Mountain View IV
Drainage Study

November 3, 2006

Prepared by
Stantec

Executive Summary

The Mountain View IV project contains approximately 900+ acres for an energy windmill project located in Riverside County. More specifically, the project site is located at the north end of Palm Springs, just west of North Indian Canyon Drive and about a mile south of Interstate 10.

The purpose of this drainage study is to estimate the 100-year water surface elevation at the project, and the scour depth estimation at the foundation of the windmills. The project site is situated in an area where hydrologic/hydraulic data is very limited. Research was conducted to obtain data from the following agencies: Riverside County Flood Control District (RCFCD), Federal Emergency Management Agency (FEMA), United States Army Corps of Engineers (USACE), the City of Palm Springs and the Coachella Valley Water District. As a result of this research, we concluded that very limited drainage information is available for Whitewater River in this reach of study. The total area draining through the project site in Whitewater River is larger than 264 mi^2. Due to the lack of any detailed information available, indirect methods were used in estimating the water surface elevation at the project site. The study report summarizes the method used to estimate the water surface elevation. The water surface elevation obtained here are for planning purposes and are of order of magnitude only. The scour depth was calculated for the estimated 100-year flow in order to design the foundation of the windmills. However, since the design life of the structures are 20-years, the scour depths were also calculated for the 25-year frequency flood.

MOUNTAIN VIEW IV

Table of Contents

LIST OF APPENDICES

LIST OF EXHIBITS

1.0 Introduction

The Mountain View IV project site is located at the north end of Palm Springs, just west of North Indian Canyon Drive, and approximately a mile south of Interstate-10. The site lies within the flow path of the Whitewater River. The project site location is illustrated in the Vicinity Map, **Exhibit A**.

The purpose of this drainage study is to estimate 100-year water surface elevation at the project site and the scour depth corresponding to that flow. The estimated water surface would be preliminary in nature for planning purposes and to give an order of magnitude estimate of the water depth at the site. This depth will be used for designing the minimum height of the foundation above ground where windmill facilities would be installed. The estimated scour depth will be used for designing the depth of the foundation.

Since no water surface elevation is available in any of the past available drainage study in Whitewater River near the project site, it was decided to calculate the water surface elevation (depth) using available hydrologic data (flows) at the project site.

The upstream drainage area is large, approximately 264 square miles, per USGS data, the flows were estimated using indirect methods. An attempt was made to use the hydrologic data from available sources. Research was conducted to obtain data from the following sources: Riverside County Flood Control District (RCFCD), Federal Emergency Management Agency (FEMA), United States Army Corps of Engineers (USACE), the City of Palm Springs and the Coachella Valley Water District. This drainage analysis estimates the 100-year water surface elevation at the Mountain View IV project site.

1.1 TECHNICAL APPROACH

Research was conducted to gather hydrologic data that assisted in the determination of flow depth across the Mountain View IV project site. Several agencies were contacted to request for hydrologic data with little success. With the obtained data, three methods were used to estimate the flows/ water surface in project areas. The three methods are described below.

1. Method 1: This method used Riverside County Flood Insurance Study (FIS) Data and Flood Insurance Rate Map (FIRM) Panel. In this method, the flow at a known location downstream of site was estimated for a depth shown in FIS and the width of flow shown in the FIRM panel. This flow was used to estimate the water depth at the project site.

2. Method 2: This method used USGS regional regression equation to estimate the flow rate at the project site. With the estimated flow rate and cross-section across the project site (available from RCFCD 4' contour topography), the depth was estimated at the project site.

3. Method 3: This method used City of Palm Springs FIRM panels and FIS to determine an approximate flow depth near the project site.

The scour depth was calculated using Colorado State University (CSU) method, as modeled in HEC-RAS computer program.

2.0 Hydrology

2.1 HYDROLOGIC DATA RESEARCH

Research was conducted to gather hydrologic data that assisted in the determination of flow depth across the Mountain View IV project site. Several agencies were contacted to request for hydrologic data with little success. The contacted agencies are: Riverside County Flood Control District (RCFCD), Federal Emergency Management Agency (FEMA), United States Army Corps of Engineers (USACE), the City of Palm Springs and the Coachella Valley Water District.

2.1.1 Riverside County Flood Control District

There was no hydrologic data given to accurately calculate the discharge that impacts the project site.

County topography maps were used to create cross-sections for the hydraulic analysis. RCFCD topographic maps obtained are:

- Section 28, Township 3 South, Range 4 East
- Section 22, Township 3 South, Range 4 East
- Section 21, Township 3 South, Range 4 East
- Section 36, Township 3 South, Range 4 East
- Section 31, Township 3 South, Range 5 East
- Section 1, Township 4 South, Range 4 East
- Section 6, Township 4 South, Range 5 East

2.1.2 Federal Emergency Management Agency

The Federal Emergency Management Agency (FEMA) leads the effort to prepare the nation for all hazards and effectively manage federal response and recovery efforts following any national incident. FEMA also initiates proactive mitigation activities, trains first responders, and manages the National Flood Insurance Program.

Floodplain management is the operation of a community program of corrective and preventative measures for reducing flood damage. These measures take a variety of forms and generally include requirements for zoning, subdivision or building, and special-purpose floodplain

ordinances. FEMA publishes Flood Insurance Rate Map (FIRM) Panels and Flood Insurance Studies (FIS) of communities to determine flooding hazards.

FIRM Panels are an official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community.

Flood Insurance Study (FIS) is a book that contains information regarding flooding in a community and is developed in conjunction with the Flood Insurance Rate Map (FIRM). The FIS, also known as a flood elevation study, frequently contains a narrative of the flood history of a community and discusses the engineering methods used to develop the FIRMs. The study also contains flood profiles for studied flooding sources and can be used to determine Base Flood Elevations for some areas.

FIRM Panels were gathered that corresponded to the Mountain View IV Project site area, which is part of Riverside County, California (Unincorporated Areas). FIRM Panel 060245 0900 D, effective date of November 20, 1996, illustrates the project site is within a Zone A designation. Zone A is categorized as *areas of 100-year flood; base flood elevations and flood hazard factors not determined.*

FIRM Panels 060257 0004 D, effective date of July 7, 1999 and Panel 060257 0003 B, effective date March 2, 1983, cover the southern boundary of the project site. Both of these panels fall within the City of Palm Springs, California. Panel 060257 0004 D has Zone A, Zone A2 and Zone A5 designations as described as:

> Zone A is categorized as *areas of 100-year flood; base flood elevations and flood hazard factors not determined.*
>
> Zone A1-A30 is categorized as *areas of 100-year flood; base flood elevations and flood hazard factors determined.*

FIRM Panel 060257 0003B has a Zone A designation. Refer to the FIRM Panel Index Map, **Exhibit B**.

Approximately 8,300 feet downstream from our site, FIRM Panel 060245 1560 B, effective date March 22, 1983, was used as reference material. This panel illustrates that there was a detailed study completed for this section of Whitewater River. The panel shows base flood elevations and determined the flood hazard factors.

From the FIRM Panels it was approximated that the floodplain width across the Mountain View IV Project site area is 12,000 feet.

The FIS for Riverside County, California, effective date August 18, 2003, was used to obtain the depth of flow for the detailed studied section of Whitewater River, as shown on FIRM Panel 060245 1560 B. The water surface profile on panel 92P, of the FIS, shows a depth of flow of 2 feet at the upstream limit of the detailed study. This depth was used in the hydraulic analysis to

determine the approximate flow rate. The FIS did not detail the 100-year flow rate for Whitewater River.

2.1.3 U.S. Army Corps of Engineers

There was no hydrologic data given to accurately calculate the discharge that impacts the project site.

2.1.4 City of Palm Springs

City of Palm Springs is the local agency just south of the Mountain View IV project site. A request was made to the City for hydrologic data that can aid in the calculation of runoff that impacts the project site. City staff provided FIS for the City of Palm Springs, California, Riverside County, effective date July 7, 1999. This study states that the 100-year discharge for Whitewater River downstream of the Palm Canyon Wash confluence is 47,000 cfs. The Palm Canyon Wash confluence is approximately 7.7 miles (40,656 feet) downstream from the project site.

The City of Palm Springs also provided the Flood Profile for the Whitewater River illustrating that 100-year discharge may have a depth of 1-foot across the project site. This is shown in the FIS on panel 25P, which is included in the appendix.

2.1.5 Coachella Valley Water District

There was no hydrologic data given to accurately calculate the discharge that impacts the project site.

2.1.6 U.S. Geological Survey

The Nation's largest water, earth, and biological science and civilian mapping agency, the U.S. Geological Survey (USGS) collects, monitors, analyzes, and provides scientific understanding about natural resource conditions, issues, and problems.

The USGS collects data, via rain gages, to keep record of rainfall events throughout the United States. The closest rain gage is 10257550, Whitewater River at Windy Point, near White River, California. The location of the gage is Latitude 33 degrees 53 minutes and 56 seconds, Longitude 116 degrees 37 minutes and 13 seconds, in SW ¼ NE ¼ of Section 24, Township 3 South, Range 3 East, Riverside County, on the right bank 200 feet north of Highway 111, 2 miles southeast of White Water, and 3.8 miles east of the junction of Highway 111 and Interstate 10. The drainage area to this gage is 264 square miles and the maximum computed discharge was 2,530 cfs, which was dated in January 10, 1995. The Mountain View IV Project site is approximately 2.4 miles downstream of this rain gage.

USGS topography maps were used to assess the project site's surrounding watershed.

Research was gathered from *U.S. Geological Survey Water-Resources Investigations Report 94-4002: Nationwide summary of U.S. Geological Survey regional regression equations for*

estimating magnitude and frequency of floods for ungaged sites, 1993. In summary the report states that California is divided into six hydrologic regions: North Coast Region, Northeast Region, Sierra Region, Central Coast Region, South Coast Region and South Lahontan-Colorado Desert Region. The project site is within the South Lahontan-Colorado Desert Region. The regression equations developed for these regions are for estimating peak discharges having recurrence intervals that range from 2 to 100 years. The variables used in the equations are drainage area (A), in square miles; mean annual precipitation (P), in inches; and an altitude index (H), which is the average of altitudes in thousands of feet at points along the main channel at 10 percent, and 85 percent of the distances from the site to the divide. The variables A and H may be measured from topographic maps. Mean annual precipitation is determined from a map in Rantz (1969). The regression equations were developed from peak – discharge records of 10 years or longer, available as of 1975, at more than 700 gaging stations throughout the State. The regression equations are applicable to unregulated stream but are not applicable to some parts of the State. The report is included in the appendix.

The equation used to estimate the 100-year runoff that impacts the project site is as follows:

$$Q_{100} = 1080A^{0.71}$$

From this equation the approximate runoff generated from the project's upstream 279.5-acre watershed is 58,900 cfs. Refer to **Exhibit C** for an illustration of the watershed map. The exhibit shows the additional 15.5-square miles added to the upstream 264 square miles that impact Rain Gage 10257550. Therefore am approximate total of 279.5 square miles of watershed area impact the site. It must be noted the equation is defined only for basins of 25 square miles or less in the Northeast and South Lahontan-Colorado Desert region. However since the drainage yield (cfs/acre) for larger drainage area (279.5 mi^2) is smaller, we estimate that the drainage flow estimated using USGS method would be more conservative (larger). Therefore, in the spirit of finding the depth corresponding to a more conservative situation, we decided to use the USGS Regression Equation. The corresponding 25-year flow was also estimated using USGS Equation, which is:

$$Q_{25} = 410A^{0.63}$$

The 25-year frequency flow was estimated to be 14,300 cfs.

3.0 Hydraulic Analyses

Whitewater River near the project site is very flat (about 1.7% longitudinal slope), and there has no immediately constriction to cause a backwater. Therefore Manning's Normal Depth method was used to establish relationship of depth with estimated flow.

The Manning equation is an empirically derived formula used to determine the flow in open channels.

$$Q = (1.49/n)\ AR^{(2/3)}\ S_0^{(1/2)}$$

Where the variables are:

Q = Flow in cubic feet per second

n = roughness coefficient

A = cross-sectional area of flow in square feet

R = hydraulic radius = A/P, if feet

P = wetted perimeter in feet

S_0 = slope of the channel

Haestad Methods' FlowMaster Program, Version 2005, was used to perform the hydraulic analysis. This program was used to solve for discharge and normal depth. FlowMaster has been accepted by the U.S. Federal Emergency Management Agency (FEMA) and added to its list of numerical models accepted for use in the National Flood Insurance Program (NFIP).

Riverside County topography maps were obtained to extract two cross-sections (cross section A and B). These cross section locations are shown on **Exhibit D**.

The three methods used to estimate the water surface elevation at the project site are discussed below.

Method 1

Cross-Section-A illustrated on **Exhibit D.1** has a 100-year water depth of 2 feet, as shown on the Riverside County FIS. This depth, when used with normal depth formula and the extracted cross section, we estimated a flow of 29,664 cfs at Section-A. This discharge amount was taken approximately 8,300 feet (1.6 miles) downstream from the project site. Thus, the

discharge is a conservative approximation for the discharge used for the cross-section, Cross-Section B, across the project site, refer to **Exhibit D.2**.

Using the FIRM Panel 060245 0900 D, a flow width was taken to be approximately 12,690 feet across the project site at Cross Section B. Given a discharge of 29,664 cfs and a bottom width of 12,690 feet, FlowMaster was used to calculate the normal depth across the Mountain View IV project site. With a channel slope of 0.017 ft/ft and a Manning's roughness coefficient of 0.030, a normal depth of 0.54 feet was estimated.

Method 2

Comparatively, the discharge calculated from the regional regression equation for the South Lahontan-Colorado Desert Region yielded a flow rate of 58,900 cfs. Using the Cross-Section B, a normal depth of 0.82 feet was estimated for the flow estimated by Regression Equation.

Method 3

From City of Palm Springs FIS, the Confluence of Whitewater River at Canyon Wash has a flow rate of 47,000 cfs. This location is downstream of the project site and using this value would only be a conservative estimate (larger) flow at the project site. Therefore a flow depth using this flow would be somewhere between Method 1 and 2. Therefore, no hydraulic calculation was further pursued for this method.

Based on the three methods above, the maximum flow depth is 0.82', which we establish to approximately 1'.

The flow rates from the gathered hydrologic/hydraulic data and the estimated flow rates calculated in this study are plotted on the Discharge Point Locations Map, **Exhibit E**. This exhibit illustrates the discharge comparison of the Whitewater River data to the Mountain View IV project site calculated discharges.

4.0 Scour Analysis

The computation of scour at piers, within HEC-RAS was based upon the methods outlined in Hydraulic Engineering Circular No. 18 (FHWA, 2001).

4.1 MODELING GUIDELINES

In order to perform a pier scour analysis (the wind turbine and transformer foundations are modeled as piers), a hydraulic model of the river reach containing the piers was analyzed. This model included several cross sections downstream from the piers, such that any user defined downstream boundary condition does not affect the hydraulic results inside and just upstream of the bridge. The model included several cross sections upstream of the piers, in order to evaluate the long term effects of the bridge on the water surface profile upstream.

Pier scour was computed by the Colorado State University (CSU) equation. The CSU equation predicts maximum pier scour depths for both live-bed and clear-water pier scour. The maximum velocity and depth were used in order to account for the potential of the main channel thalweg to migrate back and forth within the piers. The migration of the main channel thalweg could cause the maximum potential scour to occur at any one of the piers.

Pier scour occurs due to the acceleration of flow around the pier and the formation of flow vortices (known as the horseshoe vortex). The horseshoe vortex removes material from the base of the pier, creating a scour hole. As the depth of scour increases, the magnitude of the horseshoe vortex decreases, thereby reducing the rate at which material is removed from the scour hole. Eventually, equilibrium between bed material inflow and outflow is reached, and the scour hole ceases to grow.

The factors that affect the depth of local scour at a pier are: velocity of the flow just upstream of the pier; depth of flow; width of the pier; length of the pier if skewed to the flow; size and gradation of bed material; angle of attack of approach flow; shape of the pier; bed configuration; and the formation of the debris.

4.2 HYDRAULIC MODEL

A cross section was created to represent the row of wind turbines and transformers that are proposed for the Mountain View IV project. As mentioned above several cross sections were modeled upstream and downstream of the structures, refer to **Exhibit F**.

Based on the normal depth analysis (FlowMaster), a cross section with a bottom width of 12,690 feet and a flow rate of 58,900 cfs generated a depth of 0.82 feet. The cross section conveys 4.64 cfs/ft (unit flow) based upon the given width and flow rate. The cross section selected in HEC-RAS is 2,000 feet wide for a typical 10 foundations. With the given unit flow the flow rate used in the model was 9,280 cfs. This flow rate calculated a flow depth of 0.87 feet in the HEC-

RAS analysis which is close to the originally anticipated depth of 0.82 ft. A similar analysis was made for 25-year frequency flow of 14,300 cfs, which has a unit flow of 1.13 cfs/ lineal foot.

4.3 SCOUR RESULTS

After the river hydraulic model was completed the wind turbine and transformer data was entered as piers in the HEC-RAS model. As a result of the scour analysis the wind turbines and transformers will have a scour depth of 11.3 ft and 10.7 ft, respectively for 100-year scenario. The same scour for a 25-year flow is 7.1 ft and 6.8' for the wind turbines and transformers, respectively. Since the structure expected life is 20-years, the appropriate design frequency for scour is 25-years or less. Therefore the design foundation depth (30' for turbines and 10' for transformers) is larger than the scour depth for 25-year flood (7.1' for turbines and 6.8' for transformers). Thus the foundation design depth is adequate for 25-year flood protection against scour.

5.0 Summary

In order to determine the flow depth across the Mountain View IV project site research was conducted to obtain hydrologic/hydraulic data from several agencies. With the data gathered, three methods were used to determine the flow depth across the project site, and they were:

4. Method 1: This method used Riverside County Flood Insurance Study (FIS) Data and Flood Insurance Rate Map (FIRM) Panel. In this method, the flow at a known location downstream of site was estimated for a depth shown in FIS and the width of flow shown in the FIRM panel. This flow was used to estimate the water depth at the project site.

5. Method 2: This method used USGS regional regression equation to estimate the flow rate at the project site. With the estimated flow rate and cross-section across the project site (available from RCFCD 4' contour topo), the depth was estimated at the project site.

1. Method 3: This method used City of Palm Springs FIRM panels and FIS to determine an approximate flow depth near the project site.

It was determined, based on the analyses above, that the Mountain View IV project will encounter a flow depth of approximately 1-foot. Thus, in order for proposed structures to be safe from the 100-year flow, the finished pad elevations of proposed structures must be 2-feet (including 1-foot of freeboard) above the existing ground. It is to be noted the method used to estimate the water surface elevation is approximate and is to be used for planning purposes only.

The structure (turbine and transformer) expected life is 20-years. Therefore 25-year frequency flood was chosen for estimating the scour depth against the safety. As a result of the scour analysis the wind turbines and transformers will have a scour depth of 7.1 ft and 6.8 ft, respectively. Thus, the wind turbines and the transformers with its foundation depth of approximately 30 ft and 10 ft respectively will be adequate.