PRELIMINARY
HYDROLOGY/HYDRAULIC STUDY

For

San Marcos Highlands
Las Posas Road
City of San Marcos
County of San Diego, California

Prepared For:

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TABLE OF CONTENTS

OBJECTIVE

The objective of this study is to determine the amount of 100 year 6-hour storm runoff that is generated by the proposed project. This study will guide the design of the proposed private and public storm drain facilities. Also included is the analysis of the off-site runoff coming to the site.

The main goal for this study is to prove that the proposed project will not adversely affect the downstream ecosystem by comparing the peak runoffs between the pre-development condition and the post-development condition.

OVERVIEW

1. Project Location

The proposed development is located at the end of North Las Posas Road, approximately 2 miles north of Freeway 78 and Las Posas Road intersection, County of San Diego, California (See Appendix 1 – Vicinity Map).

2. Existing Condition

The site is currently vacant with some perennial vegetation generally consisting of low vegetation with some thick brush scattered around the area but denser along the natural swales or brooks. The topography of the site is relatively hilly and steep slopes with elevations ranging from approximately 665 feet to 875 feet above mean sea level.

Off-site and on-site runoffs are currently conveyed and confluence together toward the center of the tributary basin. This basin is an origin upstream of Agua Hedionda Creek.

3. Proposed Project Site Description

The subject site has an approximate gross area of 262.14 acres. The area of development is approximately 50.86 acres for single family residential homes that consists of 198 residential lots, 8 water quality lots, and 3 parks. Open space area is approximately 56.86 acres after the proposed boundary adjustment.

The development will include construction of 198 pads and the buildings and other supporting structures. Improvements are proposed to include access streets, sidewalks, surface parking, play grounds, and water quality trenches and ponds.

Low Impact Development (LID) in Stormwater Management Plan

This project utilizes a bio-strip system to pre-treat the storm water discharge from the impervious areas, such as the streets and sidewalks, and bio-retention ponds that detain/retain stormwater flow from the pads and discharge it gradually through an outlet. 100% of run-off is directed to and to be treated at integrated management practices areas.

The roof downspouts are directed to landscape areas, which drain to a storm drain system that discharges to bio-retention ponds. From the detention basin, the stormwater is released to the earthen swale lined with cobble stones on the southeast of the site.

METHODOLOGY

1. ***Hydrology***

The Rational Method as outlined in the San Diego County Hydrology Manual 2003 Edition was followed in this study. The *CIVILCADD / CIVILDESIGN software version 7.4* was used to calculate the storms. Specifically, we used the software's San Diego 2003 Rational Method module. This computer program has taken into account the changes that the 2003 manual implemented. Such changes include, but are not limited to, the time of concentration and urban area runoff coefficients. Please see the calculation printouts and the hydrology basin maps in the Appendix.

A runoff hydrograph for the 100 year event was developed using the *Rick Engineering Rational Method Hydrograph* software. The CivilD input and output data, including the hydrograph data, are shown in Appendix 5. The next step was to route the runoff through a typical water quality basin. The bio-strips and bio-retention ponds provid dual functions. The basins clean storm runoff and act as detention basins to attenuate the peak flows and satisfy hydro-modification requirements. A typical section of a water quality basin is shown in Appendix 7 under SWMM report. For the purpose of peak flow attenuation, the 24" gravel layer, 18" soil layer, and 6" surface above the bio-strip are considered for reservoir storage (for water quality purposes, this storage only considers 2" depth for the bio-strip and 6" for the bio-pond in the SWMM model). A void ratio of 35% is assumed for the gravel layer and 40% for the soil. Using *Hydraflow Hydrographs 2004* by Intelisolve, the hydrographs developed by CivilD were routed through the water quality basins and peak discharges for the 100-yr storm were established.
To simplify the calculation, a tributary area was taken from the largest area in this group of bio-strip subcatchment basins to size the universal bio-retention size for the typical location and situation. Therefore, we did only one storage routing calculation and one bio-strip size representing these similar basins.
The SWMM program was used to calculate the bio-strip area for this street at 139 sqft typical.
In the CivilD program, the system was calculated twice. The first run calculates the system by considering the storm water draining into the inlets and disregarding the detention system to get the Qin to generate the hydrograph.

2. ***Hydraulics***

Culvert Hydraulic Computations
For low flow computations the program first uses the momentum equation to identify the class of flow. This is accomplished by first calculating the momentum at critical depth inside the culvert at the upstream and downstream ends. The end with the higher momentum will be the controlling section in the bridge, therefore the most constricted section. The momentum at critical depth in the controlling section is then compared to the momentum of the flow downstream of the culvert when performing a subcritical profile (upstream of the bridge for a supercritical profile). Since the momentum downstream is less than the momentum at critical depth in the culvert, then it is assumed that the constriction will cause the flow to pass through critical depth and a hydraulic jump occurred at some distance downstream therefore the low flow is categorized as Class B low flow.

Calculation Method

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Water-surface elevations for the flood of the selected recurrence intervals were computed through use of the USACE HEC-RAS version 4.1.0 January 2010 computer program.

a. Setting up Geometric data and river delineation

Several river cross sections are established from downstream to the upstream within an approximately 4000 foot long reach started from station 0+00 to 40+00. This reach is labeled as Agua Hedionda in the program. Please notice that the stationing mentioned in this study is not referring to any river stationing from the FEMA study but cross sections numbered specifically for this study.

b. Cross sections

From the present topographic data, the cross sections are generated based on the computer surface modeling projections. The cross section geometric data consists of the: X-Y coordinates, reach lengths, Manning's n values, location of levees, and contraction and expansion coefficients. There are 18 cross sections and 1 culvert cross section as a data input to model the creek channel.

For this study the appropriate n values were established as n=0.03 for the main channel and n=0.035 for the side over banks.

c. Steady flow water surface profiles

This analysis is used to calculate water surface profiles for steady gradually varied flow with a sub-critical flow regime and is designed for application in flood management. The basic computational procedure is based on the solution of the one-dimensional energy equation. Energy loses are evaluated by friction (manning's equation) and contraction/expansion (coefficient multiplied by the change in velocity head). The momentum equation is utilized in situations where the surface profile is rapidly varied.

Water surface profiles are computed from one cross section to the next by solving the energy equation with an iterative procedure called the standard step method as follows:

$$Z_2 + Y_2 + \frac{a_2 V_2^{\,2}}{2g} = Z_1 + Y_1 + \frac{a_1 V_1^{\,2}}{2g} + h_e \quad (1)$$

Where: Z_1, Z_2 =elevation of the main channel inverts

Y_1, Y_2 =depth of water at cross sections

V_1, V_2 =average velocities (total discharge/ total flow area)

a_1, a_2 = velocity weighting coefficients

g = gravitational acceleration

h_e = energy head loss

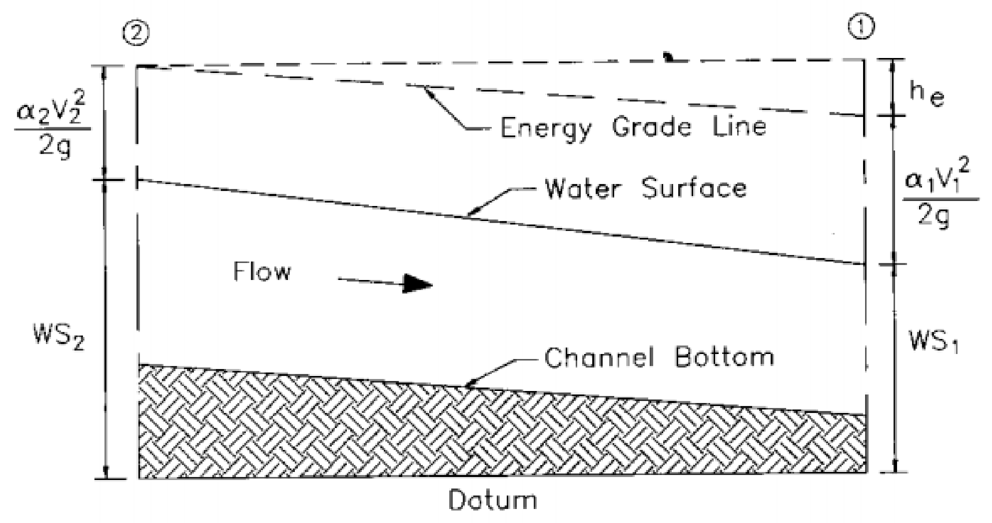

Fig2. Representation of terms in the energy equation

The energy head loss h_e between two cross sections is comprised of friction losses and contraction or expansion losses. The equation can be written as follows:

$$h_e = L\overline{S}_f + C\left|\frac{a_2 V_2^2}{2g} - \frac{a_1 V_1^2}{2g}\right| \quad (2)$$

Where:

L = discharge weighted reach length

$\overline{S}_f$ = representative friction slope for reach between two sections

C = expansion or contraction loss coefficient

The distance weighted reach length, L is calculated as:

$$L = \frac{L_{lob}\overline{Q}_{lob} + L_{ch}\overline{Q}_{ch} + L_{rob}\overline{Q}_{rob}}{\overline{Q}_{lob} + \overline{Q}_{ch} + \overline{Q}_{rob}} \quad (3)$$

Where:

L_{lob}, L_{ch}, L_{rob} = cross section reach lengths specified for flow in the left overbank, main channel, and right overbank, respectively

$Q_{lob} + Q_{ch} + Q_{rob}$ = arithmetic average of the flows between section for the left overbank, main channel, and right overbank, respectively.

CALCULATIONS

1. ***Determine the Watershed that affects the project***

The project site is located on the 5,663 acre Agua Hedionda Hydrologic Sub-Area (HAS 904.32), which is part of the San Marcos Hydrologic Area (HA 904.30) and Carlsbad Hydrologic Unit (HU 904.00). Please see the "watershed Topographic Map" for both the Existing and Existing+Project conditions in attachment D.

Existing/Pre-Development Condition:

In general, this site is vacant with some perennial vegetation generally consisting of low vegetation with some thick brush scattered around the area but denser along the natural swales or brooks. The topography of the site is relatively hilly and steep slopes with elevations ranging from approximately 665 feet to 875 feet above mean sea level.

Post-Development Condition:

This proposed development is designed to mimic or improve the existing conditions. See the proposed tributary basins shown on Post Development Maps in Appendix 7. There are 10 major basins that drain to the existing creek that flows parallel to, and is southeast of, Las Posas Road. Throughout the site, bio-strips were used to treat and detain the runoff from the impervious areas, such as the street, curb and gutters, and sidewalks. After filtering through the bio-strips, the runoff was directed to the storm drain system and discharged to the creek. In a separate drainage system, the runoff from the pads is captured and conveyed to bio-retention ponds. Once again, after passing through the filtering system, the runoff discharges into the existing creek. There are 10 outfalls from the proposed development that discharges into the existing creek.

2. ***Determine the average Runoff Coefficient for the site***

Currently the project site is classified as undisturbed natural terrain. The surrounding neighborhood is residential in character with a mix of agricultural area and small-lot single family dwellings. Soil type for the site is soil type D.

The off-site as of today has some impervious areas from but not limited to the following: rock outcrops, patches of dirt & ac driveways, agricultural building structures, etc. it is estimated that the impervious area is approximately 10%. Therefore it is our stand to use the C=0.41 established for a "Low Density Residential / 1.0 DU/A or less" which has 10% impervious surface for the existing condition.

For Existing + Proposed (post-development) condition, the runoff coefficient is determined based on County of San Diego Hydrology Manual section 3.1.2, Table 3-1.
The proposed development is planned to be Medium Density Residential with 10.9 Dwelling Units per Acre or less. Therefore, the coefficient runoff for the proposed site is 0.60.

In CivilD calculation, the runoff will be calculated as Q=CIA. By choosing Medium Density Residential (**MDR) 10.9 DU/A** or less for **soil type D** for C value of 0.60.

3. ***Calculate Q_{100} using Rational Method***

On-site Basin

Here is the summary of the Hydrology calculations for the proposed development:

Table 3-1 Summary of Hydrology Analysis for Outfall 1

CONDITION	NODE	AREA	RUN OFF	Tc
		Ac.	Cfs.	Min.
Proposed (before detention)	511	0.94	3.65	8.91
Proposed (after detention)	511	0.94	3.65	8.91
Difference				

Note: Detention effect from the bio-retention strips was not taken into account.

Table 3-2 Summary of Hydrology Analysis for Outfall 2

CONDITION	NODE	AREA	RUN OFF	Tc
		Ac.	Cfs.	Min.
Proposed (before detention)	523	0.86	4.05	6.55
Proposed (after detention)	523	0.86	4.05	6.55
Difference				

Note: Detention effect from the bio-retention strips was not taken into account.

Table 3-3 Summary of Hydrology Analysis for Outfall 3

CONDITION	NODE	AREA	RUN OFF	Tc
		Ac.	Cfs.	Min.
Proposed (before detention)	82	103.8	212.09	9.46
Proposed (after detention)	82	103.8	182.90	9
Difference			29.19	

Note: Detention effect from the bio-retention strips on Street A was not taken into account.

Table 3-4 Summary of Hydrology Analysis for Outfall 4

CONDITION	NODE	AREA	RUN OFF	Tc
		Ac.	Cfs.	Min.
Proposed (before detention)	543	5.79	20.05	7.08
Proposed (after detention)	543	5.79	20.05	7.08
Difference				

Table 3-5 Summary of Hydrology Analysis for Outfall 5

CONDITION	NODE	AREA	RUN OFF	Tc
		Ac.	Cfs.	Min.
Proposed (before detention)	552	4.48	13.8	7.05
Proposed (after detention)	552	4.48	13.8	7.05
Difference				

Table 3-6 Summary of Hydrology Analysis for Outfall 6

CONDITION	NODE	AREA	RUN OFF	Tc
		Ac.	Cfs.	Min.
Proposed (before detention)	559	4.62	13.04	7.05
Proposed (after detention)	559	4.62	13.04	7.05
Difference				

Table 3-7 Summary of Hydrology Analysis for Outfall 7

CONDITION	NODE	AREA	RUN OFF	Tc
		Ac.	Cfs.	Min.
Proposed (before detention)	430	1.85	8.78	6
Proposed (after detention)	430	1.85	8.78	6
Difference				

Table 3-8 Summary of Hydrology Analysis for Outfall 8

CONDITION	NODE	AREA	RUN OFF	Tc
		Ac.	Cfs.	Min.
Proposed (before detention)	648	15.31	49.7	10
Proposed (after detention)	648	15.31	7.16	10
Difference			42.54	

Table 3-9 Summary of Hydrology Analysis for Outfall 9

CONDITION	NODE	AREA	RUN OFF	Tc
		Ac.	Cfs.	Min.
Proposed (before detention)	243	8.28	24.2	9
Proposed (after detention)	243	8.28	24.2	9
Difference				

Table 3-10 Summary of Hydrology Analysis for Outfall 10

CONDITION	NODE	AREA Ac.	RUN OFF Cfs.	Tc Min.
Pre-Development	6	577.6	924.11	19
Proposed (before detention)	6	577.6	969.08	21
Proposed (after detention)	6	577.6	919.35	21
Difference between before/after detention			49.73	0
Difference between Pre-and Post-Development with detention			4.76	2

Outfall 10 is the point of comparison between pre- and post-development (located downstream of the creek).

SUMMARY AND CONCLUSION

- For Existing + Proposed (post-development) condition, the runoff coefficient is determined Based on County of San Diego Hydrology Manual section 3.1.2 the run-off coefficient is 0.60.

- The proposed detention will mitigate runoff to less than existing condition levels.

- This Hydrology and Hydraulic study has evaluated the potential effects on runoff of the proposed project. In addition, the report has addressed the methodology used to analyze the pre- and post-development condition which was based on the San Diego County Hydrology and Design Manual and San Diego County Drainage Design Manual.

- As presented in this study, we have shown that the proposed project has been designed adequately to treat required amount of storm water generated by the proposed project while reducing the post development flows below the existing condition; therefore, we anticipate that there will be no adverse impacts to the downstream property or habitat.