# Hydrology Study

**October 6, 2019**

## MOJAVE NARROWS SENIOR MEDICAL PAVILION

**San Bernardino County, California**


PROFESSIONAL ENGINEER'S AFFIRMATIVE STATEMENT

I have examined and am familiar with the information in this document and all appendices, and based on my inquiries of individuals immediately responsible for obtaining the information in this document, I believe that the information is true, accurate, and complete

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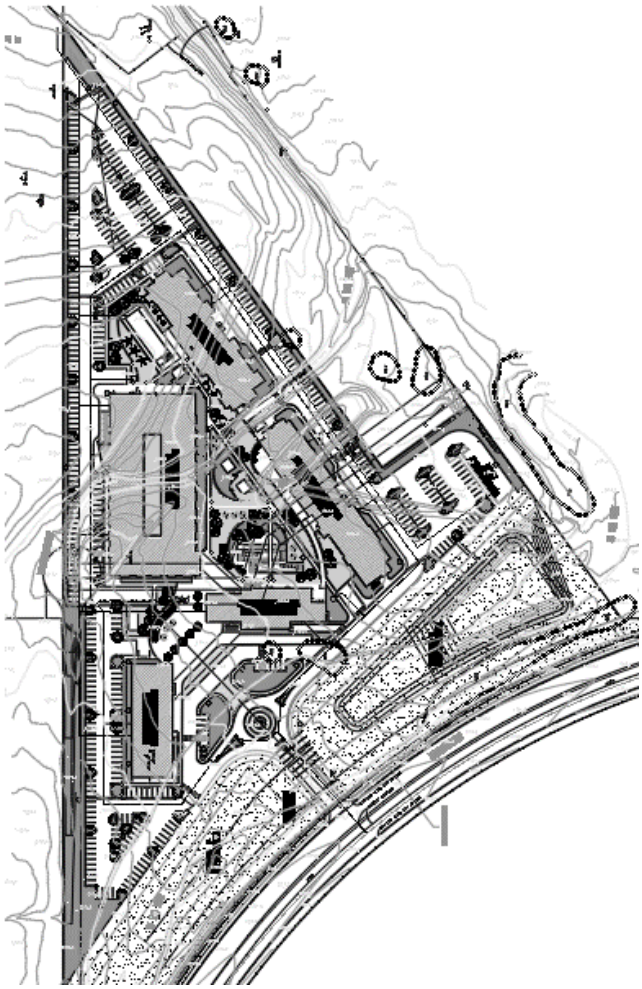
# I. INTRODUCTION

## A. LOCATION OF PROPERTY

The 18.66-acre project site (APN: 0479-131-09 / Lot 520, Tract No. 8027) is located between the Mojave Narrow Regional Park and Spring Valley Lake Development. It is bounded on the west by the Union Pacific railroad tracks, on the north and east by the Regional Park, and on the south by Yates Road. A ridgeline by-sects the site dividing it into two (2) drainage area **(see Exhibit C)**. The northern area receives very little off-site flows due to the diversion caused by the elevated railroad tracks on the west that carries the flows north away from the site. The southern drainage area consists of a wash that receives 3370 cfs of off-site tributary drainage flows concentrated through a culvert crossing the railroad tracts to the west.



The proposed development is an 18.66 acres senior retirement facility consisting of independent living, assisted living, skilled nursing, rehabilitation, and a medical office building, nestled between the San Bernardino County Mojave Narrows Regional Park and Spring Valley Lake Home Owners Association.

## B. PURPOSE AND SCOPE

Tract No. 8027 designated the entire project site, Lot 520 as a San Bernardino County Drainage Easement. The purpose of this study is to show that the existing flood plain is limited to the southern half of the site which can be intercepted at the westerly boundary and released in its historic conveyance channel at its native velocity size and depth prior to exiting along the eastern boundary.

Another purpose is to set flood water elevations and recommendations for on-site grading and pad elevations that will ensure the development meets or exceeds the level of flood protection required for the development.

## C. METHODOLOGY

This study is based on the stormwater Q's reported under the City of Hesperia Master Plan of Drainage Figure J-01 **(see Appendix A Exhibit H**) that is verified using San Bernardino County's Unit Hydrograph method and using the Corp of Engineers HEC-RAS 4.1 software to model the storm channel flows.

The following criteria were used for the off-site tributary flows:

| | | |
|---|---|---|
| 1. | Current land use: | Vacant Undisturbed |
| 2. | Proportion Impervious: | 10% |
| 3. | Intended Use: | Pre-developed open Brush |
| 4. | NOAA 14 Precipitation | 100-year 1-hour=1.07 |
| 5. | Soil Type | Group A & B |
| 6. | San Bernardino County Hydrology Manuel | Unit Hydrograph Method |
| 7. | Hesperia Master Plan of Drainage | Figure J-01 Sta. 10+00, Q100 = 3370 cfs |

## D. COMPLIANCE WITH REGULATIONS

All calculations are based on generally accepted engineering practices in accordance with the San Bernardino County Hydrology Manual's Hydrologic Criteria and Drainage Design including the April 2010 Addendum that addresses the Antecedent Moisture Condition (AMC) for arid regions of the County.

## E. FLOODPLAIN INFORMATION

The project site is located outside of the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map Panel 06071C5820J effective September 2, 2016, indicates that the site is located in "Zone X". Zone X (no hatching) is defined by FEMA as "areas determined to be outside the 0.2% annual chance flood plain" (see Exhibit B) for the San Bernardino County.

## F. MASTER PLANNING/PROPOSED MASTER PLAN FLOOD CONTROL FACILITIES

The City of Hesperia Master Plan of Drainage (HMPD) proposes Master Plan Facilities up to our westerly property line. In a conversation with the San Bernardino County Flood Control District, it was expressed that they have no intention or budget to build the extension of this HMPD J-01 storm channel and direct these flows to the Mojave River. Since the current 60-foot base width channel improvements do not match the recommendations for the J-01 channel improvements specified on **Exhibit F** and considering the design and maintenance of the new channel improvements will be at the discretion of the property owner and will not be annexed into the County or the Cities, then the design will be per the recommendations found herein. A drainage acceptance easement will be granted to convey these off-site flows through the project **(See Exhibit G**).

# II. OFF-SITE HYDROLOGY

## A. OFFSITE DRAINAGE DESCRIPTION AND HYDROLOGY

The Off-site tributary area consists of one major 7182-acre drainage area and a minor 9.09-acre drainage area. The 7182-acre historic offsite drainage area flows generally from southwest to northeast according to the USGS topographic survey of the area from the north side of the California Aqueduct and the 15 freeway approximately northwesterly 39,877 linear feet to our project site. See the Off-Site Tributary Drainage Maps presented as **Appendix A Exhibit E.** The minor 9.09-acre off-site area flows are generally captured within a naturally occurring drainage conveyance that borders the project site on the west up to the railroad tracks. The minor off-site area drainage conveyance has a base width of approximately 10 feet with a 3:1 side slope that flows north along the westerly property line approximately 600 feet and enters the project site turning east and flowing across the project site to the east property line. The off-site areas were assumed as pre-developed open brush terrain to establish our historic natural flows. Capacity Limitations do to existing street culvert restrictions especially under Bear Valley Road have been ignored to be more conservative. Debris and Bulked flows would also be limited on the west side of bear valley road and are not considered in the San Bernardino Hydrology Manuel.

The 7182-acre and 9.09-acre off-site tributary drainage areas were analyzed using the San Bernardino County Hydrology Manuel and CivilDesign software to perform a Unit Hydrograph and Rational method analysis of the off-site flows respectively. The off-site tributary area was determined by reviewing the Hesperia Master Plan of Drainage (HMPD) and confirming the boundary for the tributary flows **(see Appendix A Exhibit E).** The soils type data was also determined by reviewing and confirming data supplied in the HMPD **(see Appendix A Exhibit D).** Curve Numbers were determined based on pre-developed conditions as open brush fair cover and yielding a value of 46 for Soils Type A and 66 for Soils Type B. **(see Appendix A Exhibit M).** The results of this analysis are presented in **Appendix D** as the "Off-Site Tributary Unit Hydrograph Analysis" which shows that the 7182-acre off-site tributary area develops a 100-year Q of 3129 CFS. This Q is less than the Q analyzed in the Hesperia Master Plan of Drainage Channel J-01 conveyance developed by Williamson Schmid that has a Q100 of 3370 CFS.

Red Brick Solutions, LLC accepts the City of Hesperia Master Plan of Drainage (HMPD) Q100 as a conservative value based on the following.

- The NOAA isohyet data for this area has been reduced from 1.15 (figure B-10. SBCHM) to 1.09 (NOAA 14 Precipitation) or approximately 5 percent.

- New open channel construction requirements that eliminate concrete along the bottom to allow infiltration to occur.
- Up-stream master planned storm drain, and channel improvements have not been constructed. This lengthens the TC and lowers the peak Q100.

The 9.09-acre off-site tributary area associated with on-site drainage area (DA1) is bounded upstream by the railroad tracks that limits its area and Q100 flows to 9.65 cfs and 25-year flows to 2.95 cfs along the westerly property line and flows approximately 600 north of the major tributary off-site tributary area channel and enters our project site. (**See Exhibit H**) The developed site will capture this flow in a storm drain and convey these flows southwesterly to confluence with the major channel flows prior to exiting the site.

Drainage area (DA2) has a small off-site area that produces storm flows that do not influence the on-site tributary area because the flows drain north parallel with our westerly property-line. These flows are not considered in this report. (see Exhibit H)

## B. THE EXISTING MASTER DRAINAGE CHANNEL DESCRIPTION

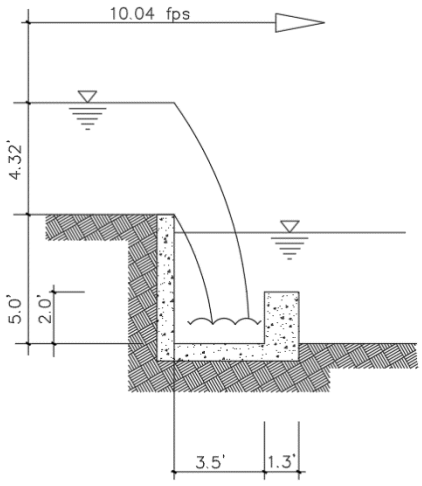
The site is bisected by a naturally occurring ridgeline running from west to the east approximately 800 feet north of the southern property line. The two off-site flows mentioned above are tributary to the southern half of the site. A hydraulic analysis of the existing major off-site area drainage conveyance shows that the off-site concentrated flows exiting the culvert crossing under the railroad tracks west of the site are contained within a 55 to 60-foot base width developed channel that enters the project site at the southwest corner and parallels Yuma Road running easterly 1492 linear feet to the southeast corner of the site. This existing channel begins to fan out to 150-feet in width as it enters the project site and exists the site as a floodway base width of 225-feet and floodplain width of approximately 560-feet.

The minor tributary 9.06 acre off-site tributary flows enter the site approximately 625 feet north of and parallel to the southern property line flowing northeast approximately 480 linear feet to the eastern project boundary where this minor off-site tributary flows confluences with the major off-site tributary flows heading northeasterly into the regional park site. **(see Exhibit H)**

# III. PROPOSED CHANNEL DRAINAGE FACILITIES

## A. GENERAL DESCRIPTION

The proposed project will capture the major 3370 cfs off-site drainage at the southwest corner of the project where the existing channel base width is approximately 60-foot wide by continuing the channel along the projects southern boundary to the first of three drop structures and proposed diversion dikes to channelize the flows and reduce their velocities as they pass through the proposed site. The proposed 1372 linear foot on-site earthen channel varies in base width from 55 feet to 235 feet with three concrete drop structures with 3-foot high steps allowing the channel to maintain a 0.0015 slope **(see Section A-A on Appendix A, Exhibit I ).** Maintenance of these structures will be part of the "Operators" agreements to be maintained along with the landscape and facilities. The side slopes were analyzed at 3:1 due to the granular nature of the in-situ soil material.




**CONCRETE DROP STRUCTURES**

In addition, the proposed project will capture the minor 9.06 acre undeveloped 100-year 9.35 cfs off-site drainage flow within an earthen channel along the westerly property line as it travels approximately 625 feet north of the southern property line to a concrete headwall entrance into a proposed 24-inch diameter storm drain directing these flow southeasterly approximately 500 linear feet at a slope of 1% to confluence with the major 3370 cfs tributary flows prior to exiting the southeast corner of the site. **(see Appendix A Exhibits I & J)**

Detailed calculations of the existing hydraulic conveyances are referenced and provided in **Appendix D.**

## B. PROPOSED CHANNEL HEC-RAS HYDRAULIC ANALYSES

The US Corp of Engineers Hydraulic Software "HEC-RAS" was employed to analyze the flow characteristics through the project site for both the pre-developed and post-developed channels. This will allow the comparison between the two conditions with regards to their velocities, cross-sectional area, and depths of flow. Each of these developed characteristics must be equal to or less than the pre-developed prior to exiting the site.

### Existing and Proposed Conditions Entering the Site:

As existing off-site flows enter the southwest corner of the proposed site **(see Appendix A Exhibit H & I)** the velocities in both the existing and proposed conveyances have erosive velocities more than 10 fps and will transport granular material downstream. Our developed channel velocity at the westerly property line is within -4.9% of the existing channel and reduces the flood depth 0.03 feet. Approximately 550 feet into the site the developed site continues to mimic the existing channel characteristics flowing at -3.3% of the velocity with an increased depth of 0.96 feet, but with a water surface below existing due A to

lowering the channel invert elevation. A summary of the results is listed in **Table 1**. Detailed output files are provided in **Appendix C & D.**

To prevent shifting flood limits, a proposed erosion control system (i.e. blankets, armor, or concrete) shall be placed along the side slopes and extended six (6) feet below the proposed invert of the channel.

**TABLE 1. INITIAL ON-SITE CONVEYANCE CONDITIONS BASED ON**

**Q100 = 3370 CFS**

| Location Top of North Bank | River / Channel Drainage Station | Pre-Developed $V_{100}$ [fps] | Pre-Developed Depth [ft] | River / Channel Drainage Station | Post-Developed $V_{100}$ (cfs) | Post-Developed Depth (ft) | Velocity Reduction |
|---|---|---|---|---|---|---|---|
| West PL | 15+50.00 | 11.87 | 4.81 | 22+92.12 | 11.29 | 4.78 | -4.9% |
| Above Bridge | 9+94.21 | 9.23 | 3.56 | 10+06.00 | 8.92 | 4.52 | -3.3% |

## Existing and Proposed Conditions as Flood Waters Leave the Site:

A summary of the existing and proposed conveyances exiting the site for the 100-year 3370 cfs storm event is provided in Table 2. The proposed conveyances will spread out from as narrow as a 55-foot base width channel to a 225-foot base width channel at the easterly boundary to mimic the historic natural flows previously exiting the site at the same location. A summary of the results is listed in **Table 2**. Detailed output files are provided in **Appendix C & D.**

**TABLE 2. EXISTING AND PROPOSED CONDITIONS EXITING THE SITE**

| River / Channel Drainage Station | Pre-Developed $V_{100}$ [fps] | Pre-Developed Depth [ft] | River / Channel Drainage Station | Post-Developed $V_{100}$ (cfs) | Post-Developed Depth (ft) | Velocity Reduction |
|---|---|---|---|---|---|---|
| 0+12.04 | 2.65 | 2.29 | 0+00.00 | 4.39 | 1.89 | -17.5% |

# IV. ON-SITE HYDROLOGY

## A. UNDEVELOPED CONDITIONS

The undevelopable site consists of approximately 12.61 acres divided by an existing ridgeline into two drainage areas consisting of 10.64 acres (DA1) and 1.97 acres (DA2) respectively (See Appendix A Exhibit H). DA1 is divided into four (4) subareas that confluence off-site in an existing natural channel conveyance that flows north parallel to our eastern property line. For the purposes of this study, we are assuming the confluence occurs prior to exiting the site. Using the San Bernardino County Hydrology Manuel and CivilDesign software to perform a Rational method analysis of DA1 for a 25-year AMC II storm event we have determined that the undeveloped storm flows are approximately 6.23 cfs. DA2 was calculated as an initial subarea with an undeveloped storm flow of approximately 1.33 cfs.

## B. DEVELOPED CONDITIONS

The developable site also consists of approximately 12.61 acres but it is divided a little differently due site constraints leaving two drainage areas consisting of 11.51 acres (DA1) and 1.10 acres (DA2) respectively (See Appendix A Exhibit I ). DA1 is divided into twelve (12) subareas that confluence on-site the southeasterly corner of the site where it combines with the off-site major tributary storm flows prior to exiting the site and flows into the existing natural channel conveyance that flows north parallel to our eastern property line. Using data from the San Bernardino County Hydrology Manuel and CivilDesign software to perform a Rational method analysis of DA1 for a 100-year AMC III, a Unit Hydrograph Analysis was performed and determined that the developed storm flows are approximately 29.15 cfs. **(See Appendix B DA1 On-Site Developed and Appendix C DA1 On-site Developed Unit Hydrograph calculations)**

DA2 was calculated as an initial subarea with a developed storm flow of approximately 4.56 cfs. **(See Appendix C DA2 On-site Developed calculations)**

## C. DETENTION BASIN ROUTING SIZING

Using data from the San Bernardino County Hydrology Manuel and Addendum B, RBS used CivilDesign Route Software to design a detention basin that will limit the 100-year developed 29.15 cfs storm flows to below the 25-year 6.23 cfs storm flows. An underground detention infiltration basin as shown in Appendix A Exhibit K & L was used consisting of a 60-inch diameter perforated pipe system 50-feet wide by 147-feet long. A wire/orifice structure will be designed to allow 1.5 cfs of initial storm flows to exit the system at a depth of 1-foot up to 5.5 cfs at a depth of 5-feet. A basin design shown on Exhibit K was imputed into our analysis that determined the basin requirements to be 0.368 acre-feet with a maximum effluent of 3.73 cfs which is less than the 6.23 undeveloped flow.

## D. RECOMMENDED ON-SITE FLOOD PROTECTION

The proposed project should be designed to maintain one foot of freeboard on the channel embankments and set finish floor elevations approximately one foot above the water surface elevation perpendicular to the channel centerline. A preliminary design has been developed meeting or exceeding these recommendations and is attached in **Appendix A Exhibit J.**

# V. CONCLUSIONS

The proposed project follows regional and local laws and ordinances that require off-site flows after passing through the project to be released in the historic drainage conveyance at the pre-developed velocity and depth of flow. Per San Bernardino County Flood Control District, this site and channel improvements are not designated as a master planned facility, and will not be maintained by the County. All improvements will be required to be maintained by the property owner or assigns. The project is also located outside the 100-year floodplain in Zone X (no hatching) which is defined by FEMA as "areas determined to be outside the 0.2% annual chance flood plain" (see Appendix A) requiring no special mitigation measures.

The historic drainage discharge points have been maintained with this design, and the offsite 3370 cfs 100-year flood flows are conveyed around the site via an improved channel designed to have 1.5-2.0 feet of freeboard. This reduces the floodplain area from across the entire parcel to the area designated in Exhibit D.3 as a "Drainage Acceptance Easement".

The developed on-site flows are being detained in an underground detention/ / infiltration basin and the developed 100-year 29.15 cfs storm flows are mitigated to 3.73 cfs which is below the 25-year undeveloped flow of 6.23 cfs.

# VI. REFERENCES:

County San Bernardino of Public Works Low Impact Development Standards Manual. Updated February 2014.
County of San Bernardino Public Works Hydrology Manual. Created in August 1986.
http://cms.sbcounty.gov/Portals/50/floodcontrol/HydrologyManual.pdf
Federal Emergency Management Agency website: https://msc.fema.gov/portal accessed December 2016.
NOAA Atlas 14, Volume 6, Version 2 POINT PRECIPITATION FREQUENCY (PF) ESTIMATES WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION. Accessed December 2016.
NRCS Soils Data from Soil Map; San Bernardino County, California, Mojave River Area; Version 8, Sep 12, 2016 Accessed December 2016.