within the alluvial fan due to the large storm event. The AMC map from the 2010 Addendum shows the watershed is within areas of AMC I, II, and III; however, only AMC III values were used for the current study. Curve numbers across the watershed are depicted on Figure 6.

Surface roughness is based on Manning's "n" values. Manning's "n" values were determined based on land cover data (Figure 5) from National Land Cover Database (NLCD), using Manning's "n" tables from "Open-Channel Hydraulics" (Chow, 1959).

2.2 ON-SITE DRAINAGE AREA

2.2.1 METHODOLOGY

A Rational Method analysis in accordance with the San Bernardino County Hydrology Manual was completed to calculate the peak discharges for both the existing condition and project conditions for the expansion area. Development types were chosen based on the corresponding recommended impervious values from Hydrology Manual Figure C-4. In addition, hydrologic soil type A and AMC of III was used to calculate the 100-year peak flow. The Advance Engineering Software (AES) Hydrosoft package was used to complete the rational method analysis.

2.2.2 RAINFALL

The local climate is characterized as a desert climate. Although annual rainfall is typically quite low, there is a precedent for flash flooding in the area. The National Oceanic and Atmospheric Association (NOAA) Atlas 14 database was used to find the 100-year 1-hour storm, which had a depth of 0.74 inches.

2.2.3 EXISTING CONDITIONS

On-site drainage areas were delineated using existing available topographic mapping and aerial images. Soil types were determined using the United States Department of Agriculture (USDA) Web Soil Survey. The project site consists of soil type A, which have low runoff potential. Type A soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well-drained sands or gravels. These soils have a high rate of water transmission.

The natural cover was determined to be narrowleaf chaparral in fair condition, meaning that 50-75% of the ground surface is protected by vegetation. The determination of vegetation coverage was made using satellite imagery.

2.2.4 PROJECT CONDITIONS

The project site will be developed to include new support buildings, hangar buildings, asphalt roads, and parking lots. In general, the site grading divided the site into two major subareas. The west subarea (Area A) drains overland directed to a drainage ditch. The ditch directs water to a headwall and a single (1) 24-inch HDPE pipe that conveys flows under the existing taxiway and to a 500-ft x 100-ft (180,500-cf) detention basin. Out flow from the basin is via an overland ditch towards the east, into a head wall, and then through a single 24-inch HDPE pipe that conveys flows under a proposed roadway to the east sub area. The east subarea (Area B) drains toward a proposed trapezoidal perimeter earthen ditch, which has been designed to intercept off-site flows. The combined peak flows from the east subarea and attenuated peak flows from the detention basin have been designed to not exceed existing conditions.

3 HYDRAULICS

3.1 OPEN CHANNEL AND DETENTION BASIN HYDRAULIC ANALYSIS

Hydraulic calculations for the perimeter ditch was completed using Manning's equation. The preliminary hydraulic results showed that a 10-ft (bottom width) x 2.6 ft (depth) trapezoidal channel would be able to convey the 100-year offsite peak flow.

Routing analysis results for the detention basin showed that the maximum storage during the 100-year storm event was 4.1 acre-feet, and peak outflow of 3.67 cfs. The basin routing analysis was completed with Bentley PondPack, which uses the Modified-Puls method for flow-through basin analysis in accordance with the SBC Hydrology Manual. The San Bernardino County Small Area Unit Hydrograph Method was used to develop the unit hydrograph for Area A.

The conditions of approval required the detention of the 100-year storm. The existing conditions Rational Method analysis results showed a peak flow of 32.19 cfs. The peak flow for project conditions A and B was 28.09 cfs and 27.86 cfs, respectively. The peak flow for Area A was reduced to 3.67 cfs after detention basin routing, so the total peak flow from the site for project conditions was 31.53 cfs (3.67 cfs + 27.86 cfs).

4 RESULTS AND DISCUSSION OF POTENTIAL IMPACTS

The inundation area, for the 100-year, 24-hour events are summarized in Figures 7 and 8 in Appendix A. The 100-year flow depths through the project site range between approximately 0.16-ft and 2.0-ft. Total flow entering the site is summarized by cross-sections on Figure 11. Maximum expected runoff onto the expansion site is 87 cfs. A trapezoidal channel is recommended to divert off-site flows around the perimeter of the project site.

Velocities on-site are not expected to exceed 1.0 ft/s with regards to flows entering the site from our off-site analysis (Figure 9). Due to hydrologic conditions upstream caused by the Sheep Creek Dike, much of the flow from the creek, will be diverted west and then around our site. In addition, the high infiltration capacity of the Type A soil (Figure 4) within the alluvial fan should be expected to reduce runoff potential. It is therefore expected and reasonable that our on-site analysis shows relatively low flood inundation levels of a couple inches (Figure 8) throughout the site and velocities below 1.0-ft/s (Figure 9). Building finished floor elevations should be set at the 100-year water surface elevation.

A Rational Method Analysis was completed for the on-site existing and project conditions. Initial results showed that a detention basin would be required to reduce project conditions peak flows (55.95 cfs) to existing conditions (32.19 cfs). A detention basis was sized to reduce the peak outflow for project conditions to 31.53 cfs.

5 REFERENCES

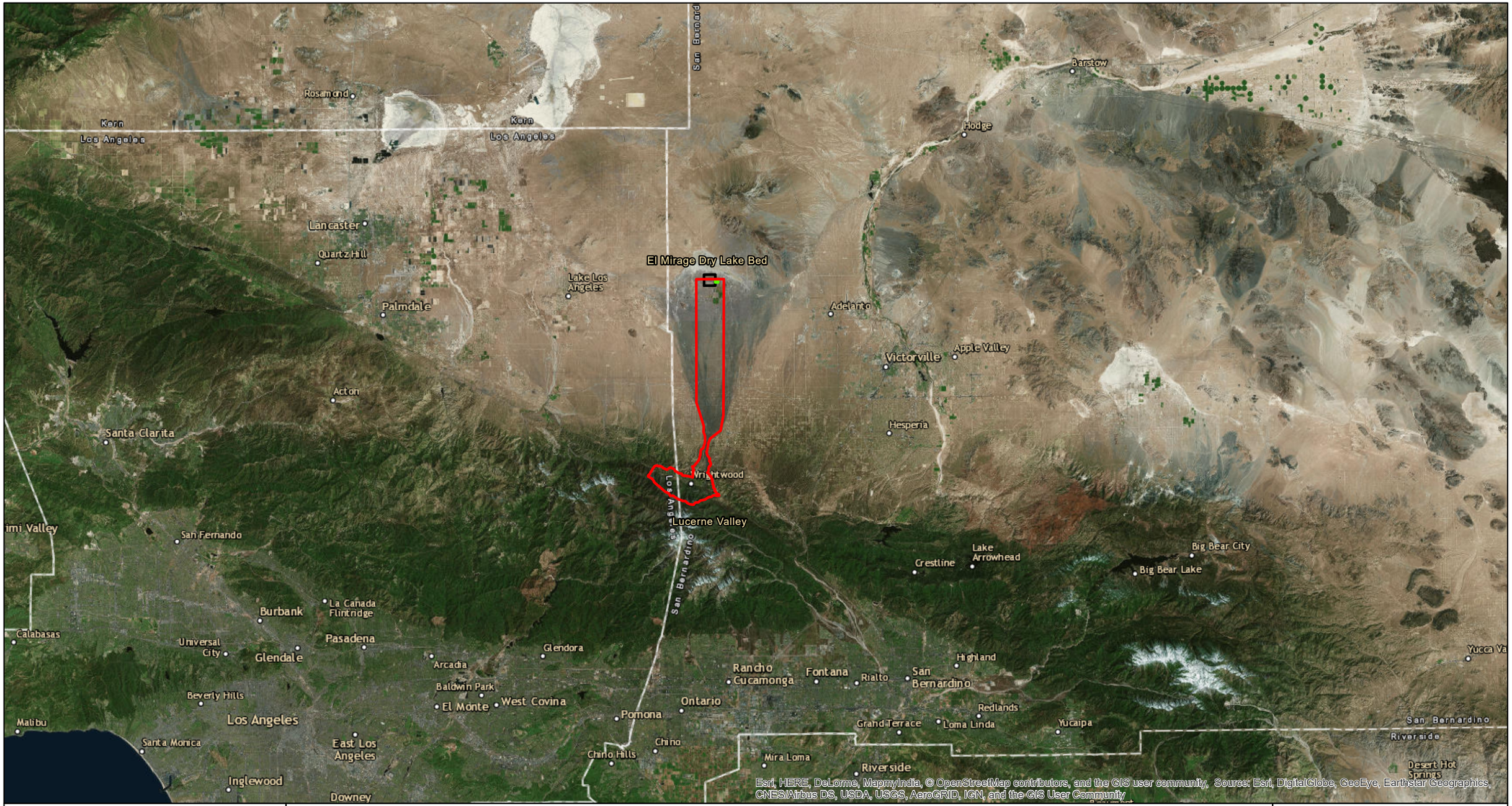
1. U.S. Department of Agriculture, Urban Hydrology for Small Watersheds, TR-55. June 1986.

2. San Bernardino County Department of Public Works (SBCDPW), *Hydrology Manual* , August, 1986.

3. San Bernardino County Department of Public Works (SBCDPW), *County of San Bernardino Hydrology Addendum for Arid Regions*, April, 2010.

4. Chow, V. T. (1959). *Open-Channel Hydraulics.* New York: McGraw-Hill.

Appendix A – Off-Site Hydrology Analysis



0 2.5 5 10 15 20 Miles

N

Kimley»Horn

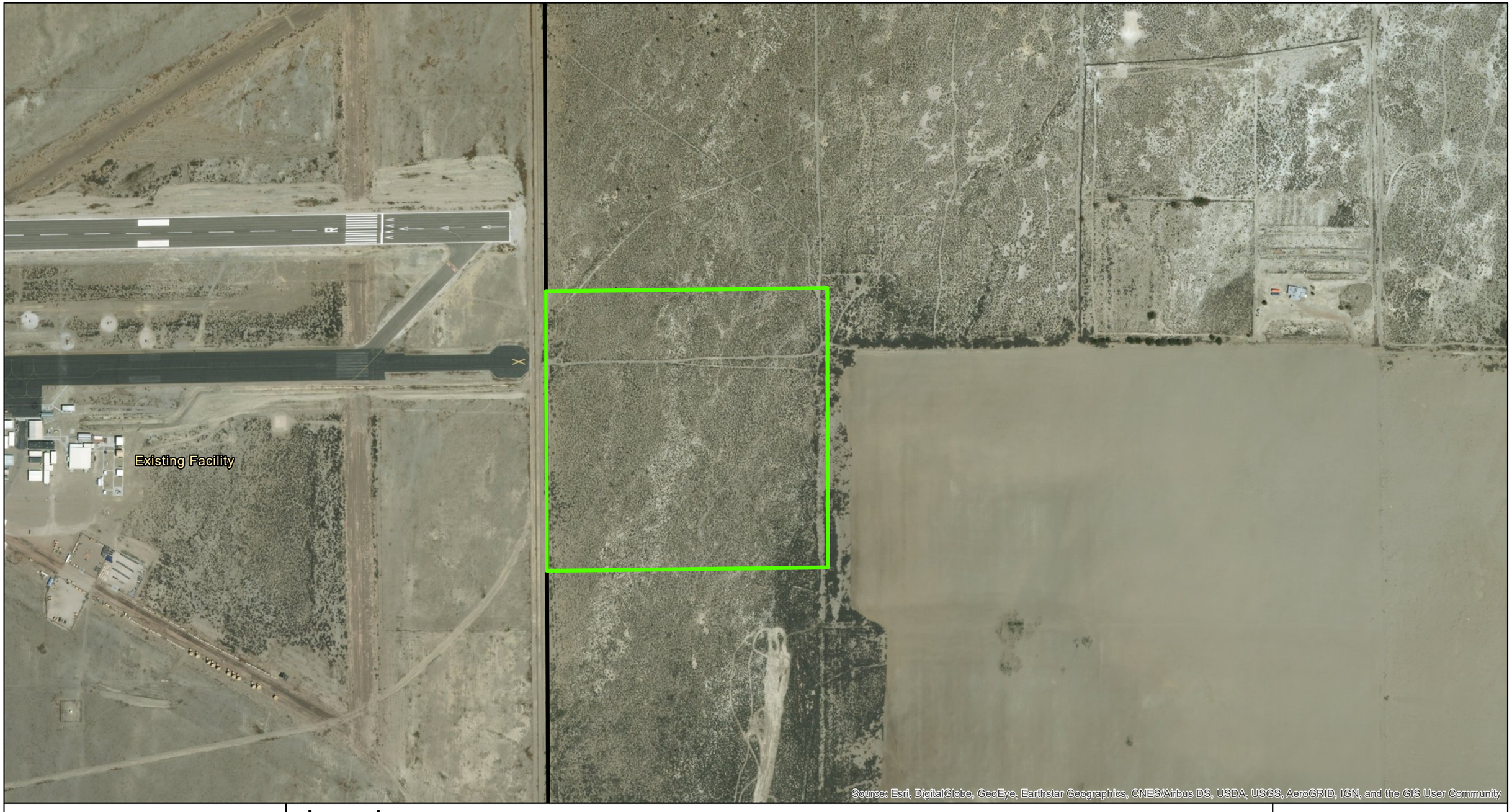
Legend

- FLO-2D Model Boundary
- Site Expansion Area
- Site Existing Area

Figure 1

El Mirage Facility Expansion Location Map

San Bernardino County, California



0 290 580 870 1,160 Feet

N

Kimley»Horn

Legend

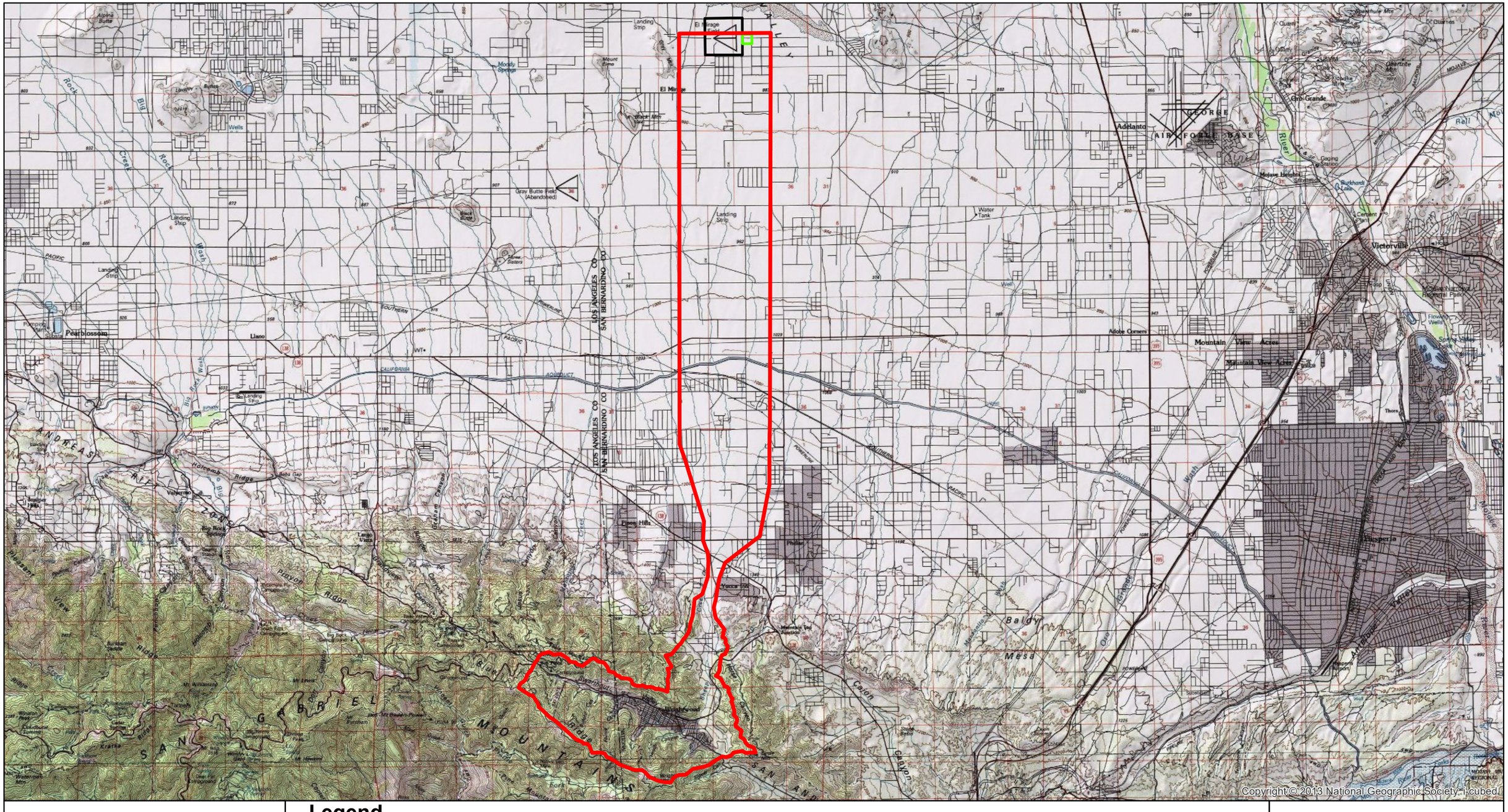
Site Expansion Area

Site Existing Area

Figure 2

El Mirage Facility Expansion Site Map

San Bernardino County, California



0 0.75 1.5 3 4.5 6 Miles

N

Kimley»Horn

Legend

- FLO-2D Model Boundary
- Site Expansion Area
- Site Existing Area

Figure 3

El Mirage Facility Expansion
Topographic Map
San Bernardino County, California

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Source: NRCS Web Soil Survey

0 0.751.5 3 4.5 6 Miles

N

Kimley»Horn

Legend

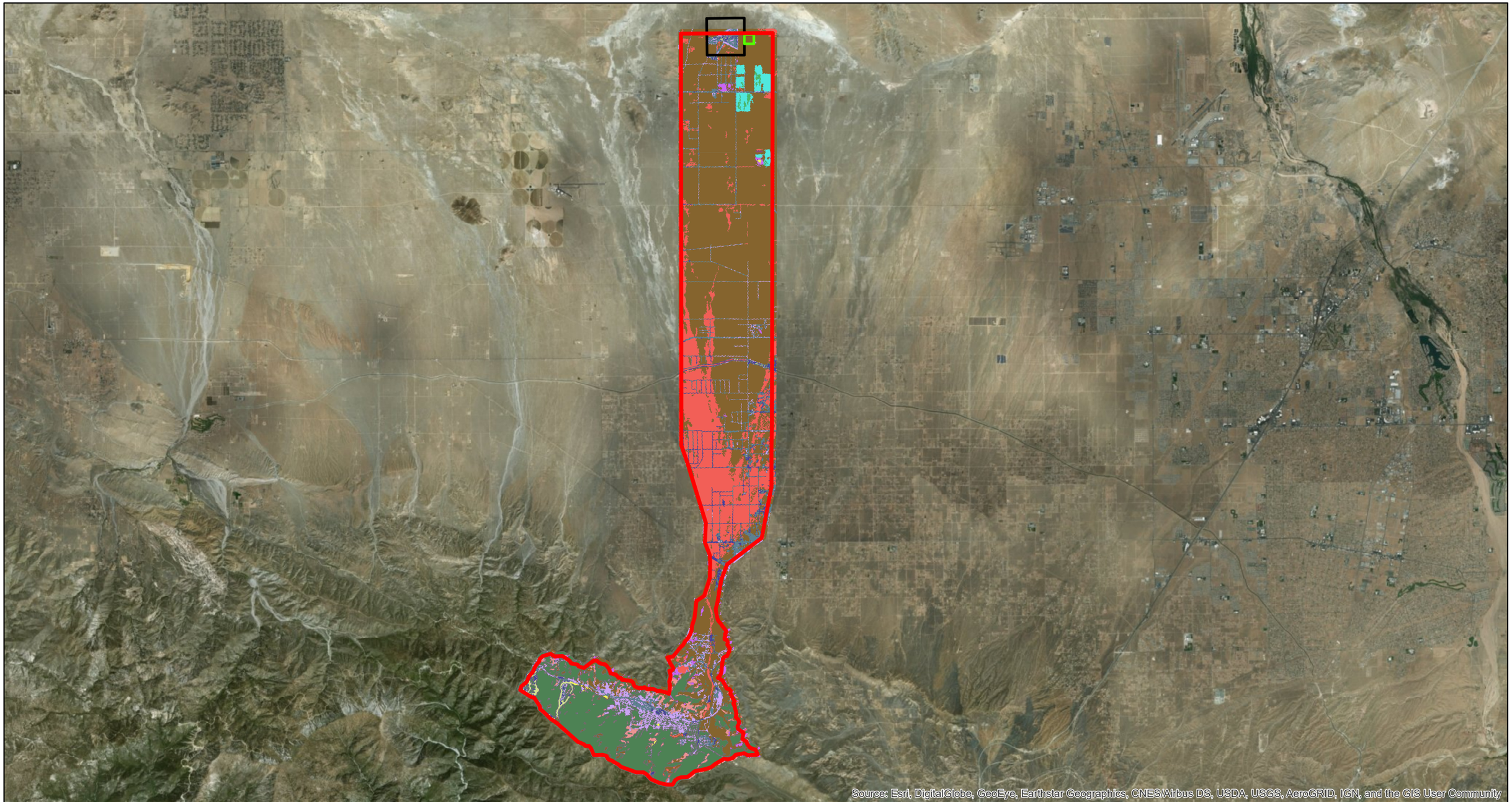
- FLO-2D Model Boundary
- Site Expansion Area
- Site Existing Area

Hydrologic Soil Group

- A
- B
- C
- D

Figure 4

El Mirage Facility Expansion
Hydrologic Soil Group
San Bernardino County, California



Source: National Land Cover Database (NLCD)

0 0.75 1.5 3 4.5 6 Miles

N

Kimley»Horn

Legend

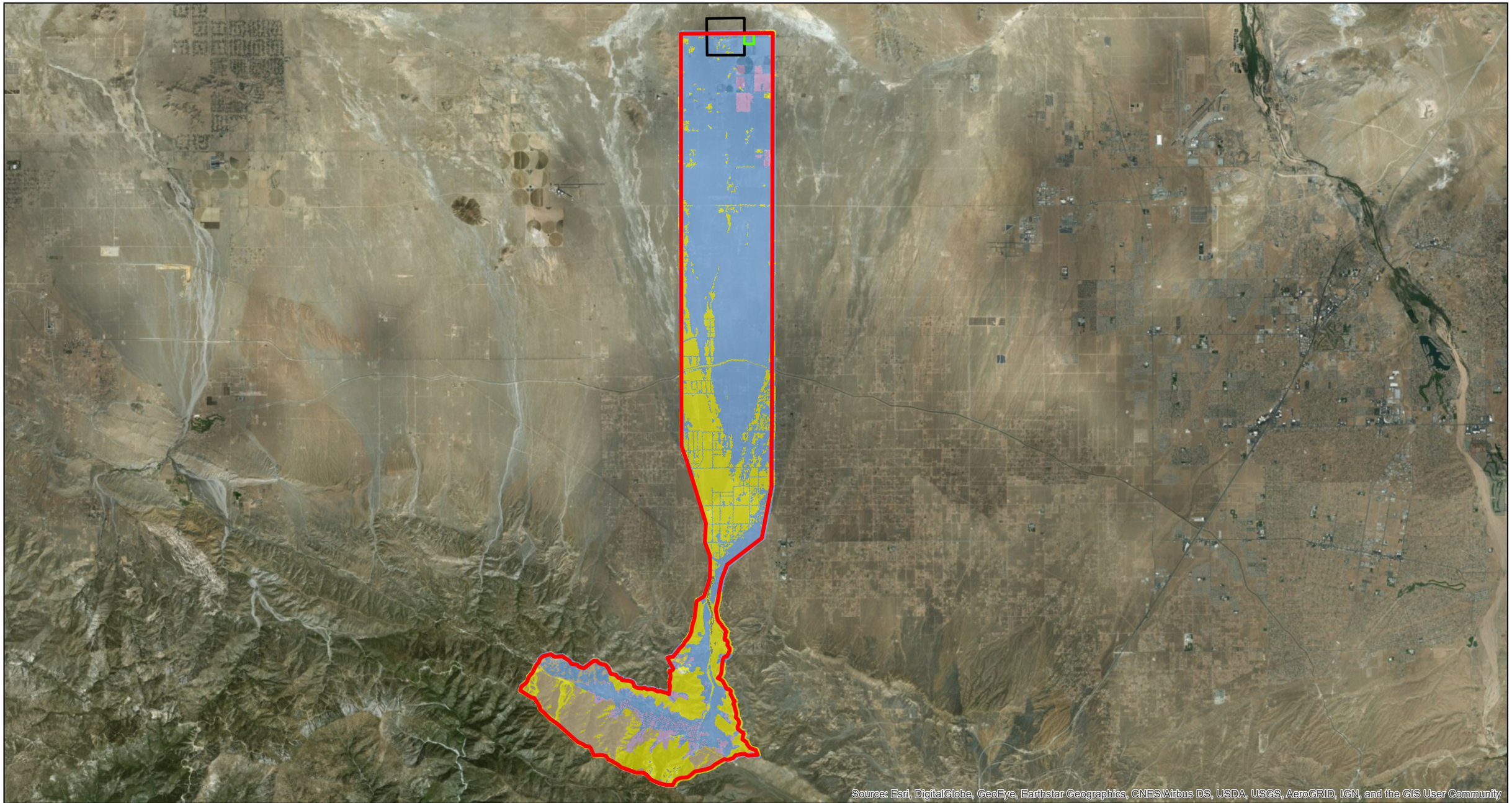
- FLO-2D Model Boundary
- Site Expansion Area
- Site Existing Area

Land Cover Type

- Barren Land
- Cultivated Crops
- Developed, High Intensity
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, Open Space
- Evergreen Forest
- Grassland / Herbaceous
- Mixed Forest
- Open Water
- Pasture / Hay
- Shrub / Scrub
- Woody Wetlands

Figure 5

El Mirage Facility Expansion
Land Cover Map
San Bernardino County, California



Source:NRCS Web Soil Survey, SBC Hydrology Manual

0 0.751.5 3 4.5 6 Miles

N

Kimley»Horn

Legend

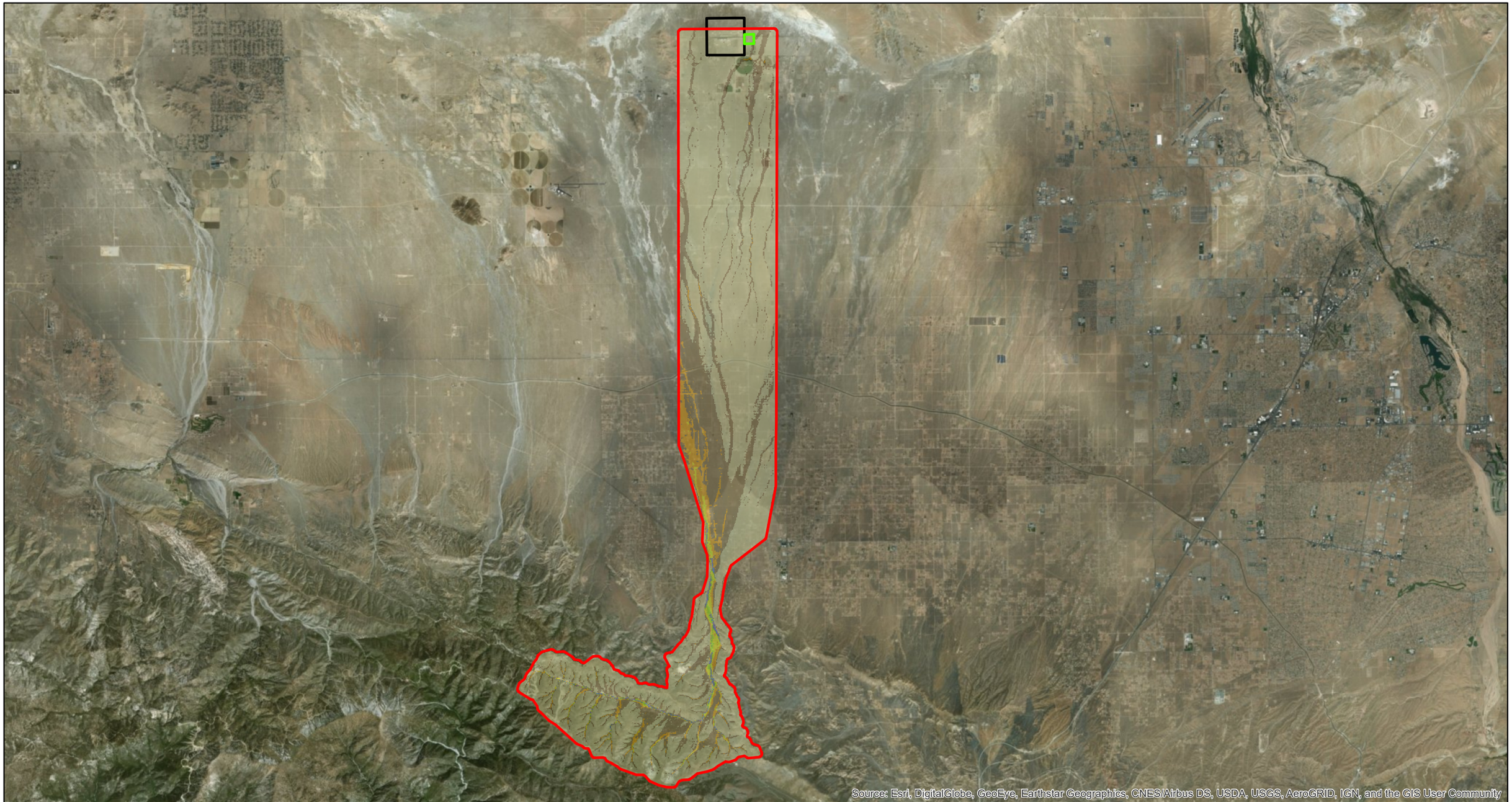
- FLO-2D Model Boundary
- Site Expansion Area
- Site Existing Area

Curve Number

- 36 - 50
- 51 - 65
- 66 - 80
- 81 - 91
- 92 - 98

Figure 6

El Mirage Facility Expansion
Curve Number Map
San Bernardino County, California



0 0.75 1.5 3 4.5 6 Miles

N

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Legend

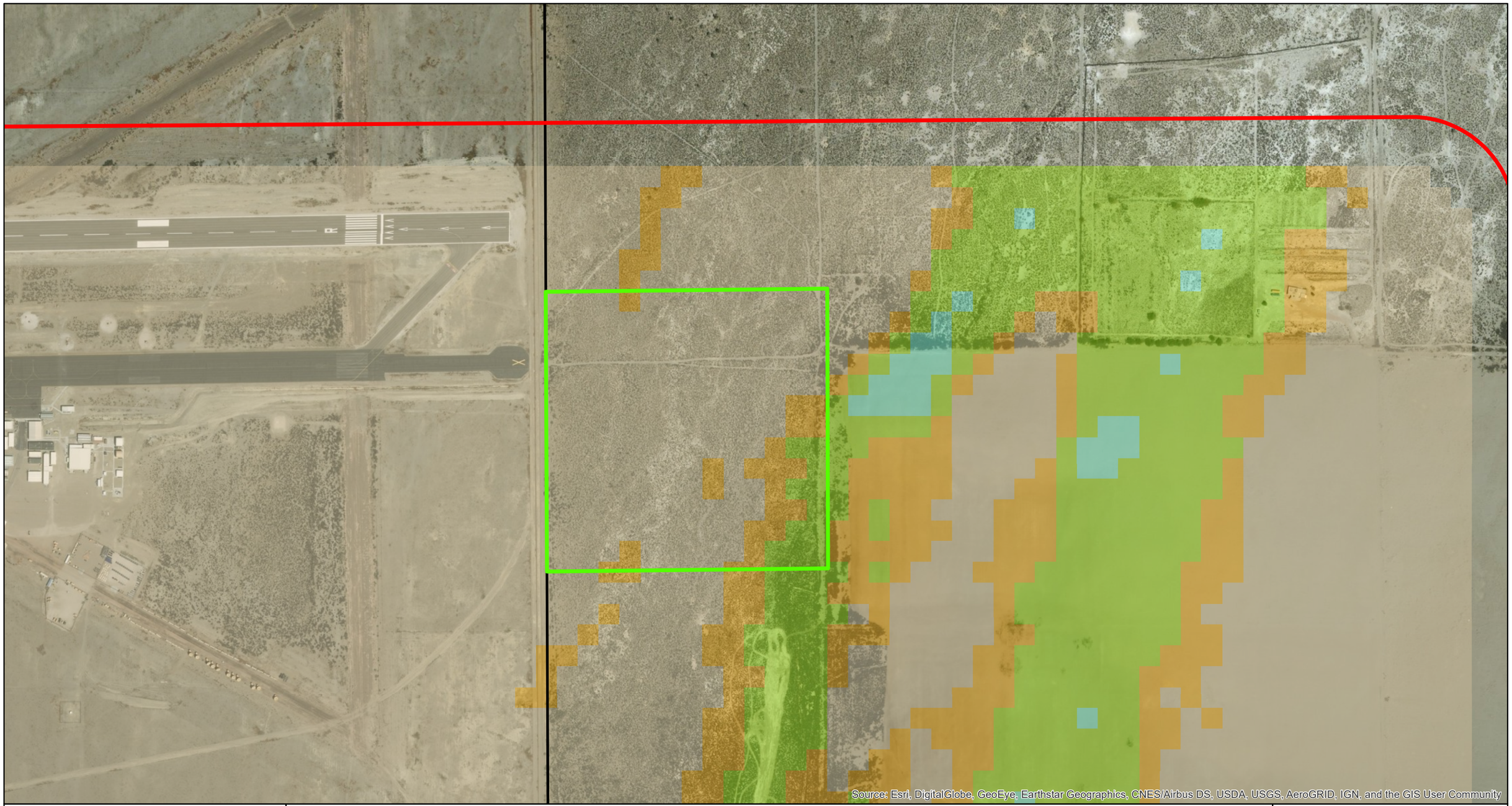
- FLO-2D Model Boundary
- Site Expansion Area
- Site Existing Area

Max Flow Depth (Ft)

- 0.0 - 0.25
- 0.25 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- 6.0 - 7.0

Figure 7

El Mirage Facility Expansion
Off-Site Max Flood Depth Map
100-Year, 24-Hour Flood
San Bernardino County, California



0 290 580 870 1,160 Feet

N

Kimley»Horn

Legend

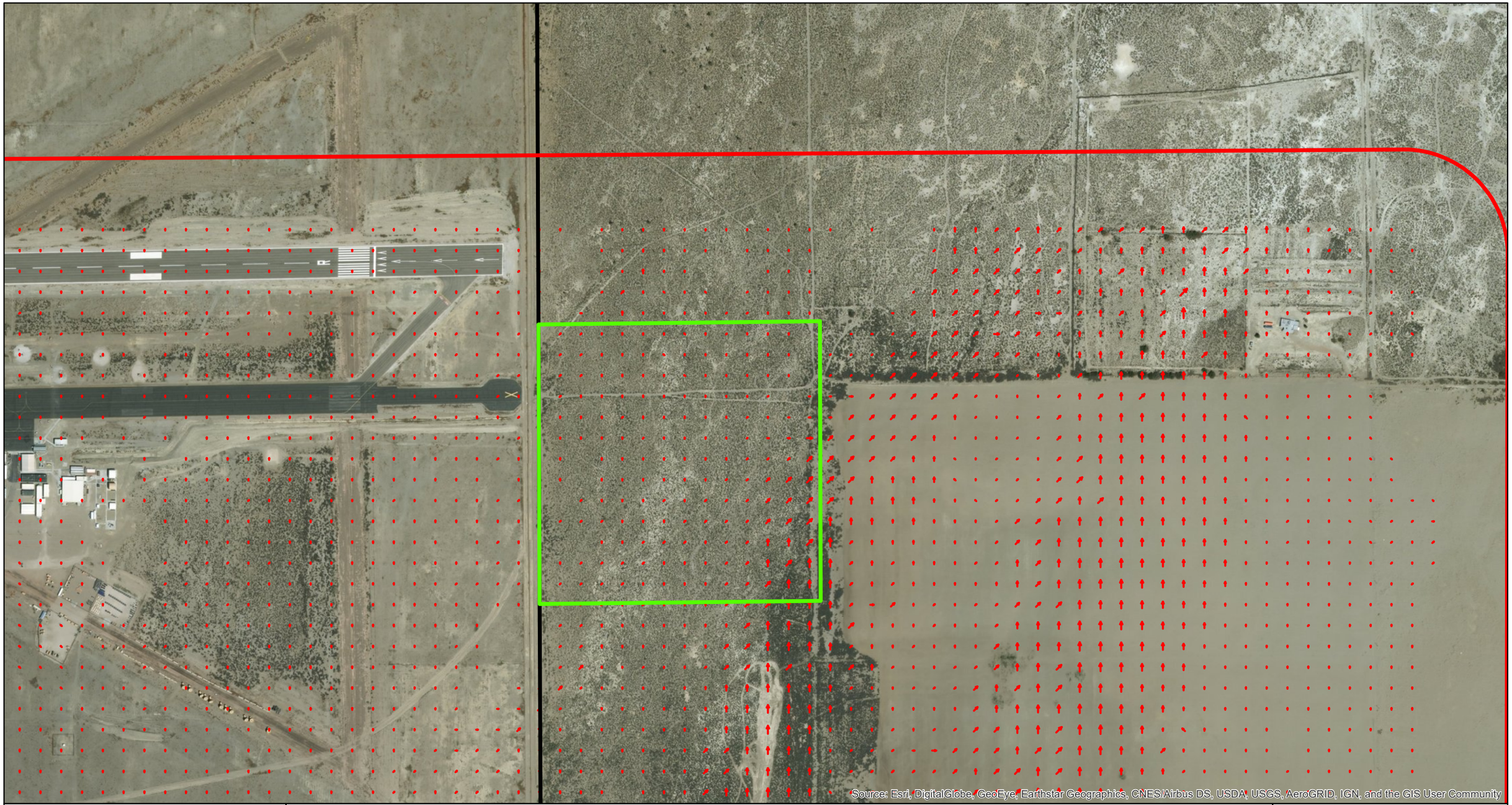
- FLO-2D Model Boundary
- Site Expansion Area
- Site Existing Area

Max Flow Depth (Ft)

- 0.0 - 0.16
- 0.16 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0

Figure 8

El Mirage Facility Expansion
On-Site Max Flood Depth Map
100-Year, 24-Hour Flood
San Bernardino County, California



0 290 580 870 1,160 Feet

N

Kimley»Horn

Legend

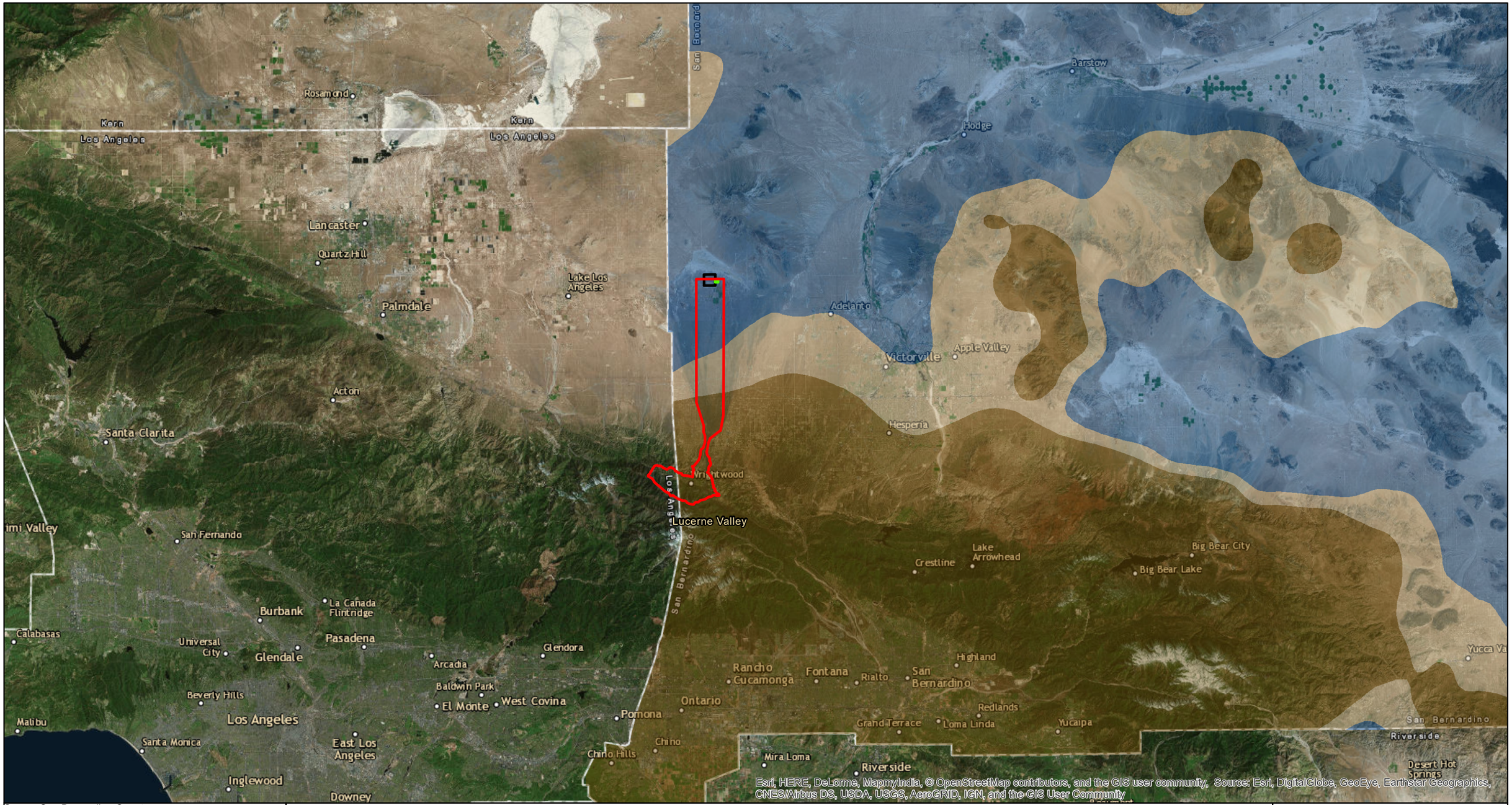
- FLO-2D Model Boundary
- Site Expansion Area
- Site Existing Area

Max Velocity (Ft/s)

- 0.0 - 1.0
- 1.0 - 2.0

Figure 9

El Mirage Facility Expansion
On-Site Max Velocity Map
100-Year, 24-Hour Flood
San Bernardino County, California



Source:San Bernardino County

0 2.5 5 10 15 20 Miles

N

Kimley»Horn

Legend

- FLO-2D Model Boundary
- Site Expansion Area
- Site Existing Area

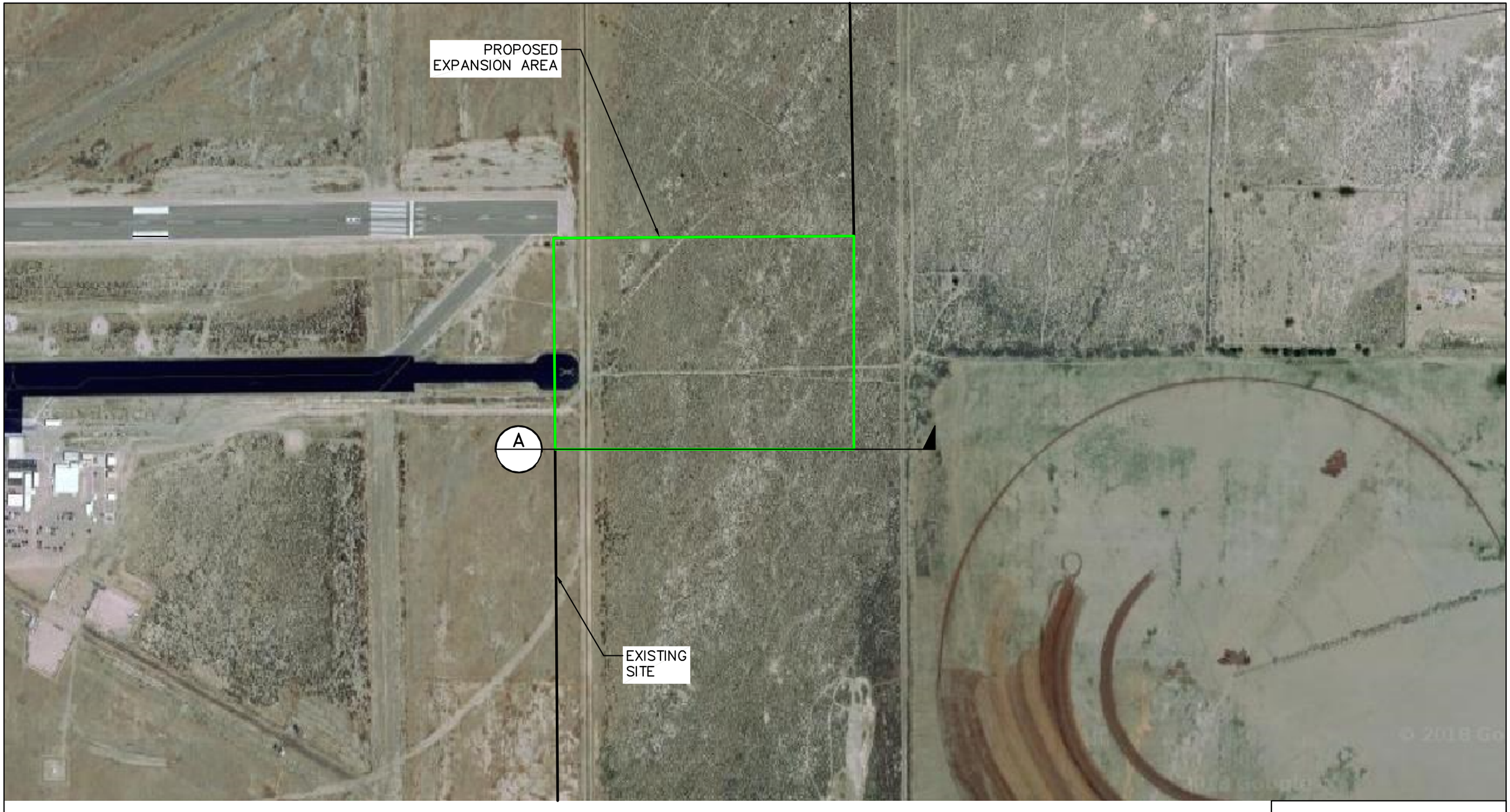
Antecedent Moisture Condition (AMC)

- 1
- 2
- 3

Figure 10

El Mirage Facility Expansion AMC Map

San Bernardino County, California



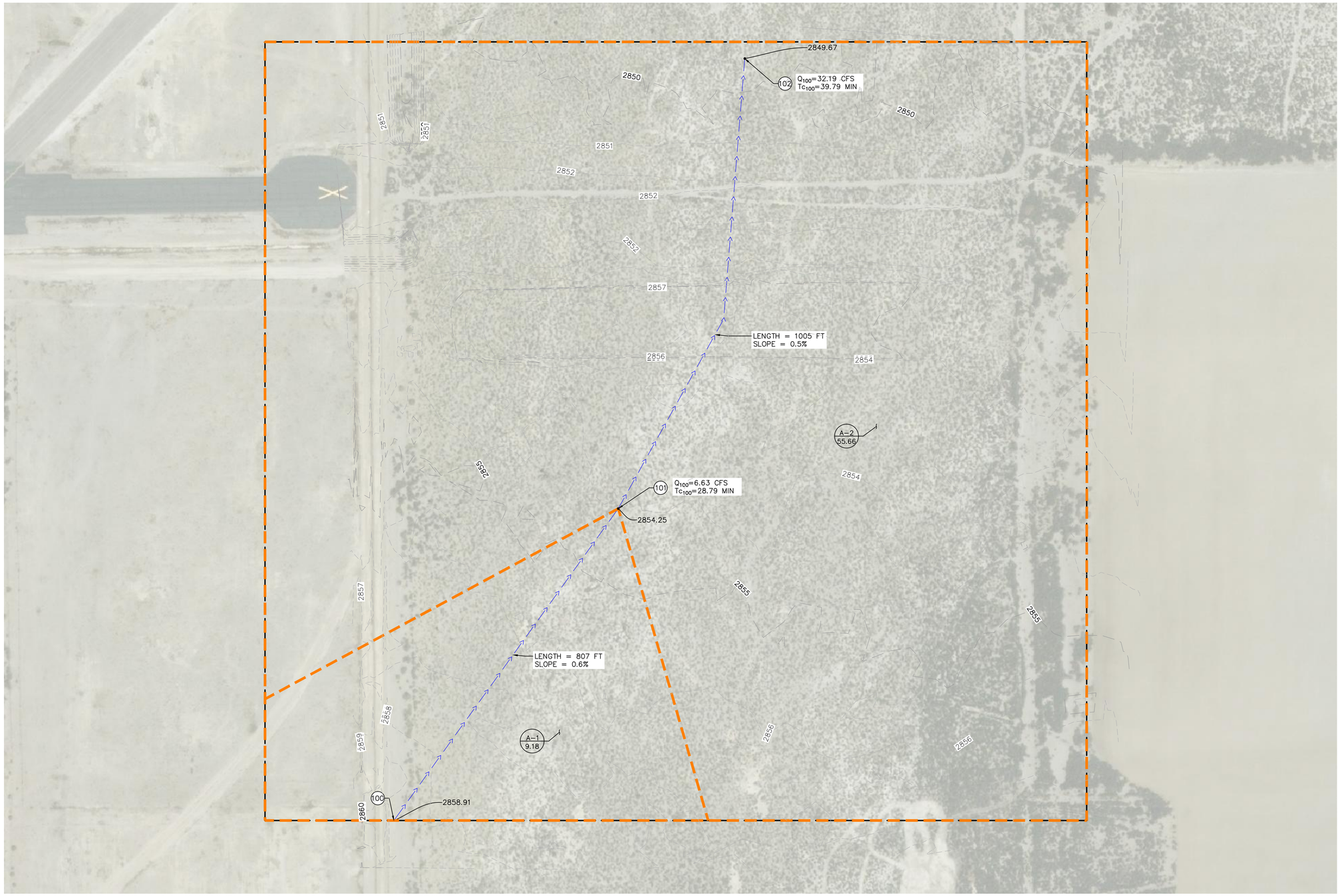
SECTION A

MAX FLOW: 87.0 CFS
TIME TO MAX: 29.2 HRS

FIGURE 11

CROSS–SECTIONS

Appendix B – On-Site Hydrology Analysis



LEGEND

- FLOW DIRECTION LINE
- SUBAREA BOUNDARY
- A-1 / 0.93 — SUBAREA ID / AREA (ACRES)
- 101 — HYDROLOGY NODE
- SURFACE FLOW DIRECTION

HYDROLOGIC SOIL TYPE: A

NORTH

GRAPHIC SCALE IN FEET
0 50 100 200
1" = 100'
WHEN PRINTED AT FULL SIZE
(24" X 36")

EL MIRAGE AIRPORT
EXISTING CONDITIONS
HYDROLOGY MAP
JUNE 2018

Kimley»Horn

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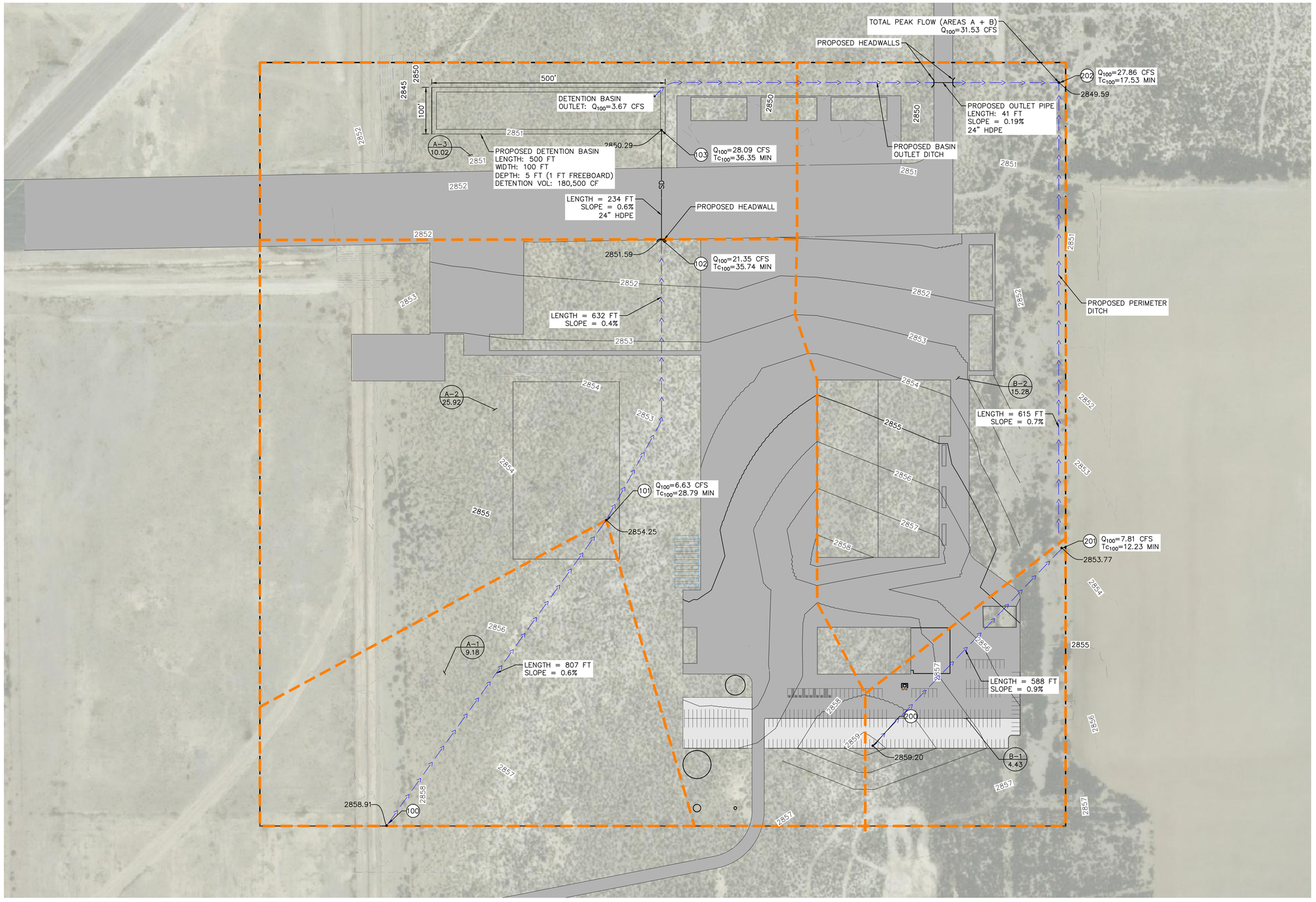
```
**************************************************************************
            RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
         (Reference: 1986 SAN BERNARDINO CO. HYDROLOGY CRITERION)
        (c) Copyright 1983-2011 Advanced Engineering Software (aes)
            Ver. 18.0  Release Date: 07/01/2011  License ID 1499

                          Analysis prepared by:

                     Kimley-Horn and Associates, Inc.
                            765 The City Drive
                                Suite 200
                             Orange, CA 92868

 ************************* DESCRIPTION OF STUDY *************************
* General Atomics                                                       *
* El Mirage Airport                                                     *
* Existing Conditions                                                   *
 ************************************************************************

  FILE NAME: GADRAIN.DAT
  TIME/DATE OF STUDY: 13:33 06/08/2018
==========================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
==========================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =   6.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.95
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.7000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 0.7400

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  ================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.00 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint =  6.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
```

```
 OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
*USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
 FLOW PROCESS FROM NODE    100.00 TO NODE    101.00 IS CODE =  21
----------------------------------------------------------------------------
 >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
 >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
 INITIAL SUBAREA FLOW-LENGTH(FEET) =   807.00
 ELEVATION DATA: UPSTREAM(FEET) =   2858.91  DOWNSTREAM(FEET) =   2854.25

 Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
 SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   28.791
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.237
 SUBAREA Tc AND LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
 NATURAL FAIR COVER
 "CHAPARRAL,NARROWLEAF"     A        9.18      0.44     1.000    75   28.79
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.44
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  1.000
 SUBAREA RUNOFF(CFS) =      6.63
 TOTAL AREA(ACRES) =      9.18   PEAK FLOW RATE(CFS) =      6.63

****************************************************************************
 FLOW PROCESS FROM NODE    101.00 TO NODE    102.00 IS CODE =  52
----------------------------------------------------------------------------
 >>>>>COMPUTE NATURAL VALLEY CHANNEL FLOW<<<<<
 >>>>>TRAVELTIME THRU SUBAREA<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =   2854.25  DOWNSTREAM(FEET) =   2849.67
 CHANNEL LENGTH THRU SUBAREA(FEET) =  1005.00   CHANNEL SLOPE =  0.0046
 CHANNEL FLOW THRU SUBAREA(CFS) =       6.63
 FLOW VELOCITY(FEET/SEC) =   1.52 (PER LACFCD/RCFC&WCD HYDROLOGY MANUAL)
 TRAVEL TIME(MIN.) =  10.99   Tc(MIN.) =   39.79
 LONGEST FLOWPATH FROM NODE    100.00 TO NODE    102.00 =    1812.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE    102.00 TO NODE    102.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
 MAINLINE Tc(MIN.) =   39.79
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  0.987
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 NATURAL FAIR COVER
```

```
  "CHAPARRAL,NARROWLEAF"     A       55.66      0.44     1.000    75
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.44
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  1.000
  SUBAREA AREA(ACRES) =   55.66      SUBAREA RUNOFF(CFS) =   27.63
  EFFECTIVE AREA(ACRES) =     64.84   AREA-AVERAGED Fm(INCH/HR) =  0.44
  AREA-AVERAGED Fp(INCH/HR) =  0.44  AREA-AVERAGED Ap =  1.00
  TOTAL AREA(ACRES) =       64.8       PEAK FLOW RATE(CFS) =      32.19
================================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       64.8  TC(MIN.) =     39.79
  EFFECTIVE AREA(ACRES) =     64.84  AREA-AVERAGED Fm(INCH/HR)=  0.44
  AREA-AVERAGED Fp(INCH/HR) =  0.44  AREA-AVERAGED Ap = 1.000
  PEAK FLOW RATE(CFS)   =      32.19
================================================================================
================================================================================
  END OF RATIONAL METHOD ANALYSIS
```



LEGEND

- FLOW DIRECTION LINE
- SUBAREA BOUNDARY
- A-1 / 0.93 — SUBAREA ID / AREA (ACRES)
- 101 — HYDROLOGY NODE
- SURFACE FLOW DIRECTION

NORTH

GRAPHIC SCALE IN FEET
0 50 100 200
1" = 100'
WHEN PRINTED AT FULL SIZE
(24" X 36")

EL MIRAGE AIRPORT
PROJECT CONDITIONS
HYDROLOGY MAP
JUNE 2018

Kimley»Horn

765 THE CITY DRIVE, SUITE 200, ORANGE, CA 92868
PHONE: 714-939-1030 FAX: 714-938-9488

```
**************************************************************************
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                          Analysis prepared by:

                     Kimley-Horn and Associates, Inc.
                            765 The City Drive
                                Suite 200
                             Orange, CA 92868

 ************************* DESCRIPTION OF STUDY *************************
* General Atomics                                                       *
* El Mirage Airport                                                     *
* Project Conditions - Area A                                           *
 *************************************************************************

  FILE NAME: GAPR-A.DAT
  TIME/DATE OF STUDY: 22:12 06/08/2018
==========================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
==========================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =   6.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.95
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.7000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 0.7400

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  ================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.00 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint =  6.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
```

```
 OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
*USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
 FLOW PROCESS FROM NODE    100.00 TO NODE    101.00 IS CODE =  21
----------------------------------------------------------------------------
 >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
 >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
 INITIAL SUBAREA FLOW-LENGTH(FEET) =   807.00
 ELEVATION DATA: UPSTREAM(FEET) =   2858.91  DOWNSTREAM(FEET) =   2854.25

 Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
 SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   28.791
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.237
 SUBAREA Tc AND LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
 NATURAL FAIR COVER
 "CHAPARRAL,NARROWLEAF"     A        9.18      0.44     1.000    75   28.79
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.44
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  1.000
 SUBAREA RUNOFF(CFS) =      6.63
 TOTAL AREA(ACRES) =      9.18   PEAK FLOW RATE(CFS) =      6.63

****************************************************************************
 FLOW PROCESS FROM NODE    101.00 TO NODE    102.00 IS CODE =  56
----------------------------------------------------------------------------
 >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
 >>>>>TRAVELTIME THRU SUBAREA<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =   2854.25  DOWNSTREAM(FEET) =   2851.59
 CHANNEL LENGTH THRU SUBAREA(FEET) =   632.00   CHANNEL SLOPE =  0.0042
 GIVEN CHANNEL BASE(FEET) =   10.00   CHANNEL FREEBOARD(FEET) =  0.0
 "Z" FACTOR =  20.000   MANNING'S FACTOR = 0.030
 *ESTIMATED CHANNEL HEIGHT(FEET) =   0.51
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.063
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 RESIDENTIAL
 "5-7 DWELLINGS/ACRE"       A       25.92      0.74     0.500    52
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.74
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.500
 TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      14.75
 TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   1.52
 AVERAGE FLOW DEPTH(FEET) =   0.49   TRAVEL TIME(MIN.) =   6.95
 Tc(MIN.) =   35.74
 SUBAREA AREA(ACRES) =    25.92       SUBAREA RUNOFF(CFS) =   16.15
```

```
  EFFECTIVE AREA(ACRES) =     35.10     AREA-AVERAGED Fm(INCH/HR) =   0.39
  AREA-AVERAGED Fp(INCH/HR) =   0.61  AREA-AVERAGED Ap =   0.63
  TOTAL AREA(ACRES) =       35.1         PEAK FLOW RATE(CFS) =      21.35
  GIVEN CHANNEL BASE(FEET) =   10.00   CHANNEL FREEBOARD(FEET) =  0.0
  "Z" FACTOR =  20.000   MANNING'S FACTOR = 0.030
  *ESTIMATED CHANNEL HEIGHT(FEET) =   0.58

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.58   FLOW VELOCITY(FEET/SEC.) =   1.68
  LONGEST FLOWPATH FROM NODE    100.00 TO NODE    102.00 =    1439.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    102.00 TO NODE    103.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  2851.59  DOWNSTREAM(FEET) =  2850.29
  FLOW LENGTH(FEET) =   234.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  27.0 INCH PIPE IS  21.0 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   6.44
  ESTIMATED PIPE DIAMETER(INCH) =  27.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      21.35
  PIPE TRAVEL TIME(MIN.) =   0.61    Tc(MIN.) =   36.35
  LONGEST FLOWPATH FROM NODE    100.00 TO NODE    103.00 =    1673.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    103.00 TO NODE    103.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   36.35
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.051
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  CONDOMINIUMS               A       10.02      0.74     0.350    52
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.74
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.350
  SUBAREA AREA(ACRES) =   10.02      SUBAREA RUNOFF(CFS) =    7.14
  EFFECTIVE AREA(ACRES) =     45.12   AREA-AVERAGED Fm(INCH/HR) =  0.36
  AREA-AVERAGED Fp(INCH/HR) =  0.63  AREA-AVERAGED Ap =  0.57
  TOTAL AREA(ACRES) =       45.1       PEAK FLOW RATE(CFS) =      28.09
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       45.1  TC(MIN.) =     36.35
  EFFECTIVE AREA(ACRES) =     45.12  AREA-AVERAGED Fm(INCH/HR)=  0.36
  AREA-AVERAGED Fp(INCH/HR) =  0.63  AREA-AVERAGED Ap = 0.568
  PEAK FLOW RATE(CFS)   =      28.09
```

==========
==========

END OF RATIONAL METHOD ANALYSIS

```
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                          Analysis prepared by:

                     Kimley-Horn and Associates, Inc.
                            765 The City Drive
                                Suite 200
                             Orange, CA 92868

 ************************* DESCRIPTION OF STUDY *************************
* General Atomics                                                       *
* El Mirage Airport                                                     *
* Project Conditions - Area B                                           *
 *************************************************************************

  FILE NAME: GAPR-B.DAT
  TIME/DATE OF STUDY: 22:44 06/08/2018
==========================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
==========================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =   6.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.95
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.7000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 0.7400

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  ================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.00 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint =  6.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
```

```
 OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
*USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
 FLOW PROCESS FROM NODE    200.00 TO NODE    201.00 IS CODE =  21
----------------------------------------------------------------------------
 >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
 >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
 INITIAL SUBAREA FLOW-LENGTH(FEET) =   588.00
 ELEVATION DATA: UPSTREAM(FEET) =   2859.20  DOWNSTREAM(FEET) =   2853.77

 Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
 SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   12.233
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.252
 SUBAREA Tc AND LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
 RESIDENTIAL
 "8-10 DWELLINGS/ACRE"      A        4.43      0.74     0.400    52   12.23
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.74
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.400
 SUBAREA RUNOFF(CFS) =      7.80
 TOTAL AREA(ACRES) =      4.43   PEAK FLOW RATE(CFS) =      7.80

****************************************************************************
 FLOW PROCESS FROM NODE    201.00 TO NODE    202.00 IS CODE =  56
----------------------------------------------------------------------------
 >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
 >>>>>TRAVELTIME THRU SUBAREA<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =   2853.77  DOWNSTREAM(FEET) =   2849.59
 CHANNEL LENGTH THRU SUBAREA(FEET) =   615.00   CHANNEL SLOPE =  0.0068
 GIVEN CHANNEL BASE(FEET) =   10.00   CHANNEL FREEBOARD(FEET) =  0.0
 "Z" FACTOR =  20.000   MANNING'S FACTOR = 0.030
 *ESTIMATED CHANNEL HEIGHT(FEET) =   0.52
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.752
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 APARTMENTS                 A       15.28      0.74     0.200    52
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.74
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.200
 TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      18.89
 TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   1.94
 AVERAGE FLOW DEPTH(FEET) =   0.49   TRAVEL TIME(MIN.) =   5.28
 Tc(MIN.) =   17.52
 SUBAREA AREA(ACRES) =    15.28       SUBAREA RUNOFF(CFS) =   22.05
 EFFECTIVE AREA(ACRES) =     19.71     AREA-AVERAGED Fm(INCH/HR) =   0.18
```

```
  AREA-AVERAGED Fp(INCH/HR) =   0.74  AREA-AVERAGED Ap =   0.24
  TOTAL AREA(ACRES) =       19.7         PEAK FLOW RATE(CFS) =      27.86
  GIVEN CHANNEL BASE(FEET) =   10.00   CHANNEL FREEBOARD(FEET) =  0.0
  "Z" FACTOR =  20.000   MANNING'S FACTOR = 0.030
  *ESTIMATED CHANNEL HEIGHT(FEET) =   0.59

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.59   FLOW VELOCITY(FEET/SEC.) =   2.15
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    202.00 =    1203.00 FEET.
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       19.7  TC(MIN.) =     17.52
  EFFECTIVE AREA(ACRES) =     19.71  AREA-AVERAGED Fm(INCH/HR)=  0.18
  AREA-AVERAGED Fp(INCH/HR) =  0.74  AREA-AVERAGED Ap = 0.245
  PEAK FLOW RATE(CFS)   =      27.86
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

Appendix C – On-Site Hydraulic Analysis

Worksheet for Perimeter Trapezoidal Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	87.00	ft^3/s

Results

Normal Depth	1.55	ft
Flow Area	22.68	ft^2
Wetted Perimeter	19.79	ft
Hydraulic Radius	1.15	ft
Top Width	19.29	ft
Critical Depth	1.17	ft
Critical Slope	0.01383	ft/ft
Velocity	3.84	ft/s
Velocity Head	0.23	ft
Specific Energy	1.78	ft
Froude Number	0.62	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.55	ft
Critical Depth	1.17	ft
Channel Slope	0.00500	ft/ft

Worksheet for Perimeter Trapezoidal Channel

GVF Output Data

Critical Slope	0.01383	ft/ft

Project Summary	
Title	General Atomics Drainage
Engineer	Jimmy Medellin, P.E.
Company	Kimley-Horn and Associates, Inc.
Date	6/8/2018

Notes	Basin routing for project conditions (Area A).

Table of Contents

Subsection: Master Network Summary

Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)
Area A	Area A 100 year	0	7.273	16.200	29.47

Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)
Perimeter Ditch	Area A 100 year	0	3.755	18.000	3.67

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
Detention Pond (IN)	Area A 100 year	0	7.233	16.200	29.47	(N/A)	(N/A)
Detention Pond (OUT)	Area A 100 year	0	3.755	18.000	3.67	2,849.29	4.138

Subsection: Read Hydrograph
Label: Area A

Peak Discharge	29.47 ft³/s
Time to Peak	16.200 hours
Hydrograph Volume	7.273 ac-ft

HYDROGRAPH ORDINATES (ft³/s)
Output Time Increment = 0.600 hours
Time on left represents time for first value in each row.

Time (hours)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)
0.000	0.00	1.64	1.67	1.72	1.74
3.000	1.80	1.83	1.90	1.93	2.01
6.000	2.05	2.15	2.20	2.31	2.38
9.000	2.52	2.61	2.80	2.91	3.17
12.000	3.33	4.03	4.29	5.03	5.77
15.000	7.72	9.30	29.47	6.54	4.62
18.000	3.78	3.03	2.70	2.45	2.26
21.000	2.10	1.97	1.86	1.77	1.69
24.000	1.62	0.00	0.00	(N/A)	(N/A)

Subsection: Addition Summary
Label: Perimeter Ditch

Summary for Hydrograph Addition at 'Perimeter Ditch'

Upstream Link	Upstream Node
Outlet-1	Detention Pond

Node Inflows

Inflow Type	Element	Volume (ac-ft)	Time to Peak (hours)	Flow (Peak) (ft^3/s)
Flow (From)	Outlet-1	3.755	18.000	3.67
Flow (In)	Perimeter Ditch	3.755	18.000	3.67

Subsection: Time vs. Elevation
Label: Detention Pond (OUT)

Time vs. Elevation (ft)

Output Time increment = 0.600 hours
Time on left represents time for first value in each row.

Time (hours)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)
0.000	2,847.50	2,847.52	2,847.55	2,847.59	2,847.63
3.000	2,847.66	2,847.70	2,847.73	2,847.77	2,847.80
6.000	2,847.84	2,847.87	2,847.91	2,847.94	2,847.98
9.000	2,848.02	2,848.05	2,848.09	2,848.12	2,848.16
12.000	2,848.20	2,848.24	2,848.29	2,848.34	2,848.41
15.000	2,848.50	2,848.62	2,848.95	2,849.24	2,849.27
18.000	2,849.29	2,849.28	2,849.26	2,849.24	2,849.22
21.000	2,849.19	2,849.16	2,849.13	2,849.09	2,849.06
24.000	2,849.02	(N/A)	(N/A)	(N/A)	(N/A)

Subsection: Time vs. Volume
Label: Detention Pond

Time vs. Volume (ac-ft)

Output Time increment = 0.600 hours
Time on left represents time for first value in each row.

Time (hours)	Volume (ac-ft)	Volume (ac-ft)	Volume (ac-ft)	Volume (ac-ft)	Volume (ac-ft)
0.000	0.000	0.039	0.116	0.193	0.269
3.000	0.345	0.420	0.495	0.570	0.646
6.000	0.722	0.799	0.877	0.956	1.038
9.000	1.119	1.198	1.277	1.357	1.439
12.000	1.524	1.622	1.736	1.864	2.018
15.000	2.225	2.497	3.303	4.016	4.111
18.000	4.138	4.125	4.085	4.032	3.968
21.000	3.897	3.821	3.739	3.654	3.567
24.000	3.477	(N/A)	(N/A)	(N/A)	(N/A)

Subsection: Elevation-Area Volume Curve
Label: Detention Pond

Elevation (ft)	Planimeter (ft²)	Area (ft²)	A1+A2+sqr (A1*A2) (ft²)	Volume (ac-ft)	Volume (Total) (ac-ft)
2,847.50	0.0	91,980.000	0.000	0.000	0.000
2,849.50	0.0	112,500.000	306,203.891	4.686	4.686

Subsection: Volume Equations
Label: Detention Pond

Pond Volume Equations

* Incremental volume computed by the Conic Method for Reservoir Volumes.

Volume = (1/3) * (EL2 - El1) * (Area1 + Area2 + sqr(Area1 * Area2))

where:	EL1, EL2	Lower and upper elevations of the increment
	Area1, Area2	Areas computed for EL1, EL2, respectively
	Volume	Incremental volume between EL1 and EL2

Subsection: Outlet Input Data
Label: Composite Outlet Structure - 1

Requested Pond Water Surface Elevations	
Minimum (Headwater)	2,847.50 ft
Increment (Headwater)	0.50 ft
Maximum (Headwater)	2,849.50 ft

Outlet Connectivity

Structure Type	Outlet ID	Direction	Outfall	E1 (ft)	E2 (ft)
Culvert-Circular	Culvert - 1	Forward	TW	2,847.50	2,849.50
Tailwater Settings	Tailwater			(N/A)	(N/A)

Subsection: Outlet Input Data
Label: Composite Outlet Structure - 1

Structure ID: Culvert - 1 Structure Type: Culvert-Circular	
Number of Barrels	1
Diameter	15.0 in
Length	784.00 ft
Length (Computed Barrel)	784.01 ft
Slope (Computed)	0.005 ft/ft

Outlet Control Data	
Manning's n	0.013
Ke	0.200
Kb	0.023
Kr	0.200
Convergence Tolerance	0.00 ft

Inlet Control Data	
Equation Form	Form 1
K	0.0045
M	2.0000
C	0.0317
Y	0.6900
T1 ratio (HW/D)	1.093
T2 ratio (HW/D)	1.195
Slope Correction Factor	-0.500

Use unsubmerged inlet control 0 equation below T1 elevation.
Use submerged inlet control 0 equation above T2 elevation

In transition zone between unsubmerged and submerged inlet control,
interpolate between flows at T1 & T2...

T1 Elevation	2,848.87 ft	T1 Flow	4.80 ft³/s
T2 Elevation	2,848.99 ft	T2 Flow	5.49 ft³/s

Subsection: Individual Outlet Curves
Label: Composite Outlet Structure - 1

RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Culvert - 1 (Culvert-Circular)

Mannings open channel maximum capacity: 4.91 ft³/s
Upstream ID = (Pond Water Surface)
Downstream ID = Tailwater (Pond Outfall)

Water Surface Elevation (ft)	Flow (ft³/s)	Tailwater Elevation (ft)	Convergence Error (ft)
2,847.50	0.00	2,846.58	0.00
2,848.00	0.80	2,846.58	0.00
2,848.50	2.84	2,846.58	0.00
2,849.00	3.48	2,846.58	0.00
2,849.50	3.82	2,846.58	0.00

Computation Messages
Upstream HW & DNstream TW < Inv.El
BACKWATER CONTROL.. Vh= .119ft hwDi= .358ft Lbw= 422.9ft Hev= .00ft
BACKWATER CONTROL.. Vh= .239ft hwDi= .714ft Lbw= 214.0ft Hev= .00ft
FULL FLOW...Lfull=784.01ft Vh=.125ft HL=2.421ft Hev= .00ft
FULL FLOW...Lfull=784.01ft Vh=.150ft HL=2.920ft Hev= .00ft

Subsection: Composite Rating Curve
Label: Composite Outlet Structure - 1

Composite Outflow Summary

Water Surface Elevation (ft)	Flow (ft^3/s)	Tailwater Elevation (ft)	Convergence Error (ft)
2,847.50	0.00	2,846.58	0.00
2,848.00	0.80	2,846.58	0.00
2,848.50	2.84	2,846.58	0.00
2,849.00	3.48	2,846.58	0.00
2,849.50	3.82	2,846.58	0.00

Contributing Structures
None Contributing
Culvert - 1
Culvert - 1
Culvert - 1
Culvert - 1

Subsection: Diverted Hydrograph
Label: Outlet-1

Peak Discharge	3.67 ft³/s
Time to Peak	18.000 hours
Hydrograph Volume	3.755 ac-ft

HYDROGRAPH ORDINATES (ft³/s)
Output Time Increment = 0.600 hours
Time on left represents time for first value in each row.

Time (hours)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)
0.000	0.00	0.03	0.09	0.15	0.20
3.000	0.26	0.31	0.37	0.43	0.48
6.000	0.54	0.59	0.65	0.71	0.77
9.000	0.86	1.01	1.15	1.30	1.44
12.000	1.60	1.77	1.98	2.20	2.47
15.000	2.84	2.99	3.41	3.64	3.66
18.000	3.67	3.67	3.66	3.64	3.63
21.000	3.61	3.59	3.56	3.54	3.52
24.000	3.49	(N/A)	(N/A)	(N/A)	(N/A)

Subsection: Elevation-Volume-Flow Table (Pond)
Label: Detention Pond

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Water Surface, Initial)	2,847.50 ft
Volume (Initial)	0.000 ac-ft
Flow (Initial Outlet)	0.00 ft³/s
Flow (Initial Infiltration)	0.00 ft³/s
Flow (Initial, Total)	0.00 ft³/s
Time Increment	0.600 hours

Elevation (ft)	Outflow (ft³/s)	Storage (ac-ft)	Area (ft²)	Infiltration (ft³/s)	Flow (Total) (ft³/s)	2S/t + O (ft³/s)
2,847.50	0.00	0.000	91,980.000	0.00	0.00	0.00
2,848.00	0.80	1.084	96,916.459	0.00	0.80	44.52
2,848.50	2.84	2.225	101,981.945	0.00	2.84	92.59
2,849.00	3.48	3.426	107,176.459	0.00	3.48	141.65
2,849.50	3.82	4.686	112,500.000	0.00	3.82	192.83

Subsection: Level Pool Pond Routing Summary
Label: Detention Pond (IN)

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Water Surface, Initial)	2,847.50 ft
Volume (Initial)	0.000 ac-ft
Flow (Initial Outlet)	0.00 ft³/s
Flow (Initial Infiltration)	0.00 ft³/s
Flow (Initial, Total)	0.00 ft³/s
Time Increment	0.600 hours

Inflow/Outflow Hydrograph Summary			
Flow (Peak In)	29.47 ft³/s	Time to Peak (Flow, In)	16.200 hours
Flow (Peak Outlet)	3.67 ft³/s	Time to Peak (Flow, Outlet)	18.000 hours

Elevation (Water Surface, Peak)	2,849.29 ft
Volume (Peak)	4.138 ac-ft

Mass Balance (ac-ft)	
Volume (Initial)	0.000 ac-ft
Volume (Total Inflow)	7.233 ac-ft
Volume (Total Infiltration)	0.000 ac-ft
Volume (Total Outlet Outflow)	3.755 ac-ft
Volume (Retained)	3.304 ac-ft
Volume (Unrouted)	-0.174 ac-ft
Error (Mass Balance)	2.4 %

Subsection: Pond Routed Hydrograph (total out)
Label: Detention Pond (OUT)

Peak Discharge	3.67 ft³/s
Time to Peak	18.000 hours
Hydrograph Volume	3.755 ac-ft

HYDROGRAPH ORDINATES (ft³/s)
Output Time Increment = 0.600 hours
Time on left represents time for first value in each row.

Time (hours)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)
0.000	0.00	0.03	0.09	0.15	0.20
3.000	0.26	0.31	0.37	0.43	0.48
6.000	0.54	0.59	0.65	0.71	0.77
9.000	0.86	1.01	1.15	1.30	1.44
12.000	1.60	1.77	1.98	2.20	2.47
15.000	2.84	2.99	3.41	3.64	3.66
18.000	3.67	3.67	3.66	3.64	3.63
21.000	3.61	3.59	3.56	3.54	3.52
24.000	3.49	(N/A)	(N/A)	(N/A)	(N/A)

Subsection: Pond Inflow Summary
Label: Detention Pond (IN)

Summary for Hydrograph Addition at 'Detention Pond'

Upstream Link	Upstream Node
<Catchment to Outflow Node>	Area A

Node Inflows

Inflow Type	Element	Volume (ac-ft)	Time to Peak (hours)	Flow (Peak) (ft^3/s)
Flow (From)	Area A	7.273	16.200	29.47
Flow (In)	Detention Pond	7.233	16.200	29.47

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Appendix D – Hydrologic Data Sources

Figure ADD-1
Antecedent Moisture Condition (AMC)

5-day Rainfall - NOAA Atlas 14
(50% of Total Rainfall Prior to Peak)*

*1/2 (11-day - 1-day) =
1/2 (([10-day] + (1/10 ([20-day] - [10-day]))) - [1-day])

5 0 5 10 15
Miles

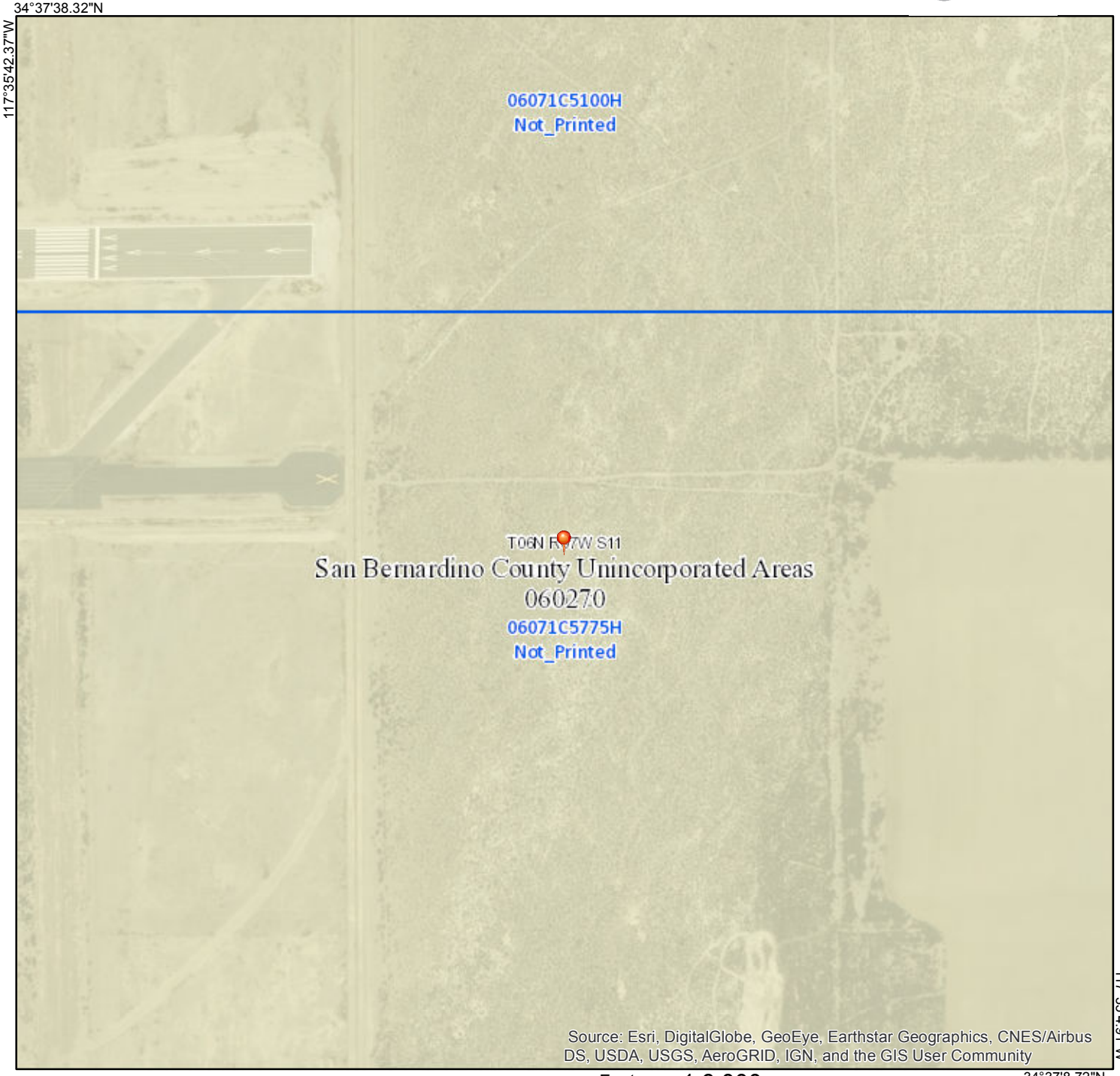
N
W E
S

Growing Season
- AMC I
- AMC II
- AMC III

Baxter Valley
Ridgecrest
STATE HWY 127
I-15
Boron
US HWY 395
Barstow
Needles
I-40
Adelanto
George AFB
George AFB
Victorville
Apple Valley
Mountain View Acres
Hesperia
STATE HWY 247
Wrightwood
Crestline
Lake Arrowhead
Big Bear City
Big Bear Lake
Running Springs
Claremont
Twentynine Palms
Yucca Valley
Joshua Tree
Morongo Valley
STATE HWY 62
Parker Dam
Blythe

National Flood Hazard Layer FIRMette

FEMA



Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth
- Regulatory Floodway *Zone AE, AO, AH, VE, AR*

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 / 17.5 Cross Sections with 1% Annual Chance / Water Surface Elevation
- Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The base map shown complies with FEMA's base map accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 5/17/2018 at 2:42:27 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: base map imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

Definitions of FEMA Flood Zone Designations

Flood zones are geographic areas that the FEMA has defined according to varying levels of flood risk. These zones are depicted on a community's Flood Insurance Rate Map (FIRM) or Flood Hazard Boundary Map. Each zone reflects the severity or type of flooding in the area.

Moderate to Low Risk Areas

In communities that participate in the NFIP, flood insurance is available to all property owners and renters in these zones:

ZONE	DESCRIPTION
B and X (shaded)	Area of moderate flood hazard, usually the area between the limits of the 100-year and 500-year floods. B Zones are also used to designate base floodplains of lesser hazards, such as areas protected by levees from 100-year flood, or shallow flooding areas with average depths of less than one foot or drainage areas less than 1 square mile.
C and X (unshaded)	Area of minimal flood hazard, usually depicted on FIRMs as above the 500-year flood level. Zone C may have ponding and local drainage problems that don't warrant a detailed study or designation as base floodplain. Zone X is the area determined to be outside the 500-year flood and protected by levee from 100-year flood.

High Risk Areas

In communities that participate in the NFIP, mandatory flood insurance purchase requirements apply to all of these zones:

ZONE	DESCRIPTION
A	Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas; no depths or base flood elevations are shown within these zones.
AE	The base floodplain where base flood elevations are provided. AE Zones are now used on new format FIRMs instead of A1-A30 Zones.
A1-30	These are known as numbered A Zones (e.g., A7 or A14). This is the base floodplain where the FIRM shows a BFE (old format).
AH	Areas with a 1% annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones.
AO	River or stream flood hazard areas, and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Average flood depths derived from detailed analyses are shown within these zones.
AR	Areas with a temporarily increased flood risk due to the building or restoration of a flood control system (such as a levee or a dam). Mandatory flood insurance purchase requirements will apply, but rates will not exceed the rates for unnumbered A zones if the structure is built or restored in compliance with Zone AR floodplain management regulations.
A99	Areas with a 1% annual chance of flooding that will be protected by a Federal flood control system where construction has reached specified legal requirements. No depths or base flood elevations are shown within these zones.

High Risk - Coastal Areas

In communities that participate in the NFIP, mandatory flood insurance purchase requirements apply to all of these zones.

ZONE	DESCRIPTION
V	Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage. No base flood elevations are shown within these zones.
VE, V1 - 30	Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones.

Undetermined Risk Areas

ZONE	DESCRIPTION
D	Areas with possible but undetermined flood hazards. No flood hazard analysis has been conducted. Flood insurance rates are commensurate with the uncertainty of the flood risk.

From FEMA Map Service Center:
http://msc.fema.gov/webapp/wcs/stores/servlet/info?storeId=10001&catalogId=10001&langId=-1&content=floodZones&title=FEMA%20Flood%20Zone%20Designations

NOAA Atlas 14, Volume 6, Version 2
Location name: Adelanto, California, USA*
Latitude: 34.6163°, Longitude: -117.6015°
Elevation: 2872.71 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.055** (0.045-0.067)	**0.075** (0.061-0.091)	**0.102** (0.084-0.125)	**0.125** (0.102-0.155)	**0.159** (0.125-0.204)	**0.186** (0.144-0.243)	**0.215** (0.162-0.288)	**0.246** (0.180-0.338)	**0.289** (0.204-0.415)	**0.325** (0.221-0.482)
10-min	**0.078** (0.065-0.096)	**0.107** (0.088-0.131)	**0.146** (0.120-0.180)	**0.180** (0.147-0.223)	**0.228** (0.180-0.292)	**0.267** (0.206-0.349)	**0.308** (0.232-0.413)	**0.352** (0.258-0.485)	**0.415** (0.292-0.595)	**0.465** (0.316-0.691)
15-min	**0.095** (0.078-0.116)	**0.129** (0.107-0.158)	**0.177** (0.145-0.217)	**0.217** (0.177-0.269)	**0.276** (0.217-0.353)	**0.323** (0.249-0.422)	**0.373** (0.281-0.499)	**0.426** (0.312-0.587)	**0.502** (0.353-0.720)	**0.563** (0.383-0.836)
30-min	**0.135** (0.111-0.165)	**0.184** (0.152-0.225)	**0.251** (0.207-0.309)	**0.309** (0.252-0.383)	**0.392** (0.309-0.502)	**0.459** (0.354-0.600)	**0.530** (0.399-0.709)	**0.606** (0.444-0.834)	**0.713** (0.502-1.02)	**0.800** (0.544-1.19)
60-min	**0.187** (0.154-0.229)	**0.255** (0.210-0.312)	**0.348** (0.286-0.428)	**0.428** (0.349-0.530)	**0.543** (0.428-0.695)	**0.635** (0.491-0.831)	**0.734** (0.553-0.983)	**0.839** (0.615-1.16)	**0.988** (0.695-1.42)	**1.11** (0.753-1.65)
2-hr	**0.270** (0.223-0.331)	**0.368** (0.303-0.450)	**0.502** (0.413-0.617)	**0.617** (0.503-0.764)	**0.781** (0.617-1.00)	**0.914** (0.706-1.20)	**1.06** (0.795-1.41)	**1.21** (0.884-1.66)	**1.42** (0.997-2.03)	**1.59** (1.08-2.36)
3-hr	**0.335** (0.277-0.410)	**0.456** (0.376-0.559)	**0.622** (0.512-0.764)	**0.764** (0.624-0.947)	**0.967** (0.763-1.24)	**1.13** (0.874-1.48)	**1.30** (0.984-1.75)	**1.49** (1.09-2.05)	**1.75** (1.23-2.51)	**1.96** (1.33-2.91)
6-hr	**0.477** (0.394-0.584)	**0.649** (0.535-0.795)	**0.885** (0.728-1.09)	**1.09** (0.886-1.35)	**1.37** (1.08-1.76)	**1.60** (1.24-2.09)	**1.84** (1.39-2.47)	**2.10** (1.54-2.90)	**2.47** (1.74-3.54)	**2.76** (1.88-4.10)
12-hr	**0.643** (0.531-0.786)	**0.880** (0.726-1.08)	**1.21** (0.991-1.48)	**1.48** (1.21-1.83)	**1.86** (1.47-2.39)	**2.17** (1.68-2.84)	**2.50** (1.88-3.34)	**2.84** (2.08-3.91)	**3.32** (2.33-4.76)	**3.70** (2.51-5.49)
24-hr	**0.882** (0.782-1.01)	**1.22** (1.08-1.40)	**1.68** (1.48-1.94)	**2.06** (1.80-2.40)	**2.59** (2.19-3.12)	**3.01** (2.50-3.70)	**3.45** (2.80-4.35)	**3.92** (3.08-5.07)	**4.56** (3.45-6.16)	**5.07** (3.70-7.09)
2-day	**1.03** (0.911-1.18)	**1.43** (1.27-1.65)	**1.97** (1.74-2.28)	**2.43** (2.13-2.83)	**3.06** (2.60-3.69)	**3.56** (2.96-4.38)	**4.08** (3.31-5.15)	**4.63** (3.65-6.00)	**5.39** (4.07-7.29)	**6.00** (4.38-8.38)
3-day	**1.10** (0.978-1.27)	**1.54** (1.37-1.78)	**2.14** (1.89-2.47)	**2.63** (2.31-3.07)	**3.32** (2.82-4.00)	**3.87** (3.21-4.76)	**4.43** (3.59-5.59)	**5.03** (3.96-6.52)	**5.86** (4.42-7.91)	**6.51** (4.75-9.10)
4-day	**1.17** (1.04-1.35)	**1.64** (1.46-1.89)	**2.28** (2.02-2.64)	**2.82** (2.47-3.28)	**3.56** (3.02-4.29)	**4.14** (3.44-5.10)	**4.75** (3.85-5.99)	**5.39** (4.25-6.99)	**6.28** (4.75-8.48)	**6.98** (5.10-9.76)
7-day	**1.27** (1.12-1.46)	**1.78** (1.58-2.06)	**2.49** (2.20-2.88)	**3.08** (2.70-3.59)	**3.91** (3.31-4.71)	**4.56** (3.78-5.61)	**5.23** (4.24-6.59)	**5.94** (4.68-7.70)	**6.92** (5.23-9.35)	**7.69** (5.61-10.8)
10-day	**1.32** (1.17-1.52)	**1.87** (1.65-2.15)	**2.62** (2.31-3.02)	**3.25** (2.84-3.78)	**4.13** (3.50-4.97)	**4.82** (4.00-5.93)	**5.54** (4.49-6.98)	**6.30** (4.96-8.16)	**7.35** (5.55-9.93)	**8.18** (5.97-11.4)
20-day	**1.53** (1.35-1.76)	**2.19** (1.94-2.52)	**3.11** (2.75-3.59)	**3.88** (3.40-4.52)	**4.98** (4.22-5.99)	**5.85** (4.85-7.19)	**6.75** (5.47-8.51)	**7.71** (6.07-9.99)	**9.03** (6.82-12.2)	**10.1** (7.35-14.1)
30-day	**1.68** (1.49-1.94)	**2.44** (2.16-2.81)	**3.48** (3.08-4.02)	**4.38** (3.83-5.10)	**5.65** (4.79-6.80)	**6.66** (5.53-8.19)	**7.71** (6.25-9.72)	**8.83** (6.95-11.4)	**10.4** (7.83-14.0)	**11.6** (8.45-16.2)
45-day	**1.97** (1.75-2.26)	**2.87** (2.54-3.30)	**4.12** (3.64-4.76)	**5.20** (4.56-6.06)	**6.75** (5.72-8.13)	**8.00** (6.64-9.84)	**9.31** (7.54-11.7)	**10.7** (8.41-13.8)	**12.6** (9.52-17.0)	**14.1** (10.3-19.7)
60-day	**2.24** (1.98-2.57)	**3.26** (2.88-3.75)	**4.69** (4.15-5.42)	**5.93** (5.20-6.91)	**7.72** (6.55-9.30)	**9.18** (7.62-11.3)	**10.7** (8.67-13.5)	**12.3** (9.71-16.0)	**14.6** (11.0-19.7)	**16.4** (12.0-22.9)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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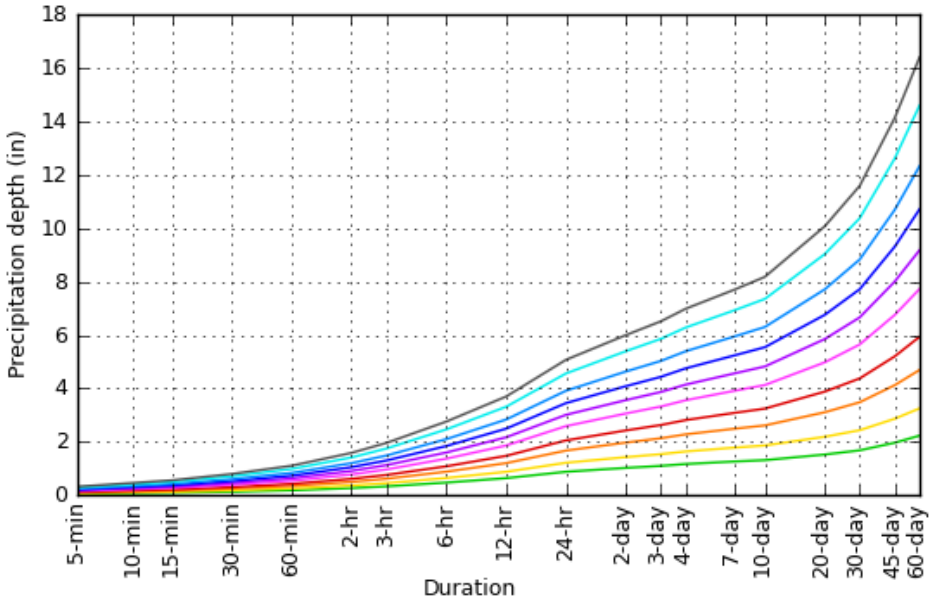
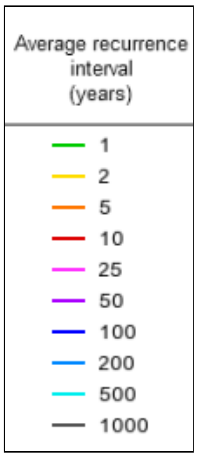
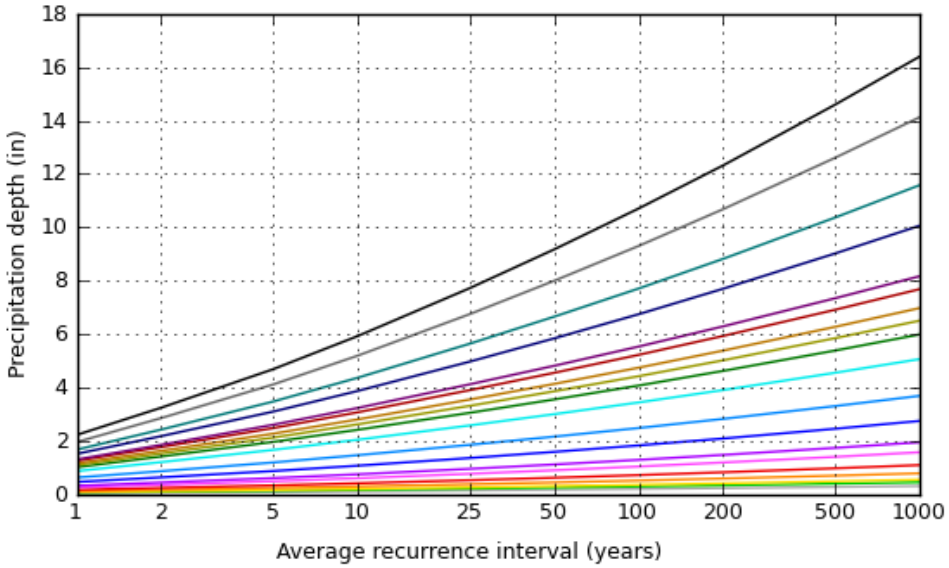
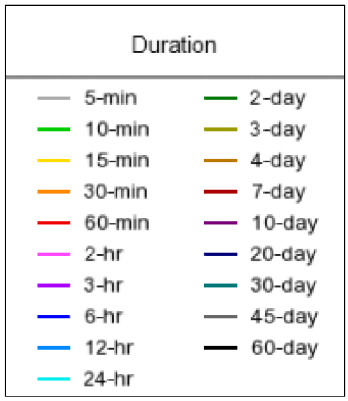
PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 34.6163°, Longitude: -117.6015°









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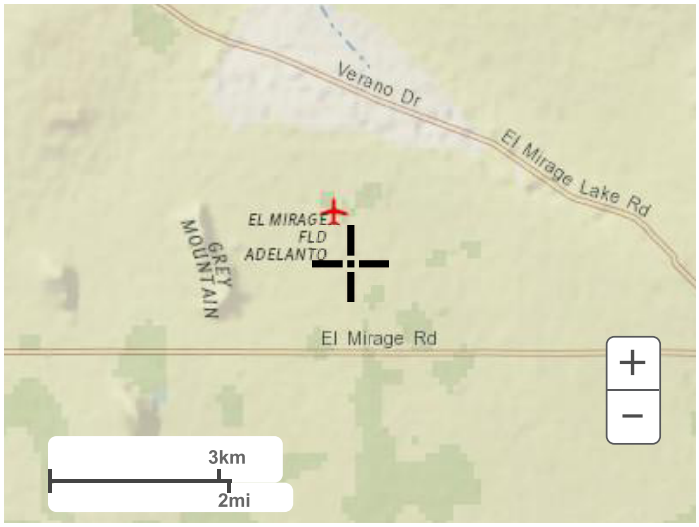
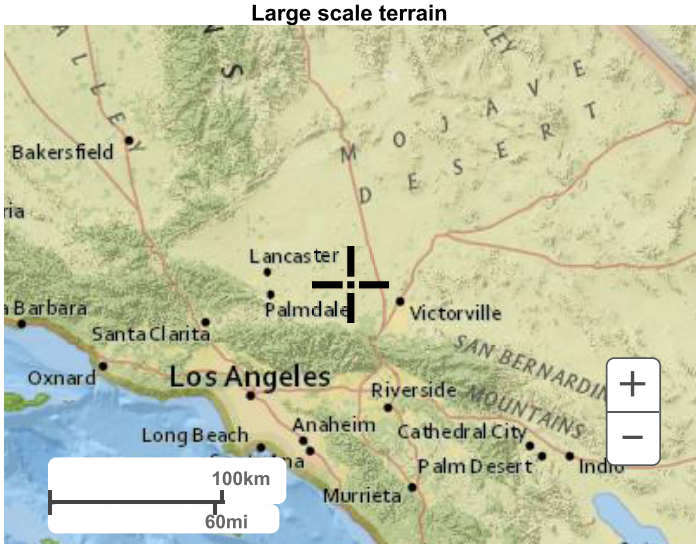
Maps & aerials

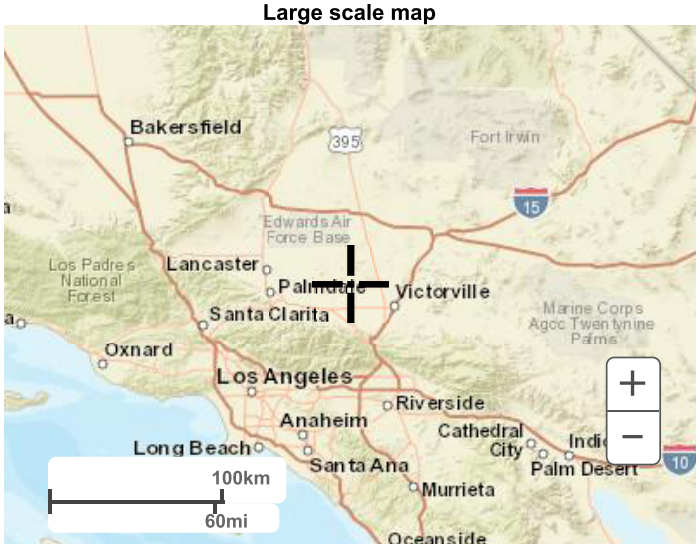
Small scale terrain



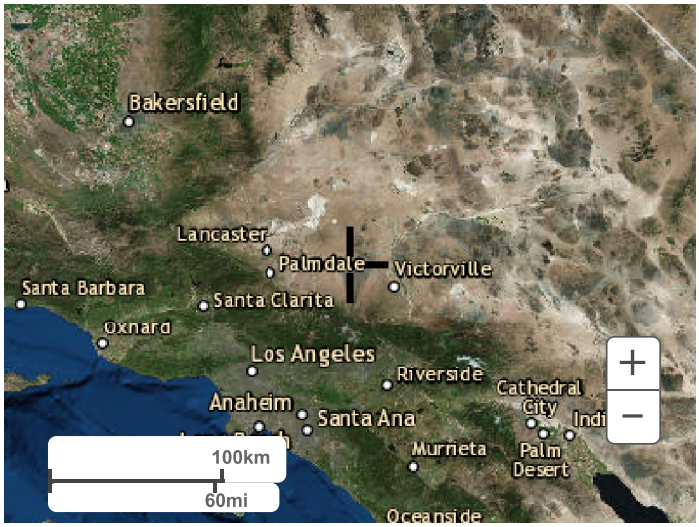
Large scale terrain



Large scale map



Large scale aerial



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