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FREQUENCIES FOR STORM EVENTS OF JANUARY AND FEBRUARY 2005

Prepared for Poseidon

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EXECUTIVE SUMMARY

A hydrology study has been made to determine the discharges of Agua Hedionda Creek on January 12 and February 23, 2005. The discharges were determined by hydrologic simulation of stream flows using rainfall data and the Agua Hedionda Creek watershed model. The January 12th stream flow has been determined to have a return period of 25.8 years; and the February 23rd flow has a return period of 35.7 years. Such stream flows with long recurrence intervals are very rare events. Two such rare events occurred in early 2005. The probability of surpassing two such large events in any particular year is only 0.12%, or 1.2 times in 1,000 years. It was an extremely rare combination of stream flows.

Total rainfall for 2004-5 was about 26 inches for the area, far exceeding the long-term average of about 13 inches. The stream flows on January 12 and February 23 are far outliers. After discarding the two outliers, the weekly impingement sampling events captured a sufficient number of storm runoff events to reflect typical wet weather conditions for the watershed. Since the remaining rainfall amount still far exceeds the annual average, there was a sufficient number of storms to be representative of a typical, twelve-month period.

QUALIFICATIONS

I am a registered civil engineer with a specialty in hydrology. I have practiced hydrology in this region for over 40 years. I prepared the hydrology study covering northeastern Carlsbad in 1989 (Chang, 1989). This study has since been used by the City as the standard for stream flows of Agua Hedionda Creek and Calavera Creek. My curriculum vitae is attached.

INTRODUCTION

Certain questions have been raised by the staff of the Regional Water Quality Control Board regarding the data used to support Poseidon's Impingement and Entrainment Assessment for the Agua Hedionda Lagoon. The staff questioned whether the sampling set is skewed because the data were collected during a year that was atypical with regard to rainfall.

The purpose of this study is to determine the frequencies of two unusually large storm events that occurred prior to January 12 and February 23 of 2005. Relatively higher impingement on these two dates may have been related to the fresh water flow in Agua Hedionda Lagoon, which recevives freshwater inflows primarily from Agua Hedionda Creek and Calavera Creek.

METHOD OF STUDY

In a natural stream without stream gages, hydrological simulation is the standard, and generally accepted, method for determining the stream flow. Hydrologic simulation uses the rainfall data and the drainage basin characteristics to generate the stream flow at selected points of concentration. More details of using this method as applied to the Agua Hedionda Creek basin are described below:

Rainfall Records of 2005 - I contacted the County of San Diego for the 2005 rainfall data. For the Agua Hedionda watershed, rainfall data for the periods of January and February 2005 were obtained from the following gaging stations:

- Oceanside Pumping Plant, Thomas Guide p.1086, D5, corner of Jones Rd and San Luis Rey Rd.
- Agua Hedionda, Thomas Guide p.1107, B7, SW corner of El Camino Real and Cannon Rd. Station installed Feb 4, 2005
- Carlsbad AP, Thomas Guide p.1127, D2, central N side of McClellan Palomar AP
- Deer Springs, Thomas Guide p.1089, C7, Mesa Rock Rd at the Deer Springs Fire Station

These are the County stations that are inside and immediately surrounding the Agua Hedionda watershed. The records in the attached spreadsheet represent individual bucket tips (0.04" resolution) that were received by a radio at the County office. The rainfall data have been analyzed to determine the 24-hr total rainfall for the time period immediately before January 12 and February 23. The results for these two dates are tabulated in Tables 1 and 2. The rainfall collected at the reference stations for the period beginning July 1, 2004 and ending June 30, 2005 is tabulated in Table 3. As noted in Table 3, total rainfall for 2004-5 was about 26 inches for the area, far exceeding the long-term average for the Agua Hedionda watershed of about 13 inches.

Table 1. 24-hr Rainfall Immediately Before January 12, 2005

Gaging station	Rainfall depths, inches
Agua Hedionda	---
Carlsbad AP	1.12
Deer Springs	2.20
Oceanside Pumping Station	1.40
Average of three readings	1.57

Table 2. 24-hr Rainfall Immediately Before February 23, 2005

Gaging station	Rainfall depths, inches
Agua Hedionda	2.12
Carlsbad AP	2.08
Deer Springs	2.04
Oceanside Pumping Station	2.00
Average of four readings	2.06

Table 3. Total Rainfall 2004-2005[1]

Gaging station	Rainfall depths, inches
Agua Hedionda	---
Carlsbad AP	24.95
Deer Springs	27.81
Oceanside Pumping Station	26.39
Average of three readings	26.39

Antecedent Moisture Conditions (AMC) – The stream flows of January 12 and February 23 were both preceded by at least five days of heavy rainfall. It is easy to see from the rainfall tabulations that unusual amounts of rainfall occurred preceding these two dates. For this reason, we had very wet antecedent moisture conditions, for which the AMC number is 3.

Hydrological Simulation - This hydrology study is guided by, and consistent with, the Hydrology Manual of the County of San Diego. As specified in the manual, the SCS method for hydrology is applied to drainage basin that is larger than 0.5 square miles in surface area. For this study, the HEC-1 computer model developed by the U. S. Army Corps of Engineers that applies the SCS method was used.

1 The rainfall collected at the Agua Hedionda and Oceanside stations is for the period beginning July 1, 2004 and ending June 30, 2005; data for the Deer Springs Station is for the period beginning November 1, 2004 and ending June 30, 2005.

Hydrological simulation for the storm events that preceded the January 12 and February 23 sampling events have been made using the HEC-1 model.2 This model is used extensively by engineers for hydrologic simulation of watersheds, and is a generally accepted method for this purpose. This model was used in the 1989 Chang study for northeastern Carlsbad, and is considered to provide an appropriate means by which to simulate rainfall/runoff in the subject watershed.

The hydrologic simulation is based on the rainfall, delineation of the drainage basin and hydrologic parameters for the selected subbasins. For the purpose of hydrological computation, certain basin characteristics are required. Such characteristics include the basin and subbasin areas, precipitation zone number (PZN), antecedent moisture condition (AMC), precipitation amounts for the 24-hr. storms, SCS curve number (CN), lag time, etc. Since the drainage basin of the Agua Hedionda Creek is large, the 24-hour storm produces greater flows than the 6-hour storm. For this study, we used the same hydrologic parameters that were used in the 1989 hydrology study for Agua Hedionda Creek. The rainfall depths and AMC values were changed according to the 2005 storm conditions.

Summary of Results – The peak discharges for Agua Hedionda Creek just before the Calavera Creek confluence have been obtained to be 2,715 cfs for the storm events leading up to January 12, and 3,609 cfs for the storm events leading up to February 23. At this point of concentration, the drainage basin area for Agua Hedionda Creek is 17.3 square miles. Input/output listings for the HEC-1 runs are attached to this report.

In order to determine the occurrence frequency of these two storm events, their peak discharges were compared with the FEMA-adopted peak discharges for Agua Hedionda Creek taken from the FEMA publication "Flood Insurance Study", 1999. Table 4 lists the FEMA-adopted discharges at two points of concentration along Agua Hedionda Creek. The FEMA-adopted discharges are for the developed, or ultimate, conditions of the watershed. The table also has the discharge for the current (existing) conditions of the watershed.

Table 4. FEMA-Adopted Peak Discharges along Agua Hedionda Creek

Point of Concentration	Basin Area	Peak Discharge in cfs		
		10-yr	50-yr	100-yr
At confluence with Buena Creek (ultimate)	6.3	1,600	4,800	7,000
Upstream of Calavera Creek (ultimate)	17.3	---	---	8,080
Upstream of Calavera Creek (existing)	17.3			6,366

From this study, the stream flow resulting from the storm events prior to January 12th has the peak discharge of 2,715 cfs. The peak discharge for the stream flow from the storm events prior to February 23 has the value of 3,609 cfs. The return periods of these events may be determined from the log-probability paper shown in Fig. 1. The peak discharge versus frequency relation for stream flows in this region follows the long-normal distribution. The return period is

2 *See* http://www.hec.usace.army.mil/software/legacysoftware/hec1/hec1.htm for documentation and software.

the reciprocal of the frequency. The storm return period is plotted against the peak discharge as a straight line on the log-probability paper. Fig. 1 shows one straight line for the concentration point at the confluence with Buena Creek and two straight lines for the concentration point just upstream of Calavera Creek.

The discharges of the stream flows from the storm events preceding January 12 and February 23 are plotted on line 3 in Fig. 1 as Point A and Point B, respectively. Point A has the frequency of 4.2. In other words, the January 12th flow occurs 4.2 times in 100 years. The return period, as the reciprocal of the frequency, is therefore 23.8 years. Point B for the February 23rd flow has the frequency 2.8, for which the return period is 35.7 years.

In summary, the probability to have a storm with the peak discharge greater than 2,715 cfs in a year is 4.2 %. The probability that a storm discharge of 3,607 cfs would be exceeded in any given year is 2.8%. Both events have low probabilities of occurrence; they are rare events. Two such rare events occurred in early 2005. The probability for two events to be exceeded in a year is the product of the two probabilities. In this case, the probability of having two such events in any given year = 0.042 x 0.028 = 0.0012, or 0.12 %

In conclusion, the storm events preceding January 12, 2005 have been determined to have the return period of 23.8 years, the storm events preceding February 23, 2005 have been determined to have the return period of 35.7 years. Such storms are very rare events. The probability of surpassing two such large events in year is only 0.12%, or 1.2 times in 1,000 years.

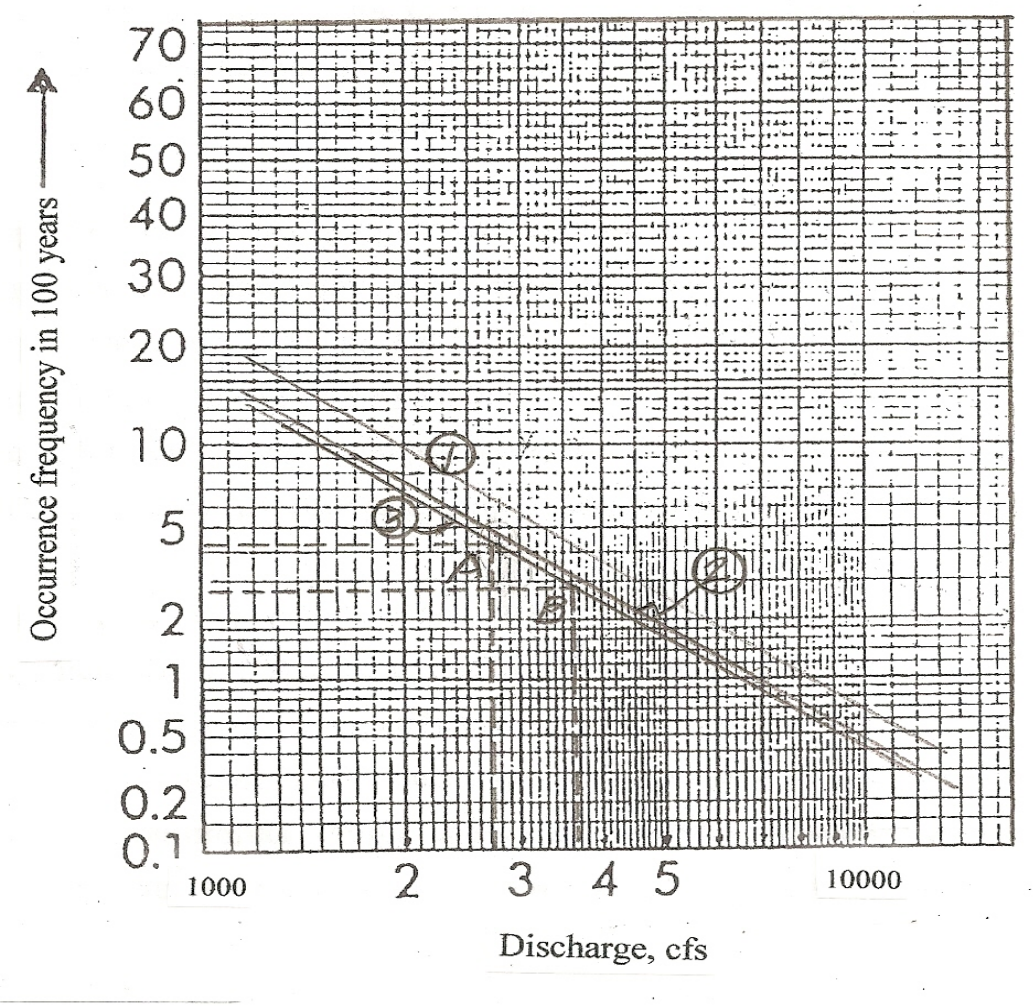

Fig. 1. Log-probability relations of frequency-discharge for Agua Hedionda Creek
Line 1: At confluence with Buena Creek (ultimate)
Line 2: Upstream of Calavera Creek (ultimate)
Line 3: Upstream of Calavera Creek (existing)
Point A: Storm of January 12, 2005
Point B: Storm of February 23, 2005

The distribution of mean annual rainfall in San Diego County is shown in Fig. 2. The mean annual rainfall for the Agua Hedionda Creek watershed varies from 11.5 inched at the coast to 15 inches at the eastern boundary. The total rainfall for 2004-5 was about 26 inches for the area, far exceeding the long-term average of about 13 inches. The storms of January 12 and February 23 are far outliers. After discarding the two outliers, the weekly impingement sampling events captured a sufficient number of storm runoff events to reflect typical wet weather conditions for the watershed. Since the remaining rainfall amount still far exceeds the annual average, there was sufficient number of storms to be representative of a normal twelve month period.

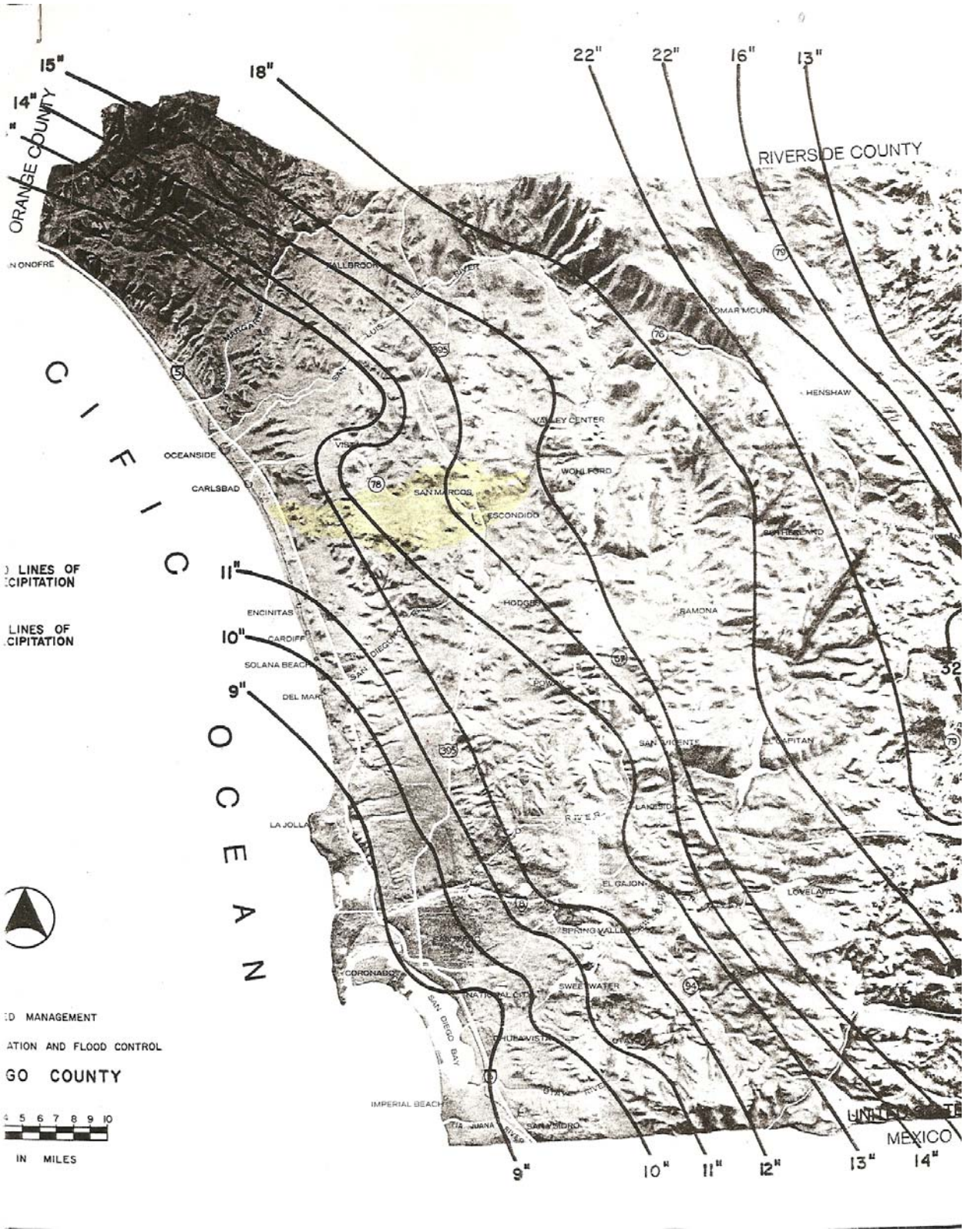

Fig. 2. Mean annual rainfall in San Diego County according to the County Hydrology Manual. The approximate location of the Agua Hedionda Creek watershed is marked in yellow.

REFERENCES

Chang, Howard H., “Hydrological Study for Northeastern Carlsbad – Basins of Calavera Lake Creek and Agua Hedionda Creek”, July 1989.

FEMA, “Flood Insurance Study – San Diego County”, Volume 1 of 7, 1999.

ATTACHMENTS

This report has the following attachments:

JAN12.OUT: Hydrologic simulation for the Agua Hedionda watershed model based on the January 12, 2005 storm
FEB23.OUT: Hydrologic simulation for the Agua Hedionda watershed model based on the February 23, 2005 storm

2005 RAINFALL DATA

CHANGCV.DOC: Curriculum vitae of Howard H. Chang