BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Application of San Diego Gas & Electric Company (U 902 M) for Authorization to Recover Costs Related to the 2007 Southern California Wildfires Recorded in the Wildfire Expense Memorandum Account	Application No. 15-09-010 (Filed September 25, 2015)

DIRECT TESTIMONY OF THE MUSSEY GRADE ROAD ALLIANCE

SDG&E WILDFIRE EXPENSE MANAGEMENT ACCOUNT

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INTRODUCTION

Q. Please state your name, address, company and qualifications.

A. My name is Dr. Joseph W. Mitchell. My business address is 19412 Kimball Valley Road, Ramona, CA 92065. I am the principal of M-bar Technologies and Consulting, also in Ramona, CA. I have been an expert witness at the CPUC since 2007 on issues of wildland fire. I have a Ph. D. in physics, and have been working in the area of wildland fire since 2002, and have several publications in this field. My full qualifications are provided in Appendix I of this testimony.

Q. On whose behalf are you submitting this testimony?

A. I am submitting this testimony on behalf of the Mussey Grade Road Alliance (MGRA or Alliance).

Q. What is the purpose of your testimony?

A. The purpose of this testimony is to examine the conditions related to the ignitions of the 2007 wildfires for which San Diego Gas and Electric Company (SDG&E) is currently seeking to recover its losses from ratepayers. It examines the factual basis of SDG&E's testimony related to these ignitions with particular attention to whether SDG&E was prudent in its design, construction, maintenance, and operation of its infrastructure prior to and during the 2007 fires.

BACKGROUND

Q. What is your personal experience the October 2007 fires?

A. My wife, Diane Conklin, spokesperson for the Mussey Grade Road Alliance and I live in Ramona California. Our neighborhood was impacted heavily in the 2003 Cedar fire which destroyed approximately two thirds of the homes. At the time of the 2007 fires, we were already intervening at the CPUC and we were in the process of preparing briefing on the potential for power-line ignited fires. We remained in our home as the

Witch fire surrounded our area on three sides, taking shifts with neighbors to keep watch on the fire until the danger had passed.

Q. What CPUC activities related to the 2007 fires have you been involved in?

A: My post-fire activities are described in detail in my CV, attached as Appendix I. Briefly, I've submitted testimony, comment and analysis in a number of CPUC proceedings related to power line fire safety including the fire safety rulemaking, SDG&E's application for a power shut-off plan, and the first application for wildfire cost recovery ("WEBA"). I've used data from these CPUC proceedings to produce two academic papers on the topic of power line ignited wildfires.

SUMMARY OF MGRA TESTIMONY

Q. What is the scope of the MGRA testimony?

A. The Mussey Grade Road Alliance has coordinated closely with other intervenors, and its testimony is designed to supplement the testimony of other experts. This testimony will specifically address the standards to which SDG&E built its infrastructure, prior knowledge SDG&E had of weather conditions in its service area, and prior knowledge of fire hazards related to infrastructure that SDG&E had prior to the October 2007 fires.

As per instructions in the scoping memo, Phase 1 testimony is to address "Whether SDG&E's operation, engineering, and management (of) the 6 facilities alleged to have been involved in the ignition of the fires was reasonable. Each of the three fires should be addressed separately."[1] Accordingly, the issues raised by MGRA testimony will relate primarily to the Witch fire ignition, though general conclusions regarding the

[1] A.15-09-010; Scoping Memo and Ruling of Assigned Commissioner and Assigned Administrative Law Judge; April 11, 2016; p.6.

fire hazards and weather conditions of the SDG&E service area may also be applied to the Rice and Guejito fire conditions. ORA has addressed SDG&E's culpability in the ignition of the Witch, Guejito and Rice fires in its own testimony, submitted on October 4th, and it is our understanding that the conditions related to both the ignition of all fires will be addressed in both UCAN and that POC (Protect Our Communities) testimony will address both ignition of the 2007 fires and historical power line fires.

Q. What basic facts does this testimony seek to establish?

A. This testimony is intended to lay out the following facts:

- Prior to the 2007 fires, SDG&E built its lines according to its interpretation of the GO-95 standard Rule 48 and built to a required wind loading of 56 mph plus safety factor.
- This interpretation of the GO-95 wind loading standard is not shared by the CPUC's Safety and Enforcement Division (SED) or its predecessor the Consumer Protection and Safety Division (CPSD), which interpreted the same standard to require a wind loading of 92 mph for existing construction and 112 mph for new construction. Commission Decision D.14-02-015 upheld SED's interpretation of Rule 48.
- "Santa Ana" wind storms have historically been known to have gusts exceeding 56 mph.
- Prior to 2007, SDG&E itself commissioned wind studies of its service area that indicated that it could expect wind gusts exceeding 56 mph.
- Firestorms involving multiple ignitions due to power lines under extreme weather conditions had previously been seen in historical records from Australia.
- Fires resulting from power lines in San Diego County were on the average much larger and more destructive than fires from other ignition sources, even prior to the October 2007 firestorm.

- Significant fires due to powerlines under adverse weather conditions had been observed previously in the area.
- SDG&E itself currently recognizes that the standard it had in place in 2007 for design, construction, maintenance and operation of its powerline was insufficient for the local conditions and has significantly enhanced these standards.
- SDG&E currently has a program in place to upgrade significant portions of its infrastructure in high fire risk areas using enhanced wind loading standards.

POWER LINE IGNITED WILDFIRES

Q. What factors lead to the ignition of power line fires?

A. Weather events with high winds and low humidity create conditions favorable to the rapid spread of fire. Known generically as "Foehn" winds, the local name for these wind events in California are "Santa Ana", "Diablo", and "Sundowner" winds.[2,3] While fire ignitions are a common occurrence in Southern California, fire agency response is highly effective, extinguishing 97% of fires before they reach 100 acres in size. During conditions of high winds and low humidity, however, this fraction drops to 80%, and firefighting resources can be overwhelmed by ignitions they would be able to handle under normal conditions.[4]

This situation is further complicated in the case of power line fires because the very conditions that lead to ignition (through clashing of lines, tree contact with lines or

[2] Schroeder, M, et. al. . 1964. Synoptic weather types associated with critical fire weather. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 492 p; 1964.
[3] Moritz, et. al.; Spatial variation in extreme winds predicts large wildfire locations in chaparral ecosystems; Geophysical Research Letters; v. 37; L04801, doi:10.1029/2009GL041735, 2010.
[4] R.08-11-005; MUSSEY GRADE ROAD ALLIANCE PRE-HEARING CONFERENCE STATEMENT; Appendix A (Mitchell, Joseph W.; Power Lines and Catastrophic Wildland Fires in Southern California; Fire & Materials 2009;San Francisco, CA; January 26-28, 2009), February 2, 2009. (Mitchell, 2009)

infrastructure failure), also favor the rapid spread of fires that ignite wildland fuels.[5,6] Under sufficiently extreme conditions this leads to a "power line firestorm", since wind conditions that are extreme enough can lead to multiple failures of electrical infrastructure or downed trees or branches throughout a utility's system. This phenomenon has been observed several times in Australia – in 1977, 1983, and most recently in the catastrophic "Black Saturday" fires of 2009.[7]

Q. Were significant power line fires observed in the SDG&E service area prior to 2007?

A. Yes, fires attributed to power lines and fire weather conditions had occurred in the SDG&E service area prior to 2007. In May of 2007, MGRA submitted testimony in the Sunrise Powerlink proceeding A.06-08-011 that described the history of power line fires in the SDG&E service area and in California in general.[8] This testimony was served on SDG&E and all parties to the proceeding.

At the time of the MGRA analysis, Cal Fire's ranking of the worst historical fires both in terms of homes lost and of area burned showed that three of the 20 top fires were power line caused, even though power lines were generally responsible for only 3% of overall fire ignitions state-wide. The MGRA analysis showed that this was a statistically significant excess and concluded that "power line fires are more likely to burn large areas and destroy more homes than fires initiated by other causes."[9]

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[5] Id.
[6] OSFM, CDF, USFS, PG&E, SC Edison, SDG&E; Power Line Fire Prevention Field Guide; Mar 27, 2001.
[7] 2009 Victorian Bushfires Royal Commission; Final Report; Volume II; Chapter 4; (Victorian Bushfires Report) p. 148.
http://royalcommission.vic.gov.au/finaldocuments/volume-2/PF/VBRC_Vol2_Chapter04_PF.pdf
[8] A.06-08-010; MG-1 Appendix D.
[9] Id. p. 5.

MGRA's 2007 analysis also performed analysis of Cal Fire's FRAP database in order to determine the relationship between historical power line fires and fires from all causes. It concluded that: "Examination of historical data reveals that while power line-related fires have been fairly rare in San Diego County, constituting less that [sic] one percent of all fires, they have been extremely destructive, burning 17% of all the area burned during this period. This supports the hypothesis that the increased likelihood of power line faults during wind events will make it more likely that power line fires are large, wind-driven fires. Average fire sizes for power line fires have been around 20 times larger than for all fires, while the median fire size has been roughly five times as large…"[10] This effect occurs because, while the exact source of ignition may not have an effect on the extent of a fire, the timing of the ignition does – and power line fires tend to ignite during extreme fire weather conditions when high winds stress utility infrastructure.

The threat to power lines from Santa Ana winds is also well known. SDG&E's current meteorologist and witness Steve Vanderberg in 2004 revised a 1998 NOAA Technical Memorandum that examined San Diego's climate history. Among notable events in San Diego history, the report lists a September 26, 1963 event in which: "A MASSIVE HIGH PRESSURE AREA OVER NEVADA AND UTAH PUSHED WINDS UP TO 50 MILES PER HOUR THROUGH THE MOUNTAINS. TREES WERE DOWNED AND FLYING DEBRIS BROKE OR SHORTED MANY POWER LINES. WINDS WERE UP TO 30 MILES PER HOUR IN MANY PARTS OF THE CITY. LINDBERGH FIELD HAD A PREVAILING WIND FOR THE DAY FROM THE EAST-NORTHEAST AND THE AVERAGE SPEED WAS 6.9 MILES PER HOUR. THE STRONGEST GUST WAS 18 MPH FROM THE EAST."[11]

[10] Id. p. 10.
[11] NOAA Technical Memorandum NWS WR-270; CLIMATE OF SAN DIEGO, CALIFORNIA; Revised by: Emmanuel M. Isla, Steve Vanderburg, Christopher Medjber, Daniel Paschall; September 2004; First Edition: Thomas E. Evans, III, Donald A. Halvorson-October 1998 (NWS WR-270).

Among the historical power-line related fires in the SDG&E service area, the 1970 Laguna fire was the largest and most destructive. It resulted from tree-line contact during a Santa Ana wind event,[12] and was one of the largest and most destructive fires in recorded history.[13] According to contemporary reports, winds gusted to 70 mph during this event.[14]

The 2002 Pines fire was ignited by helicopter contact with power lines, and while it grew large did not spread west of the mountains due lack of Santa Ana conditions. Then in 2006, the 300 acre Open fire occurred very close to the origin of the Witch fire. The Cal Fire investigation of the Open fire revealed that it was due to cross arm failure of a 69 kV transmission line during a Santa Ana wind event.[15]

SDG&E began collecting its own power line fire history in the aftermath of the 2003 San Diego Firestorm. Its record shows that a number of fires prior to the October 2007 fires were ignited under high wind conditions:

Historical Data for Wind-Related Power-Line Fires[16]

Fire Event	Date Started	Location	Size in	Injuries & Property	Wind-
1	12/16/04	Wynola	5	None	Power line down
2	12/16/04	Descanso	1	None	Power line down

[12] 1970 California Wildfires September/November; Pacific Fire Rating Bureau; 465 California Street; San Francisco California 94104; p. 8. Attached as Appendix I.
[13] 20 Largest California Wildfires; (By Structures Destroyed) and (By Acreage Burned); CAL FIRE; 11/9/2007 edition. As of 1970, the Laguna fire ranked second in terms of acreage and third in terms of structures destroyed since 1932. As of 2015, Laguna ranked 11th in terms of acres burned and 16th in terms of damage.
[14] Op. Cite.
[15] State of California Department of Forestry & Fire Protection; Investigation Report, Case number 06-33-011123-18; Case Name Open; November 30, 2006. Obtained by MGRA through a Public Records act request, to be submitted into evidence by Protect Our Communities.
"The cause of the fire was determined to be an energized, 69 kV power line conductor, that broke off, and fell to the ground causing a fire."
[16] This table is presented in D.09-09-030, p. 28 based on data provided by SDG&E.

3	12/17/04	Ramona	1	None	Power line down
4	2/19/05	Fallbrook	1	None	Tree branch into power line from
5	2/7/06	Laguna Niguel	1	None	Tree branch into power line from
6	6/27/06	Fallbrook	1	None	Tree branch into power line from
7	10/27/06	Boulder Creek	2	None	Power line down
8	11/30/06	San Ysabel	130	Damage to bridge; loss of pasture land	Power line down. High winds of 40 mph w/gusts to 60 mph
9	12/27/06	Camp Pendleton	3	None noted	Power line down from heavy winds
10	3/3/07	Jamul	0.1	None noted	Tree branch into power line from high winds
11	10/21/07	Guejito, San Pasqual	197,990*	Extensive damage & injuries*	Alleged contact w/conductor. High winds observed in area.
12	10/21/07	Witch, Ramona	197,990*	Extensive damage & injuries*	Alleged arcing between power lines. Santa Ana winds in area.
13	10/22/07	Rice, Rainbow	9,472	Extensive damage & injuries	Alleged tree branch into power line from high winds
* Witch and Guejito acreage, injuries, and damage are aggregated.					

Q. Are there other known occurrences of multiple power line fire ignition during fire weather prior to 2007?

A. In my study of power line fire history in California I have not seen any other similar incident where a weather incident was associated with multiple power line fires. However, Australia experienced two similar occurrences where high winds during fire weather were linked to the ignition of multiple fires from power lines. In a 1977 event, power lines were associated with 9 of 16 major fires, and during the Ash Wednesday fires of 1983 power lines were associated with 4 of 8 major fires.[17] In the subsequent Black Saturday fires of 2009, power lines were associated with 5 or 6 of the 11 major fires that were responsible for the deaths of 173 people.[18]

SDG&E DESIGN AND CONSTRUCTION

Q: What wind loading did SDG&E design for in its service area?

A: According to the testimony of Gerry Akin of San Diego Gas & Electric Company put forward in investigation I.08-11-006, the spans that were involved in the Witch fire ignition were "were designed to withstand a wind pressure of at least 8 pounds per square foot of projected area on these conductors (which equates to a wind speed of 56 miles per hour)."[19] According to SDG&E's response to MGRA Data Request 18, prior to 2007 SDG&E did no additional structural analysis besides applying its interpretation of GO 95

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[17] 2009 Victorian Bushfires Royal Commission Final Report, v.2, p. 148. Government printer for the state of Victoria. PP. No. 332, Session 2006–2010, ISBN 978-0-9807408-4-4, July 2010. Archived at: http://pandora.nla.gov.au/pan/96781/20100923-0223/www.royalcommission.vic.gov.au/Commission-Reports/Final-Report.html
Last accessed 8/21/2016.

[18] Id.

[19] I.08-11-006; DIRECT TESTIMONY OF GERRY AKIN SAN DIEGO GAS & ELECTRIC COMPANY (WITCH FIRE)

Rule 44, and in particular did no probabilistic failure analysis of its infrastructure at potential wind speeds above 56 mph.[20]

Q: Is 56 mph wind speed accepted by the Commission as the correct interpretation of General Order 95, Rule 31.1 and 48?

A: No, the Safety and Enforcement Division of the CPUC and Decision D.14-02-015 currently maintains that the correct interpretation of GO 95 Rule 48 requires new construction to be built to a wind loading of 112 mph and for that existing construction withstand wind gusts of 92 mph.[21] Additionally, SED interprets the "will not fail" provision of Rule 48 as a mandatory performance standard.[22]

D.14-02-015 upheld the current SED interpretation in this matter:

"*To the extent practical, Rule 48 and related rules should reflect location-specific fire hazards.* ***Currently, Rule 48 establishes a single wind-load standard of 112/92 mph for Grade A wood poles in the Light Loading District****. We anticipate the fire-threat map(s) developed in Track 3 will allow a more granular and cost-effective wind-load standard that better protects public safety. A blanket requirement that all facilities should be built to the same wind-load standard (e.g., 112/92 mph) may not be necessary or appropriate. We anticipate that some areas of the State may need to retain the existing 112/92 mph standard, some areas may need a higher standard, and in other areas a lower standard may be reasonable*."[23] (emphasis added).

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[20] Appendix A; SDG&E response to MGRA Data Request 18 and Data Request 19; "Prior to 2007 SDG&E conducted a structural analysis that was performed using a deterministic analysis as dictated by General Order 95 (GO 95) Section IV, Rule 44. The deterministic analysis takes the breaking strength of a material as provided by a manufacturer, divided by load being imparted by wind and other factors, and checks that the value is greater than the minimum safety factor as dictated in GO 95. Based on this deterministic analysis, the pole, conductor or cross-arm either passes or fails the calculation."
[21] D.14-02-015; pp. 56-70.
[22] Id., p. 67.
[23] Id. p. 69.

It should be noted that SDG&E and other utilities do not agree with the Commission's current interpretation of Rule 48, and have historically built infrastructure assuming 56 mph wind loading plus safety factor. While the discussion of the correct interpretation of Rule 48 would lie more appropriately in the realm of argumentation, it is appropriate to show that SDG&E's interpretation of Rule 48 as necessitating only a 56 mph wind loading plus safety factor is not universally accepted as correct or adequate – particularly by the Commission itself.

Additionally, GO 95, Rule 31.1 requires SDG&E to design for known local conditions. This is reaffirmed by D.14-02-015, which states that "*electric utilities and CIPs shall continue to comply with the Rule 31.1 requirement to design and construct their facilities based on known local conditions, including Santa Ana windstorms*."[24]

KNOWN WEATHER CONDITIONS IN SDG&E'S SERVICE AREA

Q: Did SDG&E have prior knowledge that wind gust speeds could exceed 56 mph in its service area?

A: Yes, SDG&E commissioned engineering studies for transmission projects that included meteorological studies. As part of these studies, maximum wind speeds were estimated for 50-year recurrence intervals along the transmission routes, which included portions of its service area in San Diego County.

Q: What meteorological studies did SDG&E have performed for its transmission projects in San Diego County?

A: SDG&E had studies performed for two transmission projects for which it submitted responses to the MGRA data request. The first of these was published in 1981

[24] Id. p. 70.

and was for the Southwest Powerlink Project ("SWPLs study"). Selected portions of this report have been submitted as Appendix B of this testimony. There was another meteorological study performed for the proposed route of the Sunrise Powerlink (SPL) project in 2006 (revised in March 2008) that also examined expected wind loading conditions in the SDG&E service area. This report was provided by SDG&E in response to a data requests and has been submitted as Appendix B of this testimony.[25]

Both the 1981 SWPL and 2006 SPL studies estimated 50-year return interval maximum wind gust speeds along the proposed transmission route using historical weather data and accepted methodology for estimating extreme values from statistical distributions.

Q: What expected 50-year return interval wind speeds did SDG&E's 1981 contracted wind studies find for its proposed transmission routes?

A: The 1981 study done for the Southwest Powerlink ("SWPL study") found estimated maximum wind speeds that varied from 65 to 95 mph.[26] These wind studies were performed using a measure for wind speed known as "the probable maximum sustained 1-minute wind speed."[27] For modern engineering purposes, a three-second gust speed is used. Using the method recommended by the ASCE,[28] the conversion from one-minute to three-second wind gusts is to apply a multiplicative factor of 1.22. Hence the 50 year peak wind values provided in the SWPL study will be 22% higher using standard

[25] Appendix C; METEOROLOGICAL AND STRUCTURE WIND LOAD STUDIES, Prepared for San Diego Gas & Electric Company, Sunrise Powerlink Project; Contract Release No. 5660002512, Activity 55325; April 27, 2006; Revised March 12, 2008; S&L Project 11877 -136; Prepared by Sargant & Lundy Engineers, Ltd. Document is dated 27 February 2007.
[26] Appendix B; METEOROLOGICAL STUDY FOR THE APS/SDGE INTERCONNECTION PROJECT; Prepared April 1981; pp. SDGE0300539 (p.24/32) to SDGE0300547 (p.32/32). Column WEATHER DATA, sub-column WIND (mph).
[27] Id. p. SGDE030052 (p. 3)
[28] ASCE 7-05 commentary Figure C6-4, the "Durst Curve". Factor was obtained by dividing value at 3 seconds (1.53) by the value of the curve at 60 seconds (1.25) to get 1.22.

wind measurements now used for calculating GO 95 compliance, or between 79 mph and 116 mph.

MGRA did not request specific locations for the SWPL towers where the wind studies were performed because we wanted to be able to publicly disclose all testimony, but using a technique suggested by SDG&E[29] we were able to determine an approximate geographical location for each wind estimate. Using this information, MGRA was able to produce the following map of estimated 50-year wind speeds.

[29] SDG&E; MGRA-SDG&E DR-04, Q25-27; SDG&E WEMA PROCEEDING - A.15-09-010; SDG&E SUPPLEMENTAL RESPONSE; DATE RECEIVED: August 22, 2016; DATE RESPONDED: September 19, 2016; Request 27: "SDG&E believes the following response will meet MGRA's needs if three approximations are utilized.
The three approximations are: 1) assume that SWPL is predominately uni-directional (i.e. west to east) with only moderate variation to the angle of its path; 2) that the spacing between towers is relatively uniform; and 3) the numeric labeling of the towers is indicative of an arithmetic sequence (for example, one can assume that tower 150 is approximately halfway between tower 100 and tower 200). Much of the appropriateness of these three approximations is due to the fact that not every tower used in SWPL had a unique weather study performed, and those towers that were mentioned in the study utilized approximations of weather data not available at each specific site."

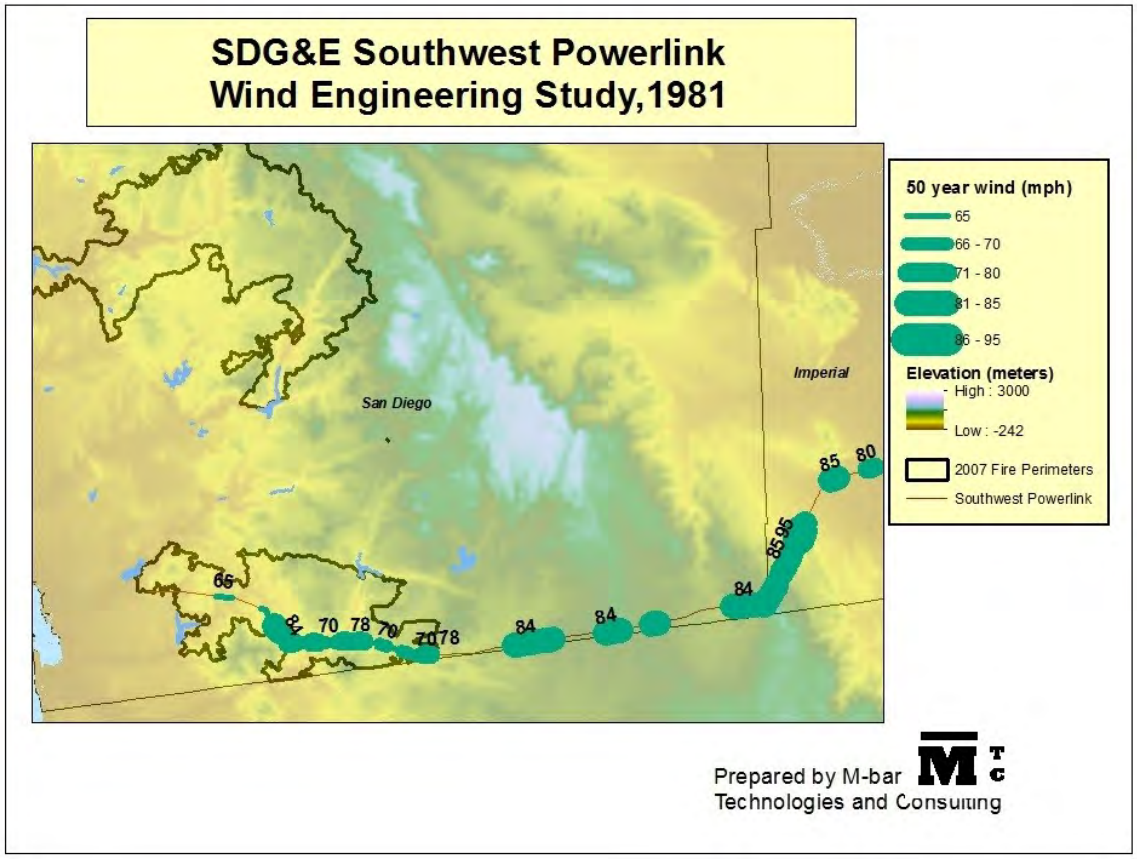

Figure 1 - Southwest Powerlink wind speed estimations from 1981 engineering study. Wind speeds shown is the probable maximum sustained 1-minute wind speed. Three second gust speed will be 22% larger.

Q: What expected 50-year return interval wind speeds did SDG&E's 2006-2008 contracted wind study find for its proposed transmission routes?

A: The 2006-8 Sunrise Powerlink study found 50-year return interval expected hourly average wind speeds that varied from 43 mph to 76 mph[30] depending on

[30] Appendix C; p. 1-35 (SDGE0250482_TLM, p.43/80); H. Table 8 - Maximum Annual Wind Speeds Statistically Estimated with the NBS Simiu Program based on Input Annual Maximum Wind Speeds (mph) at Weather Monitoring Stations in the SDG&E 500 kV Interconnect Project Region.

geographic location along the transmission route.[31] Additionally, 100-year return intervals for hourly average wind speeds were calculated that varied from 45 mph to 91 mph.[32] Wind speeds used for wind loading purposes use maximum three-second gust speed rather than hourly averages. The SPL study used a gust factor of 1.59 for its calculations to convert hourly average wind speeds to three-second wind gusts.[33] Applying this gust factor one would expect 50-year maximum wind gusts to vary between 68 mph and 121 mph and 100-year maximum wind gusts to vary between 72 mph and 145 mph, depending on geographic location.

SDG&E also produced a map of wind loadings along its preferred route for the Sunrise Powerlink. This is attached as Appendix D. The segment of the route near Santa Ysabel, where the Witch fire originated, is shown below:

[31] Mappings of transmission line segments to weather conditions can be found in Appendix C; p. 2-6 (p. 74/80) Table 7 – Project Areas and Associated Weather Stations. Also these mappings can be found as a function of elevation at p. 1-43 (p. 51/80) P Figure 3 - Profile of Topographic Elevations along the Transmission Corridor, with Annotated Elevations of Meteorological Monitoring Stations for which Data were Analyzed, and Corridor Segments for which Specific Wind Projections Are Recommended.
[32] Op.Cite.
[33] Appendix C; p. 1-18 (SDGE0250465_TLM, p. 26/80).

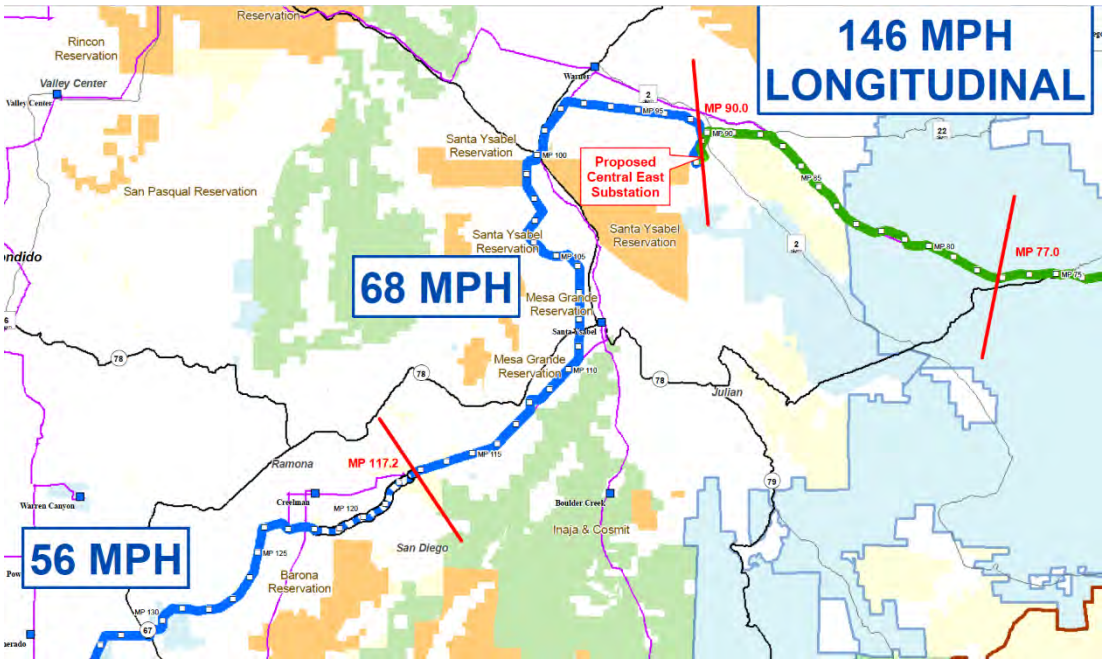

Figure 2 - Proposed Sunrise Powerlink Route Wind Speeds – Sargent & Lundy study 2006-2008. The 2007 Witch fire originated in the Santa Ysabel area. Full map attached as Appendix D.

This map differs significantly from what was recommended by the SPL engineering study. Specifically the map recommends that the region in the area of Santa Ysabel (near the Witch fire ignition site) be designed for 68 mph wind gusts. "P Figure 3" of Appendix C (p. 1-43; SDGE0250490_TLM; 51/80, shown below in Figure 3) shows that all areas above 2000 feet of elevation should be given wind loadings determined by maximum wind gusts generated by the Campo weather station. The 50-year maximum average hourly wind speed for Campo is estimated to be 54.3 mph, which corresponds to 86 mph gusts using the proposed gust factor of 1.59. Instead, the SPL map used calculated maximum 50-year values for the Ramona weather station. The figure that was intended to be used to guide the design is shown below:

P Figure 3 - Profile of Topographic Elevations along the Transmission Corridor, with Annotated Elevations of Meteorological Monitoring Stations for which Data were Analyzed, and Corridor Segments for which Specific Wind Projections Are Recommended

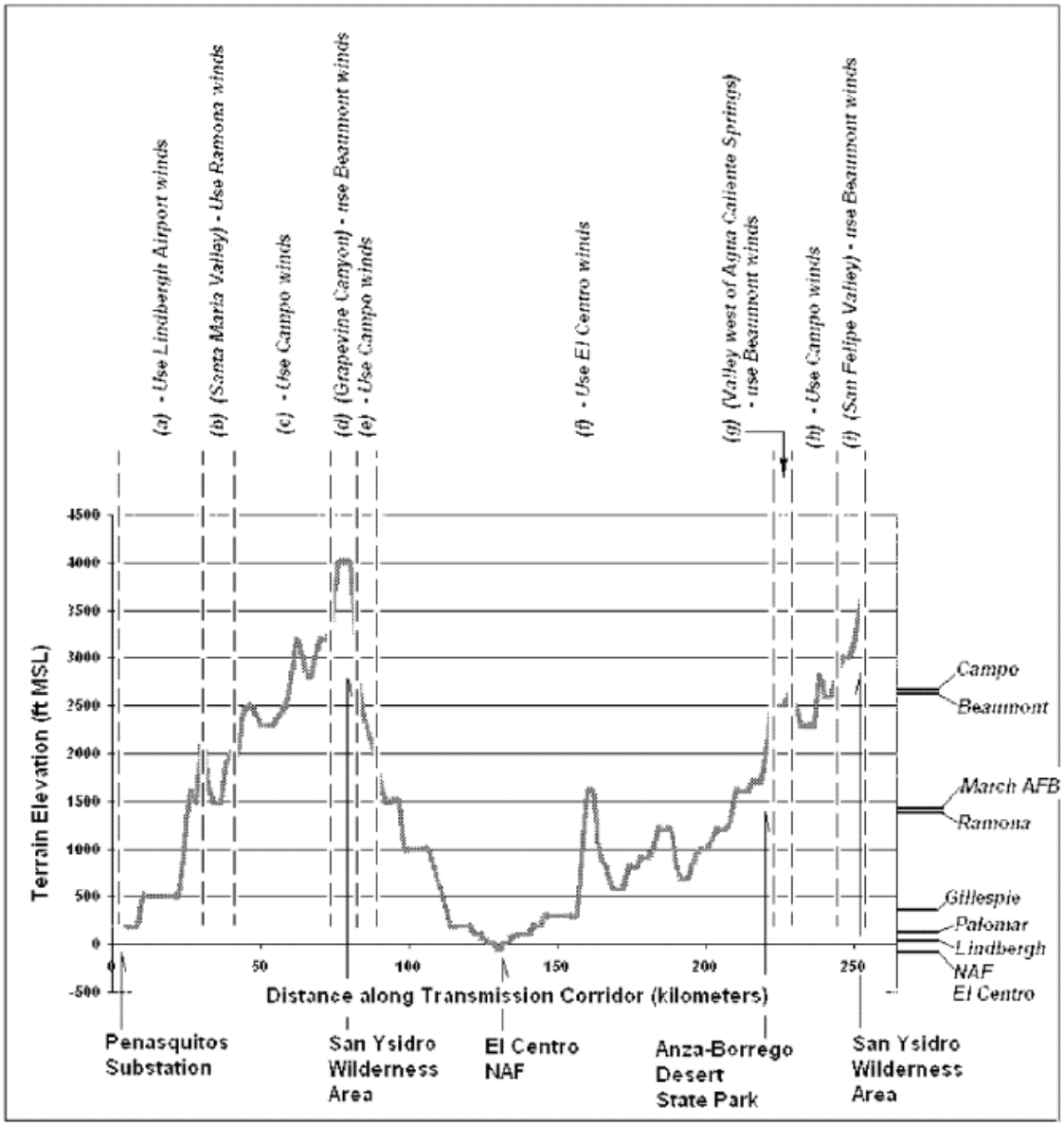

Figure 3 - SPL engineering study - proposed mapping of elevation to corresponding weather station for wind loading purposes. Sargent & Lundy 2006-2008.

Q: How do SDG&E's historical meteorological transmission studies relate to the ignition sites for the 2007 fires?

A: The reported site for the origin of the Witch fire is at 33° 4'59.48"N, 116°41'37.64"W, at an approximate elevation of 3000'. The reported site for the origin of the Guejito fire is at 33° 5'37.34"N, 116°57'41.95"W, at an elevation of approximately 400'. The reported site for the origin of the Rice fire is on Rice Canyon Road, near Fallbrook, at an approximate elevation of 900'.

The 2006-2008 study conducted for the Sunrise Powerlink evaluates areas in close proximity to the Witch and Guejito fire origins, and classifies them with wind loadings according to maximum values derived from the Campo weather station (86 mph maximum 50-year gust speed) for the area of Santa Ysabel, or the Ramona weather station (68 mph maximum 50-year gust speed). The Rice fire origin, being closer to the coast might, hypothetically be classified by the SPL authors in the "San Diego Lindbergh" weather station zone, but in fact the Lindbergh weather 50-year return interval wind speeds are higher than those for Ramona. So in general, the SPL Study suggests that maximum wind gust speeds significantly greater than 56 mph should occur much more frequently than every 50 years.

Likewise, the 1981 study performed for the Southwest Powerlink shows that the area along the proposed route is also subject to wind speeds in excess of 56 mph much more frequently than every 50 years. While in the southern part of San Diego County, it is subject to the same type of weather conditions as the northern half of the County, including Santa Ana winds west of the mid-County ridge. In fact the Campo weather station, mentioned as the basis for wind speed calibration for segments of the transmission line above 2000' elevation in the later SPL study, is not far from the SWPL route. No place along the route was found to have expected 50 year return interval wind gusts of less than 56 mph.

CHANGES TO SDG&E STANDARDS & PRACTICE AFTER 2007

Q: Does SDG&E build new infrastructure or rebuild infrastructure to 56 mph wind loading standards?

A: No. Since 2007 SDG&E has come up with new design and construction standards for its infrastructure that significantly exceed 56 mph. Modifications in SDG&E design, construction, operation, and fire preparedness since the 2007 fires are discussed extensively in the SDG&E testimony prepared by David Geier (pp. 19-25) and in the testimony of other SDG&E witnesses. In its most recent GRC, SDG&E requested funding for its FiRM (Fire Risk Mitigation) program to rebuild infrastructure that it deemed to be in the highest risk fire areas, which it terms the FTZ (Fire Threat Zone).[34] Wind loading requirements for new construction and rebuilding depend on local conditions, but currently always exceed 56 mph.

Q: What wind loading does SDG&E currently design for in its service area?

A: SDG&E has analyzed its service area using the network of weather stations that it constructed to determine what it believes to be the maximum potential wind gust speed in those areas. In response to an MGRA data request, SDG&E has provided its electric transmission and distribution engineering standards (ET&DE), excerpts of which we attach as Appendix G to this testimony. The ET&DE standards designate three tiers, which it bases on its estimate for 50-year return interval maximum wind gust speeds:

"*SDG&E KNOWN LOCAL WIND LOADING (SDG&E standard exceeding GO 95 minimums derived from 50-yrwind maps and HRFA boundaries). All overhead facilities shall be evaluated at an elevated wind speed determined from the "SDG&E Known Local Wind Map" specified in Figure 1, also located in the Geographic Information System*

[34] A.14-11-003, SDG&E-09, DIRECT TESTIMONY OF JOHN D. JENKINS, ELECTRIC DISTRIBUTION CAPITAL, EX-SDGE-13.

(GIS), regardless of elevation. Structures will fall into one of three wind zones: 65 mph, 85 mph, or 111 mph. The following assumptions apply:

i. For conductor and pole surfaces, the corresponding wind pressures are as follows:

Horizontal wind speed = 65 mph -> Wind pressure = 10.8 lbs/ft^2

Horizontal wind speed = 85 mph -> Wind pressure = 18.5 lbs/ft^2

Horizontal wind speed = 111 mph -> Wind pressure = 31.5 lbs/ft^2"[35]

Additionally, SDG&E's current overhead construction standards now incorporate an "Extreme Wind Loading" designation for infrastructure that it finds in its "Fire Threat Zone", in addition to "Light", "Heavy Loading" and "Extra Heavy Loading" designations.[36] Furthermore SDG&E's recent Distribution System Design Manual lays out general processes circuit rebuilding prioritization in its Fire Threat Zone, which includes specification of hardware and construction standards to reduce fire risk.[37] While all of these changes indicate an attempt to design infrastructure for the conditions present in its service area, significantly more stringent standards only came into place after the 2007 fires.

Q: Where are the wind zones defined by SDG&E located in its service area?

A: In its reply to MGRA Data Request 3, Question 24, SDG&E supplied its Known Local Wind map.[38] SDG&E maintains this map in its GIS system, and it is dynamically

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[35] Appendix G; MGRA Data Request 3, Question 24; SDG&E ELECTRIC TRANSMISSION & DISTRIBUTION ENGINEERING, DWG. NO 12100, SHT. NO 7 of 15; p. 9/17.

[36] Appendix E; MGRA Data Request 3, Question 24; SDG&E ELECTRIC OVERHEAD CONSTRUCTION STANDARDS; OH 340.1; Sheet 1 of 3.

[37] Appendix F; MGRA; SDG&E DISTRIBUTION DESIGN MANUAL; RURAL DISTRIBUTION CIRCUIT REBUILDING ANALYSIS; 6232.1.

[38] Appendix G; MGRA Data Request 3, Question 24; SDG&E ELECTRIC TRANSMISSION & DISTRIBUTION ENGINEERING, DWG. NO 12100, SHT. NO 10 of 15; p. 12/17.
Note SDG&E disclaimers regarding this document:
"FOR REFERENCE ONLY: Refer to Enterprise GIS System for Latest Map"
"THIS MAP IS NOT SUREVEY GRACE, and SDG&E makes no XXX or warrantees, expressed or implied as to the accuracy, correctness…"

updated with new information when available. A reference version of this map produced on 1/9/2015 is shown below:

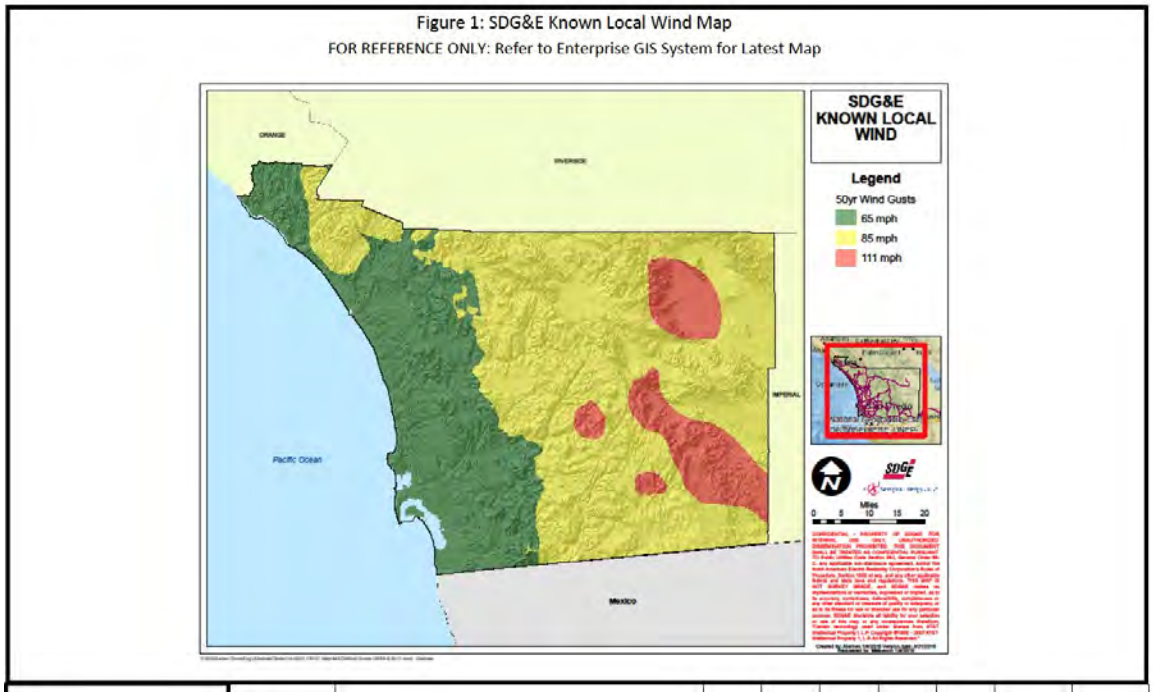

Figure 4 - SDG&E Wind Zones. See disclaimer.[39]

This map shows the 65 mph / 85 mph / and 111 mph wind loading zones designated by SDG&E at the time of the map's production. The 65 mph zones are designated by the green zones (coastal band), the 85 mph zone by the yellow region (most of eastern San Diego County) and the 111 mph region by the red zones (select areas of desert and mountains).

[39] SDG&E Response to MGRA Question 31: "SDG&E is providing this map to you as a courtesy. SDG&E makes no representations or warranties, whether expressed or implied, as to the accuracy, correctness, defensibility, completeness or any other standard or measure of quality or adequacy or as to its use or intended use for any particular purpose. SDG&E disclaims all warranties, expressed or implied, including the warranty of fitness for a particular purpose. You are solely responsible for selecting this map to use and you are solely responsible for any consequences resulting from your use. Reproduction, duplication, or modification of this map is not allowed without written permission from SDG&E Land Services GIS."

Q. What are the implications of SDG&E's current design standards and wind map for the present proceeding?

A. SDG&E now has weather data that allow it to do a detailed analysis of peak winds in its service area. Based on this analysis, it has decided to design for 65 mph, 85 mph or 111 mph maximum gust speeds based on geography. This indicates a tacit recognition that the 56 mph standard it was using prior to 2007 is not appropriate for its service territory. Its inclusion of additional fire prevention measures in its fire hazard zone also indicates that SDG&E now recognizes that additional measures above and beyond what it had in place in 2007 are required to prevent catastrophic fires.

Comparison of the SDG&E Wind Zone map with the earlier SWPL and SPL engineering studies reveals that extreme wind loading within the SDG&E service area was foreseeable using methods of meteorological practice used at the time. Specifically, wind gusts of greater than 56 mph were to be expected across SDGE's service area, and areas above 2000 feet in elevation were anticipated to have gusts in excess of 70 mph.

Q. Did SDG&E adopt more stringent engineering requirements immediately after the 2007 fires?

A. No, it was not until relatively recently that more stringent construction standards were applied across in high fire risk areas of the SDG&E service area. While SDG&E did adopt a "wood-to-steel" pole replacement program, but initially this was designated only for transmission pole replacements and replaced only about 1,000 poles per year in its first few years.[40] In the safety rulemaking R.08-11-005, SDG&E aggressively fought against the interpretation of GO 95 Rule 48 as requiring a 92 mph wind loading standard, putting forward its own proposal that would have weakened the provisions of Rule 48,

[40] A.08-12-021; MUSSEY GRADE ROAD ALLIANCE COMMENTS ON SDG&E'S SHUTOFF PLAN AND PROPOSED RULE 14 CHANGE; March 27, 2009; Appendix B (attached); SDG&E Response to MGRA Data Request #1, part 1. Feb. 24, 2009. MGRA-6, MGRA-8.

which it maintains is being incorrectly interpreted by the Commission.[41] Instead, SDG&E sought permission to conduct controlled power outages in the event of Santa Ana wind storms, even those with winds significantly less than 56 mph.

CONCLUSIONS

Q. Did SDG&E build, construct and maintain its line in accordance with known local conditions at the time of the October 2007 fires?

A. SDG&E had conducted engineering studies that included extensive wind speed calculations in its service area, both in 1981 in preparation for the Southwest Powerlink and later in 2006-2008 for the Sunrise Powerlink. While it might be possible to argue that the Sunrise Powerlink study was received too late to be actionable to prevent the 2007 fires, no such argument exists for the 1981 Southwest Powerlink study, which reached generally similar conclusions regarding the potential for high winds in the SDG&E service area. These engineering study followed an accepted practice of establishing maximum wind speeds based upon the worst case event expected in a specific return interval, which in both cases was 50 years. SDG&E, on the other hand, applied an interpretation of GO 95 Rule 48 that infrastructure wind loading should be based on 56 mph gusts in a rote manner and without regard to the known local conditions.

Additionally, the potential for Santa Ana winds to reach extreme speeds has been long known in the academic literature,[42] including publications by SDG&E's own meteorologist.[43] The meteorological conditions associated with the October 2007 fires and for conditions generally in the SDG&E service area will be covered extensively by

[41] D.14-02-015; p. 58.
[42] Schroeder MJ, M Glovinski, VF Hendricks, and others. 1964. Synoptic weather types associated with critical fire weather. Berkeley, CA: US Forest Service, Pacific Southwest Range and Experiment Station.
[43] NWS WR-270; p. 13; "Stronger Santa Ana Winds can have gusts greater than 60 knots over widespread areas, and gusts greater than 100 knots in favored areas, such as the Santa Ana Canyon." 60 knots is equivalent to 69 mph. 100 knots is equivalent to 115 mph. See ORA Testimony p. 34.

the testimony of UCAN and ORA, who demonstrate that conditions such as those experienced in October 2007 could have been anticipated.

Q. Should SDG&E have been aware of the potential for catastrophic fires due to extreme weather in its service area?

A. Yes, SDG&E had a long history of fires in its service area, some of which were catastrophic. In particular, the Laguna fire of 1970 was ignited by tree-vegetation contact and was at the time the largest fire and most destructive fire in recorded California history. This fire occurred during a Santa Ana event. In fact there, there were a number of additional significant fires associated with the SDG&E infrastructure, including the Pines fire of 2002, started by helicopter-conductor contact.

The most prescient example is the Open fire of 2006, less than a year before the Witch fire ignition. This fire burned 300 acres and was only stopped due to a rare frontal attack on the fire head by firefighters during a lull in the winds, as reported in a contemporaneous news report,[44] included as Appendix H. The Cal Fire report on this fire, which will be further addressed by POC testimony and submitted into the record by POC, states that it was due to a broken cross-arm on a transmission line. MGRA did not receive the Cal Fire investigation report in time to inquire whether the transmission line is in fact TL-637, which was responsible for the ignition of the Witch fire. Regardless, the location of the Open fire ignition so near to the subsequent Witch fire ignition clearly

[44] Appendix H – Downed power line blamed for morning blaze that burned almost 300 acres in Santa Ysabel; By J. Harry Jones and Kristina Davis; UNION-TRIBUNE STAFF WRITERS; December 1, 2006. "Shortly before sunrise yesterday, a risky, even daring, decision was made that may well have prevented the county's next huge fire…
'We knew that if the fire started climbing the next mountain, it would be off to the races and there would be no controlling it,' [Battalion Chief] Chaney said…
'We took a calculated risk this time and put everything we had on the head of the fire.'said [Division Chief] Clayton, who is retiring next week after 48 years on the job. 'We'd figured we'd either catch it and it would remain small, or it would get real, real big.'"

indicates that SDG&E's transmission infrastructure in the Santa Ysabel area was at risk during high-wind Santa Ana events.

Q. Could the Witch fire have been prevented?

A. SDG&E had a number of pieces of information that should have warned it that its infrastructure was putting the public at risk. It's San Diego service area had long been subject to extreme winds during Santa Ana events, and it was known that wind speeds during these events could potentially exceed 56 miles per hour. It had commissioned engineering studies that had predicted extreme wind events would affect its service area. Nevertheless, it applied a 56 mph wind loading standard to its infrastructure because that was its interpretation of General Order 95.

If SDG&E had built to a higher wind loading standard in accordance with the foreseeable weather conditions in its service area, the failure which it asserts led to decreased tension in the TL-637 transmission line and the subsequent line-slap and arcing would likely have not occurred. SDG&E had also been forewarned by the Open fire less than a year before that the transmission line in question was subject to failure during Santa Ana winds in a manner capable of causing the ignition of a wildfire. Had SDG&E acknowledged and acted upon these forewarnings, it might have turned off reclosing on this circuit without manual inspection, which would have prevented this particular ignition, which in this case occurred on the third trip.[45] Unfortunately SDG&E did not act on available information and de-energize the conductor before the fire was ignited.

[45] ORA Testimony; pp. 14-15.

APPENDICES

APPENDIX A – SDG&E Data Request Responses

MGRA DATA REQUEST MGRA-SDG&E DR-01, Q1-13 SDG&E WEMA PROCEEDING - A.15-09-010 SDG&E SUPPLEMENTAL RESPONSE DATE RECEIVED: July 5, 2016 DATE RESPONDED: July 20, 2016

Request 1:
Please provide detail of what specific information was unavailable to SDG&E in October 2007 that SDG&E would have found necessary to prepare for wildfire conditions and deploy appropriate resources.

Objection: SDG&E objects to this request on the grounds set forth in General Objection 3. Subject to the foregoing objection, SDG&E responds as follows.

Response:

SDG&E is unable to identify what, if any, specific information was unavailable to it in October 2007 which SDG&E would have found necessary to further prepare for wildfire conditions and deploy appropriate resources. Based on information available prior to the 2007 wildfires, SDG&E believed it was reasonably prepared for wildfire conditions and had the appropriate resources in place. As discussed in the prepared direct testimony of several SDG&E witnesses in this proceeding, including Messrs. Geier, Weim, Walters and Akau, the 2007 wildfires led to many updates to policies and procedures at SDG&E, as well as in regulations promulgated by the CPUC. These witnesses further explain that SDG&E's engineering, construction and maintenance of its facilities were undertaken with great care and with the goal of maximizing safety in light of the risk known prior to the fires.

Request 2:

Please provide documentation supporting the assertion that SDG&E in 2007 believed that strong Santa Ana winds would be funneled through passes and canyons rather that result from downslope windstorms. Include all relevant references and citations.

Objection: SDG&E objects to this request on the grounds set forth in General Objection 2. Subject to the foregoing objection, SDG&E responds as follows.

Response:

Although it has long been understood by the meteorological community that there is a downslope component to Santa Ana winds, it was often stated that the strongest winds occurred through and below passes and canyons. The following National Weather Service products or media reports from 2007 provide examples of such statements.

• Excerpt from Issuance of the High Wind Warning for San Diego County issued October 2007: "SANTA ANA WINDS WILL DEVELOP SUNDAY MORNING WITH AREAS OF NORTHEAST WINDS INCREASING TO 25 TO 35 MPH WITH STRONGEST GUSTS TO 70 MPH THROUGH AND BELOW PASSES AND CANYONS." *See* https://mesonet.agron.iastate.edu/vtec/#2007-O-NEW-KSGX-HW-W-0011/USCOMP-N0R-200710211000. (Click Text Data > Issuance)

• Excerpt from the National Weather Service San Diego's "The Weather Guide": "Santa Ana winds are strong, dry offshore winds that blow from the east or northeast. These winds are strongest below passes and canyons of the coastal ranges of Southern California." *See* http://www.wrh.noaa.gov/sgx/document/The_Weather_Guide.pdf (p. 43).

• Excerpt from the San Francisco Chronicle: "Santa Ana wind makes October the cruelest month in California" published on October 24, 2007. *See* http://www.sfgate.com/news/article/Santa-Ana-wind-makes-October-the-cruelest-month-3237215.php ("It is the dread Santa Ana wind, moving down the canyons and through the gaps in the mountains, driving wildfires before it like a fiery torch."

• American Meteorological Society's Online Glossary of Meteorology: "Santa Ana - a dry, foehnlike desert wind in southern California, generally blowing from the northeast or east, especially in the pass and river valley of Santa Ana, California, and other nearby passes, where it is further modified as a mountain-gap wind." *See* http://glossary.ametsoc.org/wiki/Santa_ana.

• Excerpt from the City of San Diego's After Action Report to the October 2007 Wildfires: "The October 2007 San Diego Wildfires, consisting of seven separate fires within San Diego County, began on October 21, 2007, during a major Santa Ana wind event that lasted for three days. These winds are characterized by warm temperatures, low relative humidity, and increased wind speeds. As the Santa Ana winds are channeled through the mountain passes they can approach hurricane force." *See* https://www.sandiego.gov/sites/default/files/legacy/fire/pdf/witch_aar.pdf (p. 5).

Request 3:

Mr. Vanderberg's testimony on page 7 states, regarding variability between nearby weather stations that "This variability is not random, however, and in many cases is now predictable based on historical observation and the local, known characteristics of downslope winds." Please provide supporting calculations and worksheets that support the assertion that the variability between weather stations is not random but allows prediction of wind values during specific events.

Response:

In this context, "variability" refers to the observed difference in wind speed between Ramona, Santa Ysabel, and Julian mentioned earlier in the same paragraph. In other words, the pattern of strong winds in the Santa Ysabel area with much weaker winds in Julian to the east and in Ramona to the west is not random, but is a common feature of Santa Ana wind events. This can be seen through an examination of historical observations following the installation of SDG&E's weather stations and by reading recently published research of Santa Ana winds in San Diego County, including the following:

• Fovell, R. G., Y. Cao, 2016: The Santa Ana winds of Southern California: Winds, gusts, and the 2007 Witch fire. Wind and Structures in press.

(http://www.atmos.albany.edu/facstaff/rfovell/papers/2016-fovell-cao-santa-ana_WS.pdf)

• Cao, Y., R. G. Fovell, 2016: Downslope windstorms of San Diego County. Part I: A Case Study. Mon. Wea. Rev. 144, 529-552.
(https://www.researchgate.net/publication/293944387_Downslope_Windstorms_of_San_Diego_County_Part_I_A_Case_Study)

Request 4:

Following on to the previous question MGRA-3, define what differentiates Santa Ana events where the variability is "predictable" and those in which it is not.

Response:

The two research papers referenced in response to Request 3 above address issues of variability and predictability.

Request 5:

Please provide the dates and times that characterize all Santa Ana events that were used in the analysis referred to on page 7.

Response:

The dates and times are already provided on pages 6-7 of Mr. Vanderburg's prepared direct testimony, as well as in Appendix 2 to that testimony.

Request 6:

What is the basis for the "atmospheric rapids" model referred to in the testimony? Please cite all relevant sources.

Response:

Hydraulic Theory is often used to describe the dynamics of downslope windstorms. The term "atmospheric rapids" was used instead of "Hydraulic Theory" to make it easier to visualize and understand the behavior of Santa Ana winds in San Diego County. There are many examples of people using Hydraulic Theory to describe downslope windstorms. Two examples are provided below.

• Excerpt from the Encyclopedia of Atmospheric Sciences, 2003, pp. 644-650, Elsevier Science Ltd. - Downslope Winds: "The dynamics governing the development of strong downslope winds in the atmosphere are analogous to those governing the rapid increase in speed that occurs when water flowing over a rock in a river undergoes a transition from a relatively slow velocity upstream to a thin layer of high-velocity fluid over the downstream face."

• Excerpt from Mountain Weather Research and Forecasting: Recent Progress and Current Challenges, 2012, pg. 163, Springer Science & Business Media: "[T]he fundamental dynamics are qualitatively explained as an analog to the hydraulic flow of water over an obstacle resulting in rapid, supercritical flow along the obstacle's lee slope, which terminates in a turbulent, hydraulic jump."

Request 7:

Was Mr. Vanderberg aided in the preparation of this testimony by other experts? If so, please name them and their affiliation.

Response:

No.

Request 8:

Based on your current understanding of variation and spatial wind patterns across San Diego County, please rank the weather stations listed below in the order of highest to lowest peak wind gust speeds you would expect to occur during Santa Ana events:
Valley Center (VLCC1), Alpine (ANEC1), Goose Valley (GOSC1), Pine Hill (PIHC1), Santa Rosa Plateau (SRUC1), Descanso (DENC1), Campo (KCZZ), Potrero (POTC1), and Ramona (KRNM).

Objection: SDG&E objects to this request on the grounds set forth in General Objections 2, 5 and 9. Subject to the foregoing objection, SDG&E responds as follows.

Response:

Any potential ranking would be speculation and may not be representative of true wind speeds and patterns in the area. Accordingly, SDG&E does not rely on these weather facilities; rather, SDG&E relies on data from its own installed weather stations. Data from these wind stations, however, is publicly available through http://mesowest.utah.edu/

Request 9:

Regarding the answer to the previous question MGRA-8, based on your understanding of SDG&E's state of knowledge in 2007, would you expect the relative ranking of highest and lowest wind areas to differ? If so, which weather stations would have in 2007 been expected to have the highest and lowest peak wind speeds?

Objection: SDG&E objects to this request on the grounds set forth in General Objections 2, 5 and 9. Subject to the foregoing objection, SDG&E responds as follows.

Response:

See response to Request 8 above.

Request 10:

Please provide all data, calculations and worksheets that indicate that underlie the conclusion stated on page 13 of Mr. Vanderberg's testimony that peak wind gusts would be 1.56 times stronger in West Santa Ysabel than they would be in Julian using RAWS data.

Objection: SDG&E objects to this request on the grounds set forth in General Objection 2. Subject to the foregoing objection, SDG&E responds as follows.

Response:

The 1.56 was based on all Santa Ana wind events where WSY measured a peak wind gust equal to or greater than 45 mph. See attachment "JULC1_WSY_SIL_Comparison." Note: The number has changed to 1.57 as the table has been updated with the latest data.

Request 11:

What physical parameters or wildfire impacts would you expect the Santa Ana Wildfire Threat Index to be directly proportional to?

Objection: SDG&E objects to this request on the grounds set forth in General Objection 3. Subject to the foregoing objection, SDG&E responds as follows.

Response:

The Santa Ana Wildfire Threat Index measures the probability that an ignition will go beyond initial attack and become a large fire (250+ acres).

Request 12:

Please provide documentation and citations supporting the claim that 300 fires were ignited during the October 2007 fire siege.

Response:

The reference to "some 300 fires" in Mr. Vanderburg's prepared direct testimony (p. 16) derives from reports indicating that there were many active fires burning during the 2007 firestorms, plus even more fires that ignited but were extinguished soon thereafter. For instance, one report indicates that there were "17 significant fires and dozens of smaller ones" (see Appendix 2 to Mr. Schavrien's prepared direct testimony, p. 57); another report indicates that there were 23 major fires (see Appendix 4 to Mr. Schavrien's prepared direct testimony, pp. 30-32), and that report later indicates that there were "24 fires burning" (see id. at 38). In addition to these active fires, one report indicates that there were 251 fire starts

caught on initial contact (see Appendix 4 to Mr. Schavrien's prepared direct testimony, p. 33).

Request 13:

Kindly provide a copy of all received data requests and responses from other parties. Preferably, these can be posted on SDG&E's regulatory website as they were in A.14-11-002.

Objection: SDG&E objects to this request on the grounds set forth in General Objection 10. Subject to the foregoing objection, SDG&E responds as follows.

Response:

Subject to the foregoing objection, these materials are being made available to MGRA through SDG&E's WEMA SharePoint website, with the exception of the hard drive discussed below. Access instructions for the WEMA SharePoint website are set forth within the cover letter accompanying these responses. Please note that SDG&E is not producing at this time its response to one of the five sets of ORA data requests to which it has responded to date (ORA-SDG&E DR-01) on the grounds that those requests, to which SDG&E responded prior to the prehearing conference and issuance of the Scoping Memo, concerned Phase 2 issues.

As discussed during our July 19, 2016 meet and confer, in response to an ORA data request (ORA-SDG&E DR-02), SDG&E produced its document production and relevant discovery responses, as well as deposition transcripts, from the civil litigation associated with the Witch, Rice and Guejito Fires of 2007 on a removable hard drive. As noted in SDG&E's April 29, 2016 objections and responses to ORA-SDG&E DR-02, Requests 2-3, certain materials on the hard drive were marked as "confidential" in the course of the civil litigation under the applicable protective order. SDG&E further noted that in the interest of providing those materials as promptly as possible to ORA, SDG&E did not separately mark those materials as "Confidential Pursuant to P.U. Code § 583 and General Order 66-C" but produced them on the understanding that they would be treated as confidential pursuant to those provisions. SDG&E also indicated that it would be willing to further examine and discuss the appropriateness of any confidentiality designation with ORA.

SDG&E is preparing a copy of this hard drive for MGRA and will provide it to you as soon as possible. As discussed during our July 19, 2016 meet and confer, SDG&E will need to enter into a Non-disclosure Agreement with MGRA due to the confidentiality of certain of these materials prior to providing them and is producing these materials with the understanding that documents or files marked "Confidential" will be deemed "Protected Materials" under the Non-disclosure Agreement. SDG&E is willing to further examine and discuss with MGRA the appropriateness of any such designations of confidentiality (i.e., Protected Materials). Please also note that there is a log of the confidential documents in excel format that was produced to ORA on April 29, 2016 in connection with these responses and which will be available on the WEMA SharePoint website.

MGRA DATA REQUEST; MGRA-SDG&E DR-02, Q14-20;
SDG&E WEMA PROCEEDING - A.15-09-010
SDG&E RESPONSE
DATE RECEIVED: July 26, 2016
DATE RESPONDED: August 9, 2016

Request 14:

Related to the testimony of Steve Vanderberg;
Please provide a full description of the characteristics of the anemometers making up the SDG&E mesonet, including make and model. Specifically include a description of the algorithms used to calculate both gust and average wind speeds, including sampling frequency, length of sample, and frequency of data transmission.

Response:

SDG&E uses an RM Young anemometer model 05103 mounted at a height of 20 feet above ground level. Data is transmitted every 10 minutes. Wind speed is measured every 3 seconds. The reported sustained wind speed is the average of all 200 wind speed measurements during the previous 10 minutes. The reported wind gust is the highest measured 3-second wind speed during the previous 10 minutes.

Request 15:

Related to the testimony of Steve Vanderberg;
Please provide the exact geographic coordinates for the SDG&E weather station at West Santa Ysabel (WSY).

Response:

See SDG&E's response to ORA-SDG&E DR-05, Request 3.

Request 16:

Related to the testimony of Steve Vanderberg;

[a] In reference to SDG&E's response to question MGRA-3, elaborate on the finest scale over which SDG&E expects geographic and topographical features to influence wind speed measurements during Santa Ana wind events. [b] Does SDG&E observe significantly different wind measurements from weather stations that are close to each other during Santa Ana events? [c] Based on SDG&E's analysis of wind data in Eastern San Diego County, what is the largest distance scale over which variations between wind measurements at two points can be expected to vary significantly? [d] How close do measurement points need to be to each other in order to guarantee that wind speed measurements at those points will be approximately equal to each other, and how much would they be expected to vary from each other?

Objection: SDG&E objects to this request on the grounds set forth in General Objections 2, 3, 5 and 9. Please note that SDG&E has separated the original request into subparts (a) through (d) since the request contained multiple, separate questions. Subject to the foregoing objections, SDG&E responds as follows.

Response:

a. The answer to this question depends on the location where the wind speed measurements are being made, and could vary from location to location.

b. The answer to this question depends on which weather station(s) MGRA is referring to, which are not specified in the question, nor is the term "significantly" explained.

c. See responses to subparts (a) and (b).

d. See responses to subparts (a) and (b). In addition, SDG&E does not understand what MGRA means by "approximately equal"and does not know how to answer the second part of the question.

Request 17:

Related to the testimony of Steve Vanderberg;

In regard to the SDG&E response to MGRA-11, which states: "The Santa Ana Wildfire Threat Index measures the probability that an ignition will go beyond initial attack and become a large fire (250+ acres).": Please give the calibration between the Santa Ana Wildfire Threat Index that demonstrates the relationship between the index and ignition probability for 250+ acre fires, where probability is defined by a standard probability scale of 0-100%. Provide all calculations and references required to support this calibration.

Objection: SDG&E objects to this request on the grounds set forth in General Objections 3 and 9. Subject to the foregoing objection, SDG&E responds as follows.

Response:

Below is a summary of the results for San Diego County, using data provided by the U.S. Forest Service.

Zone 3	No Rating	Marginal	Moderate	High	Extreme
LFP - Final	< 10	10-16	17-24	25-35	> 36
Number of Fire Days	3777	35	14	4	5
Number of Large Fire Days	118	5	4	1	3
	3%	14%	29%	25%	60%

Request 18:

Related to the testimony of Gerry Akin in the proceeding I.08-11-006;

The June 9, 2009 testimony of Gerry Akin in the proceeding I.08-11-006 states that the transmission span between Z4616675 and Z416676 was built to withstand wind speeds of 56 mph. Prior to 2007, did SDG&E conduct a failure analysis on conductors or rely on any third party analysis to estimate the pole, conductor, or cross-arm failure rates at wind speeds higher than 56 mph?

Response:

Prior to 2007 SDG&E conducted a structural analysis that was performed using a deterministic analysis as dictated by General Order 95 (GO 95) Section IV, Rule 44. The deterministic analysis takes the breaking strength of a material as provided by a manufacturer, divided by load being imparted by wind and other factors, and checks that the value is greater than the minimum safety factor as dictated in GO 95. Based on this deterministic analysis, the pole, conductor or cross-arm either passes or fails the calculation.

Request 19:

Related to the testimony of Gerry Akin in the proceeding I.08-11-006;
Using methods applicable at the time of the 2007 fires, please calculate the expected failure rates of conductors, poles and crossarms using the configuration of Z4616675 and Z416676 and its spanning conductors as it was in October 2007, using peak wind speeds of 60 mph, 70 mph, 80 mph and 90 mph.
Objection: SDG&E objects to this request on the grounds set forth in General Objections 5 and 9. Subject to the foregoing objection, SDG&E responds as follows.

Response:

See response to Request 18 above.

Request 20:

Related to the testimony of Gerry Akin in the proceeding I.08-11-006;
Please calculate the approximate number of SDG&E transmission and distribution poles that are within 10 miles east of a line determined by the maximum elevation of San Diego County on a north-south axis, and additionally lie within SDG&E's Fire Threat Zone.
Objection: SDG&E objects to this request on the grounds set forth in General Objections 3 and 9. Subject to the foregoing objection, SDG&E responds as follows.

Response:

6811 poles with distribution and 636 poles with transmission.

MGRA DATA REQUEST

MGRA-SDG&E DR-03, Q21-24

SDG&E WEMA PROCEEDING - A.15-09-010

SDG&E RESPONSE

DATE RECEIVED: July 29, 2016

DATE RESPONDED: August 15, 2016

Request 21:

Please provide all meteorological and wind studies performed internally or by third party contractors prior to 2009 for SDG&E engineering projects taking place in eastern San Diego County. Please provide both final and draft copies of said studies.

Objection: SDG&E objects to this request on the grounds set forth in General Objections 2, 3, 5 and 10. Subject to the foregoing objections, SDG&E responds as follows.

Response: Please see the "Meteorlogical and Structure Wind Load Studies" report prepared in connection with the Sunrise PowerLink Project ("Sunrise Study.pdf") and the "Meteorological Study for the APS/SDGE Interconnection Project" report prepared in connection with the Southwest PowerLink Project ("SWPL Study.pdf").

Request 22:

For any meteorological or wind study performed by third party contractors as per MGRA-21, please provide the name of the contracting company or individuals, the date that the work was initiated, and the date the work was completed. Please provide a copy of the applicable contract stating the terms of work.

Objection: SDG&E objects to this request on the grounds set forth in General Objections 2, 3, 5 and 10. Subject to the foregoing objections, SDG&E responds as follows.

Response: See response to Request 21 above.

Request 23:

In regard to SDG&E's RIRAT program for fire reduction, described in its GRC filings, what specific system design specifications have been modified to enhance system integrity and reduce the potential for fires?

Objection: SDG&E objects to this request on the grounds set forth in General Objections 2, 5 and 9. SDG&E further objects to this request on the grounds that it calls for information that is outside of the scope of this proceeding. Subject to the foregoing objection, SDG&E responds as follows.

Response:

See the "San Diego Gas & Electric Company Fire Prevention Plan" (dated October 31, 2014) attached as Appendix 2 to the September 25, 2015 Prepared Direct Testimony of David L. Geier in this proceeding. The Fire Prevention Plan provides a discussion of design and construction standard modifications undertaken in connection with fire prevention efforts on page 12. More detailed information regarding modified design standards is set forth in Sections 5122 and 6232 of SDG&E's Distribution Design Manual, which was developed to reduce fire potential. See Distribution System Design Manual 5122_6232.pdf. Additionally, several of SDG&E's overhead construction standards contain specific standards for equipment that take into account work in the Fire Threat Zone ("FTZ") or High Risk Fire Area ("HFRA"). The relevant standards are provided herewith. See Overhead Construction Standards.pdf.

Please note that the Reliability Improvements in Rural Areas Team ("RIRAT") referenced in the question has now been incorporated into the Fire Risk Mitigation ("FiRM") program, as discussed in the SDG&E Direct Testimony of John D. Jenkins in SDG&E's 2016 GRC A.14-11-003). The FiRM program addresses aging infrastructure within the Fire Threat Zone, while taking into account data on local meteorological and

fire conditions that were not considered or known when the facilities were originally constructed.

Request 24:

For infrastructure upgrades and replacements under RIRAT, and for new construction in high fire hazard areas, what wind loading is being applied to distribution and transmission equipment, and what safety factors are being applied? If the wind loading used for engineering standards is site or situation specific, provide the specific criteria used for adopting the chosen wind speed, and list specific wind speed used for engineering calculations by circuit number and nearest SDG&E weather station.

Objection: SDG&E objects to this request on the grounds set forth in General Objections 2, 5 and 9. SDG&E further objects to this request on the grounds that it calls for information that is outside of the scope of this proceeding. Subject to the foregoing objection, SDG&E responds as follows.

Response:

See "ET&DE Standard 12100.pdf" provided herewith. This document contains SDG&E's Electric Transmission and Distribution Engineering standard for pole loading, including wind loading criteria.

MGRA DATA REQUEST
MGRA-SDG&E DR-04, Q25-27
SDG&E WEMA PROCEEDING - A.15-09-010
SDG&E SUPPLEMENTAL RESPONSE
DATE RECEIVED: August 22, 2016
DATE RESPONDED: September 19, 2016

Request 25:

Based on SDG&E's knowledge of the wind conditions in the territory covered by its weather stations, would you expect that there will be locations where variations in wind speed of >30% could occur between two locations within ½ mile of each other?

Objection: SDG&E objects to this request on the grounds that MGRA claims that the response to Request MGRA-16 "was incomplete." SDG&E fully responded to that request. Subject to the foregoing objection, SDG&E responds as follows.

Response: Yes.

Request 26:

Based on SDG&E's knowledge of the wind conditions in the territory covered by its weather stations, would you expect that there will be locations where variations in wind speed of >50% could occur between two locations within ½ mile of each other?

Objection: SDG&E objects to this request on the grounds that MGRA claims that the response to Request MGRA-16 "was incomplete." SDG&E fully responded to that request. Subject to the foregoing objection, SDG&E responds as follows.

Response: Yes.

Request 27:

The following question is intended to provide general geographic information related to the engineering study performed in preparation for construction of Southwest Powerlink provided in response to MGRA-21. The goal of this request is to provide publicly disclosable information and protect sensitive information.

In reference to SDG&E's response to MGRA-21, a table of expected 50-year wind speeds was provided that references specific tower numbers (pp. SDGE0300538 to SDGE300547). Please provide in response to this data request an excel spreadsheet containing a table of the following form: SWPL mile # Estimated 50 year wind speed at nearest tower SWPL mile number should start at 0 at the San Miguel substation and run to the Imperial Valley substation. The estimated 50 year wind speed should be the from the tower location in the table of wind speeds that is closest to the specified mile marker.

Objection: SDG&E objects to this request on the grounds set forth in General Objections 1, 3, 5, 8 and 9. Subject to the foregoing objection, SDG&E responds as follows.

Response:

At our September 15, 2016 meet and confer regarding Request 27, SDG&E reiterated its objection to this request, including relevance, the burden entailed, and the fact that SDG&E is under no obligation to perform studies or analyses that do not already exist. Nevertheless, during the meet and confer, SDG&E agreed to discuss this request with knowledgable personnel to determine whether the analysis you requested could be performed quickly and easily, as Dr. Mitchell asserted.

Based on that inquiry, it appears that the analysis you have requested would take several hours. Accordingly, SDG&E provides the following response.

The data presented in the document you referenced in your request refers to a section of the Southwest Powerlink (SWPL) that begins in the west at Miguel Substation and ends at the Imperial Valley substation. For the purposes of quickly and efficiently responding to this request and to avoid disclosing sensitive information regarding SWPL, SDG&E

believes the following response will meet MGRA's needs if three approximations are utilized.

The three approximations are: 1) assume that SWPL is predominately uni-directional (i.e. west to east) with only moderate variation to the angle of its path; 2) that the spacing between towers is relatively uniform; and 3) the numeric labeling of the towers is indicative of an arithmetic sequence (for example, one can assume that tower 150 is approximately halfway between tower 100 and tower 200). Much of the appropriateness of these three approximations is due to the fact that not every tower used in SWPL had a unique weather study performed, and those towers that were mentioned in the study utilized approximations of weather data not available at each specific site.

The westernmost tower is labeled '25', and the easternmost is labeled '313'. The straight line distance between these two towers is approximately 70 miles. Hence, the numerical difference implies that the value of 288 be used as the count of towers (313-25=288). Dividing the 70 miles by 288 yields an approximate distance of 1280 feet (or .24 miles) per span between towers. To determine the approximate location of tower '100', one could note that it is 75 towers east of tower '25' (i.e. the westernmost tower), and therefore multiply 75 by 1280 feet per span. The distance generated by that approximation would be the distance in feet east of the western terminus, in this example 96,250 feet or 18 miles. In this manner, MGRA can estimate the location of each tower in the referenced document.

MGRA DATA REQUEST
MGRA-SDG&E DR-05, Q28-33
SDG&E WEMA PROCEEDING - A.15-09-010
SDG&E RESPONSE
DATE RECEIVED: September 19, 2016
DATE RESPONDED: October 3, 2016

Request 28:

Please provide the following document that was referenced in SDG&E's response to MGRA DR-3. This is required in order to identify the treatment of gust factors: "Meteorological Evaluation of the Proposed 500 kV Transmission Routes Miguel Substation - Laguna Dam and Rainbow Substation - Laguna Dam", February 1979, SDG&E Contract 4/2820078."

Objection: SDG&E objects to this request on the grounds set forth in General Objections 5 and 8. Subject to the foregoing objection, SDG&E responds as follows.

Response: After a diligent search of its files, SDG&E has not located the referenced document from February 1979.

Request 29:

In regard to SDG&E's response to DR-3, Question 21, section titled: "METEOROLOGICAL STUDY FOR THE APS/SDGE INTERCONNECTION PROJECT, Prepared April 1981", please clarify:
On pages SGDE0300538 to SGDE0300547, how is the value for column WEATHER DATA, subcolumn "WIND (mph)" determined? Is the value cites an average hourly value? If it is a gust value please specify the time interval used to measure the gust.

Objection: SDG&E objects to this request on the grounds set forth in General Objections 5 and 8.
Subject to the foregoing objection, SDG&E responds as follows.

Response: SDG&E does not have information beyond what is contained in the referenced study.
Page 3 of the report provides some information about "[t]he meteorologic data used" for the study.

Request 30:
In regard to SDG&E's response to DR-3, Question 21, section included as attachment:
Attachment:
ET&DE Standard 12100.pdf: Referring to Figure 1: SDG&E Known Local Wind Map, Drawing number 12100, p. 10 of 15:
Please provide the date on which this map was produced.

Response: The referenced map was produced in early 2015.

Request 31:
In regard to SDG&E's response to DR-3, Question 21, section included as attachment:
ET&DE Standard 12100.pdf: Referring to Figure 1: SDG&E Known Local Wind Map, Drawing number 12100, p. 10 of 15:
Please provide any disclaimer language that SDG&E would prefer to have included in reference to this map, since the disclaimer on the image provided is illegible.

Response:
SDG&E's preferred disclaimer language for the referenced map is the following:
SDG&E is providing this map to you as a courtesy. SDG&E makes no representations or warranties, whether expressed or implied, as to the accuracy, correctness, defensibility, completeness or any other standard or measure of quality or adequacy or as to its use or intended use for any particular purpose. SDG&E disclaims all warranties, expressed or implied, including the warranty of fitness for a particular purpose. You are solely responsible for selecting this map to use and you are solely responsible for any

consequences resulting from your use. Reproduction, duplication, or modification of this map is not allowed without written permission from SDG&E Land Services GIS.

Request 32:

In regard to SDG&E's response to DR-3, Question 21, section included as attachment: ET&DE Standard 12100.pdf: Referring to Figure 1: SDG&E Known Local Wind Map, Drawing number 12100, p. 10 of 15:

Please provide GIS files in shapefile (.shp) format corresponding to the wind zones shown on the map, for the version of the map shown in Question 21. If the version corresponding to the date on the map provided in DR-3, Question 21 cannot easily be obtained, then please provide a recent version of the Known Local Wind map.

Response:

The latest Known Local Wind Map is attached.

Request 33:

In regard to SDG&E's response to DR-3, Question 21, section included as attachment: Sunrise Study.pdf: Referring to title page: 5DGE0250443_ TLM: The document is dated April 27,2006, Revised March 12, 2008. Please state what revisions were made between the April 27, 2006 revision and March 12, 2008 revision.

Objection: SDG&E objects to this request on the grounds set forth in General Objections 1, 2 and 5.

Appendix B – Southwest Powerlink Engineering Design Excerpts

Attachment: SWPL Study.pdf

METEOROLOGICAL STUDY

FOR THE

APS/SDGE INTERCONNECTION PROJECT

Prepared April 1981

Prepared By T. M. Snow

Reviewed By B. E. Blankenbush

Approved By T. M. Winter

Noted By W. E. Wendland 4-16-81

SGDE0300519

ABSTRACT

This report documents the development and utilization of meteorologic data used for the design of the 500 kV transmission line for the APS/SDG&E Interconnection Project.

SGDE0300520

INTRODUCTION

The minimum meteorological loading conditions are established by rule 43 of the California Public Utilities Commission's General Order No. 95 (G.O. 95). Because of the importance of the 500 kV transmission line, a meteorological study covering the specific area traversed by the proposed line was performed to confirm the minimum loading required by G.O. 95 or to establish a more severe loading criteria.

The meteorologic study was conducted by Meteorology Research, Inc. (MRI) of Altadena, California. The original study was completed in February of 1979.

SCOPE OF STUDY

The purpose of the meteorological study was to determine the probable extreme values of wind, temperature, ice loading, and combined wind on ice loading to be experienced along the proposed transmission line routes from the Miguel Substation to Laguna Dam on the Colorado River. The study consisted of four phases: a field survey, climatology survey, data acquisition and reduction, analysis of data and application to the proposed route.

MRI REPORT

The original study was completed and submitted to SDG&E in February of 1979. The original study documents all of the data and recommendations performed by MRI. The final reports and all correspondence are kept in the project files of the APS/SDG&E Interconnection Project maintained in Transmission Engineering.

The data obtained by MRI was applied to a line routing supplied by the Transmission Engineering Section of SDG&E. The exact location of the PI's of this line routing are recorded on U.S.C.G.S. Quads maintained in Transmission Engineering. A general descriptive location of each PI is also contained within the MRI report. The actual line route is not necessarily the same route as the one supplied to MRI. Therefore, as the actual line route is established, the meteorologic data is reviewed. If the actual line route varies significantly, or traverses different terrain than the route originally supplied to MRI, then a formal request is made to MRI to interpolate the meteorologic data for the new route. This new information is documented and kept in the project files in Transmission Engineering.

SGDE0300521

UTILIZATION OF METEOROLOGIC DATA

The meteorologic data utilized in the design of the 500 kV transmission line is the probable extreme values of ice loading, wind on ice loading, and wind loading. The probable extreme values for each of these items was provided for a return period of 25, 50 and 100 years. Assuming the transmission line has a book life of 34 years, the risk factor associated with a 25, 50 and 100 year return period is 75%, 50% and 30% respectively. (The risk factor is the probability of exceeding the design criteria within the selected time duration, i.e., book life). A risk factor of 50% has been selected as the design criteria for the 500 kV transmission line. Therefore, the meteorologic data for a 50 year return period is utilized in the design of the transmission line.

The meteorologic data used for the design of the 500 kV transmission line is the probable maximum sustained 1-minute wind speed and it's probable direction. In order to analyze the effect of the wind upon a particular line section, the wind is broken up into two components: an axial component, which is parallel to the axis of the wire, and a component normal to the longitudinal axis of the wire. Only the normal component is used in the design, the axial component is negligible and is neglected. The axial component may produce a longitudinal load on the towers. However, the towers are designed to handle longitudinal loads produced during construction or due to differential ice loading and are capable of withstanding the small magnitude of longitudinal load which may be produced by the axial component of the wind.

In order to ascertain the maximum impact, the design value used for a particular line section is equal to the maximum normal component of wind which occurs when the probable wind direction is varied $\pm$ 22.5 degrees from the value given in the MRI report. The variation of the wind from the probable direction given in the MRI report is based on consultation with MRI.

Once the wind component for a particular section is obtained, then the unit wind pressure (lb/ft^2) which will be used for the line design is calculated. These calculations are performed by a program written on the HP 9825. The program generates all of the meteorologic parameters used for the design of the 500 kV transmission line. The program output is shown in Figures 1 and 2. The documentation of the program is attached as Appendix A.

SGDE0300522

APPENDIX A

ABSTRACT

This appendix documents the meteorologic program which was developed to calculate the design parameters used for the design of the 500 kV transmission line for the APS/SDG&E Interconnection project. This appendix contains a user's guide, documentation of the basic equations used, and a copy of the program.

SGDE0300525

REFERENCES

1. IEEE, "Loading and Strength of Transmission Line Systems - Part 2 Designing for Wind Loads", Paper A77299-8 presented January 30 - February 4, 1977 at the IEEE PES Winter Meeting, New York, N.Y.

2. U.S. Department of Energy, "Electrical and Mechanical Design Criteria for EHV and UHV Overhead Transmission Lines", June 1980, DOE/RA/2133-01.

3. "Meteorological Evaluation of the Proposed 500 kV Transmission Routes Miguel Substation - Laguna Dam and Rainbow Substation - Laguna Dam", February 1979, SDG&E Contract #Z820078.

SGDE0300536

times the maximum hourly or maximum hourly average values.

HEIGHT FACTORS

Wind speed generally increases with height above the surface of the earth. The rate of increase is dependent on the speed of the wind, the variation with height of the air temperature, and the roughness of the terrain over which the wind is flowing.

There have been many studies undertaken and theories presented on the variations of wind speed with height above the surface. There is general agreement that wind profiles tend to obey a power law [1, 2, 3]. This relationship is normally used when neutral stability exists.

RETURN PERIODS

Wind speeds for design purposes are frequently expressed in terms of return periods (25-year return period, 50-year return period, etc.). These values are usually derived by assuming that the distribution of the yearly extreme wind speeds is well approximated by a Fisher-Tippett Type I (sometimes called Gumbel) distribution of extreme values [4, 5]. This symmetric extreme probability distribution cited by Court [6] as particularly applicable to extreme surface winds, is used by both the National Weather Service in the U.S. and the Canadian Department of Transport.

Return period values of maximum wind speeds may be computed using the relationship given by Weiss (1955).

$$W_t = \overline{W} + \sigma K_t \qquad (1)$$

where: W_t = magnitude of the wind speed for return period, t

$\overline{W}$ = mean of the extreme yearly wind speeds on record

σ = standard deviation of the series of extreme yearly wind speeds

K_t = constant for return period t and based on the period of record

Input data are the yearly extreme wind speeds for a given station for as long a period of record as possible. At least 20 years of record is desirable and return periods based on less than 10 years of consistent records must be used with caution. Unfortunately, stations with 20 years of hourly wind records are scarce in areas where transmission lines are constructed.

After return period values of the maximum wind speeds to be expected at the weather station site are developed, these return period wind speeds must be related to the various locations and exposures of the planned line route. In most cases, the weather stations with significant periods of recorded wind speeds will be located at airports which are usually situated in relatively flat, open areas, or broad valleys. To be meaningful for design purposes these values must be extrapolated to areas frequently quite different in altitude and exposure and perhaps many miles removed from the nearest site with records. This extrapolation should be done by someone knowledgeable in the effects of terrain and exposure on wind patterns and velocities.

In the use of return period wind speed values, it must be understood that these are only a guide as to how frequently these extreme values are expected to occur. They give no indication as to when they are expected to occur. The once in 200 years storm may occur next year or a hundred years from now. The probability of occurrence of the extreme value within the selected return period is quite high. The probability that the extreme value will occur in a given year is the inverse of the return period.

$$P = \frac{1}{T} = \frac{1}{50} = .02 \qquad (2)$$

The probability that the extreme value will not occur in a given year is then

$$= 1 - .02 = .98$$

$$s = 1 - P = 1 - \frac{1}{T} \qquad (3)$$

The probability that the extreme value will not occur within n years is

$$S = s^n = \left(.98\right)^{34} = .50 \qquad (4)$$

where S is the probability of survival, "survival factor," of the loading criteria for "n" years duration. The chance of exceeding the loading criteria within the selected period (n) is the "risk factor" (R)

$$= 1 - .50 = .50$$

$$R = 1 - S \qquad (5)$$

R and S may be determined by the following equation

$$S = 1 - R = \left(1 - \frac{1}{T}\right)^n = .50 \qquad (6)$$

where T is the return period in years and n the selected duration or lifetime in years.

For a 50-year return period (T) and a selected duration or lifetime of 50 years (n), the risk of having the loading criteria exceeded within the 50-year lifetime is then 63 per cent.

Return period values of extreme wind speed have been developed for most major weather stations in the U.S. [7] and Canada [8]. Thom in 1968 prepared maps of isotachs in miles per hour for various return periods. Figure 1 shows the 50-year Mean Recurrence Interval Map for the United States. Of course, these are smoothed isotachs drawn for the station data and do not reflect local variations in terrain.

Figure 2 shows a typical return period wind speed graph. While the slope of the curve will vary from station to station, there frequently will be only 4 or 5 mi/h (1.8 or 2.2 m/s) difference between 25-year and 50-year return period values. In most cases a small increase in design wind speeds will double the return period probability.

WIND GUSTS

Gusts are sudden brief increases in the speed of the wind resulting from eddies superimposed on the basic flow of air. Many studies of the relationship of gusts to the steady wind and their variation with speed, height, thermal stratification, and terrain have culminated in general agreement concerning the nature of these relationships [9 – 19]. However, quantitative results have varied depending on the data and analytical methods used.

Most studies of gustiness are from micrometeorological research. Though measurements obtained from such experiments are generally superior to operational data because of refined anemometry, such studies hardly ever provide data for the very high wind speeds important in design of transmission towers and conductors. Sissenwine, et al [19] analyzed a more meaningful spectrum of wind speeds and this work appears to be one of the better recent efforts in this field. Their study included the analysis of 548 wind observations taken at anemometer heights varying from 10 to 85 feet, (3.0 to 25.9 m) with one-minute steady wind speeds varying from 20 to over 80 mi/h (8.9 to 35.8 m/s) and locations varying from tropical Pacific islands to Alaska and Greenland. Since recorder charts of steady winds greater than 80 mi/h (35.8 m/s) were scarce (only 10 cases of the 548 studied), they also used 26 observations of gust factors for 5-minute steady winds ranging from 82 to 188 mi/h (36.7 to 84.0 m/s) taken at Mt. Washington, New Hampshire.

Actually, accurate data on short period gusts are quite rare. In weather station climatological records the steady state wind speed corresponding to maximum peak gusts is usually not available. The maximum hourly wind speed and maximum peak gust for the

SGDE0300537

SOUTHWEST POWERLINK
MIGUEL TO IMPERIAL VALLEY
DESIGN LOADS FOR 2156 ACSR STANDARD

APPROXIMATE LINE					WEATHER DATA				DESIGN DATA			
SDGE PI	MRI PI	TOWER No.	ANGLE (deg)	BEARING (deg)	BEARING (deg)	WIND (mph)	WIND (psf)	TWIND (psf)	WIND (psf)	VERT. (lb/ft)	HORIZ. (lb/ft)	RESULT. (lb/ft)
-	-	999	11.3									
				126.4	0.0 (22.5)	65	11.57	10.90	10.90	2.511	1.601	2.978
M1	-	22	28.9									
				97.5	0.0 (7.5)	65	11.57	11.57	11.57	2.511	1.699	3.032
M2	-	23	11.3									
				108.8	0.0 (18.5)	65	11.57	11.57	11.57	2.511	1.699	3.032
M3	-	24	23.8									
				132.5	0.0 (22.5)	65	11.57	10.21	10.21	2.511	1.500	2.925
1	1	25	39.5									
				93.1	0.0 (3.5)	65	11.57	11.57	11.57	2.511	1.699	3.032
2	2	36	6.8									
				99.9	270.0 (247.5)	65	11.57	3.32	* 3.32	2.511	0.487	2.558
-	2A	38	0.0									
				99.9	270.0 (247.5)	84	19.33	5.54	* 5.54	2.511	0.813	2.639
-	2B	43	0.0									
				99.9	67.5 (45.0)	78	16.67	11.14	11.14	2.511	1.636	2.997
3	3	50	13.3									
				113.1	67.5 (45.0)	78	16.67	14.35	14.35	2.511	2.107	3.278
3A	3A	57	40.1									
				153.2	157.5 (180.0)	70	13.42	2.72	* 2.72	2.511	0.399	2.543
3B	3B	60	6.0									
				147.3	157.5 (180.0)	70	13.42	3.92	* 3.92	2.511	0.576	2.576
-	3B1	64	0.0									
				147.3	67.5 (57.0)	78	16.67	16.66	16.66	2.511	2.447	3.506
-	3B2	66	0.0									
				147.3	157.5 (180.0)	70	13.42	3.92	* 3.92	2.511	0.576	2.576
3C	3C	68	53.4									
				93.9	45.0 (22.5)	78	16.67	14.96	14.96	2.511	2.197	3.337
3D	3C1	71	3.7									
				90.1	67.5 (45.0)	70	13.42	6.75	* 6.75	2.511	0.991	2.699
3D1	-	77	1.2									
				88.9	67.5 (45.0)	70	13.42	6.46	* 6.46	2.511	0.948	2.684
3D2	-	78	2.0									
				90.9	67.5 (45.0)	70	13.42	6.92	* 6.92	2.511	1.016	2.709
3D3	3C3	79	0.7									
				90.1	0.0 (0.5)	65	11.57	11.57	11.57	2.511	1.699	3.032
-	3C4	83	0.0									
				90.1	90.0 (67.5)	70	13.42	1.99	* 1.99	2.511	0.292	2.528
3F	-	86	2.6									
				92.8	90.0 (67.5)	70	13.42	2.45	* 2.45	2.511	0.359	2.537
9A	-	90	15.9									

	RADIAL ICE (in)	WIND (psf)	VERT. (lb/ft)	HORIZ. (lb/ft)	RESULT. (lb/ft)
GO 95 LIGHT LOAD	0.0	8.56	2.511	1.257	2.808
GO 95 HEAVY LOAD	0.5	6.0	3.917	1.381	4.154

NOTES:

1. HEAVY LOADING BETWEEN TOWERS
2. " * " DENOTES LESS THAN 8.56 PSF WIND
3. "**" DENOTES WIRE CHANGE
4. TOWERS 999 EQUAL A RACK

TMS/ GMV
09/17/82

SOUTHWEST POWERLINK
MIGUEL TO IMPERIAL VALLEY
DESIGN LOADS FOR 2156 ACSR STANDARD

APPROXIMATE LINE					WEATHER DATA				DESIGN DATA			
SDGE PI	MRI PI	TOWER No.	ANGLE (deg)	BEARING (deg)	BEARING (deg)	WIND (mph)	WIND (psf)	TWIND (psf)	WIND (psf)	VERT. (lb/ft)	HORIZ. (lb/ft)	RESULT. (lb/ft)
9A	-	90	15.9									
				108.6	90.0 (67.5)	78	16.67	7.19	* 7.19	2.511	1.056	2.724
9B	-	92	3.9									
				112.5	90.0 (67.5)	78	16.67	8.32	* 8.32	2.511	1.222	2.793
9C	-	93	2.4									
				110.1	90.0 (67.5)	78	16.67	7.64	* 7.64	2.511	1.121	2.750
11	11	106	19.8									
				90.3	247.5 (225.0)	84	19.33	9.75	9.75	2.511	1.432	2.890
-	11A	120A	39.5									
				90.3	45.0 (22.5)	84	19.33	16.56	16.56	2.511	2.431	3.495
12	12	124	11.8									
				78.5	247.5 (225.0)	84	19.33	5.88	* 5.88	2.511	0.863	2.655
14	14	130	5.3									
				83.7	247.5 (225.0)	84	19.33	7.56	* 7.56	2.511	1.110	2.746
16	16	148	3.8									
				79.9	247.5 (225.0)	84	19.33	6.34	* 6.34	2.511	0.931	2.678
16A	16A	151	4.5									
				84.5	247.5 (225.0)	84	19.33	7.81	* 7.81	2.511	1.147	2.761
16B	16B	160	19.6									
				104.1	247.5 (225.0)	84	19.33	14.24	14.24	2.511	2.090	3.267
18A	18A	163	23.4									
				80.7	247.5 (225.0)	84	19.33	6.59	* 6.59	2.511	0.968	2.691
19A	19A	187	4.9									
				75.8	247.5 (225.0)	84	19.33	5.07	* 5.07	2.511	0.744	2.619
19B	19B	188	5.1									
				70.7	247.5 (225.0)	84	19.33	3.64	* 3.64	2.511	0.534	2.567
19C	19C	189	4.0									
				66.7	247.5 (270.0)	84	19.33	3.02	* 3.02	2.511	0.443	2.550
19D	19D	193	17.3									
				84.0	247.5 (225.0)	84	19.33	7.66	* 7.66	2.511	1.125	2.751
-	20B	198	1.2									
				84.0	225.0 (202.5)	84	19.33	14.93	14.93	2.511	2.193	3.334
20B	-	201	5.5									
				89.5	247.5 (225.0)	84	19.33	9.49	9.49	2.511	1.393	2.872
-	20D	208	0.7									
				89.5	202.5 (180.0)	85	19.79	19.79	19.79	2.511	2.906	3.840
21	21	213	56.4									
				33.0	202.5 (180.0)	95	24.72	7.35	* 7.35	2.511	1.079	2.733
22	22	221	6.1									
				27.0	225.0 (247.5)	85	19.79	8.36	12.55 ~~* 8.36~~	2.511 ~~2.511~~	1.843 ~~1.227~~	3.115 ~~2.795~~
-	-	223	15.9									

	RADIAL ICE (in)	WIND (psf)	VERT. (lb/ft)	HORIZ. (lb/ft)	RESULT. (lb/ft)
GO 95 LIGHT LOAD	0.0	8.56	2.511	1.257	2.808
GO 95 HEAVY LOAD	0.5	6.0	3.917	1.381	4.154
MRI HEAVY LOAD	1.10	2.48	4.226	0.819	4.305

NOTES:

1. HEAVY LOADING BETWEEN TOWERS 130 TO 223
2. " * " DENOTES LESS THAN 8.56 PSF WIND
3. "**" DENOTES WIRE CHANGE
4. TOWERS 999 EQUAL A RACK

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SGDE0300539

SOUTHWEST POWERLINK
MIGUEL TO IMPERIAL VALLEY
DESIGN LOADS FOR 2156 ACSR STANDARD

APPROXIMATE LINE					WEATHER DATA				DESIGN DATA			
SDGE PI	MRI PI	TOWER No.	ANGLE (deg)	BEARING (deg)	BEARING (deg)	WIND (mph)	WIND (psf)	TWIND (psf)	WIND (psf)	VERT. (lb/ft)	HORIZ. (lb/ft)	RESULT. (lb/ft)
-	-	223	0.0						12.55		1.843	3.115
				27.0	225.0 (247.5)	85	19.79	8.36	* ~~8.36~~	~~2.511~~	~~1.227~~	~~2.795~~
-	23	241	0.0									
				27.0	225.0 (247.5)	80	17.53	7.40	* 7.40	2.511	1.087	2.736
24	24	254	49.7									
				76.6	225.0 (202.5)	75	15.41	10.12	10.12	2.511	1.486	2.918
26	25	270	13.5									
				90.2	225.0 (202.5)	70	13.42	11.49	11.49	2.511	1.687	3.025
27	-	280	27.5									
				117.7	247.5 (225.0)	70	13.42	12.23	12.23	2.511	1.796	3.087
28A	-	313	27.4									
				90.3	247.5 (225.0)	70	13.42	6.78	* 6.78	2.511	0.996	2.701
-	-	999	0.0									
				90.3	247.5 (225.0)	66	11.93	6.03	* 6.03	2.511	0.885	2.663
-	-	999	25.3									

	RADIAL ICE (in)	WIND (psf)	VERT. (lb/ft)	HORIZ. (lb/ft)	RESULT. (lb/ft)
GO 95 LIGHT LOAD	0.0	8.56	2.511	1.257	2.808
GO 95 HEAVY LOAD	0.5	6.0	3.917	1.381	4.154

NOTES:

1. HEAVY LOADING BETWEEN TOWERS
2. " * " DENOTES LESS THAN 8.56 PSF WIND
3. "**" DENOTES WIRE CHANGE
4. TOWERS 999 EQUAL A RACK

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09/21/82

Appendix C – Sunrise Powerlink Engineering Study Excerpts

Attachment: Sunrise Study.pdf

METEOROLOGICAL AND STRUCTURE WIND LOAD STUDIES

Prepared for
San Diego Gas & Electric Company
Sunrise PowerLink Project

Contract Release No. 5660002512
Activity 55325
April 27, 2006
Revised March 12, 2008
S&L Project 11877-136

Prepared by

Sargent & Lundy
Engineers, Ltd.

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1. Introduction and Executive Summary

As one of the preliminary engineering tasks for the Sunrise Powerlink (Project), Sargent & Lundy Engineers, Ltd (S&L) has performed a meteorological study to evaluate wind and ice conditions that can be expected along the Project Routes. This report describes that study and its results.

Maximum wind speeds, maximum icing, and maximum wind speed during icing are provided in this report for the Sunrise Powerlink transmission corridor through San Diego and Imperial Counties of California. Wind and ice estimates were statistically projected for return periods from 2 through 100 years.

For wind analysis, the transmission corridor was separated into nine segments expected to have unique airflow patterns and wind climatology. Projected maximum winds for each corridor segment were based on multi-decade measurements at a regional government weather station expected to be most representative of the wind climate. Maximum winds were expected at segments through Grapevine Canyon and the valley at Agua Caliente Springs. Those narrow valleys near mountain crests were expected to locally accelerate winds during storms.

An initial "Phase 1" ice and wind-during-ice analysis was done using an ice accretion computer simulation model. Predictions were made for storms during multi-decade periods at eight regional government weather stations. Results indicated no icing using weather observations from seven stations in San Diego and Imperial Counties. Results using weather observations at the Beaumont station 75 miles north in Riverside County indicated relatively small ice thicknesses during rare ice storm events. The Beaumont predictions were incorporated as conservative estimates for the project corridor.

A secondary "Phase 2" " ice and wind-during-ice analysis was done to supplement the Phase 1 analysis. It used the same ice accretion computer simulation model as Phase 1. Phase 2 was intended to merge and extrapolate available regional multi-decade weather data to the target location of the Cayamuca weather station. Cuyamaca is at a higher elevation than any of the weather stations used in Phase 1, and is within the project transmission corridor where it passes over highest topography. The intent was to approximate conditions in that corridor area via a composite weather database. Results supported the Phase 1 prediction that icing events should be rare and maximum ice thicknesses small, and indicated that Phase 1 Beaumont predictions of ice and wind-during-ice are conservative for the project transmission corridor.

Additional analysis of regional precipitation statistics indicated that icing predictions should be applied only to elevations above 3,000 feet above mean sea level.

2. Description of Project and Area Geography

Figure 1 presents a shaded relief map of southern California, with locations of the following annotated: the planned San Diego Gas & Electric Company (SDG&E) 500kV Interconnection Project transmission corridor (the Project), southern California climate zones, and meteorological monitoring stations for which data were analyzed.

Figure 2 presents a three-dimensional perspective view of topography in the transmission corridor area, with locations of the following annotated: meteorological monitoring stations for which data were analyzed, and approximate centerline of the transmission corridor.

Fig 3 presents a profile plot of topography along the transmission corridor, with the following annotated: elevations of meteorological monitoring stations for which data were analyzed, and landmarks along the transmission corridor.

2.1 Conductor Design

In the vicinity of Ramona California the line design will include three bundled wires separated by 18 inches, and individual conductors of diameter 1.212 inches each. Elsewhere, the line design will include the same individual diameters, but two-conductor bundles instead of three.

2.2 Climate Character

The project area includes four main climatic zones: coastal, inland, mountain, and desert (SDG&E 2003). Approximate boundaries of those four climatic zones are annotated on the shaded relief map in Figure 1. The zones are elongated in the north-south direction, and generally are in the shape of north-south strips 10 to 20 miles wide.

2.2.1 Coastal Zone

Character of the coastal zone climate is maritime (WRCC 2003). The source of air is normally over the Pacific Ocean and temperature extremes are moderated by that influence. The adjacent ocean also is a source of moisture. Therefore, mean humidity in the coastal zone is generally the highest of any within the SDG&E service territory. Within the coastal zone, wide variations of climate do occur within short distances at those locations where coastal basins and valleys influence movements of marine air.

2.2.2 Inland Zone

The inland zone is located between the coastal and mountain zones. It is a transition between those two adjacent zones, and is more continental in character than the coastal zone, in the sense that it is primarily marked by larger temperature ranges. Temperatures are slightly warmer than in the coastal zone during summer, and slightly cooler than in the coastal zone during winter.

2.2.3 Mountain Zone

The mountain zone is approximately in the center of the SDG&E service territory. Elevations within the mountain zone vary widely and reach maxima several thousand feet above mean sea level (MSL). Temperatures in the mountain zone are generally lowest of those in the SDG&E service territory. Precipitation within the service territory peaks within the mountain zone, particularly on the west sides of the various adjacent ranges. That precipitation pattern results from flow of moist maritime air towards the east that is forced upwards over the ranges. In spite of that precipitation pattern, mean humidity decreases steadily with distance eastward from the Pacific Ocean across both the inland and mountain climate zones.

2.2.4 Desert Zone

The desert zone (east of the mountain zone) has a classic desert climate, with generally the largest temp range of the service territory, small precipitation amounts and low humidity.

2.3 Winds

Winds from the west and northwest prevail in southern California (WRCC 2003). The cause is airflow out of the east side of a synoptic-scale surface high pressure area that is located during the entire year over the northeast Pacific Ocean. A number of California mountain chains deflect those prevailing winds. Therefore, local wind speeds and directions are strongly affected by local topography except near the Pacific coastline, where the prevailing westerly and northwesterly airflow is not disturbed.

During winter, migratory synoptic-scale low-pressure centers take more southerly tracks across California. When such a center is located off the Pacific coast, and a strong high pressure area is simultaneously located over the Great Basin to the east, strong and occasionally damaging winds can occur. Such strong winds can occur particularly along the coast and in the coastal mountain ranges, when airflow is from the east or southeast. Greater wind velocities can occur during such situations at the higher topographic elevations.

An additional wind condition is the "Santa Ana Wind". It also involves high pressure over the Great Basin and low pressure over the coast. It includes very dry airflow from the Great Basin into the central valleys of California. Wind speeds are strong and gusty, and are particularly strong near the mouths of canyons oriented parallel to the airflow direction.

Winds in all four climate zones can be locally enhanced or reduced by topography and other factors. Funneling of airflow through mountain passes and along deeper valleys can cause unusually high local speeds. While thunderstorms are rare at the Pacific coast, they are more frequent at the mountain ranges when airflow is forced over those ranges. They also occur occasionally over the desert regions to the east, and can have associated high wind gusts and cause dust storm events. Enclosed valleys can have a sheltering effect, reducing winds at the valley floor relative to winds at higher surrounding mountain or plateau elevations that are more exposed to regional upper-level airflow.

2.4 Precipitation and Weather Phenomena

The distribution of annual precipitation in the Project area includes a strip of highest values along the highest elevations of the mountain ranges in central San Diego County. This includes, for example, the following ranges: San Jacinto, Santa Rosa, Vallecito, Laguna, Tierra Blanca, Coyote, In – Ko Pah, Jacumba, and San Ysidro. This north-south oriented strip of maximum precipitation is the result of Pacific Ocean moisture forced up the mountains and precipitated-out near the ridgeline. Dryer air then descends towards the east, reinforcing the desert climate to the east of the mountain ranges.

A 1979 analysis of icing for portions of the Project area by MRI (MRI 1979) stated that line icing was generally not expected at mountain elevations below approximately 4,000

ft MSL. However, no justification or analysis was presented in the report to support selection of that transition elevation, although comments were obtained from personnel who lived and worked in the area and were familiar with wind or icing problems that may have occurred. Occurrence of icing was expected by MRI to be highly dependent on local topographic configurations.

The present study includes predictions of transmission wire icing in Sections 4.2 "Projected Icing and Simultaneous Winds" and 6.2 "Projected Ice and Combined Ice/Wind" below. We concluded that a review of representative regional snowfall statistics was necessary in order to decide at what elevations to apply those icing predictions. To obtain representative data, we examined variation of snowfall with elevation only at locations in a geographic area in and immediately adjacent to the mountain climate zone through which the project corridor extends. Figure 4 presents a shaded relief map with those locations and the project corridor annotated. Data included were National Oceanic and Atmospheric Administration (NOAA) cooperative climate observing (COOP) stations that have elevations above sea level and for which snowfall statistics have been published (NCDC 2001), and other sites at which extreme snowfall events have been observed (Miller 2007). Table 1 presents values of several snowfall statistics for each of those sites. Table 2 presents annual water-equivalent precipitation statistics for COOP stations.

Based on initial review of the snowfall statistics in Table 1 and Figure 4, we selected the following three parameters for determination of elevations at which to apply those icing predictions. Of available statistics, our judgement was that these three parameters, when considered simultaneously, best served as surrogates for potential significant transmission wire icing.

(1) Annual mean number of days with snowfall greater than or equal to one inch

(2) Maximum recorded 24-hour total snowfall amounts

(3) Unusual historic snowfall events of one to seven days duration

We plotted the above three snowfall parameters versus elevation above sea level. Figure 5 presents those plots. Because there were no available snowfall frequency data at elevations between 2,700 and 4,640 ft MSL, we assumed an approximately linear trend would occur between those two elevations. Our conclusion based on review of the plots was that there is a marked transition zone at approximate elevation 3,000 ft MSL. That transition includes a rapid increase of mean days per year with significant (one inch or more) snowfall from near-zero to several days per year. The transition also includes a rapid increase of the magnitude of major snowfall events from near-zero to 10 or more inches over one to seven-day periods.

Summarizing, based on review of snowfall-versus-elevation data for the project corridor area, we selected an elevation of approximately 3,000 ft MSL. We considered that elevation to be the lowest at which we would expect significant icing within the southern California mountain climate zone, and the elevation above which our icing predictions would be applied.

3. Analysis Methods

3.1 Maximum Annual Wind Speeds

The National Bureau of Standards (NBS) Simiu computer program (Simiu 1975) was used to project regional winds to various return intervals between two years and 100 years. For simplification, raw data were assumed to be measured at standardized anemometer heights above ground at all stations and across all monitoring periods. Winds were not extrapolated in the vertical to the line height above ground, because of a small expected difference.

For each of eight regional meteorological monitoring stations, inputs to the program were raw data in the form of a series of annual maximum wind speeds. Those raw values were obtained from the National Climatic Data Center (NCDC 2005). Those input values included the following.

(1) For stations for which LCD publications were available

For stations for which NOAA NCDC Local Climatological Data (LCD) published annual summaries were available, the annual "fastest mile" values were extracted and incorporated into the return interval analysis.

(2) For stations for which no LCD publications were available, but for which archived digitized hourly meteorological data files were available

For stations for which no LCD publications are available, but for which archived digitized hourly meteorological data files were available, annual maximum hourly wind speeds were extracted from those digital files and incorporated into the return interval analysis.

We made the conservative assumption that all values in the final dataset (including both annual fastest mile values from LCD publications for selected stations, and annual maximum hourly values from digital files for other selected stations) were hourly wind speeds.

Gust data were extremely inconsistent and therefore were not analyzed. Data out of range or clearly suspect were manually identified and removed from the analysis. The NCDC archived digital databases were not continuous, but all available years were used. Detailed information was not immediately available why selected years were missing, and that information was not relevant to this analysis. Table 3 presents the raw wind speeds for the eight stations: El Centro, Campo, San Diego Gillespie, Ramona, Carlsbad Palomar Airport, March AFB, Beaumont, and San Diego Lindbergh. Figures 9 through 13 present maps that show the local topographic setting of each meteorological station.

Periods of record available for the series of annual maximum hourly wind speeds shown in Table 3 varied from five to 56 years. A longer period of record is always preferred for this kind of statistical projection. However, our common practice in meteorological analysis of extremes, is to collect and analyze what we believe to be the most representative data available within project budget and time constraints. Therefore, rather than serve as a basis for exclusion of data, we considered the available station

period of record as input information to our sense of relative confidence in predicted results. That is, our confidence in return interval estimates based on such digitized long-term hourly meteorological observations increases with the period of record available and analyzed. Available periods of record were relatively short and less than 10 years for two stations: six years for Ramona and five years for March AFB. We chose to not use wind predictions based on Ramona and March AFB. Instead, we chose predictions based on data from other stations because we considered them more representative of the project corridor sections for which predictions were needed. Nevertheless, we retained the Ramona and March AFB data here to show the breadth of data that were considered, and to provide useful information for comparison purposes

Mount Palomar Observatory, at elevation 5,600 ft MSL, is located 13 miles northwest of the northernmost point of the project corridor. Unfortunately, suitable weather data were not available for Palomar. Our wind and icing analyses used as input "Integrated Surface Hourly" digitized weather observations from the National Climatic Data Center (NCDC). No such data were available from NCDC for the Mount Palomar Observatory, so no numerical analysis was done for that location. However, snowfall statistics for the Palomar observatory were used in an analysis of icing elevations, as described in Section 2.4 "Precipitation and Weather Phenomena".

Miramar Naval Air Station, at elevation 477 ft MSL, is located immediately adjacent to the western end of the project corridor. The Miramar station was not included in the analysis because it is located only a short distance (about eight miles northeast) from San Diego Lindbergh Airport, and in relatively flat terrain, and therefore would have been duplicative.

3.2 Maximum Annual Wire Ice Accumulations

3.2.1 Numerical Ice Accretion Model

The Sargent & Lundy (S&L) LLC computer program system: "Modeling of Ice Accretion on Wires" (MICEAW) (Cluts 1986) was used as a tool to predict the following.

- Maximum radial ice on wires
- Maximum wind speeds at approximately 33 ft above ground, during maximum wire icing

The above values were predicted for several return periods of interest.

MICEAW uses validated algorithms to predict three types of wire icing: in-cloud, rain, and wet snow. A statistical program is used to extrapolate predicted ice thicknesses and observed wind speeds from available years, to desired return periods.

During each hour of weather observations, MICEAW uses three separate prediction algorithms, depending on the icing type during that hour: (1) In-cloud, (2) Freezing rain, and (3) Wet snow. A methodology common to all three techniques is a time-dependent numerical model that includes calculation of heat transfer coefficients, changes in ice density during accretion (for in-cloud only), and changes in the rate of accretion due to increase in deposit size. The model also includes parameterization of water droplet trajectories for in-cloud icing, and variation of droplet/precipitation collection efficiency, particle size, and water content of the air by icing type.

Carlsbad Palomar Airport, March Air Force Base, Beaumont, and San Diego Lindbergh Airport (NCDC 2005)

- Published summaries of annual, maximum daily, and maximum monthly snowfall, mean annual number of days with snowfall, and monthly mean water equivalent precipitation and for the following southern California NOAA COOP surface observing stations: Alpine, Beaumont 1 E, Borrego Desert Park, Campo, Chula Vista, Cuyamaca, El Capitan Dam, El Centro 2 SSW, Henshaw Dam, Idyllwild Fire Department, Indio Fire Station, La Mesa, Mecca Fire Station, Oceanside Marina, Palm Springs, Palomar Mountain Observatory, Redlands, Riverside Citrus Experimental Station, Riverside Fire Station, San Diego Lindbergh Airport, Santa Ana Fire Station, and Vista 2 NNE (NCDC 2001).

- Digitized daily surface meteorological observations of daily maximum and minimum dry bulb temperature for the Campo and Cuyamaca southern California NOAA COOP surface observing stations, and daily total water equivalent precipitation for the Cuyamaca COOP station (NCDC 2007a, 2007b).

- Digitized Integrated Global Radiosonde Archive (IGRA) twice-daily upper-air meteorological observations for the San Diego California upper-air station (NCDC 2007c).

- Detailed maps of the planned transmission corridor, and planned conductor diameters

- U. S. Geological Survey topographic maps of the transmission corridor and surrounding region

- Published information on weather conditions in the region

4. Projections and Results

4.1 Projected Winds

Table 8 presents results of the Simiu program analysis of maximum winds for each of the eight stations. Either a type 1 or a type 2 statistical distribution was selected, based on which produced the largest wind values. Figure 6 presents a plot of estimated winds for various return intervals for each of the eight regional meteorological monitoring stations. These are the same estimates as presented in Table 8.

4.2 Projected Icing and Simultaneous Winds

4.2.1 Phase 1 Analysis

Wire ice accumulations for all stations except Beaumont were projected to be zero. Typically, dry bulb temps during screened potential icing episodes were too high for icing to occur. Table 9 presents annual icing predictions for Beaumont. Table 10 presents results of the Simiu program analysis of icing and winds after maximum ice accumulation, for Beaumont.

4.2.2 Phase 2 Analysis

Wire ice accumulations were projected for the composite meteorological database that was created for phase 2. Table 11 presents annual icing predictions for the phase 2 analysis. Table 12 presents results of the Simiu program analysis of icing and winds after maximum ice accumulation, for phase 2.

5. Factor for Adjustment of Wind Speeds from Hourly to Three-Second Gust and from Fastest Mile to Three-Second Gust

5.1 Wind Speed Observation Averaging Time

Calculations of wind pressures for the project required input wind speeds averaged over a three-second period.

As explained above in Section (3.1), raw data used in this analysis were in the form of a series of annual maximum wind speeds. We made the conservative assumption that all values in the input raw dataset (including both annual fastest mile values from LCD publications for selected stations, and annual maximum hourly values from digital files for other selected stations) were hourly mean wind speeds. The purpose of that assumption was to simplify and span all of the various averaging time procedures that were originally used to record the raw wind speed values at the weather stations through all periods of record. Our estimated three-second wind speed values were therefore expected to be conservative for all periods of record, for all stations.

5.2 MRI Gust Factor

Various methods are available to convert the raw hourly wind speeds to three-second gusts. For example, in its 1979 meteorological evaluation of proposed southern California transmission routes (MRI 1979), Meteorology Research, Inc. (MRI) reviewed available information on the relationship between wind gusts and steady wind. They determined that there were no hard and fast relationships to use in relating speeds of different averaging times. Their final recommendation was to use the following formula to predict two-second gusts from hourly average wind speeds.

$$G_{2\,sec} = 6.4 + (1.43)\,(V)$$

Where: $G_{2\,sec}$ = Two-second gust speed (mph)

V = Hourly average wind speed (mph)

For direct comparison to the Simiu and Scanlan and Burton gust factors presented in report sections 5.4 and 5.5, it would be necessary to adjust the MRI equation to provide a thee-second value. For that purpose, we would use a wind speed conversion factor of (1.51 / 1.53 = 0.987) based on the graph presented in Figure 7 from Simiu and Scanlan (1986). Therefore, our "revised" form of the MRI gust factor equation would be as follows.

$$G_{3\,sec} = (0.987)\,[\,6.4 + (1.43)\,(V)\,]$$

Where: $G_{3\,sec}$ = Three-second gust speed (mph)

V = Hourly average wind speed (mph)

5.3 ASCE Gust Factor

Another example is the American Society of Civil Engineers (ASCE 2006) standard for wind loads, which uses basic wind speeds in the determination of design wind loads on transmission structures. Those basic wind speeds are required by the standard to already be adjusted for equivalence to a three-second gust wind speed. But no techniques are provided in the ASCE standard for that adjustment.

5.4 Simiu and Scanlan Gust Factor

Another example is Simiu and Scanlan (1986), who present a relatively sophisticated equation for converting mean wind speeds between averaging times, as follows.

$$U_{T(Z)} = (U_{3600(Z)}) [1 + (\beta^{0.5} c(t)) / (2.5 \ln (z/zo))]$$

Where:

$U_{T(Z)}$ = Wind speed of interest, at time T and elevation above ground Z

$U_{3600(Z)}$ = Wind speed at time T and elevation above ground Z for an averaging time of 3,600 seconds, or one hour

β = Coefficient that varies with roughness length (roughness of the ground surface)

c(t) = Coefficient that represents fluctuation of atmospheric turbulence in the longitudinal direction – that is, in a direction parallel to the wind direction

Z = Height above ground elevation of wind speed of interest

Zo = Roughness length coefficient (which varies with roughness of the ground surface)

While the Simiu and Scanlan equation above is attractive because of its applicability to any ground surface scenario, a drawback is that use of it for a project requires detailed information on the ground surface character at various locations. Simiu and Scanlan (1986) also include a graph, reproduced in this report as Figure 7, that presents the ratio of probable maximum wind speed averaged over a period "t" to that averaged over one hour. It includes results applicable to open terrain conditions (roughness length approximately equal to 0.005 meters) and a wind speed elevation above ground of 10 meters. We extracted from that graph a multiplicative conversion factor of approximately (1.51) for adjusting hourly wind speed to a three-second wind speed.

5.5 Burton Gust Factor

Another example is Burton et al. (2001), who present a more recent method for converting mean wind speeds between averaging times. They recommend it for the sensitive application of design and specification of wind energy systems. Their gust factor for conversion of one-hour wind speeds to three-second average wind gusts for use in structure design is as follows.

$G(T) = 1 + [(0.42) (Iu) \ln(3{,}600/T)]$

Where: G(T) = Gust factor for specific gust time length, which is multiplied times the one-hour mean wind speed

= ratio of: [(gust wind speed) / (hourly mean wind speed)]

T = Gust length (seconds)

Iu = Coefficient representing the longitudinal turbulence intensity (%)

The longitudinal turbulence intensity "Iu" is the standard deviation of the fluctuating component of the wind in an along-wind direction. According to Burton et al. (2001), Iu depends on the ground surface roughness, and can be estimated via a complex calculation using information on the ground surface boundary layer wind speed profile with height. We assumed for our example calculation a turbulence intensity of 20%, which is a higher value specified in some standards, according to Burton et al. (2001). That higher value would result in a slightly conservatively higher calculated gust factor.

To estimate a G value to use with results of the present analysis, which approximate hourly mean wind speeds, we made the following calculation using the Burton et al. (2001) equation.

$G(3 \text{ seconds}) = 1 + [(0.42) (0.20) \ln(3{,}600 / 3) = 1.5956$

5.6 Recommended Gust Factor

Our final conclusion was to use the Burton et al. (2001) multiplicative factor of (1.5956) to adjust hourly winds predicted in this analysis to three-second gusts. The Burton three-second gust speed of 1.5956V is of a similar order of magnitude to the MRI three-second gust speed of (6.4 + 1.43V).

Generally, the magnitudes of such gust factors depend on site-specific weather conditions and topography. Our recommended value is based on a simplified approach found in recent industry reference sources, to be applied over all cases. We believe this approach is preferred to a more detailed approach that would account for detailed site-specific characteristics, but that may not significantly improve accuracy and cannot be verified by on-site measurements at this time.

6. Conclusions

6.1 Maximum Annual Winds

We reached several conclusions via review of wind analysis results, as follows.

6.1.1 Independent Checks of Wind Speed Projections

Three comparisons were made of wind speed projections. Those comparisons were made with results of previous studies for the same California weather monitoring stations, and published by other organizations. The comparisons were made of wind speeds adjusted to hourly values, and after projection to various return intervals.

6.1.3 Effects of Local Topography on Extreme Winds at Beaumont and March AFB

As illustrated by the local shaded relief map in Figure 9, the Beaumont weather monitoring station is located at the west "entrance" to the San Gorgonio Pass. That narrow valley funnels and accelerates airflow between the Los Angeles Basin to the west and the desert Coachella Valley to the east, and is the site of numerous wind energy turbines. The Beaumont wind projections for return periods above 20 years are much higher than for other regional stations because of those terrain-induced local airflow enhancements.

Also on Figure 9, it can be seen that March AFB is located in a shallow valley that trends from north-northwest to south-southeast. That trend causes some wind direction funneling.

6.1.4 Effects of Local Topography on Extreme Winds at Palomar

As illustrated by the shaded relief map in Figure 10, the Carlsbad/Palomar weather station is located at 328 ft elevation in a foothill area with good exposure but no other obvious local topographic effects.

6.1.5 Effects of Local Topography on Extreme Winds at San Diego Lindbergh, San Diego Gillespie, and Ramona

As illustrated by the shaded relief map in Figure 11, the San Diego Lindbergh, San Diego Gillespie, and Ramona weather stations are located about 15 miles apart, but have markedly different exposures. Lindbergh is at the Pacific coast, and is well exposed to winds from all directions. Gillespie and Ramona are both located on the floors of small (approximately five mile wide) enclosed valleys with narrow outlets and surrounding mountains that rise several thousand feet higher. These site exposure differences apparently explain why wind projections are lower for Gillespie and Ramona than for Lindbergh, even though both Gillespie and Ramona are at are at significantly higher elevations above sea level than Lindbergh.

6.1.6 Effects of Local Topography on Extreme Winds at Campo

As illustrated by the shaded relief map in Figure 12, the Campo weather station is located at 2,630 ft elevation on a major mountainous plateau with good exposure but no other obvious local topographic effects. This good exposure at high elevation apparently explains the third-highest projected winds at Campo of the eight regional stations analyzed.

6.1.7 Effects of Local Topography on Extreme Winds at El Centro NAF

As illustrated by the shaded relief map in Figure 13, the El Centro NAF weather station is located at elevation (- 43) ft MSL on the desert floor of the Imperial Valley. Exposure is very open, and terrain is mostly flat. The second-highest projected wind speeds (of all eight regional stations analyzed) at El Centro are remarkable but appear to be real. They include blowing dust and were occasionally due to thunderstorms.

equation (US EPA 1995) for vertical extrapolation of wind speed in the atmospheric boundary layer, as follows.

$$Unew = (Uref) [Znew / Zref]^{P}$$

Where: Unew = Wind speed estimated at "Znew" (mph)

Uref = Wind speed "measured" at "Zref"

Znew = New elevation above ground (feet)

Zref = Reference elevation above ground at which wind was "measured" (feet)

P = Exponent dependent on atmospheric stability class, that equals 0.15 for neutral or "D" stability class, which is a very turbulent atmosphere normally present during peak wind speeds

Calculating: $U(100\ ft) = (91\ mph)) [100\ ft / 1{,}300\ ft]^{0.15} = 62\ mph$

Summarizing, we recommend application to load calculations at the Grapevine Canyon and Agua Caliente Springs valleys of the following peak 100 year return interval projected hourly wind speeds.

- 100 year return interval, in a longitudinal direction through the valleys = 91 mph
- 100 year return interval, in a transverse direction across the valleys = 62 mph

6.1.10 Application of Recommended Design Winds to Conductors and Structures

Projected winds estimated via this study should be applied to conductors and structures as follows.

- Where the recommendations do not include application of wind speeds to specific wind directions, the pressures should be applied to both towers and wires, including transversely to the towers.
- In select cases, the recommendations include application of peak wind speeds to specific wind directions. The only cases of that kind in this study were for several valleys where peak winds were predicted to be oriented longitudinally down the valley long axes. In those cases, calculated peak wind pressure values should be applied longitudinally only to the towers, not to the wires.

6.2 Projected Ice and Combined Ice/Wind

6.2.1 Phase 1 Analysis

We concluded from phase 1 wire icing predictions and projections that significant conductor icing episodes should be relatively rare events in the Project area. Most precipitation in the region will not result in icing. Conductor icing events should be concentrated where the corridor crosses the highest ridge lines. At those highest ridges,

the Phase 1 Beaumont icing projections and combined icing/wind projections were developed for design at the Project corridor.

6.2.2 Phase 2 Analysis

A second set of wire icing predictions and projections, analysis phase 2, were prepared using a composite weather database. That composite database combined best available actual regional weather observations. It also included adjustments to the 850 mb pressure elevation and the elevation of Cuyamaca California, or from 4,640 to approximately 4,900 ft MSL. The objective of phase 2 was to develop more refined and representative icing predictions that could also be applied to higher elevations, should the Project corridor be rerouted to those higher elevations at a later date.

Phase 2 icing analysis results confirmed the major conclusions of the phase 1 analysis. Those conclusions included: (1) significant conductor icing episodes should be relatively rare events in the Project area, (2) most precipitation in the region will not result in icing, and (3) conductor icing events should be concentrated where the corridor crosses the highest ridge lines.

The actual phase 2 analysis ice thickness predictions differed from phase 1. Figure 19 presents a plot of both the phase 1 and phase 2 icing analysis curves. That plot shows that the phase 2 radial ice thicknesses are slightly larger for the shortest return intervals from two to 10 years. The plot also shows that that the phase 2 radial ice thicknesses are significantly lower for the largest return intervals from 20 to 100 years, and in fact diverge from the phase 1 results with increased return interval.

Comparison of wind speeds predicted to occur during icing in Tables 10 and 12 shows that phase 2 wind speeds during icing were higher than phase 1 for return intervals from two through 60 years. The table data also show that that the phase 2 wind speeds during icing were lower for the largest return intervals from 70 to 100 years.

6.2.3 Overall Conclusions on Icing Predictions

Our overall conclusions regarding icing predictions are as follows.

(1) The heights of application should be approximately above 3,000 ft MSL, as described above in Section 2.4 "Precipitation and Weather Phenomena".

(2) We recommend use of the phase 2 ice predictions, because we believe that they are more representative of Project corridor conditions than the phase 1 results. We also recommend use of phase 2 results, should the Project corridor be rerouted to higher elevations at a later date.

(3) Comparison of the present phase 2 conductor icing results with previous study results (MRI 1979) indicate significantly lower (from about 15% to about 30% of the MRI values) for return intervals of 25, 50, and 100 years. Our interpretation of why there are differences between the two studies included the following potential factors:

- Adjustments/enhancements of local raw meteorological data sets were more extensive during the earlier study,

- Meteorological station periods of record were smaller in 1979,
- The MRI ice prediction methodology was different, and
- The 1979 transmission corridor was located differently than the present design.

Conductor icing results of this study have been limited by: available stations and their unique topographic exposures, available periods of record, and daily total precipitation measurements. Actual ice accumulation along the planned transmission corridor is probably very dependent on elevation and local topographic configuration and their effects on air temperature and precipitation-producing weather systems. Therefore, we recommend that standard industry code ice and combined ice/wind design values should be relied on, unless their recommended load values are exceeded by those predicted by this study, in which case results of this study should be used.

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Prepared: _____ 27 FEBRUARY 2008

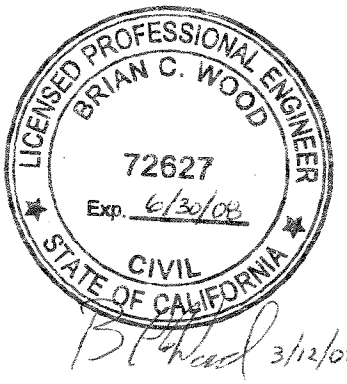
P. Derezotes — Date

Reviewed: _____ 3/10/08

W. L. Boward — Date

Approved: _____ 3/12/08

B. C. Wood — Date



3/12/08

C **Table 3 - Annual Maximum Wind Speeds (mph) at Weather Monitoring Stations in the SDG&E 500 kV Interconnect Project Region**

	El Centro	Campo	San Diego Gillespie	Ramona	Carls-bad / Palomar	March AFB	Beaumont	San Diego Lindbergh
Elevation (ft MSL)	**- 43**	**2,630**	**385**	**1,393**	**328**	**1,409**	**2,600**	**12**
Total Years Analyzed	**37**	**29**	**32**	**6**	**32**	**5**	**33**	**56**
Year								
1945	46							
1946	58							
1947	53							
1948	54						41	
1949	40						41	34
1950	46						41	28
1951	44						36	35
1952	48						30	45
1953	43						30	30
1954	40							36
1955	39							39
1956	44							32
1957	40							34
1958	43							37
1959	38							30
1960	46							33
1961								31
1962								31
1963								32
1964								34
1965								33
1966								33
1967								32
1968								32
1969								35
1970								34
1971								30
1972								29
1973		29	29		31		17	33
1974		34	29		29		17	33
1975		34	25		29		17	30
1976		40	25		28		17	32
1977		34	29		34		21	33

Table 3 (continued) Annual Maximum Wind Speeds (mph) at Weather Monitoring Stations in the SDG&E 500 kV Interconnect Project Region

	El Centro	Campo	San Diego Gillespie	Ramona	Carls-bad / Palomar	March AFB	Beaumont	San Diego Lindbergh
Elevation (ft MSL)	- 43	2,630	385	1,393	328	1,409	2,600	12
Total Years Analyzed	37	29	32	6	32	5	33	56
Year								
1978		34	23		30		23	36
1979		29	29		34		32	28
1980		46	46		29		69	56
1981		31	25		29		34	28
1982		52	29		34		34	39
1983		31	29		40		23	35
1984	40	40	26		25		31	32
1985	46	40	28		29		30	30
1986	32	40	23		25		23	26
1987	39	31	29		23		23	30
1988	28	40	29		23		22	40
1989	34	40	34		29		34	23
1990	29	40	23		23		57	26
1991	32	32	29		29		22	30
1992	30	40	23		25		23	29
1993	55	29	23		23		69	40
1994	34		22		23		23	34
1995	41		21		29		21	32
1996	34		22		30		28	29
1997	41	44	21		23		25	34
1998	35	39	28		29		21	38
1999	45	48	23	28	22		30	32
2000	39	38	34	33	25	31		38
2001	40	37	18	25	23	23		33
2002	36	39	23	36	30	30		31
2003	43	48	23	32	36	32		30
2004	46	40	23	31	32	33		46

H Table 8 - Maximum Annual Wind Speeds Statistically Estimated with the NBS Simiu Program based on Input Annual Maximum Wind Speeds (mph) at Weather Monitoring Stations in the SDG&E 500 kV Interconnect Project Region (a)

Return Period (years)	El Centro	Campo	San Diego Gillespie	Ramona	Carls-bad / Palomar	March AFB	Beaumont	San Diego Lindbergh
Appli-cable Statis-tical Distri-bution Type	1	1	2	1	1	1	2	2
2	40.00	36.98	25.03	30.36	27.54	29.40	28.47	32.02
3	43.11	39.61	26.94	32.25	29.46	31.11	34.10	33.99
4	45.11	41.29	28.30	33.46	30.69	32.20	37.70	35.37
5	46.59	42.53	29.39	34.35	31.60	33.01	40.36	36.46
10	50.95	46.21	33.05	37.00	34.29	35.40	48.23	40.00
20	55.13	49.74	37.26	39.53	36.86	37.69	58.44	43.94
25	56.46	50.86	38.76	40.34	37.68	38.41	62.29	45.31
30	57.54	51.77	40.04	40.99	38.34	39.00	65.59	46.47
40	59.23	53.20	42.19	42.02	39.39	39.93	71.10	48.39
50	60.54	54.30	43.96	42.81	40.20	40.65	75.64	49.95
60	61.61	55.20	45.48	43.46	40.85	41.24	79.54	51.28
70	62.52	55.96	46.82	44.01	41.41	41.73	82.97	52.44
80	63.30	56.62	48.02	44.48	41.89	42.16	86.05	53.47
90	63.99	57.20	49.11	44.90	42.31	42.54	88.85	54.40
100	64.60	57.72	50.11	45.27	42.69	42.87	91.43	55.25
Station Elevation (ft MSL)	- 43	2,630	385	1,393	328	1,409	2,600	12
Recom-mended Most Likely Wind Directions (deg) (from)	270	60	260	80	70 or 270	70 or 340	10 or 100	315 or 180

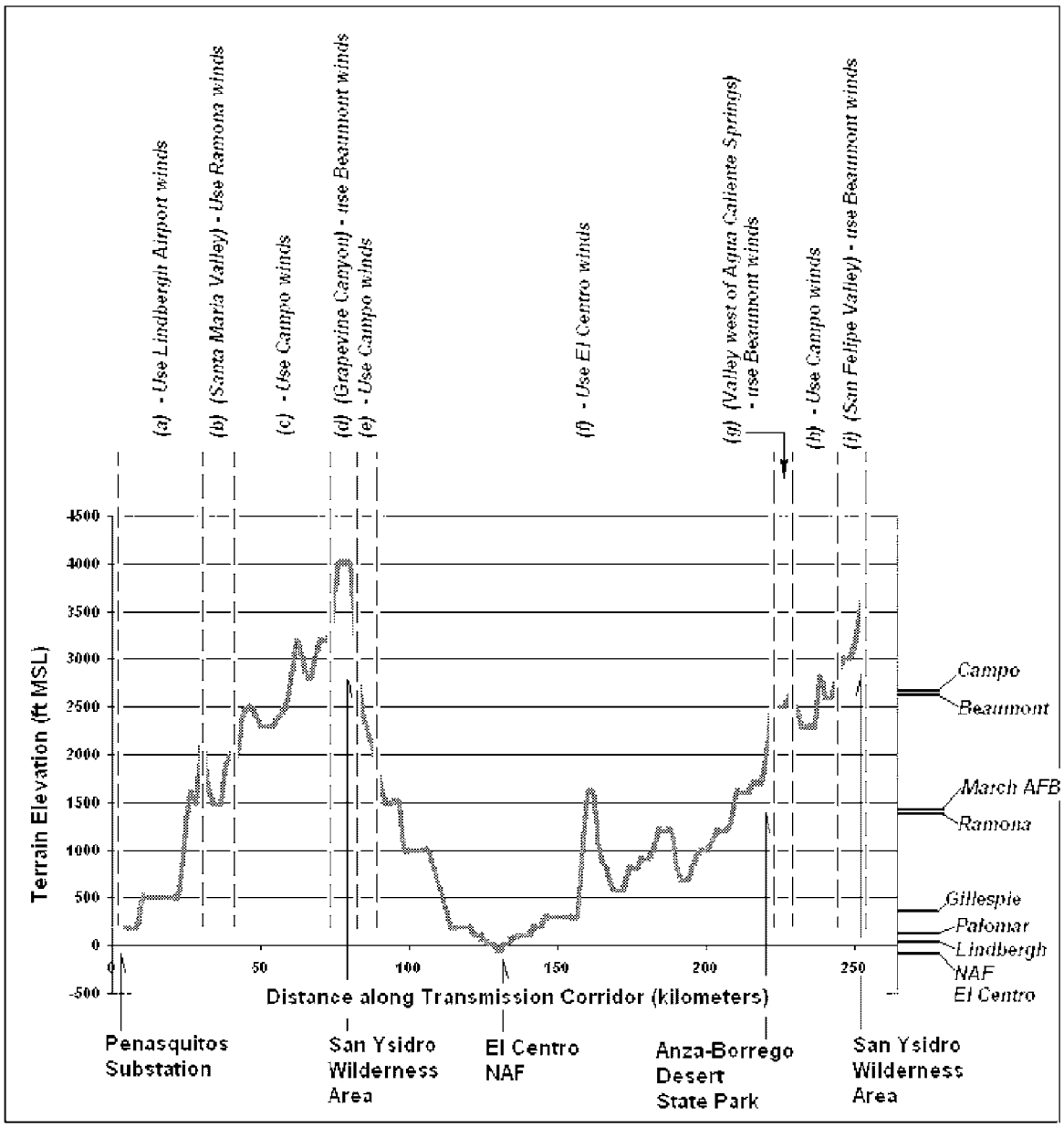
(a) Wind speeds in this table are hourly values, and have not been adjusted to represent gusts.

M Table 13 - Recommendations of Selected Station Sources for Projected Wind Speeds for Individual Segments of the 500 KV Interconnection Project

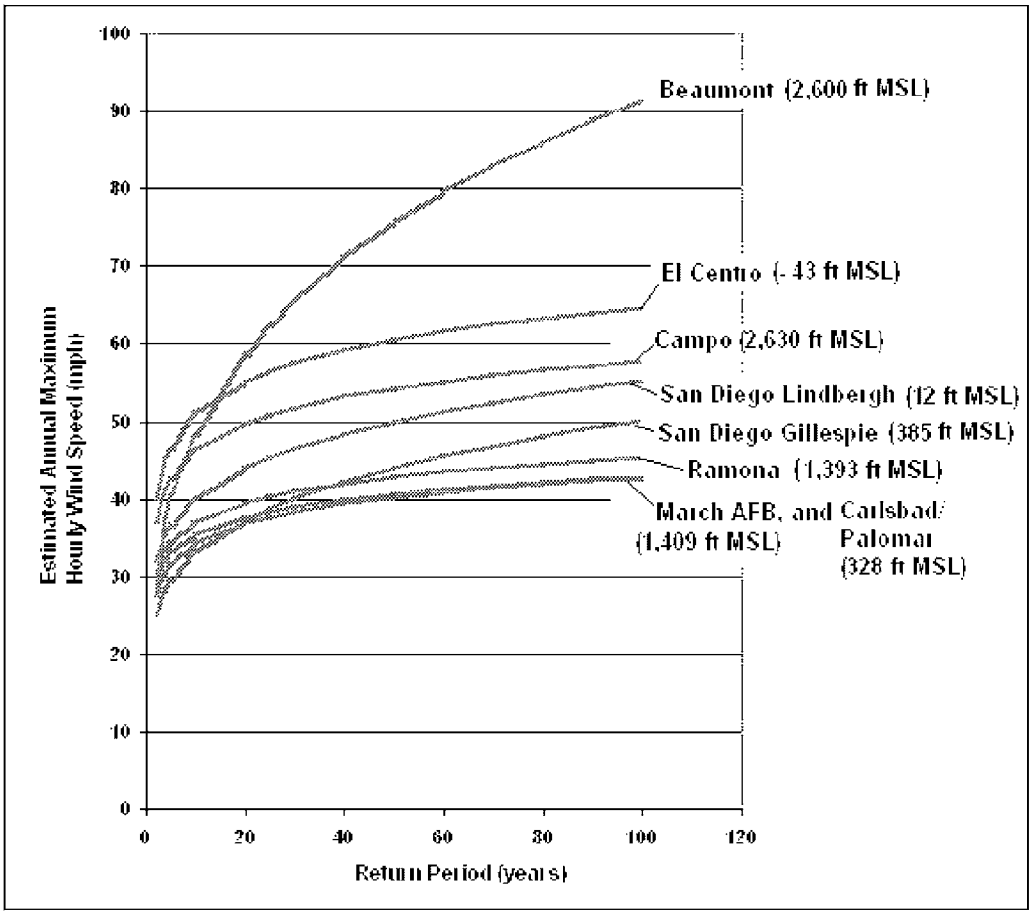
The following corridor segments correspond to those identified in Figure 3

	Segment of 500 KV Corridor	Recommended Station Source for Wind Speed Projections
(A)	From the Penasquitos substation to an elevation of about 2,200 ft MSL just south of the Santa Maria Valley (about 35 km inland).	San Diego Lindbergh
(B)	The Santa Maria Valley area southeast and east of Ramona (about 35-45 km inland)	Ramona
(C)	From the east edge of the Santa Maria Valley to a few km southeast of Ranchita (about 45-55 km inland).	Campo
(D)	The short stretch of corridor (about 10 km long) through the Grapevine Canyon mountain pass, north of Grapevine Mountain and the Volcan Mountains, and about 10 km southeast of Ranchita, California. Wind direction should be parallel to the pass orientation, from either the west-northwest or the east-southeast (about 55-65 km inland).	Beaumont
(E)	From the east end of Grapevine Valley, to the playa at the edge of the Borrego Valley (about 65-75 km inland along the corridor).	Campo
(F)	From about 1,000 ft MSL (about 60 km northwest of the El Centro weather station, and about 80 km from the Pacific coast) to the El Centro weather Station, anywhere on the flat desert surface, and the first leg of the westward corridor "return loop" through the east entrance to the narrow valley at Agua Caliente Springs.	El Centro
(G)	The narrow valley at Agua Caliente Springs, including an east-west length of about five km. Wind direction should be parallel to the valley orientation, from either the west or the east.	Beaumont
(H)	The segment from the west end of the narrow valley at Agua Caliente Springs, through Earthquake Valley, to the east end of the San Felipe Valley.	Campo
(I)	The San Felipe Valley just southwest of Ranchita, just prior to the point where the corridor loop rejoins the main corridor (a northwest-southeast oriented stretch about 10 km long) at an elevation of about 3,500 ft MSL. Wind direction should be parallel to the valley orientation, from either the northwest or the southeast.	Beaumont

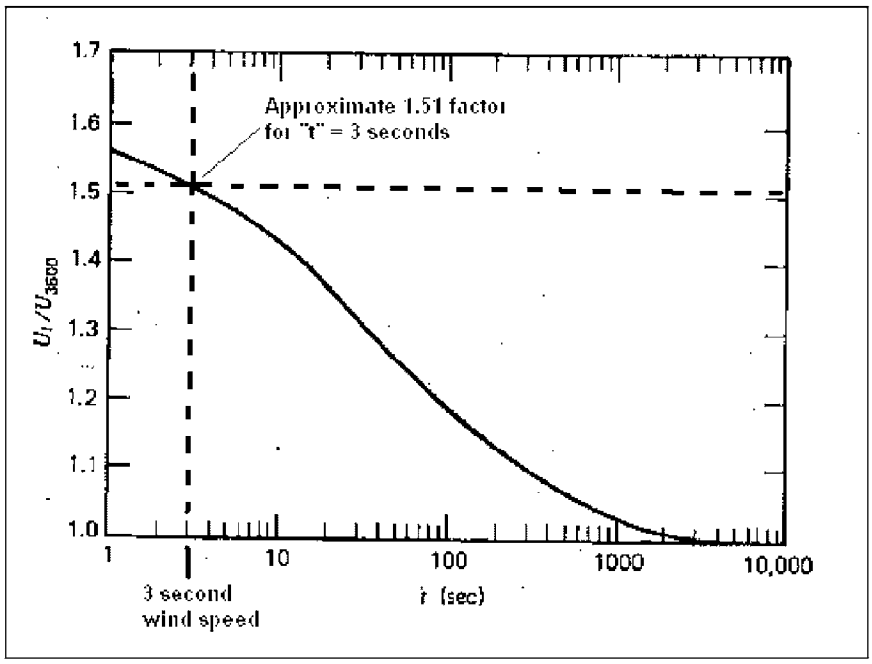
P Figure 3 - Profile of Topographic Elevations along the Transmission Corridor, with Annotated Elevations of Meteorological Monitoring Stations for which Data were Analyzed, and Corridor Segments for which Specific Wind Projections Are Recommended



S Figure 6 - Plot of Estimated Annual Maximum Hourly Wind Speeds for Various Return Intervals for Selected Meteorological Monitoring Stations



T Figure 7 - Ratio of Probable Maximum Wind Speed Averaged over Period "t" to That Averaged over One Hour



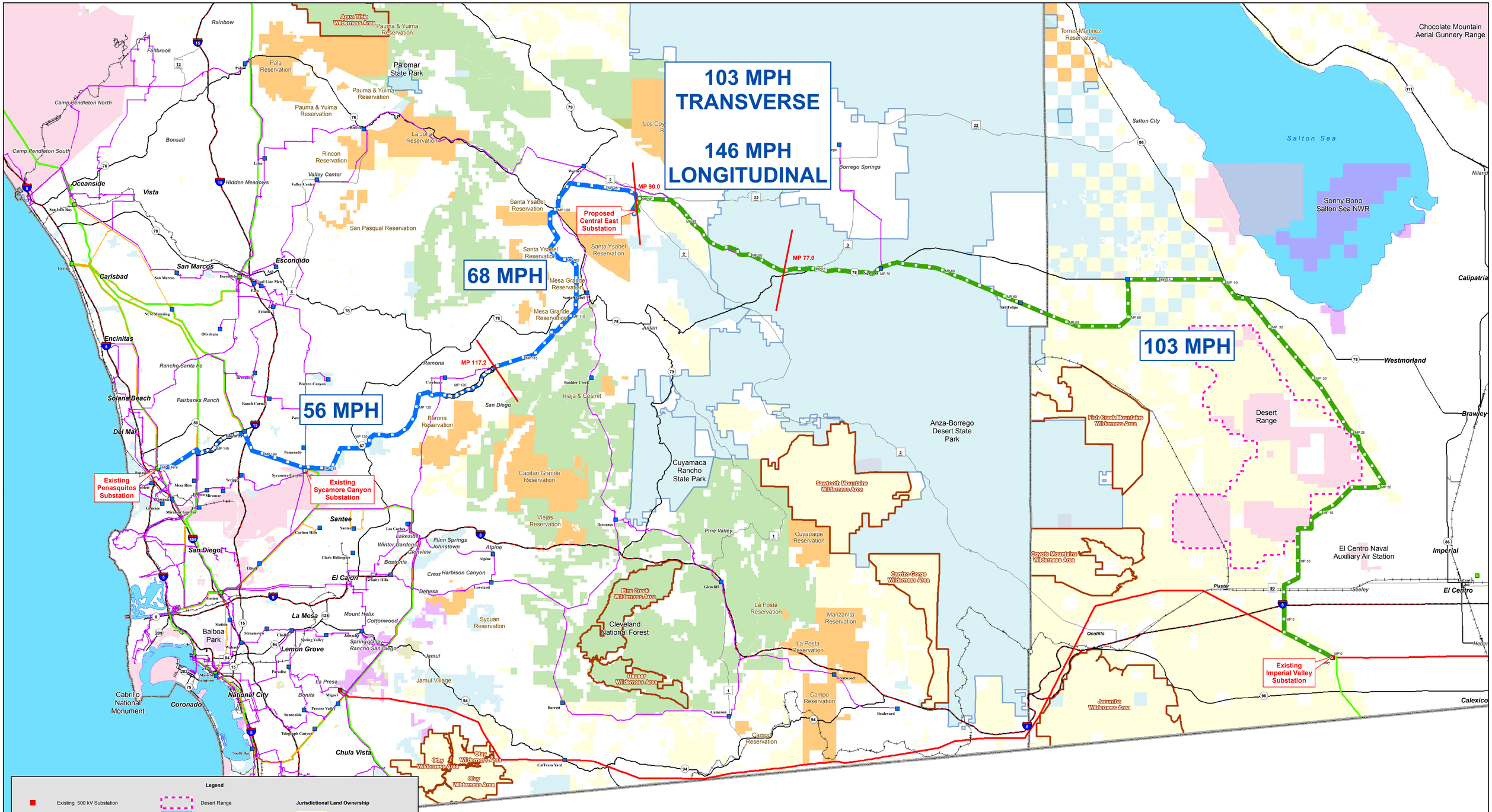
Notes:

1. Abscissa is wind speed averaging time "t" in seconds.

2. Ordinate is ratio of probable maximum wind speed averaged over period "t" ("Ut"), to that averaged over one hour ("U3600").

3. Reference source is Simiu and Scanlan (1986).

Appendix D – Sunrise Powerlink Proposed Route and Wind Loading Map


103 MPH
TRANSVERSE
146 MPH
LONGITUDINAL
68 MPH
56 MPH
103 MPH
MP 90.0
MP 77.0
MP 117.2
Proposed Central East Substation
Existing Penasquitos Substation
Existing Sycamore Canyon Substation
Existing Imperial Valley Substation
Agua Tibia Wilderness Area
Pauma & Yuima Reservation
Palomar State Park
Pala Reservation
La Jolla Reservation
Rincon Reservation
San Pasqual Reservation
Santa Ysabel Reservation
Mesa Grande Reservation
Barona Reservation
Capitan Grande Reservation
Viejas Reservation
Sycuan Reservation
Inaja & Cosmit
Anza-Borrego Desert State Park
Cuyamaca Rancho State Park
Sawtooth Mountains Wilderness Area
Pine Creek Wilderness Area
Cleveland National Forest
Hauser Wilderness Area
Otay Wilderness Area
Cuyapaipe Reservation
La Posta Reservation
Manzanita Reservation
Campo Reservation
Cerrizo Gorge Wilderness Area
Coyote Mountains Wilderness Area
Jacumba Wilderness Area
Fish Creek Mountains Wilderness Area
Desert Range
Torres-Martinez Reservation
Chocolate Mountain Aerial Gunnery Range
Salton Sea
Sonny Bono Salton Sea NWR
El Centro Naval Auxiliary Air Station
Camp Pendleton North
Camp Pendleton South
Oceanside
Vista
Carlsbad
San Marcos
Escondido
Encinitas
Rancho Santa Fe
Solana Beach
Del Mar
Fairbanks Ranch
San Diego
Santee
El Cajon
La Mesa
Lemon Grove
Spring Valley
Balboa Park
Mission Trails
Cabrillo National Monument
Coronado
National City
Chula Vista
Otay Mesa
Otay Lakes
Bonsall
Fallbrook
Rainbow
Hidden Meadows
Valley Center
Ramona
Julian
Santa Isabel
Borrego Springs
Salton City
Westmorland
Brawley
Calipatria
Imperial
El Centro
Seeley
Plaster
Ocotillo
Heber
Calexico
Boulevard
Jamul
Jamul Village
Dehesa
Harbison Canyon
Crest
Alpine
Flinn Springs
Johnstown
Winter Gardens
Lakeside
Bostonia
Granite Hills
Mount Helix
Cottonwood
Rancho San Diego
Lakeside
Pine Valley
Glencliff
Cameron
Barrett
Campo
Tecate
Mexicali
Legend
Existing 500 kV Substation
Existing 230 kV Substation
Existing 138 kV / 115 kV / 69 kV Substation
Existing 500 kV Transmission Line
Existing 230 kV Transmission Line
Existing 138 kV Transmission Line
Existing 69 kV Transmission Line
Existing IID Transmission Line
Interstate
Major Road
Road
Railroad
County Boundary
Desert Range
Major Water Body
State Park Boundary
Federal Wilderness Area
Proposed Substation Site
Proposed Project
Proposed 500 kV Project
Proposed 230 kV Project
Proposed 230 kV Underground Project
Jurisdictional Land Ownership
Bureau of Land Management Land
U. S. Forest Service Land
Department of Defense Land
Federal Land
U. S. Fish and Wildlife Land
National Park Service Land
Department of Homeland Security Land
Indian Land
State Land
0
5
10
15
Miles
State Plane Coordinate System
California Zone 6, NAD 83
Lambert Conformal Conic Projection
1983 North American Datum
Central Meridian: -116.25
First Standard Parallel: 32.78
Second Standard Parallel: 33.88
False Easting: 6561666.67
False Northing: 1640416.67
Linear Unit: Foot US
SUNRISE POWERLINK SM
Wind Speed Map
SDGE
A Sempra Energy utility
Map Extent: San Diego and Imperial Counties, California
Date: 02.22.08
Author: sjw
G:\projects\1994-SDG&E\Maps\Preferred Routes ....mxd

Appendix E – SDG&E Overhead Construction Standards Excerpts

Attachment: Overhead Construction Standards.pdf

SCOPE: THIS STANDARD DESCRIBES LOADING DISTRICTS WHICH AFFECT CONSTRUCTION OF OVERHEAD FACILITIES ACCORDING TO ELEVATION OR OTHER CONDITIONS.

1) THE FOLLOWING LOADING DISTRICTS ARE TO BE CONSIDERED IN DETERMINING THE STRENGTH REQUIRED OF POLES, TOWERS, STRUCTURES, AND ALL PARTS THEREOF, TO ACHIEVE THE REQUIRED OVERALL STRENGTH OF FACILITIES AND CLEARANCE OF CONDUCTORS.

A) LIGHT LOADING (G.O. 95 Rule 43.2, NOT SUBJECT TO PARAGRAPH D)

THIS APPLIES TO ALL PARTS OF THE SDG&E SERVICE TERRITORY:
- FOR ELEVATIONS BETWEEN 0–3,000 FEET, THE FOLLOWING ASSUMPTIONS APPLY:
  - FOR CONDUCTOR SURFACES THE HORIZONTAL WIND PRESSURE = 8 LBS PER SQUARE FOOT,
  - FOR FLAT SURFACE THE HORIZONTAL WIND PRESSURE = 13 POUNDS PER SQUARE FOOT,
  - AMBIENT TEMPERATURE = 25°F AT THE TIME OF MAXIMUM WIND LOADING, TO CALCULATE HARDWARE, POLE, AND CONDUCTOR TENSION REQUIREMENTS.
  - NO ICE LOADING IS TO BE CONSIDERED

B) HEAVY LOADING (G.O. 95 RULE 43.1, NOT SUBJECT TO PARAGRAPH D)

THIS APPLIES TO ALL PARTS OF THE SDG&E SERVICE TERRITORY:
- FOR ELEVATIONS FROM 3,001 FEET TO 5,000 FT, THE FOLLOWING ASSUMPTIONS APPLY:
  - FOR CONDUCTOR SURFACES THE HORIZONTAL WIND PRESSURE = 6 LBS PER SQUARE FOOT,
  - FOR FLAT SURFACE THE HORIZONTAL WIND PRESSURE = 10 POUNDS PER SQUARE FOOT,
  - THE AMBIENT TEMPERATURE = 0°F AT THE TIME OF MAXIMUM WIND LOADING, TO CALCULATE HARDWARE, POLE, AND CONDUCTOR TENSION REQUIREMENTS.
  - A RADIAL THICKNESS OF 1/2 INCH OF ICE LOADING IS TO BE CONSIDERED ON ALL CONDUCTORS

C) EXTRA HEAVY LOADING (SDG&E STANDARD EXCEEDING G.O. 95 MINIMUMS NOT SUBJECT TO PARAGRAPH D)

THIS APPLIES TO ALL PARTS OF THE SDG&E SERVICE TERRITORY:
- FOR ELEVATIONS ABOVE 5,000 FT, THE FOLLOWING ASSUMPTIONS APPLY:
  - FOR CONDUCTOR SURFACES THE HORIZONTAL WIND PRESSURE = 12 POUNDS PER SQUARE FOOT,
  - FOR FLAT SURFACE THE HORIZONTAL WIND PRESSURE = 19 POUNDS PER SQUARE FOOT,
  - THE AMBIENT TEMPERATURE = 0°F AT THE TIME OF MAXIMUM WIND LOADING, TO CALCULATE HARDWARE, POLE, AND CONDUCTOR TENSION REQUIREMENTS.
  - A RADIAL THICKNESS OF 1 INCH OF ICE LOADING IS TO BE CONSIDERED ON ALL CONDUCTORS

D) EXTREME WIND LOADING (SDG&E STANDARD, EXCEEDING G.O. 95 MINIMUM DERIVED FROM NESC 250C)

THIS APPLIES TO ALL PARTS OF SDG&E SERVICE TERRITORY AS AN OVERLAY, WHERE:
- OH FACILITIES:
  - RESIDE IN THE "SDG&E FIRE THREAT ZONE" AS INDICATED IN LAND SERVICES – GEOGRAPHIC INFORMATION SYSTEM (LS–GIS), REGARDLESS OF ELEVATION,
    - **NOTE:** POLES INSTALLED WITHIN THE SDG&E HIGH RISK FIRE AREA (HRFA) SHALL MEET OR EXCEED THE NESC–250C REQUIREMENT OF 85 MPH (18.5 PSF WIND PRESSURE). THE HRFA IS INCORPORATED WITHIN THE "SDG&E FIRE THREAT ZONE" IN LS–GIS.Z
  - OR, RESIDE IN THE DESERT AREAS OF BORREGO SPRINGS AND ANZA–BORREGO STATE PARK (INCLUDES CIRCUITS 170, 171, 172, AND 221) THAT ARE KNOWN TO BE SUBJECT TO MICROBURSTS OR OTHER WEATHER EVENTS THAT CAUSE LOCALIZED HIGH SPEED WIND EVENTS. **NOTE:** WEATHERING STEEL POLES SHALL BE INSTALLED FOR ALL NEW AND REPLACEMENT POLE CONSTRUCTION ON CIRCUITS 170, 171, 172 AND 221.

THE FOLLOWING ASSUMPTIONS APPLY:
- FOR CONDUCTOR SURFACES THE HORIZONTAL WIND PRESSURE = 18.5 LBS PER SQUARE FOOT,
- FOR FLAT SURFACE THE HORIZONTAL WIND PRESSURE = 30 POUNDS PER SQUARE FOOT,

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LOADING DISTRICT

- THE AMBIENT TEMPERATURE = 60°F AT THE TIME OF MAXIMUM WIND LOADING, TO CALCULATE HARDWARE, POLE, AND CONDUCTOR TENSION REQUIREMENTS.
- NO ICE LOADING IS TO BE CONSIDERED

2) LOADING CONDITIONS AS SPECIFIED IN 1) A), B) AND C) MUST BE CALCULATED FOR ALL OH FACILITIES IN SDG&E SERVICE TERRITORY, AND MUST ALSO BE COMPARED TO THE LOADING CONDITION AS SPECIFIED IN 1) D) WHEN THE OH FACILITY FALLS WITHIN THE AREAS AS SPECIFIED IN 1) D). THE MOST STRINGENT CONDITION SHALL PREVAIL IN DETERMINING THE STRENGTH REQUIRED OF POLES, TOWERS, STRUCTURES, AND ALL PARTS THEREOF TO ACHIEVE THE REQUIRED OVERALL STRENGTH OF FACILITIES AND CLEARANCE OF CONDUCTORS. IN ALL CASES FACILITIES WILL MEET OR EXCEED G.O. 95.

3) THE FOLLOWING TABLES SUMMARIZE THE CONDITIONS AS STATED IN SECTION 1) AND THE SAFETY FACTORS OF EQUIPMENT BY LOADING DISTRICT:

LOADING DISTRICT		LOADING CONDITIONS					
				WIND			
		RADIAL ICE (IN)	AMBIENT TEMP (°F)	SPEED (MPH)	FORCE ON CONDUCTOR (LBS/FT²)	FORCE ON EQUIPMENT (LBS/FT²)	ELEVATION
G.O. 95	LIGHT	0.0	25	56	8.0	13	0–3,000FT
	HEAVY	0.5	0	48	6.0	10	3,001 – 5,000FT
SDG&E	EXTRA HEAVY	1.0	0	68	12.0	19	ABOVE 5,000FT
	EXTREME WIND	0.0	60	85	18.5	30	N/A–REFER TO SDG&E LS–GIS

Table 1 – LOADING CONDITIONS OF EQUIPMENT AND POLES BY LOADING DISTRICT

ITEM #	EQUIPMENT OF LINE		LOADING DISTRICTS			
			G.O. 95		SDG&E	
			LIGHT	HEAVY	EXTRA HEAVY	EXTREME WIND
1	CONDUCTORS, SPLICES, AND CONDUCTOR FASTENING		2	2	2	2
2	PINS		2	2	2	2
3	POLE LINE HARDWARE		2	2	2	2
4	LINE INSULATORS (MECHANICAL)		3	3	3	3
5	GUY INSULATORS (MECHANICAL)	PORCELAIN	2	2	2	2
6		FIBERGLASS	3	3	3	3
7	GUYS		2	2	2	2
8	MESSENGERS & SPAN WIRES		2	2	2	2
9	POLES	WOOD	4	4	4	4
10		STEEL	1.5	1.5	1.5	1.5
11		COMPOSITE *	1.5	1.5	1.5	1.5
12	CROSSARMS	WOOD	2	2	2	2
13		STEEL	1.5	1.5	1.5	1.5
14		COMPOSITE *	2	2	2	2

Table 2 – SAFETY FACTORS FOR EQUIPMENT & LINES FOR GRADE A CONSTRUCTION.

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INSTALLATION:

(A) MULTIPLE INDENT DIE SET; MAKES MORE THAN ONE INDENT PER TOOL COMPRESSION. TABLE INDICATES NUMBER OF COMPRESSIONS.

(B) MAKE OVERLAPPING INDENTS FROM CENTER TO OUTSIDE.

(C) NO LONGER MANUFACTURED. USE EXISTING STOCK, THEN SUBSTITUTE DUAL TENSION SLEEVES FOR ACSR CONDUCTORS.

(D) BEING PHASED OUT. USE APPROPRIATE SINGLE TENSION OR AUTOMATIC SPLICE.

(F) DO NOT INSTALL SLEEVE ON GREASE CORE CONDUCTORS.

G. A MINIMUM OF 30 INCHES OF EXPOSED CONDUCTOR SHALL BE LEFT BETWEEN SPLICES AND POINT OF SUPPORT OR END OF DEADEND CLAMP.

H. THOROUGHLY CLEAN CONDUCTOR WITH A WIRE BRUSH BEFORE MAKING THE SPLICE.

I. ALL DIE INDEX NUMBERS CONTAINING A PREFIX OF "U" REPRESENT THE DIES THAT SHALL BE USED IN Y-35 HYDRAULIC TOOL. THE DIE INDEX NUMBERS HAVING A PREFIX OF "W" SHALL BE USED IN MD-6 TOOL. THE DIE INDEX NUMBERS HAVING A PREFIX OF "B" CAN BE USED IN THE Y-35 OR THE 12A TOOLS.

REFERENCE:

(J) REFER TO "DIE INDEX/STOCK NO. CROSS REFERENCE" TABLE (PG. 720.2) WHEN REQUESTING DIES FROM STOREROOM.

(K) COMPRESSION SLEEVES ARE TO BE USED IN THE HRFA (HIGH RISK FIRE AREA).

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	SDG&E ELECTRIC STANDARDS	
720.3	TENSION SLEEVES FOR ACSR/AW, AWAC, ALL ALUMINUM SECONDARY AND 5005 CONDUCTORS	REVISION DATE 2-11-2014 APPD TQ / DW

BILL OF MATERIAL:

WIRE SIZE									CLAMP RANGE (INCHES)		CLAMP DATA			STOCK NUMBER	ASSEMBLY UNITS
ACSR/AW OR 5005 (AWG)				ACSR/AW				5005							
4 6/1 OR 7	2 6/1 OR 7	1/0 6/1 OR 7	3/0 6/1 OR 7	336.4 KCMIL 18/1	336.4 KCMIL 26/7	636 KCMIL 24/7	1033.5 KCMIL 45/7	394.5 KCMIL 19	MIN	MAX	BOLT SIZE	TORQUE (FT-LBS)	(A) CLEVIS WIDTH		
–	–	–	–	–	–	X	–	–	.680	1.160	1/2	40	1	S230464	DE636
–	–	–	–	X	X	–	–	X	.440	.880	1/2	40	1	S230498	DE336
–	–	–	–	–	–	–	X	–	.684	1.213	1/2	45	13/16	(D) (II) (III) S230496	DE1033
–	–	–	–	–	–	X	–	–	.684	1.213	1/2	45	13/16	(D) (II) (III) S230464	DE636
–	X	X	X	–	–	–	–	–	.316	.502	1/2	25	13/16	S230512	DE2 / DE3/0
–	–	–	–	–	–	X	–	–	.684	.977	1/2	45	1	S230464	DE636
–	X	X	X	–	–	–	–	–	.316	.502	3/8	25	3/4	S230512	DE2 / DE3/0
X	–	–	–	–	–	–	–	–	.250	.250	1/2	50	11/16	(C) S230432	DE4

INSTALLATION:

(A) SEE CLAMP DATA COLUMN FOR CLEVIS WIDTH.

(B) HAND TIGHTEN U-BOLT NUTS AND TORQUE TO THE VALUES IN CLAMP DATA COLUMN.

(C) STRAIGHT STRAIN CLAMP FOR NUMBER 4 ACSR/AW OR 5005 WIRE DOES NOT COME WITH SIDE OPENING.

(D) USE S230464 OR S230496 FOR WIRE SIZE 1033.5 KCMIL.

NOTES:

(I) DO NOT USE STRAIGHT STRAIN CLAMPS ON AWAC CONDUCTORS.

(II) THIS CLAMP MAY BE USED IN ALL LOADING DISTRICTS.

(III) THESE ARE TO BE USED IN THE FIRE THREAT ZONE.

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SDG&E ELECTRIC OVERHEAD CONSTRUCTION STANDARDS

12KV ALUMINUM SIDE OPEN STRAIGHT STRAIN CLAMP FOR ACSR/AW & 5005 ALUMINUM ALLOY CONDUCTOR

OH 741.2

Appendix F – SDG&E Distribution System Design Manual Excerpts

Attachment: Distribution System Design Manual 5122_6232.pdf

SCOPE: This standard provides considerations for the selection of poles based on mechanical requirements, overhead construction techniques, geographical location, and known local conditions.

A. The following considerations must be included in the proper selection of a pole:

1. Poles shall be of adequate length to provide at least the minimum conductor clearances above ground and from other utility's conductors (i.e. CATV, Telco) and other structures per G.O. 95 (See OH Standards 220–224).

2. For a new pole being set, or a pole replacement, where the pole is bucket truck accessible, design into and maintain sufficient clearance to accommodate the use of a bucket truck and rubber gloving work method if economically feasible. Sufficient clearance will be seven feet between two primary levels, primary and secondary level, or primary and communication level.

   Note: A pole change–out to a taller pole, or the addition of a pole top extension, just for the purpose of rubber gloving, is not considered economically feasible.

3. A pole loading calculation analysis is required to determine if pole classes are adequate for all vertical and horizontal loadings by using approved software (contact EDE for approved software). The design shall consider the structural loading requirements of all supply and communication facilities planned to occupy the pole, and must be calculated using approved software. The "planned" facilities are those that are actually known to SDG&E at the time of design. This requirement applies to new poles and poles being replaced. A post–construction pole load calculation must be performed for all poles upon completion of construction. This post–construction "true–up" report shall include all pole loads, applicable load cases and shall state "percent remaining strength" used for the calculation and the date such intrusive data was obtained. This post–construction report shall be placed in PIDS (Pole Information Data System) within 10 months after completion of construction.

   Note: For steel pole construction, the design shall take into consideration the factory drilled hole locations to reduce the amount of field drilling required during construction. The factory drilled hole locations ("knockouts") shall be used for calculation purposes in the design when determining attachment heights on the pole for crossarms, equipment and guying. Refer to OH Standard 310 for steel pole factory drilled hole pattern.

4. Poles must be designed to meet the loading conditions as set forth in Electric Transmission & Distribution Engineering Standard 12100 "Direct Buried Pole Selection and Loading Criteria" in accordance with Electric Standard Practice (ESP) 015: Structural Pole Loading Calculation Requirements. Additionally, poles in the "SDG&E Fire Threat Zone" must be designed in accordance with OH Construction standard page 340.2, section 2. In all cases, facilities will meet or exceed G.O. 95. Refer to Table 1.

5. Determine if any special hauling and/or digging instructions are required.

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SDG&E DISTRIBUTION DESIGN MANUAL

POLE SELECTION CRITERIA

DM 5122.1

B. POLE SELECTION MATRIX

1. TABLE 1 will help to quickly identify what type of pole to use in certain locations. As always, field conditions should be taken into account when choosing the correct pole. Aesthetics should be considered in some cases.

APPLICATION LOCATION	WOOD	GALVANIZED (A) STEEL	WEATHERING (A) STEEL	FIBERGLASS
Back Lot	✓	✓	✓	✓
Cleveland National Forest	–	–	✓	*
Contamination District 1	✓	✓	–	✓
Contamination District 2 & 3	✓	✓	✓	✓
SDG&E Fire Threat Zone	–	✓	✓	*
Improved Street	✓	✓	–	–
Unimproved Street	✓	✓	✓	*
Wetland	*	–	–	✓
HIGH WIND (C–170, 171, 172, 221)	–	–	✓	–

TABLE 1

✓ = Approved

– = Not Approved

* = Approved by Deviation request only

NOTES:

(A) Steel Poles come pre–drilled from the factory with knock–out holes. If field drilling holes consistently in the same location, contact EDE for possible additional knock–outs. See OH Standard 310 for factory drilled hole locations ("knockouts").

(B) Pole Loading Calculation Compliance Training is MANDATORY before performing pole loading calculations.

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SCOPE:

This standard provides a guideline for electric distribution personnel to follow in preparing circuit improvement projects within the Fire Threat Zone (FTZ).

PURPOSE

–Reduce likelihood of the power distribution system being the cause of a fire event
–Reduce impact of power–line related fire
–Increase the ability of the distribution system to withstand wild land fire conditions
–Increase reliability in the backcountry areas

DEFINITIONS

Clear Recovery Zone (CRZ): area adjacent to unimproved roadways extending from the edge of driven way.

Edge of Driven Way (EDW): On an unimproved roadway (without a concrete curb and gutter), the EDW is defined as follows:

1. If there is an asphalt berm, EDW is the edge of the berm farthest from the roadway.
2. If there is no berm but there is a white fog line, EDW is the edge of the fog line farthest from the roadway.
3. If there is no berm or fog line, EDW is the edge of the pavement.

Fire Threat Zone (FTZ): The broad area that has been determined by SDG&E to be at heightened risk for wild fire based on vegetation, land topology, and prevailing wind conditions. Boundaries are not generally changed.

High Risk Fire Area (HRFA): A subset of the FTZ which designates a higher level of risk compared to other areas within the FTZ. Boundaries of the HRFA can change annually.

Risk Matrix: Ranking spreadsheet evaluating multiple risk factors. This matrix is used to determine the order for project analysis.

Wireless Fault Indicator (WFI): An overhead fault indicating device that senses and reports faults (along with load and ambient temperature) with the ability to adjust the fault detection trigger point based on steady state load.

REFERENCE

Design Manual 5129 Distribution Phase Spacing
Design Manual 6111 Feeder Circuit Sectionalizing and Protection
Design Manual 6112 Overhead Service Restorer Application Criteria
Design Manual 6113 Automatic Self–Resetting Fault Indicator
Design Manual 6121 Fuse Application Criteria
Electric Standard Practice 322 SEL Overhead Fault Indicators
Overhead Construction Standard 788 Hot Line Clamps and Stirrups
Overhead Construction Standard 1276 Overhead Autoranging Fault Indicator
Overhead Construction Standard 1600 Wildlife Protection

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Appendix G – SDG&E ETE&D Standard Excerpts

Attachment: ET&DE Standard 12100.pdf

APPLICABILITY:

This standard is to be used to determine the proper criteria for pole loading of new and existing direct-buried standard poles, as well as provide safety factors for other various line components. This standard is not intended for poles of excessive height or modified embedment, as those designs are to be consulted with Civil/Structural Engineering. The standard is valid for all project designs initiated after the effective date listed. At SDG&E's discretion, some projects in early stages of design as of the effective date may be required to be revised to comply with this standard.

INTERIM INFORMATION

In cases where the requirements of this standard are in conflict with an existing standard, the requirements of this standard shall supersede all others.

DEFINITIONS:

AT INSTALLATION: Any structure that is being installed, either as a completely new structure or a new structure that replaces an existing structure. This would also be used for existing structures where its identity has changed. A change of identity would be change in Class of Circuit or Grade of Construction.

AT REPLACEMENT: Any structure that is existing in the field and being evaluated in its existing condition and its identity is not changing. A change of identity would be change in Class of Circuit or Grade of Construction.

ETE&D: Electric Transmission Engineering and Design

CONFLICTING LINES: As defined by GO 95 Rule 22.1A, Lines in conflict are those that are situated with respect to each other (except at crossings) that the overturning of one line will result in contact of its poles or conductors with the poles or conductors of the second line, assuming no conductors are broken in either line except that lines on opposite sides of a thoroughfare are not considered as conflicting if separated by a distance not less than 60 percent of the height of the higher pole line above the ground line and in no case less than 20 feet.

CROSSING SPAN: As defined by GO 95 Rule 21.1, Crossing span (spans in crossing) means cables, conductors, messengers, span wires, or guys that cross other cables, conductors, messengers, span wires, or guys that are not supported on the same poles or structures.

DEAD-END:

STRAIN DEAD-END: A dead-end structure that will not fully support the longitudinal loading of a ruling span section. For example, a distribution pole with back to back dead-end insulators without inline guying would be considered a Strain Dead-End as it cannot support the unbalanced load should the wires on one side fail or be removed.

TERMINAL DEAD-END: A structure that has been designed to fully support the longitudinal loading of a ruling span section. This definition usually applies only to transmission structures. For example, a foundational steel dead-end pole or a pole with dead-ends and in-line guying in both directions is designed to support the unbalanced load of wire on one side of the structure.

GRADE OF CONSTRUCTION:

NOTE: **For existing facilities, the grade of construction should adhere to the rules in effect at the time of their original construction or reconstruction**. This includes conflicts and crossing that occur after initial construction.

GRADE A CONSTRUCTION: Any SDG&E pole/structure is classified as Grade A if any of the following conditions are met:

- Structure supports conductors that cross over a:
  - Railroad or Trolley Track
  - Freeway, Highway, or Interstate
  - Large body of water, such as a lake, river, or reservoir
- Span exceeding 500'
- Structures that support aerial marking spheres
- Any joint-use pole that supports 3rd party Communication Infrastructure Provider (CIP) attachments
- For new installations or for lines being reconstructed, any poles involved in “Conflicting Lines” or a “Crossing Span” shall be designed to Grade A
- Any stub pole or structure that supports a Grade A facility

GRADE B CONSTRUCTION: Any SDG&E pole/structure is classified as Grade B if:

- It is not occupied by a 3rd party joint-use CIP attachment, either currently attached to the pole or planned to be attached in the future
- For existing Grade B poles that are not being reconstructed, but are involved in “Conflicting Lines” or a “Crossing Span” shall continue to meet Grade B construction
- Any stub pole or structure that supports a Grade B facility

FIRE THREAT ZONE (FTZ): The SDG&E Fire Threat Zone is based on the 2006 CAL FIRE's Fire Threat Zone map that was modified by SDG&E Fire Coordinator, which takes into account Extreme and Very High Fire Threat Zones as defined by California Department of Forestry and Fire Protection’s Fire and Resource Assessment Program (FRAP) Fire Threat Map.

ii. Determine if pole classes are adequate for all vertical and horizontal loading by using software approved by Electric Distribution or Transmission Engineering with users that are properly trained and qualified to use the software. Contact Engineering for more information. The design shall consider the structural loading requirements of all supply and communication facilities planned to occupy the pole. The "planned" facilities are those that are actually known to SDG&E at the time of design. This requirement applies to new poles and poles being replaced. Reference Non-Operational Electric Standard Practice No. 015 “Structural Pole Loading Calculation Requirements” for pole loading calculation archiving.

iii. Poles must be designed to meet the loading conditions as set forth in this standard. In all cases, facilities will meet or exceed GO 95. Refer to Tables 2 & 3 below.

iv. New pole installations or pole replacements shall be designed to Grade A requirements unless otherwise specified by SDG&E.

v. Determine adequate guying for the design (reference Electric Transmission Standard 15100 and Electric Distribution Overhead Standard Section 900). Critical crossings, such as over a freeway, should eliminate the use guys and anchors where feasible, and instead use larger class poles, a modified embedment depth, and/or custom engineered pole.

vi. Weathering steel poles are not to be installed in sidewalks or other areas with finished concrete or asphalt surfaces, as they will stain the surfaces when the patina is washed off the pole due to rain or irrigation.

vii. As always, field conditions should be taken into account when choosing the correct pole. Aesthetics should be considered in some cases.

viii. For new or replacement pole installations, the designer shall consider the condition of the soil at the proposed pole location. Excessive slope, scour, poor soil conditions, high water table, or grading around vicinity of existing structures and foundations will require consultation with Civil/Structural Engineering.

B. **Requirements Specific to Transmission Poles:**

i. Steel is the preferred material for new pole installations (according to ETE&D Specification TE-0042). Weathering or dull galvanized shall be selected according to the location of the pole (refer to the most recent version of the "Galvanized vs. Weathering Steel Pole - Boundary Map" available on the Electric Transmission Engineering and Design website). At SDG&E's discretion, prestressed concrete poles may be used in appropriate areas (refer to ETE&D Specification TE-0150). Wood poles (TE-0102) may be allowed in areas with difficult construction access, but their use will be limited and will require approval from ETE&D.

ii. In the Fire Threat Zone (FTZ), guys and anchors shall be eliminated where possible. Note: Compliance-type work shall be exempt from this requirement.

iii. Determine future pole height requirements. At a minimum, new transmission poles must be able to support at a minimum (1) level of 12 kV construction, 4-wire 636 ACSR/AW and (2) levels of communication (1 for SDG&E and 1 for CIPs) assuming use of 48 count fiber, unless otherwise directed

TABLE 1: Distribution Pole Selection Matrix

Application Location	Wood	Galvanized Steel	Weathering Steel	Fiberglass
Back Lot	✓	✓	✓	✓
Cleveland National Forest	-	-	✓	*
Contamination District 1	✓	✓	-	✓
Contamination District 2 & 3	✓	✓	✓	✓
SDG&E Fire Threat Zone	-	✓	✓	*
Improved Street	✓	✓	-	-
Unimproved Street	✓	✓	✓	-
Wetland	*	-	-	✓
Cir 170, 171, 172, 220	-	-	✓	-

✓ = Approved

\- = Not Approved

* = Approved by Deviation Request Only

2. The following temperature and loading conditions are to be considered in determining the strength required of poles, structures, and all parts thereof, to achieve the required overall strength of facilities and clearance of conductors. See Table 2 for more detail.

   A. **LIGHT LOADING** (GO 95 Rule 43.2, Jan 2015): This applies to all parts of the SDG&E service territory, for elevations between 0-3,000 feet. The following loading conditions are to be used:
      i. For conductor and pole surfaces the horizontal wind pressure = 8.0 lbs/ft^2
      ii. For flat surfaces and equipment, the horizontal wind pressure = 13.6 lbs/ft^2
      iii. No ice loading is to be considered.
      iv. Ambient Temperature = 25˚F at the time of maximum wind loading, to calculate hardware, pole, and initial conductor tension requirements.

   B. **HEAVY LOADING** (GO 95 Rule 43.1, Jan 2015): This applies to all parts of the SDG&E service territory, for facilities where any part of the structure is above the elevation of 3,001 and below 5,000 feet. The following loading conditions are to be used:
      i. For conductor and round pole surfaces the horizontal wind pressure = 6.0 lbs/ft^2
      ii. For flat surfaces and equipment, the horizontal wind pressure = 10.2 lbs/ft^2
      iii. A radial thickness of ½" of ice, weighing 57.0 lbs/ft^3, shall be considered on all conductors.
      iv. Ambient Temperature = 0˚F at the time of maximum wind loading, to calculate hardware, pole, and initial conductor tension requirements.

   C. **EXTRA HEAVY LOADING** (SDG&E standard exceeding GO 95 minimums): This applies to all parts of the SDG&E service territory, for facilities where any part of the structure is above the elevation of 5,001 feet. The following loading conditions are to be used:
      i. For conductor and round pole surfaces the horizontal wind pressure = 12.0 lbs/ft^2
      ii. For flat surfaces and equipment, the horizontal wind pressure = 20.4 lbs/ft^2
      iii. A radial thickness of 1" of ice, weighing 57.0 lbs/ft^3, shall be considered on all conductors.
      iv. Ambient Temperature = 0˚F at the time of maximum wind loading, to calculate hardware, pole, and initial conductor tension requirements.

   D. **SDG&E KNOWN LOCAL WIND LOADING** (SDG&E standard exceeding GO 95 minimums derived from 50-yr wind maps and HRFA boundaries). All overhead facilities shall be evaluated at an elevated wind speed determined from the "SDG&E Known Local Wind Map" specified in Figure 1, also located in the Geographic Information System (GIS), regardless of elevation. Structures will fall into one of three wind zones: 65 mph, 85 mph, or 111 mph. The following assumptions apply:
      i. For conductor and pole surfaces, the corresponding wind pressures are as follows:
         Horizontal wind speed = 65 mph -> Wind pressure = 10.8 lbs/ft^2
         Horizontal wind speed = 85 mph -> Wind pressure = 18.5 lbs/ft^2
         Horizontal wind speed = 111 mph -> Wind pressure = 31.5 lbs/ft^2

ii. For flat surfaces and equipment, the corresponding wind pressures are as follows:
Horizontal wind speed = 65 mph -> Wind pressure = 18.4 lbs/ft^2
Horizontal wind speed = 85 mph -> Wind pressure = 31.5 lbs/ft^2
Horizontal wind speed = 111 mph -> Wind pressure = 53.6 lbs/ft^2

iii. Ambient Temperature at the time of maximum wind loading, to calculate hardware, pole, and final conductor tension requirements shall be determined from the elevation-based loading of the structure (50°F if structure is in GO 95 Light loading zone or 20°F if structure is in GO 95 Heavy or SDG&E Extra Heavy loading zone).

iv. No ice loading is to be considered unless otherwise directed by Meteorology or conditions are known to exist.

v. The SDG&E Known Local Wind layer does not include any areas of Imperial County. Contact ETE&D or Electric Distribution Engineering for structures not included in the SDG&E Known Local Wind Map. At minimum, GO95 loading must be applied.

3. All poles shall be evaluated under the elevation-based loading specified in 2. A. through 2. C. as well as the SDG&E Known Local Wind Zone loading specified in 2. D. The most stringent condition shall prevail in determining the strength required of poles, structures, and all parts thereof to achieve the required overall strength of facilities. In all cases, facilities will meet or exceed GO 95.

4. When performing pole loading calculations on wood poles, the loading calculation shall incorporate the results of an intrusive inspection report to accurately reflect the remaining pole strength. Remaining percentage of strength values shall be rounded down to the nearest increment of 5%. For example, if the intrusive records have a value of 84%, use a value of 80% in the calculation. Intrusive inspections can be requested to confirm or verify assumptions. Contact Vegetation Management via email at the following address: WPIIntrusiveDataRequests@semprautilities.com

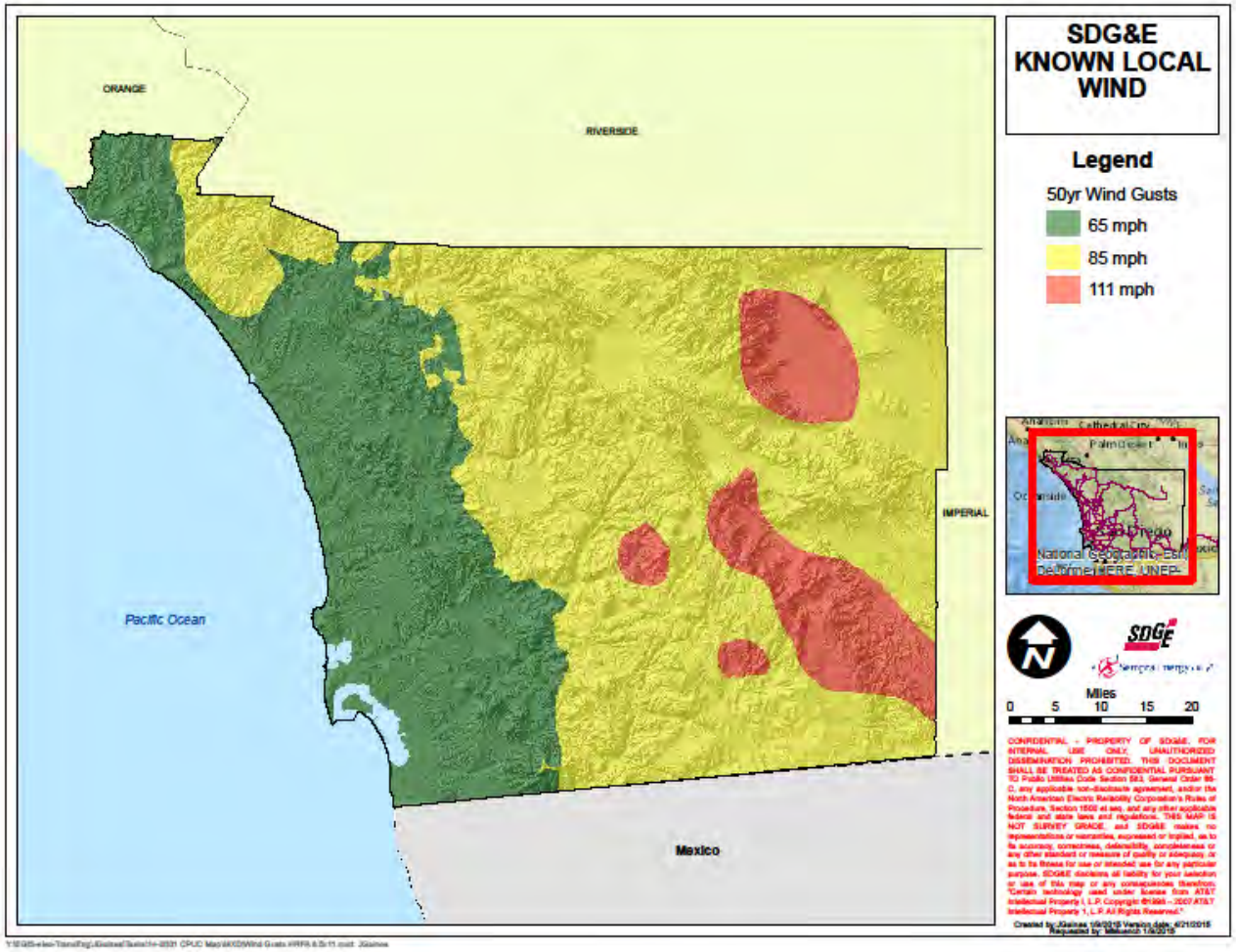
A. **Additional Construction** - If planning the addition of facilities that materially increases loads on wood structures more than 15 years old, the loading calculation shall incorporate the results of intrusive inspections performed within the previous five years from the start of design. A material increase in load is an addition that increases the load on a structure by more than five percent per installation, or ten percent over a 12-month span. Refer to GO 95 Rule 44.2. For poles 15 years old or less that do not have an intrusive inspection record, calculations shall use 80% remaining strength for poles in the Fire Threat Zone (FTZ) and 90% remaining strength in non-FTZ areas.

B. **Analyzing Existing Conditions** – If only conducting pole loading calculations for existing wood structures without a material increase in loads, use existing intrusive records regardless of the age of inspection. For poles 15 years old or less that do not have an intrusive inspection record, calculations shall use 80% remaining strength for poles in the Fire Threat Zone (FTZ) and 90% remaining strength in non-FTZ areas.

5. Lines may fall under multiple combinations of loading conditions specified in 2. A. through 2. D. above. In cases where a line crosses multiple loading boundaries, the most stringent loading criteria shall be extended to the entire ruling span. For transmission structures, if the ruling span ends more than one mile from the criteria boundary and field conditions allow, a new ruling span may be created by adding a terminal dead-end structure to the line to isolate the area of more stringent criteria. Note that this applies to both elevation and wind speed boundaries.

Figure 1: SDG&E Known Local Wind Map

FOR REFERENCE ONLY: Refer to Enterprise GIS System for Latest Map



--	ORIGINAL ISSUE	ECJ	JAE	JES	MDJ	WGT	10/16/15	10/20/15
REV	*CHANGE*	*DWN*	*CHKD*	*CHKD*	*APVD*	*APVD*	*APVD DATE*	*EFF DATE*
ELECTRIC TRANSMISSION & DISTRIBUTION ENGINEERING		SCALE: NONE						
SDGE A Sempra Energy utility	DIRECT BURIED POLE SELECTION & LOADING CRITERIA	DWG. NO 12100			SHT. NO 10 of 15			

6. The following tables summarize the conditions as stated in section 2 and the safety factors of poles, conductors, and equipment by temperature and loading conditions:

Table 2: Loading Conditions for Poles, Conductors, and Equipment

LOADING DISTRICT			LOADING CONDITIONS					
					WIND			
			RADIAL ICE (IN)	AMBIENT TEMP (˚F)	SPEED (MPH)	FORCE ON CONDUCTOR & POLE (LBS/FT^2)	FORCE ON EQUIPMENT (LBS/FT^2)	ELEVATION
G.O. 95	LIGHT		0	25	56	8.0	13.6	0 - 3,000 FT
	HEAVY		0.5	0	48	6.0	10.2	3,001 - 5,000 FT
SDG&E	EXTRA HEAVY		1	0	68	12.0	20.4	5,001 FT AND ABOVE
SDG&E KNOWN LOCAL WIND	65 MPH ZONE	LIGHT	0	50	65	10.8	18.4	WIND MAP & 0 - 3,000 FT
		HEAVY	0	20	65	10.8	18.4	WIND MAP & 3,001 FT & ABOVE
	85 MPH ZONE	LIGHT	0	50	85	18.5	31.5	WIND MAP & 0 - 3,000 FT
		HEAVY	0	20	85	18.5	31.5	WIND MAP & 3,001 FT & ABOVE
	111 MPH ZONE	LIGHT	0	50	111	31.5	53.6	WIND MAP & 0 - 3,000 FT
		HEAVY	0	20	111	31.5	53.6	WIND MAP & 3,001 FT & ABOVE

Table 3: Safety Factors for Grade A and Grade B Construction

ITEM #	EQUIPMENT OF LINE		SAFETY FACTORS BY LOADING DISTRICT***					
			GO 95 LIGHT GO 95 HEAVY SDG&E EXTRA HEAVY			SDG&E KNOWN LOCAL WIND		
			At Installation*	At Replacement**		At Installation*	At Replacement**	
			GRADE A	GRADE A	GRADE B	GRADE A	GRADE A	GRADE B
1	CONDUCTORS, SPLICES, CONDUCTOR FASTENING, PINS, & POLE LINE HARDWARE		2.00	1.33	1.33	2.00	1.33	1.33
2	LINE INSULATORS (MECHANICAL)		3.00	2.00	1.33	3.00	2.00	1.33
3	GUY INSULATORS (MECHANICAL)	PORCELAIN	2.00	1.33	1.33	2.00	1.33	1.33
4		FIBERGLASS	3.00	2.00	1.90	3.00	2.00	1.90
5	GUYS, MESSENGERS & SPAN WIRES		2.00	1.33	1.33	2.00	1.33	1.33
6	POLES	WOOD	4.00	2.67	2.00	1.50	1.13	1.13
7		STEEL	1.50	1.00	1.00	1.20	1.00	1.00
8		CONCRETE	1.80	1.20	1.00	1.20	1.00	1.00
9		COMPOSITE	1.50	1.00	1.00	1.20	1.00	1.00
10	CROSSARMS	WOOD	2.00	1.33	1.33	2.00	1.33	1.33
11		STEEL	1.50	1.00	1.00	1.50	1.00	1.00
12		COMPOSITE	2.00	1.33	1.33	2.00	1.33	1.33

*Note: All new designs shall use Grade A Safety Factors

** At Replacement safety factors use the reduction allowed in GO 95 Rule 44.3, with the exception of Wood Poles At Replacement under the SDG&E Known Local Wind condition

*** Safety Factors shall be applied as strength factors in approved software (Reference Table 4)

Table 4: Strength Factors for Grade A and Grade B Construction

ITEM #	EQUIPMENT OF LINE		STRENGTH FACTORS BY LOADING DISTRICT					
			GO 95 LIGHT GO 95 HEAVY SDG&E EXTRA HEAVY			SDG&E KNOWN LOCAL WIND		
			At Installation*	At Replacement**		At Installation*	At Replacement**	
			GRADE A	GRADE A	GRADE B	GRADE A	GRADE A	GRADE B
1	CONDUCTORS, SPLICES, CONDUCTOR FASTENING, PINS, & POLE LINE HARDWARE		0.50	0.75	0.75	0.50	0.75	0.75
2	LINE INSULATORS (MECHANICAL)		0.33	0.50	0.75	0.33	0.50	0.75
3	GUY INSULATORS (MECHANICAL)	PORCELAIN	0.50	0.75	0.75	0.50	0.75	0.75
4		FIBERGLASS	0.33	0.50	0.53	0.33	0.50	0.53
5	GUYS, MESSENGERS & SPAN WIRES		0.50	0.75	0.75	0.50	0.75	0.75
6	POLES	WOOD	0.25	0.37	0.50	0.67	0.88	0.88
7		STEEL	0.67	1.00	1.00	0.83	1.00	1.00
8		CONCRETE	0.56	0.83	1.00	0.83	1.00	1.00
9		COMPOSITE	0.67	1.00	1.00	0.83	1.00	1.00
10	CROSSARMS	WOOD	0.50	0.75	0.75	0.50	0.75	0.75
11		STEEL	0.67	1.00	1.00	0.67	1.00	1.00
12		COMPOSITE	0.50	0.75	0.75	0.50	0.75	0.75

*Note: All new designs shall use Grade A Strength Factors

** At Replacement strength factors use the reduction allowed in GO 95 Rule 44.3, with the exception of Wood Poles At Replacement under the SDG&E Known Local Wind condition

7. The following examples will help illustrate how to apply the appropriate loading conditions and safety factors:

   A. **Example 1: Analyzing** the loading of an **existing** Grade A wood pole near the Glencliff Substation.
      i. Check the GO 95 elevation based loading: Since this area is above 3,000 feet (as determined by either GIS or survey data), it would be governed by the "GO 95 Heavy" loading condition.
      ii. Check the SDG&E Known Local Wind Loading criteria: Using the SDG&E Known Local Wind Loading map, determine the elevated wind area in which the pole is located. Since the pole is near Glencliff Substation, the map indicates this area is in the 111 mph area.
      iii. Determine appropriate safety factors: Using Table 3, find the correct "At Replacement" "Grade A" safety factors to use for the loading conditions for which this pole needs to be checked. The wood pole is required to meet Safety Factor of 2.67 for the "GO 95 Heavy" loading and Safety Factor of 1.13 for the "SDG&E Known Local Wind" loading.

   B. **Example 2: Replacing** an existing Transmission Grade B wood pole near Valley Center Substation.
      i. Since this involves a pole replacement, the new pole will be steel and designed to Grade A safety factors (according to section 1 above). By referencing the "Galvanized vs. Weathering Steel Pole-Boundary Map" on the "Electric Transmission Engineering and Design" intranet site, this specific location falls in the area for weathering steel.
      ii. Check the GO 95 elevation based loading: This area is below 3,000 feet (as determined by either GIS or survey data), and therefore would be governed by the "GO 95 Light" loading condition.
      iii. Check the SDG&E Known Local Wind Loading criteria: Using the SDG&E Known Local Wind Loading map, determine the elevated wind area in which the pole is located. Since the pole is near Valley Center Substation, the map indicates this area is in the 65 mph area.
      iv. Determine appropriate safety factors: Using Table 3, find the correct "At Installation" "Grade A" safety factors to use for the loading conditions for which this pole needs to be checked. The new steel pole is required to meet Safety Factor of 1.5 for the "GO 95 Light" loading and Safety Factor 1.2 for the "SDG&E Known Local Wind" loading.

   C. **Example 3: Replacing** an existing Distribution Grade B wood pole near Valley Center Substation, along an improved street (i.e. in a sidewalk).
      i. Since this involves a pole replacement, the new pole will be steel and designed to Grade A safety factors (according to section 1 above). By referencing the "Distribution Pole Selection Matrix" in Table 1 as well as relevant field and GIS data, this specific location falls in the "SDG&E Fire Threat Zone" and "Contamination District 3". Since this specific example pole is in a sidewalk, a galvanized steel pole would be used.
      ii. Check the GO 95 elevation based loading: This area is below 3,000 feet (as determined by either GIS or survey data), and therefore would be governed by the "GO 95 Light" loading condition.

iii. Check the SDG&E Known Local Wind Loading criteria: Using the SDG&E Known Local Wind Loading map, determine the elevated wind area in which the pole is located. Since the pole is near Valley Center Substation, the map indicates this area is in the 65 mph area.

iv. Determine appropriate safety factors: Using Table 3, find the correct "At Installation" "Grade A" safety factors to use for the loading conditions for which this pole needs to be checked. The new steel pole is required to meet Safety Factor of 1.5 for the "GO 95 Light" loading and Safety Factor 1.2 for the "SDG&E Known Local Wind" loading.

--	ORIGINAL ISSUE	ECJ	JAE	JES	MDJ	WGT	10/16/15	10/20/15
REV	*CHANGE*	*DWN*	*CHKD*	*CHKD*	*APVD*	*APVD*	*APVD DATE*	*EFF DATE*

ELECTRIC TRANSMISSION & DISTRIBUTION ENGINEERING		SCALE: NONE	
SDGE A Sempra Energy utility	DIRECT BURIED POLE SELECTION & LOADING CRITERIA	DWG. NO 12100	SHT. NO 15 of 15

Appendix H – Open Fire Union Tribune Story, December 1, 2006

Downed power line blamed for morning blaze that burned almost 300 acres in Santa Ysabel

By J. Harry Jones
and Kristina Davis
UNION-TRIBUNE STAFF WRITERS

December 1, 2006

SANTA YSABEL – Shortly before sunrise yesterday, a risky, even daring, decision was made that may well have prevented the county's next huge fire.

About 5:30 a.m., strong Santa Ana winds had downed a small power line just east of Santa Ysabel, starting a fire that quickly climbed up a hill.

CHARLIE NEUMAN / Union-Tribune
Debbie Lair (with ax) and Veronica Quevedo (with chain saw) tackled a hot spot among some oak trees near the site where yesterday's fire started in Santa Ysabel. The Open fire burned almost 300 acres.

Winds were howling, and the humidity was low. The flames were heading southwest, a few hills away from thousands of acres that hadn't burned since 1961.

At 6:20 a.m., Battalion Chief Ray Chaney of the California Department of Forestry and Fire Protection was in a spotter airplane, watching as the flames crested a ridge and headed into a small valley just north of state Route 78 about a mile west of state Route 79.

Chaney, who heads CDF's Ramona Air Attack Base, concluded that firefighters had about a 10-minute window of opportunity. As long as it was in the valley, the fire was moving slowly because it was shielded from 40 mph winds by the mountain behind it.

Division Chief Bill Clayton and Battalion Chief Kevin O'Leary, who were in charge of the ground attack, were in constant radio contact with Chaney. Together, the three men decided on an aggressive and potentially dangerous plan: attacking the fire head-on.

“We knew that if the fire started climbing the next mountain, it would be off to the races and there would be no controlling it,” Chaney said.

They feared the fire could scorch 25,000 acres, burning into Ramona or beyond.

The crews of several CDF fire engines that had been the first to respond had reached similar conclusions. They were at the front of the fire, pumping water onto the flames.

“There are a couple engine company captains we owe a lot to,” Chaney said. “They decided to attack the thing right away.”

Chaney ordered the first air tanker to drop its load of fire retardant directly onto the head of the fire, while Clayton directed every engine available to the front of the blaze.

More tankers and helicopters soon followed.

“We kamikazeed the hell out of it,” Clayton said.

The strategy worked.

The fire never made it out of the valley. There were no injuries. No structures lost.

“We took a calculated risk this time and put everything we had on the head of the fire,” said Clayton, who is retiring next week after 48 years on the job. “We'd figured we'd either catch it and it would remain small, or it would get real, real big.”

“We are all very proud of (the response to) that fire,” Chaney said.

Sending firefighters to the front of a fire is seldom done because of the risks involved.

Clayton said he was concerned that the flanks of the fire could get whipped up and funnel around the head. When that happens, fire crews can get surrounded and overrun, or the flames can go around them, which is why the tactic is usually avoided when fighting wind-driven fires.

A month ago, five federal firefighters died as a result of being overtaken while fighting the Esperanza fire near Palm Springs. “In the back of our heads was the Esperanza fire,” Chaney said.

But the three commanders decided the risks were worth taking this time because several factors were in their favor. For one thing, the terrain was not very steep, allowing firetrucks access and room to maneuver. For another, the vegetation was low and relatively light, and still moist from the recent rain.

“A week from now would have been a different story,” CDF Capt. Randy Scales said.

Had the fire been in thick brush, Clayton said, he would never have ordered a direct attack.

By 9 a.m., constant bombardment from six air tankers and four helicopters, and brush-clearing by two bulldozers and nearly 200 inmate firefighters working on hand crews, had created a perimeter, containing the fire to about 295 acres.

The blaze, named the Open fire, although no one seems to know why, also tested the county's reverse 911 system, which was created after the 2003 firestorms. The Sheriff's Department made about two dozen reverse 911 calls to residents whose homes might be in the fire's path, warning them to be ready to evacuate. There were no forced evacuations.

Sheriff's Sgt. Dave Brown, who has seen many backcountry fires over the years, said his deputies were preparing for the worst.

“The wind would hold you up it was so strong,” Brown said. “We were gearing up, setting up evacuation centers, water supplies, the Red Cross was called. The elements were against us, and for some miracle, the firefighters got it under control.”

Firefighters were expected to work through last night digging fire lines around the perimeter.

Staff writers Michael Burge, Greg Gross and Karen Kucher contributed to this report.

▪J. Harry Jones: (760) 737-7579; **jharry.jones@uniontrib.com**

Appendix I – 1970 California Wildfires September/November Excerpts

1970
CALIFORNIA WILDFIRES
SEPTEMBER/NOVEMBER

PACIFIC FIRE RATING BUREAU
465 CALIFORNIA STREET
SAN FRANCISCO, CA. - 94104

PACIFIC FIRE RATING BUREAU

OFFICERS

W. H. Dillon, President
San Francisco

D. T. Shaw, Vice President
San Francisco

Governing Committee

John A. Bunting, Chairman
San Francisco

Ralph H. Dreyer – San Francisco
David Gray – San Francisco
Fred N. Hellmann – San Francisco
C. W. Homer – San Francisco
E. L. Kale – Los Angeles
D. P. Lawrence – San Francisco
W. Ludemann – San Francisco
R. A. Matthew – Los Angeles
Gorden E. Noble – San Francisco
George A. Seawell – Los Angeles
Keith D. Tibbets – San Francisco
Walter P. White, Jr. – Los Angeles

Harold S. Morr, General Manager

This report was prepared by Harry C. Bigglestone, Chief Engineer, Public Protection. Acknowledgment is made of the valuable assistance by over 500 fire departments and other agencies including the Kern County, Los Angeles City, Los Angeles County, Oakland, and Ventura County Fire Departments, the California Division of Forestry, the California Office of Emergency Services, the U.S. Forest Service and the U.S. Office of Emergency Preparedness.

1970 CALIFORNIA WILDFIRES

September - November

WEATHER

Strong, hot, dry winds, usually from the north and northeast become localized through the larger canyons and passes with recorded velocities as high as 90 miles per hour. These winds are referred to as Santana, Santa Ana, or Devil Winds. They strike southward across Southern California points such as Van Nuys, Santa Monica, and San Bernardino and southwesterly through passes such as the Santa Clara River Valley, Cajon, and the Santa Ana Canyon. Frequency of occurrence is generally near zero during May through July, starts increasing during August, reaches a peak in December, and decreases thereafter. There are accounts of these winds as early as the 1830's and, in addition to other names, they are sometimes referred to as Desert Winds. As stated by one report: "By whatever name, these characteristic dry winds will continue to be a feature of the Southern California climate, and in view of this region having developed into one of the world's great metropolitan areas, the wind and its effects may receive more and more attention in the future".

A vegetation tinder-box was created by lack of precipitation and long periods of above-normal temperature. For the period April-September, 1970 the accumulated precipitation was less than 50% of normal for most of California, ranging from about 15% to a little over 30% of normal for the south and central coasts.

A report from the Pacific Southwest Forest and Range Experiment Station summarizes the weather situation as it affected the fire conditions in September of 1970. "Precipitation for the central and south central areas was only 22-23% of normal for the April through September period. Temperatures for this area averaged more than 2 degrees above normal for May through September. A combination of these conditions caused the death of some living vegetation and low fuel moisture in the remainder. Fire danger ratings (fire load indexes) for the last ten days of September were from 200 to 600% above normal for much of the state."

On September 23 the five-day weather forecast for Southern California predicted wind probability at 70% with velocities at 50 miles per hour. The strong winds continued until September 29.

GENERAL DISCUSSION

Fire protection for structures exposed by natural growth varies considerably throughout California. Structures on the lower slopes and flat lands, served by networks of mains and hydrants, are normally thought of as having fairly good protection. Those buildings located on steep slopes, served by dead-end and narrow winding roads and remotely located from available water supplies and fire stations are literally unprotected at time of fire storm. Although California, through its disaster planning, may marshal large numbers of men and equipment for wide-area emergencies, a fire advancing on a 2 to 4 mile front at the rate of about 2 miles per hour (as was the case in Malibu in Los Angeles County) leaves little opportunity for orderly and systematic tactics for each individual structure.

Starting on September 12 with a destructive fire involving structures and approximately 100 acres in the community of Pollock Pines, the State was plagued by hundreds of wildfires* until mid-November when the City of San Bernardino was threatened by the 53,000-acre Bear Fire, which had already destroyed about 50 homes and cabins.

The greatest concentration of destruction was during the period September 22-October 4. Of nearly 800 fires, approximately 45 involved more than 100 acres each (32 of these were over 300 acres). 434 of the fires were in territory protected by the California Division of Forestry.

*"Wildfire" is a collective term for uncontrolled natural vegetation fires: forest, timber, brush, range, watershed, grass, ground cover and undergrowth.

Photo No. 4 – Laguna Fire, on a broad front, nears Descanso in San Diego County. Evening (San Diego) Tribune Photo

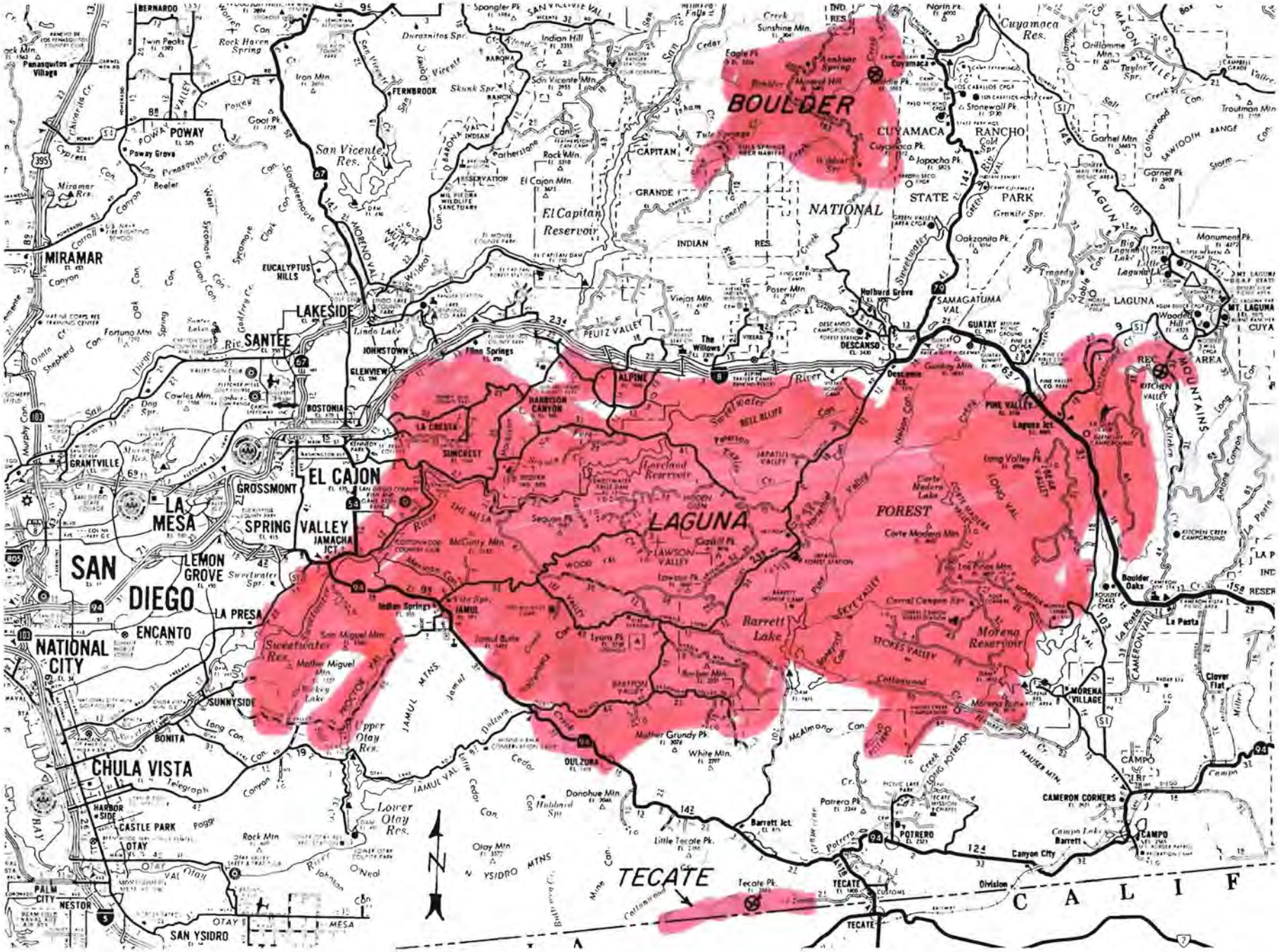
SAN DIEGO COUNTY: This county spawned the first serious fire and the largest fire of those hectic days beginning September 25 (Map E). Near the Mexican border, the Tecate Fire signaled the beginning of 39 fires within the county.

High winds in the Cleveland National Forest downed a tree which, in turn, downed electric power lines and the Laguna Fire was off and running – 60 acres in the first hour. It was soon copying the Los Angeles County fires by creating spot fires up to one mile ahead of the main fire front. Fire storm conditions prevailed and the fire spread on multiple fronts (Photo No. 4), with the community of Pine Valley the first to be threatened. It was to be threatened more than once by the idiosyncrasies of the fire storm, as were other small communities during the ensuing period.

Men and apparatus from communities in San Diego County had been dispatched northward to assist in Los Angeles and Ventura Counties. The U.S. Forest Service (USFS), the CDF, and the State OES (see Appendix) took action to move aid southward to help the overrun fire fighters from the county communities. Within three hours the fire had covered 27,000 acres.

Wind gusts to 70 mph early September 27 made it evident the fire was headed for the heavily populated areas east of the cities of San Diego and El Cajon. Communications had become a problem. The fire had covered 120,000 acres and devoured two radio communications repeaters. Small groups of structures and many isolated ones fell victim. Communities and settlements were evacuated with over 5,000 residents affected. Pine Valley, Alpine, Harbison Canyon (Photo No. 5), Suncrest and Jamul were among those areas bearing the brunt of the conflagration.

Many locations had no water normally available for fire purposes and, in some others, supplies provided by electric-driven pumps were disrupted


BOULDER
CUYAMACA
RANCHO
CUYAMACA
STATE
PARK
NATIONAL
FOREST
LAGUNA
MOUNTAINS
MIRAMAR
LAKESIDE
SANTEE
EL CAJON
LA MESA
SPRING VALLEY
LEMON GROVE
SAN DIEGO
NATIONAL CITY
CHULA VISTA
ENCANTO
LA PRESA
GRANTVILLE
GROSSMONT
JAMACHA JCT.
SUNCREST
ALPINE
DESCANSO
PINE VALLEY
LAGUNA JCT.
MT. LAGUNA
LAGUNA
GUATAY
SAMAGATUMA VAL.
Holbrook Grove
The Willows
Flinn Springs
JOHNSTOWN
GLENVIEW
EUCALYPTUS HILLS
POWAY
FERNBROOK
BERNARDO
Lake Cuyamaca
Stonewall Pk.
Cuyamaca Pk.
Japacha Pk.
Oakzanita Pk.
Granite Spr.
Garnet Pk.
Monument Pk.
Big Laguna Lake
Little Laguna Lake
Tragedy Spr.
Noble Canyon
Sweetwater
Descanso Jct.
Kitchen Creek
Kitchen Valley
Boulder Oaks
La Posta
Cameron Corners
Campo
Clover Flat
Morena Village
Potrero
Barrett Jct.
Barrett Lake
Morena Reservoir
Lake Morena
Campo Lake
Canyon City
Division
TECATE
Tecate Pk.
Little Tecate Pk.
Donahue Mtn.
Mother Grundy Pk.
White Mtn.
Hauser Mtn.
Cameron Mtn.
Potrero Pk.
Viejas Mtn.
Poser Mtn.
El Cajon Mtn.
Rock Mtn.
Iron Mtn.
Cowles Mtn.
Fortuna Mtn.
Sunshine Mtn.
Indian Hill
Eagle Pk.
Monument Hill
Oriflamme Mtn.
Taylor Spr.
Troutman Mtn.
Garnet Mtn.
Gaskill Pk.
Lawson Pk.
Los Pinos Mtn.
Corte Madera Mtn.
Corte Madera Lake
Long Valley Pk.
Lyons Pk.
McCoy Mtn.
Loveland Reservoir
El Capitan Reservoir
Sweetwater Reservoir
Upper Otay Res.
Lower Otay Res.
San Vicente Res.
Miramar Res.
Cuyamaca Res.
Barrett Reservoir
Morena Reservoir
Lake Morena
Campo Lake
Lake Cuyamaca
Laguna Lake
Little Laguna Lake
Lake Morena
Lake Cuyamaca
Lake Barrett
Lake Morena
Lake Cuyamaca
Lake Barrett
Lake Morena
Lake Cuyamaca
Lake Barrett

Appendix J - Joseph W. Mitchell Vitae

JOSEPH W. MITCHELL, PH.D.

Vitae

2008-2016 – Participation in ongoing California Public Utility Commission (CPUC) safety proceedings on behalf of MGRA. Jointly sponsored proposed rules with the Consumer Protection and Safety Division (CPSD/SED) and facilitated participation of CAL FIRE. Four rule changes I proposed on behalf of MGRA (or jointly proposed with the CPSD) were fully or partially accepted by a proposed decision of the California Public Utilities Commission. Continuing to participate on issues of fire data collection and high-resolution fire threat maps for utilities. Made key contributions to the Safety Model Assessment Proceeding (S-MAP), which affects safety prioritization for all California utilities from 2014 to present. Also analyzed utility fire safety data as a component of SDG&E's 2016 rate case.
2012-2013 – Presented on the power line fire threat at the International Conference on Engineering Failure Analysis conference in the Hague, Netherlands. Published in Engineering Failure Analysis in 2013.

2009-2012 – Provided key fire safety testimony used in the CPUC WEBA application, a joint utility proposal to pass on wildfire liability costs to ratepayers. Application was denied.
2011 – Presented on the power line fire threat and California's regulatory response at the annual Wildland Fire Litigation Conference.
2009 – Presented paper and presentation at *Fire and Materials 2009* on catastrophic power line fires, which was the first paper to demonstrate the relationship between wind, fire suppression efficiency, and power line failure rates. Served on a California State Fire Marshal Task Force, establishing a framework for testing ignition-resistant construction proposed for the 2010 update to the California Building Code. WEEDS water spray system was featured in a news segment by San Diego television station KGTV.
2008-2009 – Successfully opposed an application by San Diego Gas & Electric Company to shut off power under regularly occurring wind conditions, arguing instead for a cost/benefit analysis – a recommendation that was adopted by the CPUC.
2007-2008 – Submission of expert witness testimony on behalf of MGRA in the CPUC hearings for the proposed SDG&E "*Sunrise Powerlink*" transmission line on the subject of power lines and wildland fire, which included cross-examination and contribution to briefs. Demonstrated potential fire risks from transmission lines, and also found a significantly larger number of power line fires in San Diego County.
2007 – Presented work with Oren Patashnik at *Fire & Materials 2007* conference in San Francisco, whose Scripps Ranch data demonstrated potential ember vulnerability of curved-tile roofing (confirmed in 2009 by NIST research). Provided comment on and criticism of San Diego County's 'shelter-in-place' guidelines. Wrote an op-ed piece published in the San Diego Union Tribune and provided commentary for News 8 KFMB piece on shelter-in-place. Submitted expert testimony for CPUC on *Sunrise Powerlink* project.
2006 – Publication of peer-reviewed paper on the WEEDS water-spray wildland fire protection system in the *Fire Safety Journal*. Presentation of results at the *Third International Fire Ecology and Management Congress*, San Diego, CA.

2001-2005 – Developed the WEEDS method for structure defense during wildland fires. Completed in time for the October 26, 2003 Cedar fire, when it was validated under wildfire conditions. Founded M-Bar Technologies and Consulting to promulgate knowledge regarding WEEDS and the importance of designing for firebrand protection under high-wind conditions. Poster session at *Wildfire 2004* conference, Reno, NV. Articles published in *San Diego Reader* magazine and in *Home&fire* and *Wildfire* trade magazines. Computer modeling validates WEEDS principles.
1999 – Returned to the United States from Europe, settling in San Diego, CA.
1996-present – Work in software engineering and management for major multinational corporations.
1989-1998 – Lived and worked in Europe first as a postdoctoral physicist and then in software engineering for a multinational corporation. Resided in Switzerland, Germany, France, and Belgium.
1993-1996 – Postdoctoral work for University of California at Davis in heavy ion physics, performed at CERN. Continuing with work in lasers, optical systems and computer modeling.
1989-1993 – Postdoctoral work for McGill University in high energy physics at CERN (Center for European Nuclear Research, Geneva, Switzerland) and DESY (Deutsches Electron-Synchrotron, Hamburg, Germany). Developed expertise in energy measurement, computer modeling, lasers and optical systems.
1989 – Ph. D. in Physics received from Ohio State University, Columbus, Ohio
1981-1989 – Graduate research in elementary particle (neutrino) physics, Columbus and Los Alamos National Laboratory, NM. Trained in electronics, mechanical engineering, computing, energy measurement and statistics.
1981-1983 – Graduate teaching assistant, OSU physics department.
1981 – Bachelor of Science in Physics received from Ohio State University, Columbus, Ohio

Expert Testimony and Technical Commentary

California Public Utilities Commission (CPUC); Application Proceeding A.06-08-010; Mussey Grade Road Alliance (MGRA); MG-1; MGRA Phase 1 and Phase 2 Direct Testimony; Sunrise Powerlink Transmission Line Project; Application No. 06-08-010; March 12, 2008

DIRECT TESTIMONY OF THE MUSSEY GRADE ROAD ALLIANCE - WEBA IMPACTS ON FIRE RISK AND COSTS; Application No. 09-08-020; September, 11, 2011.

DIRECT TESTIMONY OF THE MUSSEY GRADE ROAD ALLIANCE, SDG&E 2016 RATE CASE; May 15, 2015.

Provided all technical input on wildland fire for the following CPUC Proceedings for the Mussey Grade Road (MGRA):
P.07-11-007 - Petition of San Diego Gas & Electric Company (U 902-E) to Adopt, Amend, or Repeal a Regulation Pursuant to Pub. Util. Code Section 1708.5.
R.08-11-005 - Order Instituting Rulemaking To Revise and Clarify Commission Regulations Relating to the Safety of Electric Utility and Communications Infrastructure Provider Facilities.
A.08-12-021 - Application of SAN DIEGO GAS & ELECTRIC COMPANY for Review of its Proactive De-Energization Measures and Approval of Proposed Tariff Revisions (includes J. W. Mitchell report "*When to Turn Off the Power? Cost/Benefit Outline for Proactive De-energization*", March 27, 2009)

A.09-08-021 - Application of San Diego Gas & Electric Company (U 902-M), Southern California Edison Company (U 338-E), Southern California Gas Company (U 904-G) and Pacific Gas and Electric Company (U 39-M) for Authority To Establish A Wildfire Expense Balancing Account to Record for Future Recovery Wildfire-Related Costs.
A.13-11-006 - Order Instituting Rulemaking to Develop a Risk-Based Decision-Making Framework to Evaluate Safety and Reliability Improvements and Revise the General Rate Case Plan for Energy Utilities.
A.14-11-003 – Application of San Diego Gas & Electric Company (U 902 M) for Authority, Among Other Things, to Increase Rates and Charges for Electric and Gas Service Effective on January 1, 2016.
A.15-05-002-5 – Application of SAN DIEGO GAS & ELECTRIC COMPANY (U 902 M) for Review of its Safety Model Assessment Proceeding Pursuant To Decision 14-12-025 and related matters.
R.15-05-006 – Order Instituting Rulemaking to Develop and Adopt Fire-Threat Maps and Fire-Safety Regulations.

Publications

Fire Publications & Presentations - Academic

Mitchell, Joseph W.; Power line failures and catastrophic wildfires under extreme weather conditions; Engineering Failure Analysis; Volume 35, 15 December 2013, Pages 726–735 (ICEFA V, The Hague, The Netherlands, July 3, 2012)
http://www.sciencedirect.com/science/article/pii/S1350630713002343

Mitchell, Joseph W.; "Power Lines and Catastrophic Wildland Fire in Southern California"; Presentation to the Fire & Materials 2009 Conference, San Francisco CA, Jan 26, 2009.
http://www.mbartek.com/images/FM09_JWM_PLFires_1.0fc.pdf

Mitchell, Joseph W. and Oren Patashnik**;** Firebrand Protection as the Key Design Element for Structure Survival during Catastrophic Wildland Fires; Fire and Materials 2007, San Francisco, CA; Jan 29-31, 2007.
http://www.mbartek.com/images/FM07_FirebrandsWildfires_1.1F.pdf

Mitchell, Joseph W.; REDUCING URBAN INTERFACE ECOLOGICAL IMPACTS AND FIRE LOSSES THROUGH STRUCTURAL FIREBRAND PROTECTION; Third International Fire Ecology and Management Conference; San Diego, CA; Nov13-17, 2006.

Mitchell, Joseph W.; Wind-enabled ember dousing; Fire Safety Journal; v. 41 (2006); pp 444-458.
WEEDS poster session; Wildfire 2004 conference, Reno, NV; Mar. 2004.

Fire Publications & Presentations – Trade and General Public

Mitchell, Joseph W.; **Goaded into Action: California's Regulatory Response to the Power Line Fire Threat**
Presented at the 5th Annual Wildland Fire Litigation Conference, April 16, 2011

Conklin, Diane and Joseph W. Mitchell; The PUC should deny this plan outright; The San Diego Union Tribune; May 10, 2009.
http://www3.signonsandiego.com/stories/2009/may/10/puc-should-deny-plan-outright/?uniontrib

Mitchell, Joseph W; Wind-Enabled Ember Dousing - A comparison of wildland fire protection strategies; Prepared for the Ramona Fire Recovery Center, 8/12/2008.
http://www.mbartek.com/images/Mbar_WEEDS_Comparison_web.pdf

Mitchell, Joseph W.; Playing with fire: The county's 'Shelter in Place' gamble; The San Diego Union-Tribune; May 2, 2007, p. B7.
http://www.signonsandiego.com/uniontrib/20070502/news_lz1e2mitchell.html
Mitchell, Joseph W.; Brand Dilution (Cover article); Wildfire Magazine; Mar. 2005
http://wildfiremag.com/wui/brand_dilution/
Mitchell, Joseph W.; WEEDS: Wind Enabled Ember Dousing System; Home&fire Magazine; Spring, 2005; p. 32
Mitchell, Joseph; Engineering a Miracle; San Diego Weekly Reader Magazine; April 29, 2004
Physics: List of neutrino, high-energy, and heavy ion physics publications is available upon request.

Other Experience

Technical & Managerial:
Five years of managerial experience in a software development organization. Nineteen years of experience in corporate software development environments in the financial application and consumer electronics industries.

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