Sunrise Powerlink Transmission Line Project
Application No. 06-08-010
MGRA Phase 1 Direct Testimony, Appendix F

APPENDIX F – SANTA ANA WINDS

F1. Data Sources

F1.1. Mesowest Weather Data

Distribution: Open

Location: http://www.met.utah.edu/mesowest/

Description: Data for RAWS and other weather stations in a database searchable by web interface. Hourly data can be obtained for any date extending back to the time that collection started for a particular station. This data is displayed in graphical (and optionally tabular) form for windows extending from 12 hours up to 30 days.

Fields: Temperature, relative humidity, wind speed (sustained & gust), wind direction, precipitation

Restrictions & Limitations: Data for SD County RAWS stations goes back to 1999, with many coming on-line between 1999 and 2001. Non-RAWS stations sometimes lack wind gust data. Data quality is considered marginal for older data. Anomalous functioning can often be identified by “wild swings” in measurements for one parameter or another, or by missing blocks of data. Also, there is no guarantee that the measurements taken by a RAWS station are characteristic of the general area where it is sited.

Processing: RAWS data was downloaded for a window surrounding key wind events with a width of at least 12 hours.

F1.2. Poisson statistics calculator

For determining confidence levels and statistical uncertainties for small values, the Poisson.rb[1] calculator was used (available from M-bar Technologies & Consulting). This

[1] Attached as Poisson.rb

calculator estimates the probability of a random event occurring within a specified interval for a given distribution mean. It is used iteratively to determine 90% confidence levels. For a two-tailed distribution, this entails determining the 95% upper and 95% lower interval.

F1.3. National Digital Forecast Database Archives

Distribution: Open

Location: Archived at the National Climate Data Center: http://has.ncdc.noaa.gov

Description: Archived forecast data for the National Digital Forecast Database (NDFD) consist of all forecast information from the National Weather Service in a grid format. These are the raw data used by weather offices to make their forecasts, and only over the last few months (from mid 2006) have these become available for Southern California. The grid forecast made at a given time projects outward for a certain period into the future, and each future projection constitutes its own grid. The data product is described in this reference[2].

Fields: Data for temperature, humidity, precipitation, wind speed and direction, and several other quantities are available separately. All available fields are described here: http://www.weather.gov/ndfd/technical.htm .

Restrictions and Limitations: Datasets are large, and take some time to download. For this reason, only wind data have been analyzed for the economic impact analysis. Data have only become available since mid-2006, meaning that only recent Santa Ana events can be analyzed. Grids are also coarse (5 km), meaning that local weather conditions may not be well-represented.

Processing: Datasets must be selected in order to be downloaded from NCDC. Once downloaded, they need to be processed with the *tkdegrib* program to create shapefiles that can be used by GIS systems. This is available here: http://www.weather.gov/mdl/NDFD_GRIB2Decoder/index.php

F1.4. Calfire EARS ignition data

Distribution: Restricted

Location: Contact CalFire for access to EARS data.

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[2] Glahn, Harry R. and David P. Ruth; The New Digital Forecast Database of the National Weather Service; Bulletin of the American Meteorological Society , February 2003, p. 195

Description: The EARS database lists every wildland fire ignition that Calfire (formerly CDF) has responded to, and captures a large number of variables associated with the event. This particular dataset was provided on request from Calfire, and consists of EARS data for San Diego County between 2003 and 2006.

Fields: Among relevant fields are fire name; the date and time of report, of containment, and of control; vegetation type, area type, acres burned, monetary losses, latitude and longitude; fire conditions. There are many other fields as well.

Limitations: Sometimes exact times are missing from the analysis.

Processing: Extra fields for correlation with RAWS weather station data were added.

F2. Analyses

F2.1. Santa Ana Events in RAWS data

F2.1.1. Goal

The goal of this analysis is to identify a metric that will scale both with hazard to power lines and the threat of wildland fire.

F2.1.2. Description

RAWS weather station data archived at Mesowest (section F1.1) has been analyzed to determine how many hours weather stations at different locations spend under conditions of high wind as well as low-humidity wind conditions that characterize Santa Ana events. From the point of view of power line faults, the wind speed is relevant, since the fault rate is expected to vary with wind speed. It follows that the more time that the power lines spend under stress conditions, the more likely it is that a fault will occur. Therefore, tracking the number of hours that specified locations spend under high wind conditions should allow us to gauge the relative threat to power lines. Likewise, the probability that an ignition of any sort will trigger a major fire is expected to be proportional to the time that a power line segment at a given location spends under windy, dry Santa Ana conditions.

This analysis, therefore, tallies the number of hours that the RAWS weather stations spend under windy conditions, and under dry windy conditions.

F2.1.3. Methods

Graphical RAWS data was downloaded from the Mesowest interface for the weather stations at Potrero, Ranchita, Julian, and Goose Valley. An example is shown below:

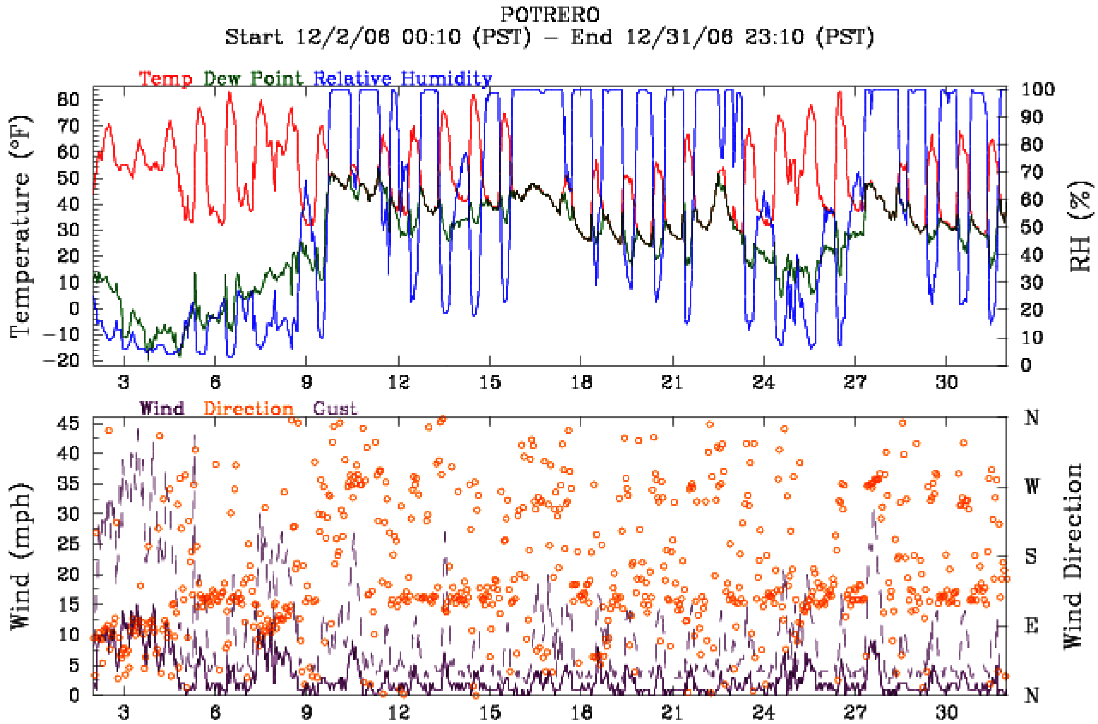


Figure F-1 – Example of RAWS weather station data provided by Mesowest (**http://www.met.utah.edu**). This graph shows data for temperature, dew point, relative humidity, wind, wind gust and direction for a period of 30 days prior to midnight 1/1/2007. Each 'tick' or point represents one hour.

To estimate the wind impact, the number of hours that the wind gust speed spent above threshold values was determined by measuring off of a graph such as that shown in Figure F-1. The threshold values used were 25, 30, 40, and 50 mph.

A parallel analysis was conducted that accepted wind values above the thresholds only if the relative humidity was less than 20%. This model is intended to capture true "Santa Ana" conditions.

F2.1.4. Analysis

The data was extracted from the 30-day graphs supplied by Mesowest for the Ranchita, Goose Valley, Julian, and Potrero RAWS. Ranchita and Goose Valley stations had data analyzed back to 2002, Potrero back to 2004, and Julian to 2005. These data can be seen in the file attached below:

Wind_SantaAna_mes
owest_Mbar_v1.0.xls

File F-1 – This file contains the data for the number of hours per month that the four weather stations from Goose Valley, Ranchita, Julian and Potrero exceeded gust wind speeds of 25, 30, 40 and 50 mph. A parallel analysis is performed to count number of hours of gust winds exceeding threshold *only if* the relative humidity is less than 20%, which characterizes Santa Ana conditions[3].

Some results are summarized in the table below:

	2006	**2005**	**2004**	**2003**	**2002**
Potrero	164/164	76/31	89/46	--	--
Goose Valley	14/14	5/2	5/5	48/41	32/27
Julian	290/65	65/0	--	--	--
Ranchita	411/12	476/6	522/26	686/31	514/61

Table F-1 – This table shows the number of hours over the given year that each weather station experienced gusting winds over 30 mph. The two numbers on either side of the slash '/' represent (all hours) / (hours with relative humidity <20%). For example, in 2005 Ranchita had 476 hours that had wind gusts over 30 mph, but only 6 of these hours were under conditions of low humidity. Some data is missing due to time constraints.

This table has several interesting characteristics. First, there is a tremendous variation from year to year in the number of hours that serious wind conditions occur at a given location. The years 2004 and 2005, for instance, were particularly mild while the year 2003, the year of the fire siege, had particularly severe Santa Ana conditions. The most extreme example of this variation is Julian, which saw 290 hours of gusting winds over 30 mph, with 65 under dry conditions in 2006, which followed 2005 in which only 65 hours were experienced, with none of them under dry conditions.

Another observation is that there is a great deal of variation from weather station to weather station. This could be due to variations in the weather patterns themselves, meaning that the high winds are very localized, or possibly that the weather stations themselves are located in places where they are sheltered from Santa Ana conditions.

[3] MGRA_Mbar_SPL_AppF-1_Wind_SantaAna_mesowest.xls.pdf

One final observation is that some locales are ‘drier’ than others. Ranchita and Julian, for instance, have the highest winds, but the number of hours spent under ‘Santa Ana’ conditions tends to be a small fraction of the windy hours. Potrero and Goose Valley, on the other hand, tend to experience windy conditions primarily under ‘Santa Ana’ conditions.

Both ‘total’ and ‘Santa Ana’ numbers are of concern for transmission line planning. The raw wind intensity has been correlated with line faults, and is more likely to lead to stress failures, as discussed in Appendix A. The probability that such a failure will lead to a catastrophic fire is better characterized by the number of these hours spent under ‘Santa Ana’ conditions. Normalizing to the number of active hours per weather station (they were not operational 100% of the time) allows us to obtain a ‘probability’ fraction per site, which gives the probability that any given moment in the specified year would have been in an hour in which Santa Ana humidity and wind conditions existed. These are listed below.

	2006	**2005**	**2004**	**2003**	**2002**
Potrero	0.0194	0.00368	0.00559	--	--
Goose Valley	0.00204	0.000291	0.000589	0.00491	.00321
Julian	0.00769	0.0	--	--	--
Ranchita	.00141	0.000716	0.00305	0.00366	0.00791

Table F-2 – This table shows the probability of Santa Ana conditions occurring at any randomly specified time during the specified year according to the weather station data. This takes the Santa Ana (relative humidity under 20%) values from table

Table F-1 and normalizes them by the number of live hours during the given year. Some data is missing due to time constraints.

Aside from the observations already made, another one is apparent – Santa Ana conditions with severe winds and low humidity are fairly rare events in the overall scheme of things, taking up just .05 – 1 % of the total time period.

F2.1.5. Limitations

No direct access to the Mesowest database has yet been obtained, meaning that all RAWS station data had to be extracted manually through a web interface. As a result, the analysis is quite incomplete, and may have some bias due to graphical measurement errors. These were consistent at least, since when counts were repeated they usually reproduced within a few percent.

A more complete set of weather station Santa Ana data should be assembled as a component of any route analysis performed in the EIR.

F2.1.6. Conclusions

Santa Ana wind conditions are rare, taking up only .1 to 1 % of the total time, as measured by weather station data. Some locations are significantly windier and drier than others, and this should be taken into account for transmission line route planning. There is also significant year-to-year variation at each location. A more complete set of weather station Santa Ana data should be assembled as a component of any route analysis performed in the EIR.

F2.2. NDFD Wind Maps for the SPL route

F2.2.1. Goal

To use the wind patterns forecasted for Santa Ana conditions to help interpolate between weather station data, thus allowing the creation of an overall 'Santa Ana wind hazard map', which can be used in transmission line route analysis.

F2.2.2. Description

NDFD (National Digital Forecast Database) information was obtained from the National Climate Data Center (NCDC), as described in F1.3. This was processed into GIS compliant files, and these were then used to compare against real RAWS data for Santa Ana events occurring in late 2006 and early 2007. By using these maps and comparing to weather station data, it should be possible to gauge Santa Ana hazards for transmission line fires as a function of location.

F2.2.3. Methods

Using RAWS weather data, described in F1.1, the exact times of Santa Ana events in the period from late 2006 to early 2007 were obtained. Data requests were placed for NDFD data corresponding to these periods. These data were downloaded from NDFD and then processed with the *tkdegrib* utility (also available for download from NCDC) to obtain GIS 'shapefiles'. These were all given the same scale.

The predicted (NDFD) versus actual (RAWS) weather station data was then collected for weather stations in Ranchita, Potrero, Julian, Goose Valley, and Ammo

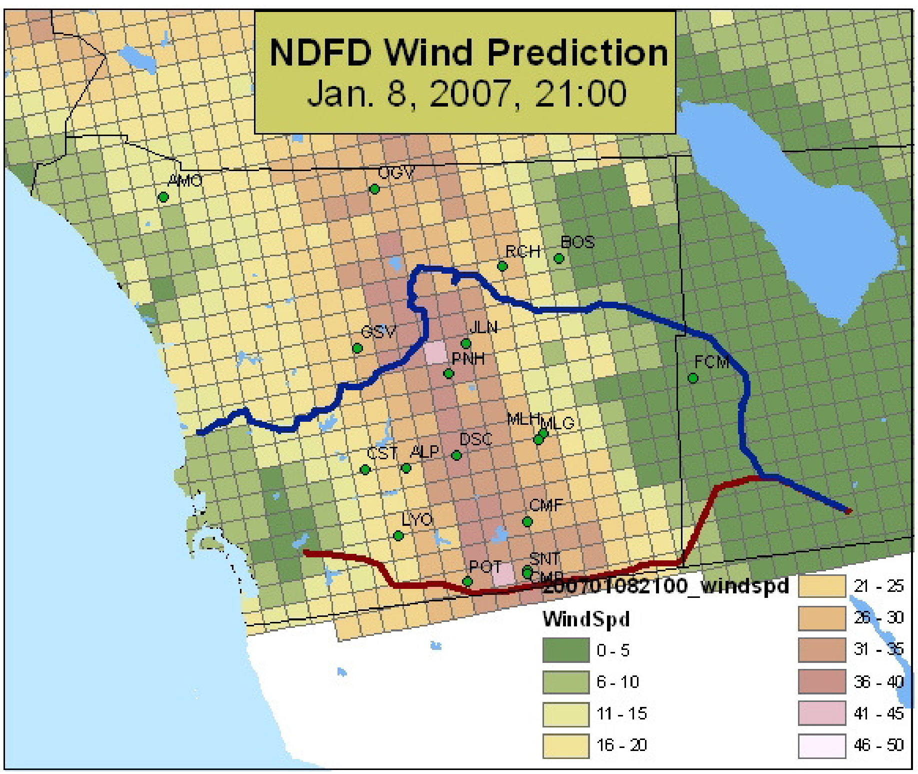
Dump. In all, four events were analyzed, with multiple times being sampled during each event. These can be found in the file *SA_Events_Mbar_0607_v1.0.xls,* attached below.

SA_Events_Mbar_0607_v1.0.xls

File F-2 – Santa Ana wind events as measured by NDFD predictions and measured RAWS weather station data[4].

F2.2.4. Analysis

Four Santa Ana wind events were analyzed. These occurred October 26, 2006; December 3-4, 2006; January 7-9, 2007, and January 15-16, 2007. Data was taken every three hours for the first event, and every six hours for the last three. The NDFD data was extracted into GIS files, and predicts one hour into the future. An example can be seen below:



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[4] Attached as SA_Events_Mbar_0607_v1.0.xls. Data in Excel spreadsheet form available from MGRA.

Figure F-2 – This figure shows a forecast from the National Digital Forecast Database for a Santa Ana event occurring on Jan. 8, 2007. Continuous wind speeds are plotted in knots. Data were compared against RAWS data from the stations Potrero (POT), Julian (JLN), Goose Valley (GSV), Ranchita (RCH) and Ammo Dump (AMO).

The event shown in Figure F-2 is typical of Santa Ana distributions observed in other events, in which the most intense winds are distributed in a band trending roughly north-south through the center of the county, with greater concentrations occurring near Julian and again near Potrero and Campo. Both SWPL and the proposed SPL route pass through regions of the most intense wind.

These data were compared against the RAWS data obtained from Mesowest in order to see how well the predictions correlate with the expected values. These results are shown in the figure below:

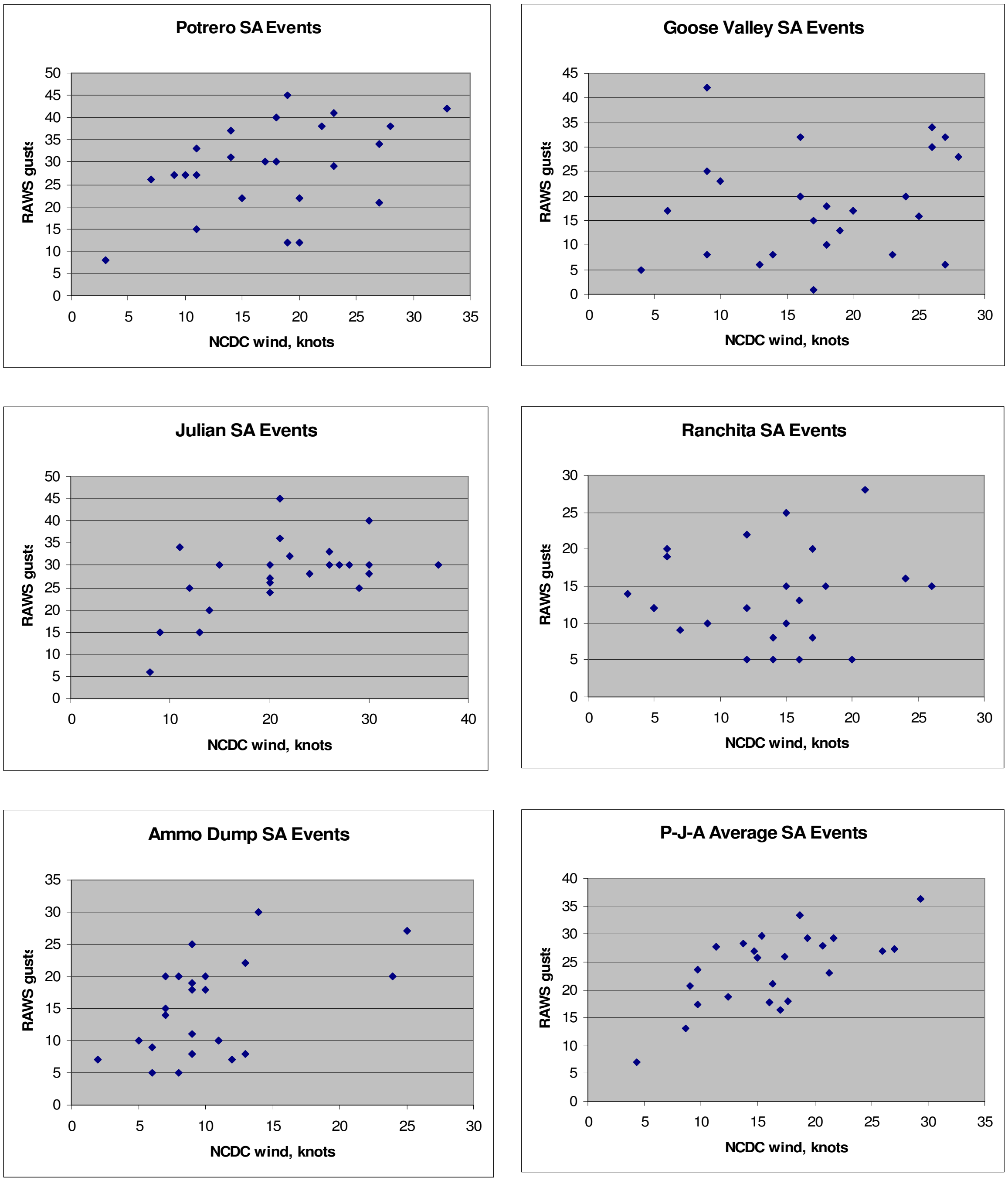

Figure F-3 – This figure shows the comparison of NDFD data and RAWS gust speeds for all Santa Ana data in the sample. Data were analyzed for five stations: Julian , Potrero, Ranchita, Ammo Dump, and Goose Valley. Correlation is observed for the Julian, Potrero, and Ammo Dump stations, but little correlation is seen for the Goose Valley and Ranchita stations. The P-J-A average shows the average over the three correlating stations (Potrero, Julian, Ammo Dump), and it can be seen that this value shows an even tighter correlation than the individual stations.

It should be mentioned that the NDFD data are for continuous wind speed in knots, whereas the Mesowest RAWS data are gust speeds in mph, so one would not expect the same values. Of the five stations analyzed, only three – Potrero, Julian, and Ammo Dump seemed to show a noticeable correlation between the NDFD predictions and the measured RAWS data. The Ranchita and Goose Valley stations do not. Some possible reasons are:

- The NDFD might not accurately model Santa Ana conditions in the grid cells containing the Ranchita and Goose Valley weather stations.

- The RAWS stations at Goose Valley and Ranchita may not provide an accurate representation of the grid cell in which they are located.

An average of the Ammo Dump, Potrero, and Julian stations is also shown in Figure F-3. This same average was used in Appendix A as the wind speed metric used for power line outages. Note that the correlation is tighter than for any of the stations individually, indicating that the average of these stations does accurately track the intensity of Santa Ana events.

Averaging over all data per location will yield an average value that helps to measure the relative Santa Ana intensities for various locations. These averages are shown in the table below:

Weather Station	NDFD avg (knots)	RAWS gust avg (mph)
Julian	21.4	27.9
Potrero	17.5	21.6
Ranchita	13.5	13.5
Goose Valley	17.5	18.1
Ammo Dump	10.2	15.0

Table F-3 – In this table the wind values measured for all time slices for all four Santa Ana events are averaged per weather station. For the three stations that show correlation between predicted and measured values, the RAWS gust speeds (in mph) are 30-50% larger than the predicted NDFD continuous wind speeds (in knots).

For the three stations that show correlation between predicted and measured values, the RAWS gust speeds (in mph) are 30-50% larger than the predicted NDFD continuous wind speeds (in knots). This supports the hypothesis that the NDFD wind maps may be used to interpolate data between weather stations.

In order to help reduce fire risk and resulting economic impacts, wind intensity needs to be included in the route hazard analysis. One way that this could be done would be to average the wind intensity maps with the highest value in order to create a 'wind hazard map'. The path of the SPL proposed route should be traced through this map as part of the Route Hazard Analysis discussed in Appendix D. <u>These analyses should be conducted as a required part of the EIR.</u>

F2.2.5. Limitations

Only four Santa Ana events were analyzed. Partially, this is due to the fact that the availability of NDFD data only started in 2006. Time constraints did not allow the full use of all 2007 events in this phase of testimony.

<u>Additionally, in order to predict full Santa Ana hazard, the humidity also needs to be compared and normalized. This is also available from the NDFD. Such an analysis should be conducted as part of the EIR.</u>

<u>An averaging over events was not performed in order to create a wind hazard map. This needs to be done as part of the EIR</u>.

F2.2.6. Conclusions

The NDFD wind prediction maps show correlation with observed weather station data. This means that they can be used to create a wind hazard map that allows extrapolation between weather stations. This wind hazard map should then be applied to an analysis of the line route as part of a Route Analysis, as shown in Appendix E. <u>These analyses should be conducted as a required part of the EIR.</u>

F2.3. Ignition During Santa Ana Events

F2.3.1. Goal

To determine how the intensity of Santa Ana events affects the success rate of fire service initial attack.

F2.3.2. Description

The EARS data (CalFire ignition database) from CDF for San Diego County is analyzed for overall ignition rates. We then look only at time periods during which Santa Ana conditions were present somewhere in San Diego County, and select these ignitions. These are then correlated with wind speed, and the success rate of firefighter initial attack (determined by acres burned) is determined.

F2.3.3. Methods

The EARS data for San Diego County between Jan 1, 2003 and Dec. 31, 2006 was obtained. Overall ignition rates can be determined by dividing by the length of time in this span, while the initial attack success rate has been determined using two different criteria: acres burned less than 10 acres, and acres burned less than 100 acres.

This analysis then uses RAWS data to determine Santa Ana conditions, using the Goose Valley and Ranchita records (since they have been analyzed back to 2002) to indicate where Santa Ana conditions might have occurred. Candidate time windows were examined using Potrero and Julian data, and if any of the stations met the criteria gust wind speed > 30 mph and relative humidity < 20 % then data were entered for Julian, Potrero, and Ammo Dump weather stations into a working copy of the database. These were averaged to obtain a wind speed metric, as was also done in Appendix A.

Another wind speed metric was also used. As part of the EARS database, the nearest RAWS weather station is recorded. The value of wind gust speed from this weather station was entered if available.

Wind speeds from the RAWS data were determined by choosing the greatest wind speed that occurred up to six hours prior to the ignition until the time of fire containment. This hopefully measures the overall strength of the event in question rather than a spatial or temporal fluctuation of the wind speed. This type of time-averaging is supported by the results shown in Section F2.2.4. These fires were selected and are listed in the table below, along with corresponding RAWS data.

EARS_RAWS_Mbar_
SAEvents_0306.xls

File F-3 – EARS data for ignitions in San Diego County between 2003 and 2006, selected for fires that started during Santa Ana periods[5].

The size of fire was plotted against the wind speed. Success rates were determined by number of fires exceeding a 10-acre threshold and a 100-acre threshold.

F2.3.4. Analysis

In the period from January 1, 2003 to December 31, 2006, there were 941 ignitions reported by the CDF within its jurisdiction. Of these, 21 fires were 100 acres or larger, while 80 fires were 10 acres or larger. If we define these as the thresholds for successful

[5] Attached as EARS_RAWS_Mbar_SAEvents_0306.xls.

initial attack, then the corresponding success rates would be 97.8% and 91.5%, respectively.

We hypothesize that during Santa Ana wind events, the success rates will be lower. The data in File F-3 has been selected so that only ignitions that occur during Santa Ana periods are included. However, the presence of the conditions does not necessarily imply that the ignition location was experiencing these conditions. In order to estimate conditions at the ignition point, two metrics were tried: First, the wind speed at the nearest RAWS station was used, and second the average of the Ammo Dump, Potrero, and Julian stations was used. The variation of acres burned with these wind speeds is plotted below:

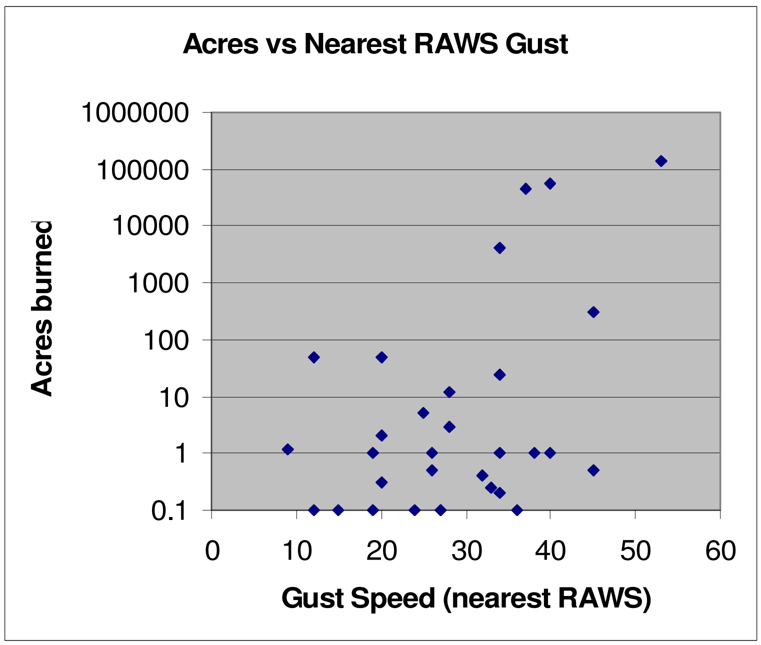

Figure F-4 – This figure shows the acres burned versus the gust speed at the RAWS station nearest to the ignition point that occurred within six hours before the ignition up to the time of containment. Speed is in mph.

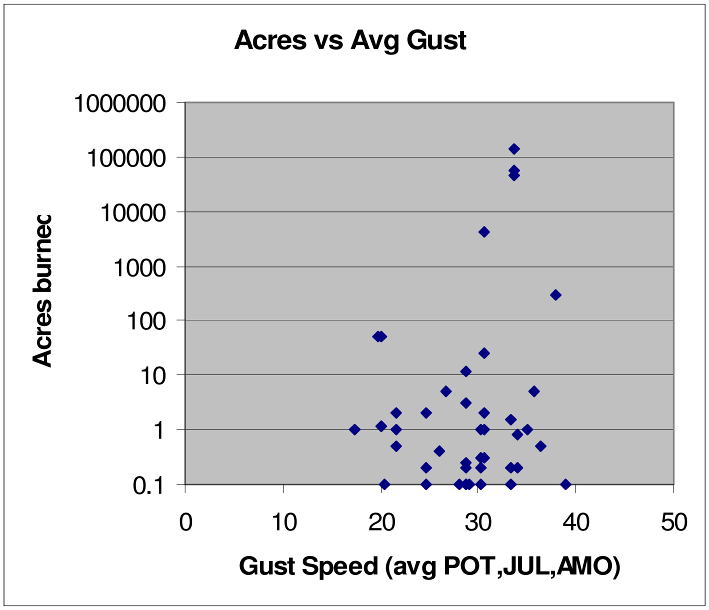

Figure F-5 - This figure shows the acres burned versus the average gust speed of the Julian, Potrero, and Ammo Dump RAWS stations. Wind values occurred within six hours before the ignition up to the time of containment. Speed is in mph.

It can be seen that the 'nearest station' RAWS data seems to be more predictive of final outcome than the averaged gust speeds.

It should be noted that the figures show that all major fires larger than 100 acres occurred for wind gust speeds in excess of 30 mph. In Figure F-4, 14 events occur in which gust speeds at the nearest RAWS station were in excess of this value. Of these, five events were larger than 100 acres and six events were larger than 10 acres, corresponding to approximate attack success rates of 64% and 57%, respectively.

The values in the above plots can be compared with those in section F2.1.4. It was estimated that the probability of any given site experiencing Santa Ana wind conditions with wind speeds in excess of 30 mph at any given time was between .05 and 1 % for the stations checked. For 941 fires, then we would expect between .5 and 9.4 ignitions to occur during peak wind periods if the distribution was random. The measured value of 14 is high, indicating a non-random effect that correlates the ignitions and Santa Ana wind conditions. Aside from power line ignitions (the Open fire, at 296 acres, is a power line fire included in this sample), there are other effects that could possibly cause this correlation:

- Arsonists may be more likely to set fires during Santa Ana wind conditions in order to achieve a greater effect.

- Fires that would ordinarily be extinguished by civilians and therefore not be included in the EARS database escape civilian control and require CDF intervention.

We can also relate this value to the predicted SPL fire rate from Appendix B (Sec. 2.3.4) of one fire every 15 years (with 90% CL from 3 years to 150 years). Since one would expect these fires to occur during SA wind conditions, we can make the further statement that the predicted rate of a large fire in excess of 100 acres that would evade initial attack would occur every 42 years, with the confidence interval even larger due to the considerable uncertainties in the initial attack rates. This assumes that success rates will be the same as they would be elsewhere in San Diego County. Due to the remoteness of many segments of the proposed route, however, we could reasonably expect the attack success rate to be somewhat lower. We could also expect that in the high-wind areas traversed by the line, there will be more events ignited during Santa Ana conditions.

F2.3.5. Limitations

It was not possible to get data for the weather station specified as FMC in the EARS database. When this station was specified, the nearby Valley Center RAWS station was used instead.

One of the differences between the ‘nearest station’ and the ‘averaged station’ plots arises from the fact that there were a large number of ignitions during a brief Santa Ana period in January 2003, and that there was no ‘nearest RAWS station’ weather data for this event.

The statistics of large events occurring during Santa Ana events is very small, and hence the attack rate success is approximate.

F2.3.6. Conclusions

Ignitions that occur during a Santa Ana event are seen to be much more likely to escape initial attack and grow to large size. The initial attack success rate of 98% for keeping the fire under 100 acres drops to very approximately 64% under these conditions. Predictive wind measurements can be determined by using data from the RAWS weather station closest to the ignition point. These indicate that there is a threshold of wind gust speed of around 30 mph above which rapid fire spread is more likely. The data for large fires exhibits “logarithmic flatness”, which means that very large fires are as common as medium or large-sized fires. <u>This establishes wind hazard as a real threat – one that should be applied to any proposed SPL route. This should be done in the EIR.</u>

F2.4. Climate change and fire weather

F2.4.1. Goal

To explain the effects that climate change will have on the likelihood of wildland fires and the concomitant economic losses.

F2.4.2. Description

We review two recent calculations that have relevance to the rate calculations performed in these appendices. These discuss how climate change will affect wildland fire conditions.

F2.4.3. Articles

F2.4.3.1. Miller and Schlegel[6]

This white paper from the California Climate Change Center evaluates the frequency of future Santa Ana events based upon two different climate models: GFDLv2 from NOAA and PCM from DOE/NCAR. These two models give different results, though the results are described as preliminary.

GFDL, under conditions of large forcing, predicts an approximately 10% drop in the number of atmospheric high-pressure events that drive Santa Ana occurrences, with the drop primarily occurring in the months of October/November for the period through 2064.

PCM, under conditions of large forcing, predicted an approximate 10% increase in the number of atmospheric high-pressure events that drive Santa Ana occurrences, with increases occurring in the months of October, November, and January, and a significant decrease in December. These results apply through 2064.

<u>Calculations of the intensities of the Santa Ana events has not yet been determined, but should be carried out as part of the EIR.</u>

[6] Miller, Norman L. and Nicole J. Schlegel; CLIMATE CHANGE–PROJECTED SANTA ANA FIRE WEATHER OCCURRENCE: A Report From: California Climate Change Center;February 2006; CEC-500-2005-204-SF

F2.4.3.2. Westerling, et al.[7]

Westerling and colleagues analyzed historical fire and climate data to determine the factors that will be changed by increasing temperatures. They predict a prolonged fire season. Primarily, they claim that the fire season is driven by an earlier snow melt and therefore a longer fire season. However, this analysis also is applicable to Southern California, since they demonstrate that the seasons of early snow melt are also seasons of curtailed winter precipitation, and therefore drought conditions. They show that large California fires share the correlation seen elsewhere in the Western US between years of early snow melt and the frequency of large fires.

F2.4.4. Conclusions

Current climate models do not predict large changes in the number of Santa Ana events (> 10% in either direction) prior to 2064. These results should be regarded as very preliminary.

There is a growing scientific consensus as the climate warms, we will experience more drought conditions in California, with reduced winter rainfalls. This will reduce fuel moisture and increase the risk of severe wildland fires.

F2.5. Alternative fire rate predictions

F2.5.1. Goal

To explore alternative methods of predicting the fire recurrence rate along SPL using different methods and hypotheses.

F2.5.2. Description

Other methods may be put forward to calculate the rate of fires and major fires along the SPL. These methods, their results and limitations will be discussed in this section.

F2.5.3. Methods

Several approaches may be taken to calculating overall fire rates, and more may be developed. We discuss three of them, their implicit assumptions and implications.

The first method will use the assumption that wind-induced transmission line fires are equally likely for 69 kV and 230 kV lines. This is identical to the previous analysis,

[7] Westerling, A. L., et al.; Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity;Science; v. 313; pp. 940-943; 18 Aug 2006

except it will take into account one extra 69 kV fire and the extra line length of the 69 kV network.

The second method will used the FRAP fire history for San Diego already analyzed in Appendix D, Section 2.2.4. In this method we use the observed rate of power line fires in San Diego over the past 50 years to try to estimate the future rate of fires. This is difficult, because the number of power lines has substantially increased in the last 50 years, thus increasing the interface between powerlines and vegetation. All fires in this sample were caused by distribution, rather than transmission lines. To get the rate for transmission lines, we can use the results from Appendix B, Section 2.1.4, particularly from Table B2-1, which shows the rate for the last three years of the number of wind-caused powerline fires. We assume a linear growth rate for transmission line lengths, thus giving us a “mid-point” 25 years ago, so that we can simply apply current rates for 20 years to get an estimate of the future rate. <u>Data should be obtained from SDG&E on the growth of the transmission network over the last 50 years in order to do this calculation properly as part of the EIR</u>. Part of the distribution network is also in Orange County. <u>The length of the Orange County distribution network should be obtained from SDG&E and subtracted as part of the EIR calculation</u>. To roughly estimate this, we observe that five of 91 fires occurred in Orange County, and so reduce the transmission line length by 5.5% of the 69kV and 230 kV segments. We also subtract off half of the SWPL length, or 70 miles, since according to SDG&E[8] this includes the length all the way to the California border with Arizona.

Another method is to estimate the significance of the fact that a major transmission line-induced fire has not yet occurred in San Diego County. Using the same assumptions about transmission line growth made in the previous section, we will look at the statistical significance of the disagreement between the rate of fires that would be predicted by extrapolating recent fire history and the fact that no transmission line fires have been observed.

Finally, we examine the hypothesis that fire rates on 230 kV lines will be lower than those for 69 kV lines, based upon the observed fault rate determined in Appendix A, Section 2.4.4. The discrepancy between this observed rate and recent fire history rate will be examined, and the impacts on the future SPL fire recurrence rate determined.

[8] SDG&E’S 1/12/07 RESPONSE TO MGRA Data Request No. 1, p. 18

F2.5.4. Analysis

F2.5.4.1. Equal fire probabilities for all transmission lines

In Appendix B, Table B-3, the rate for all wind-related transmission line fires was calculated to be 4.8 X 10^{-4}, versus the higher rate based upon the single 230 kV line fire. The original calculation led to a estimated large fire recurrence rate of 42 years. Adopting the alternative hypothesis, the probability for observing one or more 230 kV fires in the SDG&E history data under this hypothesis would be 40%, meaning that this hypothesis would also be consistent with the observation of one 230 kV fire.

Assuming equal fire start probabilities for wind-induced ignition per mile for all lines would yield a recurrence time for SPL of 79 years. This would result in a 40% chance of a large fire being started by the line and escaping initial attack along the line over its 40 year lifetime.

F2.5.4.2. Prediction using fire histories

One advantage of using the full fire history for San Diego County is that it contains only the major fires that are of interest for future fire predictions. However, it contains only distribution line fires, and the length of distribution lines in San Diego have not been obtained. In fact, the proper calculation for a fire-per-mile-per-year calculation would have to contain the length of the distribution network over time. According to the history analyzed in Section D2.2.4, there have been seven significant fires due to distribution lines. To get the ratio of distribution line fires to transmission line fires, we use the results shown in Table B-1 for wind-caused fires (smaller power line fires) over the past three years. We see that of seven fires, two were caused by transmission lines.

Assuming that the ratio of transmission line length to distribution line length over the past 50 years has stayed constant, we would expect to have seen two major transmission line fires. A statistical fluctuation to zero events – the observed value – has a 13% probability. If the ratio of transmission line length to distribution line length has grown over the last 50 years, this probability would become larger.

Using the predicted mean derived from the two transmission line fires, we can now obtain a fire rate per mile-year of transmission line by using the transmission line lengths given in Table A-2. For the purposes of this calculation, we assume the transmission line lengths have grown linearly from zero for 50 years (not that I claim that this is the case, but it may not be a completely inaccurate way to approximate the dramatic growth of San Diego over the last 50 years). For linear increase, we can simply take the midpoint (25 years) and multiply it by the line lengths of Table A-2 to obtain the total line exposure that we can use to normalize the fire rates.

To obtain the length of the current transmission network, we remove 5% of the 69 kV and 230 kV network, guessing that we can scale the number of fires over the total network to obtain the exposure in Orange County (<u>this should be recalculated in the EIR</u>). We can also subtract off half of SWPL since it is in Imperial County:

SD current transmission line network length = (884 + 387) * .95 + 79 = 1286 mi.

The transmission line fire rate prediction would then be:

(2 t-fires / 7 total) * (7 historical fires) / [(25 years) * (1286 miles t-lines)]

= 6.2×10^{-5} significant transmission line fires per mile per year.

As described in Section B2.3.4, the length of the SPL with significant fire risk is 74 miles in length. This gives an estimated number recurrence rate of 217 years, which means a 16% probability over the 40 year life of the line. One of the fires in the historical record (Laguna) was catastrophic. If this ratio is indicative of future behavior, there would be a 2% chance of major catastrophic fire from SPL during its service lifetime.

F2.5.4.3. Limits based on it not happening yet

A related observation using historical data is that "it hasn't happened yet"- that there have been no observed catastrophic transmission line fires in San Diego County. How restrictive is this? If we instead use the values in Table B-3, which include measured recent transmission line fire rates, a larger rate of 4.8×10^{-4} per mile per year was obtained. Using the method of the previous section to estimate historical transmission line lengths, we would have expected to observe 15.4 transmission line fires (large and small) over the history of the network. Assuming the 64% fire suppression efficiency noted above, we'd expect 5.6 events to have been major enough to have recorded in the fire history. The probability of a fluctuation to zero events is only .4%.

However, note that we've imposed in this calculation the requirement that the line be adjacent to flammable vegetation – a requirement not imposed on the rest of the network, and certainly over-conservative. If, on the other hand, we assume that the ratio of transmission line exposed to flammable vegetation on the SPL (47 miles out of 146) is typical of the historical value for the network, the calculations are quite different. We'd then expect only 1.8 significant transmission line fires. The probability of observing zero events under this condition is 17%.

Aside from flammable vegetation, possibilities that would lead to a discrepancy between the observed current fire rate and the historical one include: that the simple model of how transmission line exposure has grown over time used in the previous section overestimates the transmission line exposure, that the observation of two recent transmission line fires over the last two years represents a statistical anomaly, or the fire suppression efficiency for power line fires is higher than indicated in the previous sections.

F2.5.4.4. Estimates based upon outage rates

In Appendix A, Section A2.4.4, it was shown that the outage rate per mile per year due to equipment faults for 69 kV lines is 3.6 times that observed for 230 kV lines. It could be asserted that this same relationship should hold for fire starts. This would be an untested assumption, and might need to be adjusted for other effects (for instance, it could be asserted that the greater energy of 230 kV or 500 kV lines means that arcing will be more energetic and throw hot ejecta further from the faulting line section, thus making faults on these lines more likely to start fires). If correct, though, it would imply that the rates calculated in Section F2.5.4.1 would need to be adjusted downward, since the predicted rates were based assuming all transmission lines are equal. For this calculation we will use only the 230 kV SPL segment for the calculation. The adjustment ratio assuming that the outage rate for 230 kV lines are overestimated by a factor of 3.6 would be:

((69 kV distance * 3.6) + 230 kV distance) / (69 kV distance + 230 kV distance) =
(884 mi. * 3 + 387 mi.) / (884 mi. + 387 mi.) = 2.8

Applying this adjustment would give a recurrence rate of 220 years. This implies a 18% probability of major fire escaping initial attack over the lifetime of the SPL.

It should be noted anecdotally that in the last year there have been two instances of major transmission line tower collapses in California due to wind, and in at least one of these instances the tower was for a 500 kV transmission line[9,10]. One of these occurred in a marsh, and the other in the desert. This illustrates both that higher tension transmission lines are not immune from potentially catastrophic defects, and also that extreme wind conditions can cause significant damage to power line infrastructure. The portion of the proposed SPL route most exposed to extreme Santa Ana wind conditions would be in a heavily vegetated area that is considered an extreme fire hazard.

F2.5.5. Limitations

All these predictive analyses assume that SPL would be no more or less likely to starting fire than other line in the network. However, much of the work in the accompanying appendices indicates that it is unusually exposed to conditions that create a fire hazard.

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[9] Queen, Rolla; Weather Topples Powerline Tower; BLM California; News Bytes; 238; July 5, 2006. Available at
http://www.blm.gov/ca/news/newsbytes/xtra-06/238-xtra_tower.html

[10] Manekin, Michael; PG&E Tower Topples in Redwood City; Oakland Tribune; Dec. 28, 2006. Available at http://www.builderonline.com/industry-news.asp?sectionID=96&articleID=415186

Some of the SDG&E transmission network is in Orange County, and this length needs to be subtracted from the transmission network length used in these calculations. Calculations based on the historical line lengths are fabrications, and need real historical line data from SDG&E – <u>Data indicating the growth of the transmission and distribution network over time should be obtained as part of the EIR. Using this data, more accurate estimates of the fire rate using these methods should be done</u>.

An assertion that the fire start rates would be proportional to equipment faults while reasonable would be hypothetical, since we do not know the technical details of what sort of faults start fires. Also, due to the greater line voltages, the discharge of a 230 kV or 500 kV line will be much more energetic than that of a 69 kV line, which could make faults on the 230 kV or 500 kV lines more likely to start fires due to the greater velocity of hot ejecta, an effect that might offset the greater fault rates on the lower tension lines.

Statistics for all types of analysis are extremely limited, which allows for substantial statistical fluctuations in the values.

Fundamentally, all of these predictions assume that the past will be like the future, and that the proposed transmission line will be equivalent in hazard exposure to other lines on the network, both of which are dubious assumptions. Some of these assumptions, their quality, and their effect on the probability of a major fire being started by the proposed SPL, are listed in the table below:

Assumption	Quality	Effect if false
That the proposed SPL route will have the same exposure to hazardous vegetation as the rest of the network.	Very probably false.	If false, will INCREASE the probability of fire, possibly substantially.
That the proposed SPL route will have the same exposure to hazardous wind conditions as the rest of the network.	Very probably false.	If false, will INCREASE the probability of fire, possibly substantially.
Linear increase of transmission network over time.	Ad hoc, likely false	Could INCREASE or DECREASE fire risk calculated in F2.5.4.2
Ratio of transmission to distribution network has remained constant.	Ad hoc, has likely increased.	Would probably INCREASE fire risk calculated in F2.5.4.2
Number of recently observed fires is representative of the time-averaged rate	Unknown, but fewest assumptions	Could INCREASE or DECREASE predicted fire rate calculated in 2.4
Number of historically observed fires can be used to predict future fires	Unknown, but depends on assumptions regarding the transmission network, climate, population.	Could INCREASE or DECREASE predicted fire rates and limits in 2.5.4.1 and 2.5.4.2
Fire start rates are the same for 69 kV and 230 kV lines	Unknown, makes no assumptions	DECREASES the predicted rate of Section 2.4
Fire start rates are proportional to line fault rates	Possible but untested; possibly compensated for by greater energy of higher voltage lines	If false, supports original calculation; if true supports 2.5.4.3 and causes DECREASE in rate
Fire hazard will remain constant in the future	Likely to be false	Climate change expected to INCREASE risk.

Table F-4 – Assumptions made in the primary and alternative analyses.

F2.5.6. Conclusions

It can be seen that significant variations in predicted fire rates can be obtained by changing the underlying assumptions used to obtain them. Despite the broad range of obtained values, they are not outside of the range of variation stated for the original calculation. The initial assumptions chosen to perform the primary risk calculations in Appendix B and in section 2.4 of this appendix were those that used known data, made the fewest assumptions and used the simplest models. <u>The validity of all of the above assumptions should be examined within the scope of the EIR, in order to choose the best and most predictive model.</u> I would currently recommend using the primary model over all of these alternative methods. However, the limit set in F2.5.4.3, even if made more lax in future calculations, has the effect of making the lower range of variation of the primary model much less likely, and favoring higher values in the primary range. <u>A likelihood calculation combining both of these methods should be applied in the EIR once historical network information is obtained.</u>

Notably, ALL of these methods (aside from the limit in F2.5.4.3) imply that there is a significant foreseeable risk of wildland fire being caused by the Sunrise Powerlink during its estimated lifetime, even when ignoring the particular but very significant hazards of the proposed route and alternatives. Hence, it follows that economic impacts of such fires need to be calculated.