Devin Brookhart

From: Bill Powers <bpowers@powersengineering.com>
Sent: Friday, March 07, 2014 7:40 PM
To: lisa.orsaba@cpuc.ca.gov; wmetz@fs.fed.us; CNFMSUP
Cc: 'Kelly Fuller'
Subject: A.12-10-009: SDG&E's Master Special Use Permit - POC Supplemental Scoping Comments
Attachments: 07-mar-14_POC supplemental MSUP scoping comments.pdf; Footnote_average cost of solar PV system.pdf; Footnote_Blanchard_letter.pdf; Footnote_ECOsubstation_FEIS_ES.pdf; Footnote_FedReg_vol76_no72.pdf; Footnote_PowerGrid International_underground vs overhead_power line installation-cost comparison.pdf; Footnote_TVnews_story.pdf; Footnote_UT San Diego_microgrid powers Borrego during emergency.pdf

Dear Lisa,

Please find attached the supplemental scoping comments of POC Foundation on the EIR/EIS for the SDG&E Master Special Use Permit.

Two large footnote references are being sent separately.

Regards,

Bill Powers, P.E.
Board Member, POC Foundation

The Protect Our Communities Foundation
P.O. Box 305
Santa Ysabel, CA 92070
Send correspondence to: kelly@kellyfuller.net

March 7, 2014

Lisa Orsaba, California Public Utilities Commission
Will Metz, U.S. Forest Supervisor, Cleveland National Forest
c/o Dudek
605 Third Street
Encinitas, California 92024
Sent via Electronic Mail: lisa.orsaba@cpuc.ca.gov, wmetz@fs.fed.us, cnfmsup@dudek.com

Subject: A.12-10-009: SDG&E's Master Special Use Permit – Supplemental Scoping Comments

Dear Ms. Orsaba and Mr. Metz:

Thank you for the opportunity to participate in supplemental scoping on SDG&E's Master Special Use Permit (Project) under the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA). These comments are provided on behalf of The Protect Our Communities Foundation (POC).

I. Alternatives To Be Analyzed in the EIR/EIS

POC would like to see two additional alternatives analyzed in the EIR/EIS:

- Undergrounding of all 69 kV and 12 kV line segments. SDG&E generally describes the exclusive use of undergrounding as prohibitively expensive. However, the estimated cost to underground 69 kV transmission lines is $1.5 million per mile.[1] The approximate length of the MSUP 69 kV and 12 kV line segments is about 150 miles. Undergrounding the entire MSUP project would cost on the order of $1.5 million per mile × 150 miles = $225 million, or about one-half the estimated $418.5 million cost of the proposed MSUP project. Undergrounding the entire project is clearly cost-feasible relative to the cost of the proposed MSUP project.

- A no-wires alternative using microgrids in town centers such as Boulevard and off-grid systems for more remote customers to eliminate the need for the 69 kV and 12 kV line segments included in the MSUP project. POC estimates that there are no more than 4,000 to 5,000 meters/customers along the 69 kV and 12 kV line segments included in the MSUP project interconnected with substations that are south of the Santa Ysabel

[1] Power Grid International, *Underground vs. Overhead: Power Line Installation-Cost Comparison and Mitigation*, February 1, 2013. See: http://www.elp.com/articles/powergrid_international/print/volume-18/issue-2/features/underground-vs-overhead-power-line-installation-cost-comparison-.html.

substation and exclusively dependent on 69 kV lines included in the MSUP project. These substations are Descanso, Barrett, Cameron, Glencliff, Crestwood, and Boulevard. Assuming the average customer requires a 5 kW off-grid system and the cost of a typical 5 kW off-grid system is up to $50,000 (without adjusting for tax credits),[2] the total cost of a "no-wires" alternative to serve 4,000 to 5,000 meters would be in the range of $200 to 250 million. SDG&E has a successful microgrid pilot project underway at Borrego Springs.[3] The no-wires alternative is technically feasible, economically competitive with the proposed MSUP project, and would definitively eliminate the fire hazard the MSUP project is intended to address.

Clarification to like-for-like pole size replacement alternative: POC would also like to clarify the description of the like-for-like pole size replacement alternative that POC requested in its November 7, 2013 comment letter on the EIR/EIS scoping memo. The clarification is that the like-for-like poles carry conductors of the same or similar capacity to the conductors that are on the existing wood poles. For example, the minimum conductor size recommended for a 69 kV line is a 3/0 ACSR conductor.[4] Yet SDG&E is proposing to use much higher capacity 636 kcmil ACSS conductors on the 69 kV lines. The like-for-like pole size replacement alternative should assume use of a 3/0 ACSR conductor or equivalent.

II. Fire and Reliability

Two sections of 69 kV lines within the scope of the proposed project, TL625B and TL629E, will be changed from single circuit to double circuit. This will double the amount of high voltage conductor on these two segments. The potential for increased fire hazard introduced by doubling the quantity of high voltage conductor in these 69 kV segments should be addressed in the EIR/EIS.

III. Cumulative Impacts: Proposed Project Interaction with SDG&E's 1995 SNCCP

SDG&E's 1995 SNCCP allows the company to install, maintain, use, and repair its natural gas and electric system without needing in most circumstances to apply for take authorization of 110 plant and wildlife species listed under the federal Endangered Species Act and California Endangered Species Act. The 1995 SNCCP limits SDG&E to 400 acres of impacts in natural areas before Plan Amendment must occur. When the 1995 SNCCP was created, SDG&E only anticipated having created 124 acres of grading impacts in natural areas as a result of "typical expansion and maintenance activities" by 2020.[5]

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[2] Mother Earth News, *What's the Average Cost to Install a Solar-Electric System to Power Your Home*?, May 21, 2009. See: http://www.motherearthnews.com/renewable-energy/solar-electric-system-cost-z10b0blon.aspx.
[3] UT San Diego, *Microgrid powers Borrego during emergency*, November 10, 2013. See: http://www.utsandiego.com/sponsored/2013/nov/10/sgde-repair-crews-storm/.
[4] USDA, *BULLETIN 1724E-200 Design Manual for High Voltage Transmission Lines*, May 2009, Table 9-1, p. 9-6.
[5] See page vi at San Diego Gas & Electric Company. 1995. Subregional National Community Conservation Plan. Available at http://www.cpuc.ca.gov/environment/info/dudek/CNF/SDGE%20Subregional%20NCCP%20(01-25-13S).pdf.

However, predicting the future is difficult, and SDG&E's 1995 SNCCP may have underestimated the company's "typical expansion and maintenance" activities between 1995 and 2020. For example, the 1995 SNCCP estimates 8 acres of grading disturbance from the construction of 4 new substations[6], 35 acres of grading disturbance from the construction of 7 new transmission lines requiring new rights of way and access road systems, 23 acres of grading disturbances from the construction of 10 new transmission lines on existing rights of way, 11 acres of grading disturbances from the reconductoring of 16 existing transmission lines, and approximately 20 acres of grading disturbances from 240 minor operational construction and maintenance repairs (pages 79-82).

As a result, SDG&E may have already exceeded or be close to exceeding the disturbance estimates upon which its 1995 SNCCP relies, given the large amount of new construction, replacement, reconductoring and other work the utility has done on its transmission facilities since 1995. For example, in 1995 SDG&E likely did not anticipate that it would be replacing many of its wooden power poles with steel and reconductoring those lines. However, in June 2013, a San Diego TV news station reported that SDG&E had already replaced 3,000 wooden poles with steel poles.[7]

At the same time, SDG&E's RPOD for this Project shows that there are many federally and state-listed threatened, endangered and special status wildlife and plant species known to occur along the Project's electric lines and that are Covered Species in SDG&E's 1995 SNCCP. Given the large number of Covered Species that may have habitat impacted by this project, the EIR/EIS should discuss 1) how many acres SDG&E has already used of its allotted 400 acres in natural areas throughout its entire system before Plan Amendment of the 1995 SNCCP is required and 2) how many acres of impacts in natural areas will occur from this project. Conservation Plan. The EIR/EIS should also discuss in general how this Project will interact with SDG&E's 1995 SNCCP.

IV. Impacts to Two Rare Butterfly Species are of Special Concern

According to SDG&E's Revised Plan of Development (RPOD), the Hermes Copper butterfly is believed to be present along TL 625, TL 626, and C69, and to have a high likelihood of occurrence along TL 629 and C157 (page 97).[8] Currently the butterfly is not listed under the

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[6] According to the 1995 SNCCP, "The typical substation is 4.5 acres in size" (page 80). However, the land disturbance for some of the substations SDG&E is now building is more than 15 times as large. SDG&E's Suncrest Substation, built for the Sunrise Powerlink project, permanently disturbed 75 acres; this includes the substation access road (See page 3 at letter from Billie Blanchard (CPUC) to Alan F. Colton (SDG&E), December 15, 2010, http://www.cpuc.ca.gov/environment/info/aspen/sunrise/ntps/ntp11_seg13_suncrest_wilson_121510.pdf.) The Final Environmental Impact Statement (FEIS) for the ECO Substation said its 500 kV and 230/138 kV yards would impact 85.9 acres (ES-8 Executive Summary for FEIS, East County Substation Project, Available at http://www.cpuc.ca.gov/environment/info/dudek/ECOSUB/Final_EIR/01.ExecutiveSummary.pdf .

[7] See KGTV. Clairemont woman voices health concerns about new steel power pole. June 9, 2013. Available at http://www.10news.com/about/10news-team/clairemont-woman-voices-health-concerns-about-new-steel-power-pole-06092013.

[8] San Diego Gas & Electric Company. 2013. Master Special Use Permit, Cleveland National Forest Orange and San Diego Counties, California Revised Plan of Development. Available at http://www.cpuc.ca.gov/environment/info/dudek/CNF/POD2/CNF%20Revised%20POD%20(04-19-13S).pdf.

federal Endangered Species Act (ESA), but in 2011 the U.S. Fish and Wildlife Service (USFWS) stated that listing was warranted, albeit precluded due to other, higher priorities for listing.[9] Given the time necessary to obtain Project approval and estimated five-year construction time for this Project, the status of the Hermes Copper could change and the species could become listed before or during Project construction. Therefore, POC recommends taking precautions for this species during construction as if it were ESA- listed. The EIR/EIS should discuss how the Hermes Copper will be protected during construction of this Protect and what will happen if the Hermes Copper becomes listed under the ESA before or during construction of this Project.

The Laguna Mountains Skipper is a federally listed endangered species with a high likelihood of occurrence along power line C440 (RPOD page 97).[10] Since Laguna Mountains Skipper is not a Covered Species in SDG&E's 1995 Subregional Natural Community Conservation Plan (SNCCP),[11] the EIR/EIS should describe how the Skipper will be protected during construction of this Project, the procedure for SDG&E to obtain take authorization should it become necessary, and how the public can participate in that take authorization process.

V. USFWS Protocol Surveys for ESA-Listed Species Should Be Kept Up To Date and the Public Should Have Access To Them

At a minimum, the 45-day protocol survey reports submitted to USFWS should be included as appendices with the Project's draft EIR/EIS so that the public can review them during the EIR/EIS comment period. Sometimes so-called protocol surveys fail to meet USFWS protocol standards and that knowledge can be important to informed public comment on a draft EIR/EIS. Since these are imperiled wildlife species being held in trust for the public, the results of the protocol surveys should be readily available to the public during the draft EIR/EIS comment period.

Thank you for your consideration of our supplemental EIR/EIS scoping comments.

Sincerely,

Bill Powers, P.E.
Board Member, The Protect Our Communities Foundation
bpowers@powersengineering.com

[9] See page 20918, Federal Register. Vol 26 No. 72. Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition To List Hermes Copper Butterfly as Endangered or Threatened. Available at http://www.gpo.gov/fdsys/pkg/FR-2011-04-14/pdf/2011-9028.pdf.

[10] San Diego Gas & Electric Company. 2013. Master Special Use Permit, Cleveland National Forest Orange and San Diego Counties, California Revised Plan of Development. Available at http://www.cpuc.ca.gov/environment/info/dudek/CNF/POD2/CNF%20Revised%20POD%20(04-19-13S).pdf.

[11] See San Diego Gas & Electric Company. 1995. Subregional National Community Conservation Plan. Available at http://www.cpuc.ca.gov/environment/info/dudek/CNF/SDGE%20Subregional%20NCCP%20(01-25-13S).pdf.

MOTHER EARTH NEWS

What's the Average Cost to Install a Solar-Electric System to Power Your Home?

http://www.motherearthnews.com/renewable-energy/solar-electric-system-cost-z10b0blon.aspx

By Linda Pinkham

What's the average cost to install a solar-electric system to power your home?

This question is one of the most frequently asked in the industry, and also the question that makes most solar installers very uneasy — not because they don't want to give you a forthright answer, but because the correct answer for any individual will depend on a number of variables that dramatically affect the price.

For example, is your home on-grid or off-grid? If it's off grid, you will need additional equipment such as a charge controller, monitors and storage batteries. Next you will need to figure out how much energy your home will use and how much storage (number of batteries) you will need. The size of your system and battery bank will depend on how much sun your location receives (solar insolation) and how many consecutive days overcast conditions may keep your system from producing energy. More than likely, you will want to add a backup engine-generator to your system rather than having to size your battery bank to meet the worst-case scenario. A generator will also help you maintain the health of your battery bank, safeguarding a large part of your investment.

Most off-grid homes need to be very energy-wise to keep costs for a solar energy system within bounds. Although if the utility grid is located more than one-half mile away, even a fairly large solar-electric system will cost less than having the utility bring in power. To keep system costs down, the quick rule here is that every dollar spent on saving energy, such as using low wattage, compact fluorescent light bulbs and installing energy saving appliances, will save $5 or more on solar generating equipment. Some types of appliances, such as clothes dryers, electric ranges and most air conditioning units are simply altogether impractical.

For an on-grid system, the key factor to understand is what your goals are. Are you looking for self-reliance during grid outages? If yes, your system will cost a little more for batteries and a charging system, sized according to how many days of autonomy you might need before grid energy is available again.

Or is your goal a zero-energy home — where your solar-electric system offsets all of your energy use on an annual basis? Or are you just interested in doing your part for the environment by producing as large a portion of your electricity as you can afford, or for which you have space that you can allot to energy generation? In any case, the starting point is to look at your utility bill and find out how many kilowatt-hours you use on average each day.

Many people mistakenly think that the size of their home is a major factor in determining the size of their solar-electric system. In fact, a home's size is mostly irrelevant. The size of your system and its costs will depend on how much electricity you use and where you live. For example, a 2 kW system in Minnesota will produce very different results than the same system located in Arizona. A home with an electric water heater and electric range will use more electricity than a home with a tankless water heater and gas stove.

The size of your system and its costs will depend on how much of your electrical usage you want to offset and also how good the solar resource is in your area. A number of tools to determine this information are available on the Web, but the best noncommercial site is the National Renewable Energy Laboratory's (NREL) PV Watts calculator.

Take a look at the generic examples in the accompanying table and you will see a huge variance in system costs. Getting a grasp on the difference between the sizes shown in the table is not very easy because of all the variables. What size system would you need? Sizing a system can and should be a very detailed process. For general purposes of establishing some "ballpark figures," most systems installed in the United States are in the range of 2 to 5 kW, with systems larger than 5 kW being exceptionally large, and systems below 2 kW being fairly modest. To put it into a more human perspective, consider my circa 1937, 3,000-square-foot farmhouse in the Pacific Northwest, which has a 2.1 kW system on a pole-mounted tracker in the backyard. Although we use an electric hot water heater and electric stove, all of the lighting and other appliances are energy efficient models, and we are obsessively energy conscious. Our annual electrical usage each year is a miserly 4,800 kilowatt-hours, of which 75 percent is produced by the solar-electric array.

The average cost across the country for a professionally installed system is about $8 to $9 per watt, with batteries adding an additional 20 to 30 percent to the cost. If you are a handy do-it-yourselfer, you can save around $2 per watt, but your system may be more difficult to certify for incentives.

The table does not include federal, state, and utility incentives and rebates that may be available to you, sometimes reducing the overall cost by as much as 50 percent. Another factor to consider is whether your state and utility have favorable net metering regulations — the rate and methods by which your electric utility purchases your excess electricity production and credits your utility bill. Some places have wildly favorable incentives, while a few locations are much less enthusiastic about embracing renewable energy.

Currently the best federal residential solar incentives ever in existence (30 percent) are available for home energy systems, so there's not likely a better time than the present to think about installing renewable energy on your home. If you consider your investment as purchasing all or part of your electricity in advance for the next 25 years or more, the upfront costs can make excellent financial sense, especially if you believe that the cost of electricity will continue to rise during that same period.

Average Costs of a Home Solar-Electric System*

System Type	**2 kW (small/average)**	**5 kW (average/big)**	**10 kW (gigantic)**
Off-grid	$20,800	$52,000	$104,000
Grid-intertied	$16,000	$40,000	$80,000
On-grid with battery backup	$19,200	$48,000	$96,000

*Professional installation costs before incentives

— Linda Pinkham, former managing editor of Home Power magazine

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Photo by istockphoto/Markus Gunn

PUBLIC UTILITIES COMMISSION
505 VAN NESS AVENUE
SAN FRANCISCO, CA 94102-3298

December 15, 2010

Mr. Alan F. Colton
Manager – Environmental Services
Sunrise Powerlink Transmission Project
8315 Century Park Court, CP21G
San Diego, CA 92123-1550

RE: SDG&E Sunrise Powerlink Transmission Line Project - Notice to Proceed (NTP # 11)

Dear Mr. Colton,

On October 20, 2010 San Diego Gas and Electric (SDG&E) requested authorization from the California Public Utilities Commission (CPUC) to commence with construction of Link 3, Suncrest Substation and the Wilson Construction Yard, Segment 13 of the Sunrise Powerlink Project.

The SDG&E Sunrise Powerlink Transmission Line Project was evaluated in accordance with the National Environmental Policy Act and California Environmental Quality Act. The mitigation measures and applicant-proposed measures (APMs) described in the Final Environmental Impact Report/Statement were adopted by the CPUC and BLM as conditions of project approvals. The CPUC also adopted a Mitigation, Monitoring, Compliance and Reporting Program (MMCRP) to ensure compliance with all mitigation measures imposed on the Sunrise Powerlink Project during implementation. The CPUC voted on December 18, 2008 to approve the Final Environmentally Superior Southern Route (Decision D.08-12-058) and a Notice of Determination was submitted to the State Clearinghouse (SCH#2006091071). The BLM issued a Record of Decision approving the same route on January 20, 2009. The Project also crosses lands under jurisdiction of the U.S. Department of Agriculture; and Forest Service on the Cleveland National Forest; the Forest Service issued its Record of Decision and Supplemental Information report on July 9, 2010. The area requested under this NTP does not fall under Forest Service jurisdiction.

The Sunrise Powerlink Project will be constructed in 26 segments, as defined on the CPUC's project website (http://www.cpuc.ca.gov/Environment/info/aspen/sunrise/sunrise.htm). It is anticipated that, even within the 26 project segments, SDG&E will submit multiple separate requests for Notice to Proceed (NTPs) during the construction process. This is a typical process for transmission line projects. Given that the Sunrise Powerlink Project has been approved by the CPUC and BLM, as described above, this segmented construction review process allows SDG&E to proceed with individual project components where compliance with all applicable mitigation measures and conditions can be documented.

This letter and the attached Compliance Status Table document the CPUC's thorough evaluation of all activities covered in this NTP. The evaluation process ensures that all mitigation measures and Biological Opinion conditions applicable to the location and activities covered in the NTP are implemented, as required in the CPUC's Decision and in BLM's Record of Decision.

NTP # 11 for Link 3, which includes the Suncrest Substation, Wilson Construction Yard, and associated access road, is granted by CPUC for the proposed activities based on the factors described below.

SDG&E NTP Request. Excerpts from the October 20, 2010 SDG&E NTP request and updates are presented below with CPUC clarifications based on discussions and/or correspondence with SDG&E inserted **(in parenthesis and in bold)**:

SDG&E is formally requesting authorization from the CPUC to begin construction of Link 3, which includes the Suncrest Substation, Wilson Construction Yard, and associated access road (Bell Bluff Truck Trail [BBTT]). The substation site and yard are located south of BBTT approximately 2.8 miles west of Japatul Valley Road, southwest of the U.S. Interstate 8 and Japatul Valley Road intersection, and east of the City of Alpine, California in San Diego County. The substation, yard, and access road are located entirely on private land.

The Suncrest Substation is contiguous to the Project right-of-way (ROW) and is needed to accommodate the termination of one 500 kilovolt (kV) and two 230 kV overhead transmission lines. In addition to the terminals, transformer banks, capacitor banks, switches, and relays required for termination of the transmission lines, a diesel-powered emergency generator, fire prevention system, one single-story relay/control shelter, a single-story maintenance shelter, and an oil containment system would be installed as part of construction. Construction of the overhead lines into the Suncrest Substation and wire-stringing activities are not included in this request; these activities will be included during overhead construction on Links 2 and 5.

Grading and Disturbance Areas – As described in the Project Modification Report, grading and ground disturbance at the Suncrest Substation site has been reduced to minimize impacts and to accommodate requests of two adjacent landowners. The total permanent footprint has been reduced to 75.07 acres for construction of the substation and BBTT improvements, but the total temporary disturbance area has increased to 32.54 acres in order to construct the substation pad, perform BBTT improvements, and use of the Wilson Construction Yard. These impacts are described in detail on pages 4-111 through 4-114 of the Project Modification Report.

Wilson Construction Yard and Field Offices – Development of the Suncrest Substation includes use of the existing 10.78 acre Wilson Construction Yard, located approximately three-quarters of a mile to the east of the substation along BBTT. A 2.2 acre portion of the Wilson Construction Yard will be used to facilitate construction of the Suncrest Substation; with the remaining 8.58 acres used for material staging and storage associated with construction of the overhead transmission line. In addition, field offices and parking areas have been designated along BBTT as shown in the Project Modification Report Map Book (MS-106 and 107). (Helicopter transport will be utilized at the Wilson Yard.)

Construction Water Source (please note that the following water source information is being analyzed and permitted separately.) – Beta Engineering (Beta) is currently working with the California Department of Fish and Game (CDFG) and the State Water Resources Control Board (SWRCB) to use two existing ponds located on the Wilson Property, a privately owned property adjacent to the BBTT, as a source of water and for storage of potable water. The Wilson ponds are manmade, earthen stock ponds fed by rainfall and surface runoff. The project involves transporting potable water by tanker trucks from local municipal sources to supplement the water naturally in the ponds, as well as installing a system of temporary aboveground pipes and pumps to transport the water from the ponds to the BBTT.

Beta has informed SDG&E that they submitted an Application to Appropriate Water for Temporary Use to the SWRCB and a 1600 Notification of Lake or Streambed Alteration Application to the CDFG. If water becomes available from the ponds prior to or during construction of the substation, SDG&E would obtain water from a source-point at the BBTT and either truck the water to the substation or install a below ground pipe within the access road to transport the water.

Access Road Improvements – Improvements to approximately 2.6 miles of BBTT include widening the existing roadbed from 15 feet to 30 feet and upgrading the surface to pavement (asphalt) to provide a permanent access road to the substation. Some sections of BBTT will be relocated to minimize impacts to oak trees and to address access to adjacent properties (see PMR 29). The existing crossing of Peterson Creek will be improved to accommodate construction equipment deliveries.

Bell Bluff Truck Trail modification plans have been submitted to the County of San Diego for consultation and review; however, no permit is required. During construction, an electrical permit will be obtained from San Diego County for temporary power during construction. No activities associated with temporary power at the construction site will occur until this permit has been obtained.

Resource Agency Permitting– Revised 401, 404 and 1602 permit applications were submitted for review and approval on March 30, 2010. SDG&E received the signed 401 Water Quality Certification on November 15, 2010. The California Department of Fish and Game issued a Streambed Alteration Agreement (SAA) on November 17, 2010 (the Final SAA was issued by CDFG on November 29, 2010.). Impacts to streambeds will not occur until SDG&E receives the remaining ACOE 404 permit.

To the extent feasible, structures were not designed to be located within streambeds and drainage features. Construction areas are shown in the Project Modification Report Map Book which was submitted to the CPUC on May 14, 2010 and approved by the CPUC and BLM in the Determination Memorandum on September 22, 2010. Construction activities at the Suncrest Substation will include construction of a box culvert at the Bell Bluff Truck Trail and Peterson Creek crossing.

A project specific Fire Prevention and Response Plan (FPRP) was acknowledged* by CAL Fire Chief (the plan has been CPUC approved). A project Fire Marshall has been hired onto the project and is assigned to enforce the FPRP. (*In regard to the FPRP the Cal Fire Chief provided "The signatory reviewing officials are acknowledging that SDG&E has a Construction Fire Prevention Plan that is appropriate and necessary to mitigate fire hazard and risk for the SRPL construction and maintenance activities. They do not accept any responsibility for SDG&E interpretation or implementation of this Plan during the construction and maintenance of the SRPL or for any resulting actions associated with these activities.")

CPUC Evaluation of Mitigation Implementation

All applicable project mitigation measures, APMs, compliance plans, and permit conditions shall be implemented. Some measures have on-going/time-sensitive requirements and are required to be implemented prior to and during construction where applicable. For biological and cultural resources, those additional conditions are defined in this section.

Please see also the attached Compliance Status Table documenting pre-construction requirements identified in the Final EIR/EIS. Note that entries shaded in yellow are outstanding and must be completed prior to the start of construction. Entries shaded in purple are to be conducted during construction. Entries shaded in green have been fulfilled. Entries that have not been shaded are not applicable to this Link.

Following the discussion of biological, cultural, and paleontological resources, a list of bulleted conditions is presented to define additional information and clarifications regarding outstanding requirements. In some cases, these items exceed the requirements of the Mitigation Measures and Applicant Proposed Measures, and are based on specific site conditions and/or are proposed conditions by SDG&E. In these cases, the conditions will not also appear in the Compliance Status Table.

Biological Resources

This section presents background on biological resources that occur at or near the site. This summary of biological issues was provided by SDG&E in the NTP request.

On-the-ground protocol surveys have been conducted for sensitive plant and animal species in Link 3. SDG&E has submitted survey reports for the 2009 survey season. All 2010 surveys are complete and SDG&E is in the process of providing 2010 survey reports. The 2010 Riparian Bird Survey Report was submitted to the agencies on October 28, 2010 and the 2010 Quino Checkerspot Butterfly Survey was submitted to the agencies on December 3, 2010. The following reports will be submitted as soon as they are complete; the 2010 Arroyo Toad Survey, the 2010 Coastal California Gnatcatcher Survey, and the

2010 Rare Plant Survey. As described in G-CM-32 of the revised Biological Opinion dated November 10, 2010, the Wildlife Agencies state that surveys for federally listed species have been completed.

CPUC Review. The CPUC biological consultant conducted reviews of the initial NTP request and follow-up materials for completeness and compliance with Project mitigation requirements. In 2009, protocol surveys for rare plants and Quino checkerspot butterfly were completed and habitat assessments for coastal California gnatcatcher and arroyo toad were conducted. Protocol surveys for coastal California gnatcatcher were not conducted on the substation site because no suitable habitat was present. Protocol surveys for arroyo toads were not conducted because surface water was not present in 2009; however, the 2009 survey report stated "Survey recommended when water is present." No Quino checkerspot butterfly were documented on the substation site in 2009 or in 2010. Survey results were accepted by the U.S. Fish and Wildlife Service as described in the Reinitiated Biological Opinion issued on November 10, 2010.

Four non-listed, sensitive plant species were documented on the substation site in 2009 (*Chorizanthe leptotheca*, *Monardella hypoleuca* spp. *lanata*, *Quercus engelmannii*, and *Xanthisma juncea*). SDG&E has submitted a Restoration Plan for Special Status Plants (dated November 29, 2010), which addresses the restoration details for the project's impacts on *Monardella hypoleuca* spp. *lanata* (the other 3 species would either not be impacted or are low sensitivity that do not need to be addressed by the plan). The CPUC biological consultant is currently reviewing the Restoration Plan for Special Status Plants.

Cultural Resources

The Final Inventory Report of the Cultural Resources was accepted on June 2, 2010 by BLM and CPUC. Two cultural resources sites (CA-SDI-19036 and CA-SDI-19779) were identified within the Suncrest Substation boundaries. These sites have been tested and evaluated, and a report of findings will be submitted to the agencies. While the sites have been recommended as ineligible for inclusion in the National Register of Historic Places (NRHP), the BLM must formally make this determination and the State Historic Preservation Officer (SHPO) must concur with this determination of eligibility before construction work within the Suncrest Substation site can begin. However, no cultural resources are located within the associated access road (Bell Bluff Truck Trail) or the Wilson Construction Yard. Therefore, work can proceed on those elements of Link 3.

Paleontological Resources

Based on the Final Paleontological Monitoring and Discovery Treatment Plan, accepted on June 17, 2010, there is no potential to encounter paleontological resources within Link 3.

Conditions of NTP Approval

The conditions presented below shall be met by SDG&E and its contractors:

1. All applicable project mitigation measures, APMs, compliance plans, and permit conditions shall be implemented. Some measures have on-going/time-sensitive requirements and shall be implemented prior to and during construction where applicable. Please see the attached table of pre-construction mitigation measure requirements. Note that entries shaded in yellow are outstanding and shall be completed prior to the start of construction. Purple entries shall be conducted during construction. Green entries have been fulfilled. Entries that are not shaded are

not applicable to this Link. Bulleted items can be found below which provide additional information and clarifications to outstanding requirements.

2. Copies of all relevant permits, compliance plans, and this Notice to Proceed shall be available on site for the duration of construction activities.
3. Use of the two existing ponds on the Wilson property as a water source shall not commence until SWRCB and CDFG authorizations are provided to the CPUC.
4. No work shall occur within Army Corp of Engineers (USACOE) jurisdiction until the USACOE Section 404 Nationwide Permit 12 is obtained, in accordance with MM B-2a and WQ-APM-15.
5. CPUC is currently reviewing the Restoration Plan for Special Status Plants. No removal of special status plants shall occur until the subject plan is approved by CPUC. Per SDG&E, the felt-leaved mondarella populations along the Bell Bluff Trail will be fenced immediately prior to construction. In addition as provided in the Restoration Plan for Sensitive Plant Species, impacts to approximately 55 plants will be mitigated through conservation of 857 plants at the Lightner mitigation site. The HAP/HMP provides for the permanent preservation and management of the Lightner site.
6. In compliance with Mitigation Measure B-3a, the Weed Control Plan shall be implemented immediately prior to, during and post construction as appropriate for the weed species being treated at the sites being covered by NTP #11.
7. In compliance with Mitigation Measure B-8a, pre-construction surveys for nesting birds within 100 feet of the construction zone within 10 calendar days prior to the initiation of construction shall occur between January 15 and August 15. In addition, nesting surveys for listed species including raptors shall be conducted within 500 feet of the construction zone within 10 days prior to the initiation of construction shall occur between January 1 and September 15.
8. “Survey sweeps” shall occur immediately preceding and during active construction as part of required biological monitoring activities. If active nests are found, a biological monitor shall establish an appropriate buffer around the nest and no activities will be allowed within the buffer until the young have fledged from the nest or the nest fails. The biological monitor shall conduct regular monitoring of the nest to determine success/failure and to ensure that project activities are not conducted within the buffer until the nesting cycle is complete or the nest fails. The biological monitor shall be responsible for documenting the results of the surveys and the ongoing monitoring. The buffer may be adjusted with the approval of CDFG and USFWS, and with prior knowledge of the CPUC.
9. Per the mitigation measures (B-01a, LU-APM-6), limits of construction and environmentally sensitive areas shall be delineated with orange construction fencing or flagging prior to the start of construction to alert construction personnel that those areas should be avoided.
10. All construction areas and access roads identified in the NTP request submitted by SDG&E shall be flagged prior to construction. Flagging of construction areas and access roads shall be field verified by the CPUC EM prior to site use.
11. No work or other construction related activities shall occur outside of approved work areas.
12. Wildlife found to be trapped shall be removed by a qualified biological Monitor. If the biological resource monitor is not qualified to remove entrapped wildlife, a recognized wildlife rescue agency (such as Project Wildlife) will be contacted to remove the wildlife and transport it safely to other suitable habitats.

13. There shall be no earth disturbance allowed within the foot print of the Suncrest Substation until the evaluation report is finalized by the BLM in consultation with the CA SHPO.
14. Work on the Bell Bluff Truck Trail and the Wilson Construction Yard will be allowed after the installation and inspection of identified ESAs by the CPUC EM. These ESAs will be inspected and maintained over the duration of work.
15. Verification that BLM has approved the proposed archeological monitor résumés shall be submitted to the CPUC prior to any work requiring archaeological monitoring at the site.
16. If unanticipated biological, cultural or paleontological resources are detected, the CPUC EM shall be notified immediately.
17. As determined by the Traffic Study approved by San Diego County on September 29, 2010 (Permit No. 0910-77), neither detours nor lane closures along public transportation routes to the Substation are anticipated. However, if during construction, detours and or temporary lane closures are necessary, SDG&E shall obtain required permits from the County of San Diego and CALTRANS.
18. As determined by the Traffic Study approved by San Diego County on September 29, 2010, it is not anticipated that construction activities will restrict movements of emergency service providers. However, if necessary, during construction SDG&E shall coordinate with emergency service providers prior to initiation of construction activities that would restrict movements of emergency vehicles.
19. Bell Bluff Truck Trail modification plans have been submitted to the County of San Diego for consultation and review; however, no permit is required. During construction, an electrical permit will be obtained from San Diego County for temporary power during construction. No activities associated with temporary power at the construction site shall occur until this permit has been obtained.
20. Per SDG&E, Hazardous Material Business Plan (HMBP) and Spill Prevention Countermeasure and Control (SPCC) Plans will be developed during construction. The HMBP and SPCC plans shall be submitted to the CPUC and implemented (i. e., installation of secondary containment, construction of drainage basins etc.) prior to transformer oils or any other materials as covered by the plans are brought on-site.
21. In compliance with Mitigation Measure H-1a, a Grading and Drainage Plan was prepared and submitted to the CPUC. Prior to construction at the substation site, verification of RWQCB receipt and approval of the Grading and Drainage Plan shall be provided to the CPUC.
22. An NPDES storm water discharge permit for construction activities has been obtained. A SWPPP applicable to the Link 3 construction has been submitted to the CPUC. The SWPPP shall be implemented where appropriate prior to and during construction.
23. If blasting is required, a site-specific blasting plan shall be submitted to the CPUC prior to blasting.
24. All crew members shall be Safe Worker and Environmental Awareness Program (SWEAP) trained prior to working on the project. A log shall be maintained on-site with the names of all crew personnel trained. For any crew members with limited English, a translator shall be on-site to ensure understanding of the training program. In place of a translator, the SWEAP training brochure can be provided in Spanish or other languages as appropriate. All participants will receive a hard-hat sticker for ease of compliance verification.

25. As provided in the NTP request, construction work will be conducted between the hours of 7:00 a.m. to 7:00 p.m. In the event that work needs to take place outside of these hours a variance will be obtained and submitted to the CPUC. SDG&E shall comply with local noise rules, standards, and/or ordinances by implementing the noise-suppression techniques and variance standards as outlined in Mitigation Measure N-1a.

26. As proposed, the SDG&E Environmental Monitoring Program will be implemented during construction which will include implementation of the applicable environmental plans (as defined in HS-APM-1, HS-APM-2, HS-APM 3, HS-APM-8 and HS-APM-10). SDG&E has designated an Environmental Field Representative for Link 3 construction. The Representative will be on site to observe and document adherence to the applicable environmental plans.

27. In regard to the Hazard Communication Plan, to fully satisfy the intent of Mitigation Measure P-1a, documentation of training for personnel who would be working near or handling hazardous materials shall be submitted to the CPUC for review after completion of these training activities.

28. If construction debris or spills enter into environmentally sensitive areas, appropriate jurisdictional agencies and the CPUC Environmental Monitor shall be notified immediately.

29. No movement or staging of construction vehicles or equipment shall be allowed outside of the approved areas. If additional temporary workspace areas or access routes or changes in technique and mitigation implementation to a lesser level are required, a Variance Request shall be submitted for CPUC review.

30. If the application of water is needed to abate dust in construction areas and on dirt roads, SDG&E shall use the least amount needed to meet safety and air quality standards and prevent the formation of puddles, which could attract wildlife to construction sites (as requested by USFWS). Conditions of the Dust Control Plan shall be implemented and enforced throughout Link 3 construction activities.

31. All temporary facilities (i.e., portable toilets, fencing, etc.) shall be removed from the construction disturbance area at the completion of construction.

32. All complaints received by SDG&E in regard to Link 3 shall be logged and reported immediately to the CPUC. This includes complaints relevant to lighting, noise and dust, etc. Complaints should also be forwarded immediately to San Diego County. If complaints cannot be resolved, activities may need to be modified depending on the nature of the complaint.

33. When significant precipitation events are anticipated, or have occurred, access on project roads may be suspended in order to maintain the integrity of access roads and provide for personnel safety. Access will be suspended for 24 hours following a rain event in order to allow for a dry out period. The parameters for suspending access include, but are not limited to:

    a. Rutting occurring in excess of 2 inches over a distance of 50 feet

    b. Rutting and/or soil mixing occurring on 10% of the road

    c. Rills more than 10 feet in length develop

    d. Significant soil compaction

    e. Significant soil adhesion to vehicles and construction equipment

Please contact me if you have any questions or concerns.

Sincerely,

Billie Blanchard

Billie Blanchard
CPUC Environmental Project Manager
Sunrise Powerlink Transmission Project

cc: Mary Jo Borak, CPUC CEQA Unit
Nicholas Sher, CPUC Legal Division
Daniel Steward, BLM El Centro Field Office
Tom Zale, BLM El Centro Field Office
Susan Lee, Aspen Environmental Group
Vida Strong, Aspen Environmental Group
Anne Coronado, Aspen Environmental Group
Don Haines, San Diego Gas and Electric Company
Tina Carter, San Diego Gas and Electric Company
Robert Hawkins, U.S. Forest Service
Michael Bennett, BLM Palm Spring South Coast Field Office
Cliff Harvey, State Water Resources Control Board
Eric Porter, USFWS
Doreen Stadtlander, USFWS
Paul Schlitt, CDFG
Heather Pert, CDFG
Kelly Fisher, CDFG
Erin Wilson, CDFG

Attachment A: Preconstruction Status Report

Wednesday, December 08, 2010
12:15:00 PM

Report Criteria:

AGENCY: CPUC

LOCATION: Link 3

TIMING: Design; During; During and Post; Pre; Pre and During; Pre and Post; Pre, During, and Post

-To Be Implemented During Construction

-Pending OR To Be Implemented Immediately Prior to Construction

-Complete

-Not Applicable

Note: This table contains U.S. Fish and Wildlife Service Conservation Measures in addition to the mitigation measures and applicant proposed mitigation measures from the Final EIS/EIR. The conservation measures are denoted in the table as G-CM-# or SS-G-#.

The mitigation measure and APM numbers listed in this table reference the actual measures in the MMCRP. The text after the measure number provides a summary of specific tasks within each measure, but is not intended to provide the entire language contained within the MMCRP. Please note that several measures include multiple entries in this table. These multiple entries break out the various requirements or tasks contained within that measure. Please reference the MMCRP for the actual requirements for each measure or visit www.cpuc.ca.gov/Environment/info/aspen/sunrise.

Mitigation Measure and APM	Status
B-01a: Locate surface disturbing components in previously disturbed areas	The preconstruction portion of this measure is complete. Sensitive resources were mapped using GIS and project structures and work areas were designed to avoid these resources, to the extent possible. The Project Modification Report Mapbook submitted on May 14, 2010 and approved on September 22, 2010, shows both sensitive resources and the location of areas that may be disturbed. During construction, vegetation and soil impacts will be minimized.
B-01a: Use construction mats to minimize disturbance	This mitigation measure will be fulfilled during construction.
B-01a: Double mitigation ratios on lands already in mitigation	The Suncrest Substation lands are SDG&E owned and are not in use as mitigation for other projects; therefore, this portion of the mitigation measure is not applicable.
B-01a: Delineate all limits of construction	The limits of construction will be delineated with orange construction fencing or flagging prior to the start of construction.
B-01a: Coordinate gate installation 60 days prior to construction	Construction of the substation will occur on privately held property. SDG&E has consulted with private property owners regarding gate installation and will be relocating one gate on Bell Bluff Truck Trail in accordance with the property owner's request. SDG&E consulted with the County of San Diego on August 25, 2010 regarding the County owned portion of Bell Bluff Truck Trail; no requests for additional gates were made. A copy of the meeting minutes with the County of San Diego was submitted to the CPUC on October 1, 2010.
B-01a: Submit documentation of coordination with the administering agency of the road/trail 30 days prior to construction	A copy of the meeting minutes from the meeting with the County of San Diego regarding installation of gates on Bell Bluff Truck Trail was submitted on October 1, 2010.
B-01a: Post signs on access road gates prohibiting unauthorized users	Signs prohibiting unauthorized use of the Bell Bluff Truck Trail will be posted on the installed gates during construction.
B-01a: Provide funding for off-road vehicle patrols	This mitigation measure is not applicable to Link 3. New off-road access is not a concern for the portion of Bell Bluff Truck Trail owned by the County of San Diego. SDG&E met with the County of San Diego on August 25, 2010 and meeting minutes summarizing the discussions were submitted to CPUC on October 1, 2010.
B-01a: Mitigate for impacts by unauthorized activity (e.g., exceeding approved construction footprints)	This mitigation measure will be fulfilled during construction. The mitigation ratios for unauthorized impacts have been eliminated as described in the reinitiated Biological Opinion, dated November 10, 2010, G-CM-6.
B-01a: Submit a Habitat Restoration Plan	SDG&E submitted a Restoration Plan for Sensitive Vegetation Communities in Temporary Impact Areas for review and approval to the CPUC, BLM, USFS and wildlife agencies that addresses restoration of temporarily impacted areas on September 24, 2010 and a revised plan incorporating comments was resubmitted on October 25, 2010. This plan was approved by the CPUC on November 3, 2010 and by the Wildlife Agencies in the revised Biological Opinion dated November 10, 2010 (see G-CM-16 of the BO).

Location: Link 3

Mitigation Measure and APM	Status
B-01a: Mitigate for impacted habitat	In coordination with the appropriate agencies, off-site purchase and dedication of habitat will be provided for areas where habitat restoration cannot meet mitigation requirements as outlined in this measure. This will be determined during and post construction during restoration activities.
B-01a: Mitigate for the loss of native trees and tree trimming	The Wildlife Agencies have agreed that conservation of woodland areas on mitigation lands included in the Habitat Acquisition Plan/Habitat Management Plan is acceptable mitigation for impacts to native trees. This plan was approved by the Wildlife Agencies on November 10, 2010 as stated in the revised Biological Opinion.
B-01a: Submit a Habitat Acquisition Plan 120 days prior to construction	The Habitat Acquisition Plan was submitted for review and approval on February 4, 2010. The HAP was further refined and provided to the CPUC on September 22, 2010. The plan includes the requirements as outlined in this mitigation measure. The HAP/HMP was approved by the Wildlife Agencies as stated in the reinitiated Biological Opinion dated November 10, 2010.
B-01a: Submit a Habitat Management Plan	The Habitat Management Plan was submitted for review and approval on Septmeber 22, 2010. The plan includes the requirements as outlined in this mitigation measure. The HAP/HMP was approved by the Wildlife Agencies as stated in the reinitiated Biological Opinion dated November 10, 2010.
B-01a: Include legal descriptions of all legal parcels	The HMP, prepared by a qualified biologist, was submitted to the CPUC, BLM, Wildlife Agencies, and USDA Forest Service on September 22, 2010 for review and approval. All the components in this mitigation measure have been included in the HMP. This plan was approved by the Wildlife Agencies as stated in the revised Biological Opinion dated November 10, 2010.
B-01c: Provide biological monitoring and perform periodic inspections once or twice a week	A qualified biological monitor with the authority to issue stop work orders will be on-site during construction activities and weekly monitoring reports will be prepared. This mitigation measure will be fulfilled during construction.
B-01c: Send weekly monitoring reports	A qualified biological monitor with the authority to issue stop work orders will be on-site during construction activities and weekly monitoring reports will be prepared. This mitigation measure will be fulfilled during construction.
B-01c: Qualified biologists shall handle all environmental issues and have the authority to issue stop work orders	A qualified biological monitor with the authority to issue stop work orders will be on-site during construction activities and weekly monitoring reports will be prepared. This mitigation measure will be fulfilled during construction.
B-01k: Re-seed all public and private natural areas burned due to project-caused fire	This mitigation measure will be fulfilled during and post construction, as needed.
B-01k: Develop re-seeding plan	This mitigation measure will be fulfilled during and post construction, as needed.
B-02a: Avoid impacts to jurisdictional areas	Impacts to jurisdictional features were considered during the design of the project and have been avoided, to the extent feasible. The location of each jurisdictional drainage and potential impact was described in the Preliminary Jurisdictional Determination report that was approved by the Army Corps of Engineers.
B-02a: Mitigate impacted areas as required by wetland permitting	Where avoidance of jurisdictional areas is not feasible, SDG&E shall provide the necessary mitigation required as part of wetland permitting as outlined in this measure. SDG&E submitted a Habitat Mitigation and Monitoring Plan (HMMP) on July 14, 2010 and a revision to the HMMP on October 7, 2010. The HMMP has been accepted by the ACOE, CDFG and SWRCB in concept; however the agencies have asked that the report be reformatted to break out each mitigation property separately.
B-02a: Prepare jurisdictional delineation and impact assessment	The project area was surveyed and impacts to resources under the jurisdiction of the ACOE, Regional Water Boards, State Water Board, and CDFG were determined. A revised Preliminary Jurisdictional Determination was submitted on February 24, 2010 and accepted as part of the 404 permit application on August 27, 2010. Grading Plans for Suncrest Substation were submitted on March 24, 2010 and June 22, 2010.
B-02a: Mitigate for jurisdictional wetland habitat	Where avoidance of jurisdictional areas is not feasible, SDG&E shall provide the necessary mitigation required as part of wetland permitting as outlined in this measure. SDG&E submitted a HMMP on July 14, 2010 and a revision to the HMMP on October 7, 2010. The HMMP has been accepted by the ACOE, CDFG and SWRCB in concept; however, the agencies have asked that the report be reformatted to break out each mitigation property separately. The 401 Water Quality Certification was issued on November 15, 2010. The CDFG issued a Streambed Alteration Agreement on November 17, 2010. SDG&E will not impact jurisdictional areas prior to approval of the final HMMP and issuance of the 404 permit.

Location: Link 3

Mitigation Measure and APM	Status
B-02a: Obtain wetland permits prior to construction	Revisions to the 401 and 404 permit applications were submitted to the SWRCB and ACOE on August 18, 2010. Revisions to the 1600 permit were submitted to CDFG and a verbal agreement was reached on August 30, 2010. SDG&E will not impact jurisdictional areas prior to issuance of the 401, 404 and 1600 permits.
B-02a: Delineate all limits of construction	The Project Modification Report and Mapbook submitted to the CPUC on May 14, 2010 and approved by the BLM and the CPUC through a Determination Memorandum on September 22, 2010, illustrates the limits of construction. Limits of construction will be delineated immediately prior to construction with orange construction fencing, flagging or silt fencing.
B-02a: Install gates and signs at entrances of access roads	SDG&E will relocate one gate on Bell Bluff Truck Trail in accordance with the property owner's request. No other gates will be installed on the access road to the substation. This mitigation measure will be fulfilled during construction. (see B-01a Task 7)
B-02a: Mitigate impacts from unauthorized activity	This mitigation measure will be fulfilled during construction.
B-02a: Submit and implement Wetland Mitigation Plan	SDG&E prepared and submitted an HMMP on July 14, 2010 as outlined in this mitigation measure. This plan was revised and provided to the agencies on October 7, 2010. The HMMP has been accepted by the ACOE, CDFG, and SWRCB in concept; the agencies have asked that the plan be reformatted to break out each mitigation property separately. This plan was prepared by WRA, a qualified habitat restoration specialist. This plan will be implemented by a qualified habitat restoration specialist.
B-02a: Submit a Habitat Management Plan that includes jurisdictional areas	SDG&E submitted a HMMP on July 14, 2010 and a revised HMMP on October 7, 2010 that describes preservation and management of all acquired, offsite mitigation parcels as outlined in this mitigation measure. The ACOE, CDFG and SWRCB have approved the HMMP in concept, but have requested that each mitigation property be broken out separately in the report. This plan will be implemented during construction.
B-03a: Submit and implement a Weed Control Plan	A Final Weed Control Plan was approved by the BLM and CPUC on September 8, 2010. Additional comments from the USFWS, City of San Diego and USFS were incorporated into a final plan that was submitted to all agencies on November 10, 2010. The Weed Control Plan has been approved by the Wildlife Agencies as stated in the revised Biological Opinion dated November 10, 2010 (G-CM-20).
B-03a: Conduct pre-construction weed inventory	A Final Weed Control Plan was approved by the BLM and CPUC on September 8, 2010. Additional comments from the USFWS, City of San Diego and USFS were incorporated into a final plan that was submitted to all agencies on November 10, 2010. The Weed Control Plan has been approved by the Wildlife Agencies as stated in the revised Biological Opinion dated November 10, 2010 (G-CM-20).
B-03a: Implement weed control treatments	The Weed Control Plan will be implemented immediately prior to, during and following construction as appropriate for the weed species being treated.
B-03a: Annually survey for new invasive weeds for 2 years	The Weed Control Plan addresses surveying for invasive exotic species during construction and annually following construction to monitor previously-identified and treated populations and to identify new invasive weed populations for the life of the Project. Treatment of weeds will occur on a minimum annual basis unless otherwise approved by the PCA, San Diego County Agricultural Commissioner, and Cal-IPC. This mitigation measure will be fulfilled during/post construction.
B-03a: Ensure all seeds and other material are certified weed free	This mitigation measure will be fulfilled during/post construction.
B-03a: Wash vehicles and equipment	During project construction, project vehicles and equipment will be washed as required by the approved Weed Control Plan. This mitigation measure will be fulfilled during/post construction.
B-03a: Submit monthly wash logs during construction and annual logs during operation/maintenance	During project construction, project vehicles and equipment will be washed as required by the approved Weed Control Plan. This mitigation measure will be fulfilled during/post construction.
B-05a: Conduct surveys in the spring and submit a special status plant report	Rare Plant Surveys were completed by qualified biologists in 2009 and 2010. The 2009 survey report was submitted to the CPUC for review, as outlined in this measure, on November 9, 2009. The 2010 rare plant surveys are complete. The 2010 surveys included all project areas as described in the Project Modification Report submitted to the CPUC on May 14, 2010 and approved by the CPUC and BLM through a Determination Memorandum dated September 22, 2010. The Wildlife Agencies approved SDG&E's surveys for federally listed species as stated in G-CM-32 of the revised Biological Opinion dated November 10, 2010.

Location: Link 3

Mitigation Measure and APM	Status
B-05a: Stake or flag special status plant populations	Rare Plant Surveys were completed in 2009 by a qualified biologist. The 2009 survey was submitted to the CPUC for review on November 9, 2009. No state or federally listed rare plants were identified in the 2009 surveys along Link 3 or Wilson yard. The felt-leaved monardella population along the Bell Bluff Truck Trail will be fenced immediately prior to construction.
B-05a: Avoid impacts to federal and state listed plant species	Where feasible, impacts to federal or state listed species shall be avoided. The Project Modification Report and Mapbook, which was submitted on May 14, 2010 and approved by the BLM and the CPUC on September 22, 2010 through a Determination Memorandum, shows both sensitive resources and the locations of areas that may be disturbed. As noted in the revised Biological Opinion, dated November 10, 2010, SDG&E will not impact any federal or state listed species during construction activities for this project (see pages 3-4); therefore, this mitigation measure has been satisfied.
B-05a: Submit a Restoration Plan for federal and state listed plants	No federal or state listed plants will be impacted by construction activities on the project, but moderately sensitive plant species will be affected; therefore, SDG&E has prepared a Restoration Plan for Special Status Plants. This plan was submitted to the agencies for review on November 29, 2010. Impacts to special status plants will not occur until this plan is approved by the agencies.
B-05a: Avoid impacts to moderately sensitive plant species	Where feasible, impacts to moderately sensitive plants shall be avoided. The Project Modification Report Mapbook submitted on May 14, 2010, shows the locations of areas that may be disturbed. Where avoidance is not feasible, SDG&E will implement these measures during construction as described in this mitigation measure.
B-05a: Submit a Restoration Plan for special status plant species	A qualified Habitat Restoration Specialist developed the Restoration Plan for Sensitive Vegetation in Temporary Impact Areas. This plan was approved by the CPUC on November 3, 2010 and the Wildlife Agencies on November 10, 2010. Reseeding and salvage will be implemented as determined by the restoration specialist in coordination with the resource agencies.
B-05a: Submit a Habitat Management Plan that addresses offsite mitigation for rare plants	A Habitat Management Plan was submitted to the appropriate agencies for review and approval on September 22, 2010 as outlined in this measure. The Habitat Acquisition Plan and Habitat Management Plan were approved by the Wildlife Agencies as stated in the revised Biological Opinion dated November 10, 2010 (G-CM-17).
B-07a: Cover excavations or install fencing when not in use	Steep-walled trenches or excavations will be covered, fencing will be installed or sloped on one end (i.e., ramped) to prevent the entrapment of wildlife during construction. This mitigation measure will be fulfilled during construction.
B-07a: Inspect excavations 3 times per day and before backfilling	A qualified biological monitor will inspect any open trenches as required. This mitigation measure will be fulfilled during construction.
B-07a: Look under vehicles and equipment before moving for presence of wildlife	Workers will be instructed to look under vehicles for wildlife before movement and to report mortality or injury of a listed species within 48 hours. No vehicles or equipment will be moved until the animal has left or is removed by a qualified biologist. This mitigation measure will be fulfilled during construction.
B-07a: Contact within 48 hours of finding a dead or injured listed species	A qualified biological monitor will submit monitoring reports as required by this measure. This mitigation measure will be fulfilled during construction.
B-07e: Survey for least Bells' vireo and southwestern willow flycatcher within 10 days prior to initiating work in area	The Riparian Birds Survey Report 2009, which was submitted to the CPUC for review on January 14, 2010 and approved on August 26, 2010 indicates that there is no habitat for least Bell's vireo and southwestern willow flycatcher within 500 feet of Link 3; therefore, this measure does not apply.
B-07e: Survey once per week if least Bell's vireo and/or southwestern willow flycatcher are present	The Riparian Birds Survey Report 2009 submitted to CPUC for review on January 14, 2010 and approved on August 26, 2010 indicates that there is no habitat for least Bell's vireo and southwestern willow flycatcher; therefore, this measure does not apply.
B-07e: Establish 300-foot buffer if active nest found	The Riparian Birds Survey Report 2009 submitted to CPUC for review on January 14, 2010 and approved on August 26, 2010 indicates that there is no habitat for riparian birds; therefore, this measure does not apply.
B-07e: Monitor noise if construction occurs within buffer	The Riparian Birds Survey Report 2009 submitted to CPUC for review on January 14, 2010 and approved on August 26, 2010. indicates that there is no habitat for least Bell's vireo or southwestern willow flycatcher; therefore, this measure does not apply.
B-07e: Provide mitigation for temporary and permanent impacts	The Riparian Birds Survey Report 2009, which was submitted to CPUC for review on January 14, 2010 and approved on August 26, 2010 indicates that there is no habitat for least Bell's vireo or southwestern willow flycatcher within 500 feet of Link 3; therefore, this measure does not apply.

Location: Link 3

Mitigation Measure and APM	Status
B-07e: Submit a Habitat Management Plan that addresses impacts to least Bell's vireo and southwestern willow flycatcher	The Riparian Birds Survey Report 2009 submitted to CPUC for review on January 14, 2010 and approved on August 26, 2010 indicates that there is no habitat for least Bell's vireo and southwestern willow flycatcher in the vicinity of the substation; therefore, this measure does not apply.
B-07h: No activities within 4,000 ft. of eagle nest during breeding season	Data obtained from the USFS in 2009 indicates that there is an eagle nest within 4000 feet; however, 2010 surveys did not indicate any active nests within 4,000 feet of the Substation. This measure will be further implmented during construction to ensure that no construction activities occur within 4000 feet of an active eagle nest.
B-07i: Determine suitable habitat areas of QCB	Per USFWS QCB protocol, site assessments for suitable QCB habitat were conducted in 2009 and 2010 by USFWS-permitted biologists. The site assessments identified areas requiring protocol surveys. QCB surveys were completed by a USFWS-permitted biologist and a revised 2009 QCB Focused Survey Report was submitted to CPUC for review January 14, 2010. The survey report identifies QCB habitat in the area of the Suncrest Substation, but no QCB were observed during focused surveys. The survey results were accepted by the Wildlife Agencies as described in the revised Biological Opinion dated November 10, 2010.
B-07i: Conduct pre-construction protocol survey for QCB	Per USFWS QCB protocol, QCB surveys were performed in 2009 by a USFWS-permitted biologist and a revised 2009 QCB Focused Survey Report was submitted to CPUC for review January 14, 2010. Survey results indicate QCB were found by MP 116.5, 110, 79 to 80, 74.5, 71, and 36. The survey report identifies QCB habitat in the area of the Suncrest Substation, but no QCB were observed during focused surveys. The survey results were accepted by the Wildlife Agencies as described in the revised Biological Opinion dated November 10, 2010.
B-07i: Mitigation required if survey non-conclusive for determining QCB presence	A revised 2009 QCB Focused Survey Report was submitted to CPUC for review January 14, 2010. The survey report identifies that no QCB are present within the construction area but suitable habitat does exist. Since the protocol surveys were conclusive that QCB does not occur in this area, this mitigation measure is not applicable.
B-07i: Submit a Habitat Management Plan that addresses offsite mitigation for QCB habitat	A revised 2009 QCB Focused Survey Report was submitted to CPUC for review January 14, 2010. The survey report identifies that no QCB are present within the construction area. Neither USFWS critical nor occupied habitat exist at the substation site or in the vicinity of the work area; therefore, this mitigation measure is not applicable.
B-07j: Conduct pre-construction protocol survey for arroyo toad	Per USFWS protocol, arroyo toad surveys were conducted in 2009 by a permitted biologist. A revised 2009 Arroyo Toad Survey Report was submitted to CPUC for review on January 14, 2010. No arroyo toad habitat was found at the Suncrest Substation and access roads. This has been confirmed by the Wildlife Agencies as noted in Table 7 of the revised Biological Opinion dated November 10, 2010 (see page 51).
B-07j: Remove toad riparian breeding habitat October-December	Based on the 2009 and 2010 protocol-level surveys for arroyo toads, arroyo toad habitat does not exist on Link 3; therefore, this mitigation measure is not applicable.
B-07j: Install exclusion fencing if toad is present and monitor daily during construction	Based on the 2009 and 2010 protocol-level surveys for arroyo toads, arroyo toad habitat does not exist on Link 3; therefore, this mitigation measure is not applicable.
B-07j: Conduct pre- and post-exclusion fencing surveys	Based on the 2009 and 2010 protocol-level surveys for arroyo toads, arroyo toad habitat does not exist on Link 3; therefore, this mitigation measure is not applicable.
B-07j: Conduct daily surveys in the morning prior to work activities	Based on the 2009 and 2010 protocol-level surveys for arroyo toads, arroyo toad habitat does not exist on Link 3; therefore, this mitigation measure is not applicable.
B-07j: Mitigate for the loss of occupied arroyo toad habitat	Based on the 2009 and 2010 protocol-level surveys for arroyo toads, arroyo toad habitat does not exist on Link 3; therefore, this mitigation measure is not applicable.
B-07j: Submit a Habitat Management Plan that includes arroyo toad habitat	Based on the 2009 and 2010 protocol-level surveys for arroyo toads, arroyo toad habitat does not exist on Link 3; therefore, this mitigation measure is not applicable.
B-08a: Clear vegetation August 16-January 14 and remove/trim trees September 16-December 31	This mitigation measure will be fulfilled during construction.

Location: Link 3

Mitigation Measure and APM	Status
B-08a: Conduct pre-construction avian breeding surveys within 10 days of initiating work January 15-August 15 and submit surveys	Within 10 calendar days prior to construction, a qualified biologist will conduct avian breeding surveys for construction activities occurring within the general avian breeding season. Results of the surveys will be submitted to Wildlife Agencies for review and approval.
B-08a: Conduct pre-construction raptor breeding surveys within 10 days of initiating work January 1-September 15 and submit surveys	Pre-construction surveys for active raptor nests will be conducted by a qualified biologist within 10 days of construction if activities will occur during the raptor breeding season. Results of the surveys will be submitted to wildlife agencies for review and approval.
B-08a: Proceed with construction if no active nests observed	This mitigation measure will be fulfilled during construction.
B-08a: Proceed with construction if active nests found per conditions	If active nests are identified, a buffer as defined in this measure will be established and monitored on a weekly basis to allow construction to proceed. This measure will be implemented during construction.
B-08a: Monitor active nests weekly until fledged	This mitigation measure will be fulfilled during construction.
B-08a: Report survey results and monitoring	Results of surveys will be submitted as required and a qualified biologist will continue to monitor the site as appropriate. Weekly monitoring reports will be submitted.
B-09a: Conduct habitat assessment for bat nursery colonies prior to construction	A CDFG-approved biologist conducted day and night surveys. No bat nursery colonies were observed during the 2009 bat surveys performed along the Sunrise Powerlink alignment. The 2009 Bat Survey Report was submitted to the CPUC on February 19, 2010. An amendment to the 2009 Bat Survey Report was submitted on October 1, 2010 and approved by the CPUC on October 11, 2010.
B-09a: Conduct survey for bat nursery colonies prior to construction	A CDFG-approved biologist conducted a survey for bat nursery colonies. The 2009 Bat Survey Report was submitted to the CPUC on February 19, 2010. An amendment to the 2009 Bat Survey Report was submitted on October 1, 2010 and approved by the CPUC on October 11, 2010.
B-09a: No direct impacts to bat nursery colonies allowed	A CDFG-approved biologist conducted day and night surveys. No bat nursery colonies were observed during the 2009 bat surveys performed along the Sunrise Powerlink alignment. The 2009 Bat Survey Report was submitted to the CPUC on February 19, 2010. An amendment to the 2009 Bat Survey Report was submitted on October 1, 2010 and approved by the CPUC on October 11, 2010. If bat nursery colonies are observed during construction, this mitigation measure will be implemented.
B-09a: Implement methods to minimize indirect impacts to bat nursery colonies	A CDFG-approved biologist conducted day and night surveys. No bat nursery colonies were observed during the 2009 bat surveys performed along the Sunrise Powerlink alignment. The 2009 Bat Survey Report was submitted to the CPUC on February 19, 2010. An amendment to the 2009 Bat Survey Report was submitted on October 1, 2010. The amended report was approved by the CPUC on October 11, 2010. If bat nursery colonies are observed during construction, this mitigation measure will be implemented.
BIO-APM-01: Submit protocol surveys for sensitive plant and wildlife	On-the-ground protocol surveys have been conducted for sensitive plant and animal species as appropriate along the entire alignment. SDG&E has submitted survey reports for the 2009 survey season. All 2010 surveys are complete and SDG&E is in the process of providing 2010 survey reports. The 2010 Riparian Bird Survey Report was submitted to the agencies on October 28, 2010. The following reports will be submitted as soon as they are complete; The 2010 Arroyo Toad Survey, the 2010 Quino Checkerspot Butterfly Survey, the 2010 Coastal California Gnatcatcher Survey, and the 2010 Rare Plant Survey. As described in G-CM-32 of the revised Biological Opinion dated November 10, 2010, the Wildlife Agencies state that surveys for federally listed species have been completed.
BIO-APM-02: Environmental training prior to construction	Project personnel shall receive training as outlined in this measure.
BIO-APM-03: Restrict vehicle movement to existing access roads	Vehicle traffic will be restricted to existing paved and unpaved access roads when feasible. All approved work areas, including access roads, will be delineated immediately prior to construction.
BIO-APM-03: Avoid constructing roads during nesting season and submit surveys if new roads needed during nesting season	SDG&E will perform surveys along the realigned portion of the Bell Bluff Truck Trail and additional areas where vegetation clearing will occur. SDG&E will submit survey results to the USFWS and CDFG.

Location: Link 3

Mitigation Measure and APM	Status
BIO-APM-03: No parking or driving under oak trees	This mitigation measure will be monitored during construction to ensure parking or driving underneath oak trees does not occur.
BIO-APM-03: Observe a 15 mph speed limit on dirt access roads	This mitigation measure will be fulfilled during construction.
BIO-APM-04: Restrict project activity to disturbance areas	Project and survey activities will be confined to areas noted in final grading plans for Suncrest Substation, which were submitted to the CPUC on June 22, 2010. The grading plans show the limits of grading.
BIO-APM-04: Keep survey vehicles on existing roads	Survey vehicles shall remain on existing roads.
BIO-APM-04: Obtain prior approval for surveying activities in sensitive habitat	A biological monitor shall monitor project surveying activities for conformance with APMs.
BIO-APM-04: Hiking off roads or paths during survey data collection is permitted	SDG&E survey personnel will implement all appropriate APMs.
BIO-APM-04: Do not apply discoloring agents on rocks or vegetation	No paint or permanent discoloring agents shall be applied as outlined in this measure.
BIO-APM-05: Construct roads at right angles to streambeds and washes	SDG&E will improve an existing dirt road to provide access to the Substation; therefore, limiting new impacts to streambeds and washes. The Project Modification Report and Mapbook submitted May 14, 2010 and approved by the CPUC through a Determination Memorandum on September 22, 2010 identified that modifications to the Project result in reduced impacts to "waters of the U.S." or waters of the state.
BIO-APM-05: Obtain permits for streambed crossings and roads constructed parallel to streambeds	Revised 401, 404 and 1602 permit applications were submitted for review and approval on March 30, 2010. SDG&E received the signed 401 Water Quality Certification on November 15, 2010. The California Department of Fish and Game issued a Streambed Alteration Agreement (SAA) on November 17, 2010. Impacts to streambeds will not occur until SDG&E receives the remaining ACOE 404 permit.
BIO-APM-05: Minimize disturbance from construction and maintenance activities	This mitigation measure will be fulfilled during and post construction.
BIO-APM-06: Comply with all applicable environmental laws and regulations	This mitigation measure will be fulfilled during and post construction.
BIO-APM-07: Littering is not allowed	Littering will be prohibited on this project. This mitigation measure will be monitored during construction.
BIO-APM-08: Delineate and avoid sensitive plant populations	Prior to construction, the boundaries of any sensitive plant populations will be delineated with flagging and avoided to the extent practicable. The felt-leaved monardella plant population along the Bell Bluff Truck Trail will be fenced prior to construction, refer to mitigation measure B-5a.
BIO-APM-10: Do not harm wildlife	The SWEAP video, approved by the CPUC on March 15, 2010, includes instructions that no wildlife, including rattlesnakes, may be harmed except to protect life and limb. This SWEAP will be shown to all project personnel prior to construction and enforced throughout all phases of the Project. If rattlesnakes are encountered, they will be safely removed by a biologist or staff trained in safe snake handling procedures.
BIO-APM-10: Firearms are prohibited	The SWEAP video was approved by the CPUC on March 15, 2010. This SWEAP will be shown to all project personnel and enforced throughout all phases of the Project, and addresses that firearms are prohibited in all project areas, except for security personnel.
BIO-APM-11: Do not feed wildlife	The SWEAP video, approved by the CPUC on March 15, 2010, includes instructions that feeding wildlife is prohibited. The SWEAP video will be shown to all project personnel prior to construction and enforced throughout all phases of the Project.
BIO-APM-12: No pets permitted	The SWEAP video, approved by the CPUC on March 15, 2010, includes instructions that pets are prohibited at the Project site. The SWEAP video will be shown to all project personnel prior to construction and enforced throughout all phases of the Project.
BIO-APM-13: Do not collect plants or wildlife	The SWEAP video, approved by the CPUC on March 15, 2010, includes instructions that prohibit collecting plants or wildlife species for any reason. This SWEAP will be shown to all project personnel prior to construction of the Project and enforced throughout all phases of the Project.

Mitigation Measure and APM	Status
BIO-APM-14: Removal of wildlife by qualified biological monitor or wildlife agency	Wildlife found to be trapped will be removed by a qualified biological monitor. If the biological resource monitor is not qualified to remove the entrapped wildlife, a recognized wildlife rescue agency (such as Project Wildlife) will be contacted to remove the wildlife and transport it safety to other suitable habitats.
BIO-APM-15: Submit report of unavoidable environmental damage	This mitigation measure will be fulfilled during and post construction, as needed.
BIO-APM-16: Schedule tree trimming during non-sensitive times	This mitigation measure will be fulfilled during and post construction. Information regarding sensitive tree trimming locations will be put into the GEARS database.
BIO-APM-16: Vary tree removal widths to maintain edge diversity	This mitigation measure will be fulfilled during construction.
BIO-APM-17: Mow vegetation to use as access road	During construction, it is anticipated that the vegetation in Wilson yard and other temporary impact areas will be crushed or mowed to protect the natural vegetation. Following construction, it is not anticipated that vegetation removal will be required because Bell Bluff Truck Trail will be paved and the substation pad will be gravel filled.
BIO-APM-18: Design structures and access roads to minimize impacts to sensitive features	A memo was submitted to the CPUC for their administrative record documenting compliance with Mitigation Measure BIO-APM-18, on September 1, 2010. The final Project Modification Report (PMR) and Map Book, submitted to the CPUC on May 14, 2010, illustrate changes to the final design of the alignment with an overall reduction of impacts to sensitive features. They also show the redesign and relocation of the alignment to previously disturbed areas when feasible.
BIO-APM-18: Submit site surveys when constructing poles or roads in high value habitats cannot be avoided	Surveys have been performed to determine the presence or absence of endangered species in sensitive habitats along the project route. These surveys were determined to be complete by the Wildlife Agencies as described in G-CM-32 of the revised Biological Opinion. If new areas of disturbance are identified, site specific surveys will be conducted to determine the presence or absence of endangered species; this measure will be implemented during construction.
BIO-APM-18: Construct crossings at right angles to streambeds if access roads cannot avoid sensitive water features	Access roads that impact sensitive water resources shall be constructed as outlined in this mitigation measure, when feasible. SDG&E has submitted a revised 401, 404, and 1602 permit applications to the applicable agencies for review and approval on March 30, 2010 and August 23, 2010.
BIO-APM-19: Implement and comply with BLM mitigation measures	This mitigation measure will be fulfilled during and post construction.
BIO-APM-19: Use Section 7 process to obtain incidental take authorization	SDG&E has obtained an incidental take authorization through the Section 7 process (Refer to Biological Opinion FWS2008BO423-2009F0097).
BIO-APM-20: Leave vegetation in place where re-contouring is not required	This mitigation measure will be fulfilled during construction.
BIO-APM-21: Conform to "Suggested Practices for Raptor Protection on Power Lines"	A memo was submitted to the CPUC for the administrative record on September 15, 2010 describing that the conductor spacing meets recommended suggested practices where feasible and the CPUC confirmed compliance with this measure on September 16, 2010. SDG&E has designed structures in conformance with "Suggested Practices for Raptor Protection on Power Lines."
BIO-APM-22: Salvaging may include removal and stockpiling for replanting	During construction, some of the disturbed soil and vegetation from the substation pad grading will be stockpiled and reused on manufactured slopes to facilitate re-growth of vegetation.
BIO-APM-23: Remove only minimum amount of vegetation necessary for construction	During construction, only the minimum amount of vegetation required to develop the substation pad, water tank, access road, and drainage facilities will be removed.
BIO-APM-23: Conserve topsoil in areas of sensitive habitat	During construction, some of the disturbed soil and vegetation from the substation pad grading will be stockpiled and reused on manufactured slopes to facilitate re-growth of vegetation.
BIO-APM-24: Secure appropriate covers over excavations	The SWEAP video was approved by the CPUC on March 15, 2010. This SWEAP will be shown to all project personnel and enforced throughout all phases of the Project, and includes instructions on covering construction holes overnight to prevent harm to wildlife.
BIO-APM-25: Revegetate disturbed soils	During construction, the disturbed areas outside the crush rock capped or paved areas associated with the substation and access roads will be re-vegetated.

Location: Link 3

Mitigation Measure and APM	Status
BIO-APM-26: Slope excavations on one end	This mitigation measure will be fulfilled during construction.
BIO-APM-27: Remove all raptor nests outside breeding season and prior to construction	SDG&E will remove unoccupied non-threatened/endangered or non-eagle raptor species' nests that would be affected by construction acitivities outside of the raptor breeding season. Per the USFWS, the golden eagle breeding season is December through June.
BIO-APM-27: Monitor active nests during breeding season	Monitoring of an existing raptor nest during the breeding season shall occur as outlined in this mitigation measure, by an approved biologist.
BIO-APM-28: Survey potential bat roost trees to be removed and follow procedures for felling trees	A CDFG-approved biologist conducted a survey for bat maternity roost trees. The 2009 Bat Survey Report was submitted to the CPUC on February 19, 2010. A 2009 Bat Survey Report Amendment to the 2009 Bat Survey Report was submitted on October 1, 2010. The amended report was approved by CPUC on October 11, 2010. No maternity roosts were observed on the project; therefore, this mitigation measure is not applicable.
BIO-APM-29: Minimize impacts of exterior lighting adjacent to preserved habitat	The final Suncrest Substation Lighting Mitigation Plan was submitted to the CPUC on October 25, 2010; CPUC approved the final plan on October 25, 2010. Measures identified in this plan will be implemented during construction.
BIO-APM-29: Minimize vehicle speed and volume	This mitigation measure will be fulfilled during construction.
G-CM-01: Provide biological monitoring and perform periodic inspections once or twice a week	During construction, a qualified biological monitor with the authority to issue stop work orders will be on-site and periodic inspections will be performed. (see B-1c)
G-CM-02: Use SDG&Es Water Quality Construction BMP Manual.	SDG&E will implement erosion control techniques outlined in measure WQ-APM-4 and in accordance with the SWPPP submitted on September 15, 2010.
G-CM-03: Obtain NPDES permit and implement a SWPPP.	The SWPPP and NPDES permit associated with WDID #9 37C357500 was submitted to the CPUC on September 15, 2010. The conditions of the permit and SWPPP will be implemented and enforced during the construction to prevent and avoid water quality impacts. (See WQ-APM-14)
G-CM-04: Training to implement conservation measures.	A log of all personnel that participated in the SWEAP training will be periodically submitted to the CPUC throughout construction. All project personnel will receive the required training before working on the right-of-way or other work areas. Also see BIO-APM-2 for additional information on training.
G-CM-05: Limit vehicle speeds on access roads to minimize fugitive dust.	See BIO-APM-3 and AQ-1a
G-CM-06: Keep all activities within designated temporary and permanent disturbance areas.	Project and survey activities will be confined to areas noted in final engineering drawings. Grading plans for Suncrest Substation were submitted on March 24, 2010 and June 22, 2010 and show the limits of grading. See BIO-APM-4 for additional information.
G-CM-06: Keep survey vehicles on existing roads.	See BIO-APM-4
G-CM-06: No paint or discoloring agents will be applied to rocks or vegetation.	See BIO-APM-4
G-CM-06: Impacts associated unauthorized activity will be mitigated at a 5:1 ratio	This measure will be implemented during constrution if unauthorized impacts occur. Also see BIO-APM-4.
G-CM-07: Brush clearing will require prior approval from the biological monitor in conformance with the CMs.	No brush clearing will occur on the project without prior approval from the project biological monitor. This measure will be implemented during construction. Also see BIO-APM-9 for additional brush clearing requirements.
G-CM-08: Wire stringing	This measure will be implemented during construction.
G-CM-09: Disposal of wastes.	See BIO-APM-7
G-CM-10: Emergency repairs will follows the CM's to the extent feasible.	See BIO-APM-15

Location: Link 3

Mitigation Measure and APM	Status
G-CM-10: Submit written report to agencies having jurisdiction.	See BIO-APM-15
G-CM-10: If required, develop mitigation plan consistent with CMs.	See BIO-APM-15
G-CM-11: Structures and access roads should be designed to minimize impacts to sensitive features.	A memo was submitted to the CPUC documenting compliance with Mitigation Measure BIO-APM-18, on September 1, 2010 for their administrative record. The Project Modification Report (PMR) and Mapbook, which was submitted to the CPUC on May 14, 2010 and approved in a Determination Memorandum on September 22, 2010 illustrates changes to the final design of the alignment to reduce impacts to sensitive features. The USFWS confirmed that this conservation measure has been met through the final project designs (page 32, reinitiated Biological Opinion).
G-CM-12: Leave vegetation in place where re-contouring is not required. Restore disturbed soils based on HRP per G-CM-16.	This mitigation measure will be fulfilled during construction.
G-CM-13: Use lowest illumination allowed for human safety.	See BIO-APM-29
G-CM-13: Vehicle speed limits may not exceed 15 mph to prevent mortality of nocturnal wildlife species.	See BIO-APM-29
G-CM-14: Locate surface-disturbing activities in previously disturbed areas, to the extend practical.	The pre-construction portion of this measure is complete. The project structures and work areas were designed to avoid sensitive vegetation, to the extent possible. During construction, vegetation and soil impacts will be minimized. See B-01-a Task 1 for additional information.
G-CM-15: Use of construction mats.	See B-1a
G-CM-15: Incorporate impact of using mats into HRP (G-CM-16).	See B-1a
G-CM-16: Habitat Restoration Plan approval.	See B-1a. The Restoration Plan for Sensitive Vegetation Communities in Temporary Impact Areas has been approved as stated in the revised Biological Opinion dated November 10, 2010.
G-CM-16: Impacts, compensation, and a qualified habitat restoration specialist.	See B-1a
G-CM-16: Temporary impacts to desert scrub and dune habitats.	This mitigation measure does not apply to Link 3. No desert scrub or dune habitats exist along Link 3.
G-CM-17: Provide assurances to fund the acquisitions	SDG&E has acquired eight of the nine properties listed in this mitigation measure. SDG&E will continue to work with the Wildlife Agencies, as stated in this mitigation measure, regarding funding and preservation of the identified parcels.
G-CM-17: Off-site compensation and property acquisition.	The HAP/HMP was prepared by an approved biologist and was submitted for review and approval on September 22, 2010 as outlined in this mitigation measure. The HMP/HAP was approved by the wildlife agencies as stated in G-CM-17 of the reinitiated Biological Opinion dated November 10, 2010. The remaining requirements of this mitigation measure will be implemented during construction and within the timeframes described in this measure.
G-CM-18: Re-seeding of disturbed areas after a transmission line-caused fire.	See B-1k
G-CM-20: Develop a Weed Control Plan for pre-construction and long-term invasive weed abatement.	See B-3a
G-CM-21: Implementation of erosion control measures.	See GEO-APM-5
G-CM-22: Restoration where ground disturbance is substantial or where recontouring is required.	See GEO-APM-6

Location: Link 3

Mitigation Measure and APM	Status
G-CM-23: Use appropriately sized equipment.	This mitigation measure will be implemented during construction.
G-CM-24: Implement Dust Control Plan.	A Dust Control Plan was approved by the CPUC on January 20, 2010 and the Wildlife Agencies on November 10, 2010. Dust Control Plan measures will be implemented during project construction. (See AQ-1a)
G-CM-24: Implement additional dust control measures	See AQ-1a
G-CM-25: Restrict vehicle movement to access roads.	See BIO-APM-3
G-CM-26: Delineate construction limits.	See B-1a
G-CM-27: Build access roads at right-angles to stream crossings.	See BIO-APM-18
G-CM-28: Coordinate with land officer 60 days prior to initiating construction to determine the use of gates and signs at access roads.	The preconstruction component of this measure is complete (see B-1a). Signs will be posted on access roads prohibiting unauthorized users during construction.
G-CM-29: Provide funding for protection from off-road vehicle enthusiasts	This mitigation measure is not applicable to Link 3 .See measure B-1a for additional information.
G-CM-31: Mowing of access roads to maintain access for maintenance.	See BIO-APM-17
G-CM-32: Surveys for USFWS listed species.	Surveys for USFWS listed species have been completed. See B-5a for additional information.
G-CM-33: Delineate plant population boundaries.	See BIO-APM-8
G-CM-34: Native Tree Restoration	Tree mitigation will occur as described in the Habitat Acquisition/Habitat Management Plan, which was approved by the Wildlife Agencies in the revised Biological Opinion dated November 10, 2010 (see G-CM-17 of the BO).
G-CM-35: Rare plants shall be salvaged where avoidance is not feasible.	No federal or state listed plant species will be impacted by construction on Link 3. Felt-leaved monardella, a moderately sensitive plant, that occurs along the Bell Bluff Truck Trail may be salvaged where impacts cannot be avoided. This measure will be implemented during construction.
G-CM-36: Do not harm wildlife, including rattlesnakes.	See BIO-APM-10
G-CM-37: Do not feed wildlife.	See BIO-APM-11
G-CM-38: Do not bring pets to project areas.	See BIO-APM-12
G-CM-39: Cover steep-walled trenches to avoid entrapping wildlife.	See B-7a
G-CM-40: Look under vehicles and around equipment for wildlife prior to use.	See B-7a
G-CM-41: Do not dispose of excess fill, brush, or debris within waters of the U.S.	This measure will be implemented during construction.
G-CM-41: Do not dispose of fuel, oil, coolant, and other wastes within or near waters of the U.S. Do not fuel vehicles near waters of the U.S.	This measure will be implemented during construction. Routine maintenance and refueling will occur within the substation limits and in accordance with the SWPPP for Link 3.
G-CM-42: Maintain riparian buffer construction/staging areas and riparian areas.	This measure will be implemented during construction.

Location: Link 3

Mitigation Measure and APM	Status
G-CM-45: Purchase/dedicate suitable habitat for preservation.	See G-CM-17
SS-CM-01: Conduct ground- or vegetation disturbance outside of the gnatcatcher breeding season	Coastal California gnatcatcher do not occur on Link 3; therefore, this mitigation measure is not applicable.
SS-CM-03: Survey for gnatcatchers within 10 days prior to initiating activities	Coastal California gnatcatcher do not occur on this component of the project; therefore, this mitigation measure is not applicable.
SS-CM-04: Purchase and manage occupied gnatcatcher habitat	Coastal California gnatcatcher do not occur on this component of the project; therefore, this mitigation measure is not applicable.
SS-CM-05: Conduct construction and O&M activities outside the vireo breeding season or implement pre-activity surveys	Least Bell's vireo do not occur on Link 3; therefore, this mitigation measure is not applicable.
SS-CM-05: Survey for nesting vireos	Least Bell's vireo do not occur on Link 3; therefore, this mitigation measure is not applicable.
SS-CM-06: Purchase and manage suitable vireo habitat	Least Bell's vireo do not occur on Link 3; therefore, this mitigation measure is not applicable to this component of the project.
SS-CM-07: Monitor construction in critical and occupied Quino habitat	Designated critical habitat or occupied habitat for Quino does not occur on Link 3; therefore, this mitigation measure is not applicable.
SS-CM-08: Develop site-specific restoration for temporarily impacted Quino habitat	Quino habitat does not occur on Link 3; therefore, this mitigation measure is not applicable.
SS-CM-10: Purchase and manage occupied Quino habitat	Quino habitat does not occur on Link 3; therefore, this mitigation measure does not apply to this component of the project.
SS-CM-11: Implement the Arroyo Toad Translocation and Monitoring Program	See B-7j
SS-CM-12: Daylight use of access roads to avoid/minimize impacts to arroyo toads.	Arroyo toad breeding habitat does not occur on this component of the project; therefore, this mitigation measure is not applicable.
SS-CM-13: No construction activities within arroyo toad breeding habitat.	Arroyo toad breeding habitat does not occur on this component of the project; therefore, this mitigation measure is not applicable.
SS-CM-14: Remove all temporary exclusion and construction fencing at conclusion of construction.	Arroyo toad do not occur on this component of the project; therefore, this mitigation measure is not applicable.
SS-CM-15: Purchase and manage occupied arroyo toad breeding habitat	Arroyo toad do not occur on this component of the project; therefore, this mitigation measure is not applicable.
SS-CM-16: Prohibit construction and O&M activities during lambing season	Peninsular bighorn sheep do not occur on Link 3; therefore, this mitigation measure is not applicable.
SS-CM-17: Restore suitable bighorn sheep habitat	Peninsular bighorn sheep does not occur on Link 3; therefore, this mitigation measure is not applicable.
SS-CM-18: Retain a Project Biologist to oversee and implement the PBS Monitoring Plan	Peninsular bighorn sheep do not occur on Link 3; therefore, this mitigation measure is not applicable.
SS-CM-19: Purchase habitat to partially offset impacts to PBS population	Peninsular bighorn sheep do not occur on Link 3; therefore, this mitigation measure is not applicable.
SS-CM-19: Provide funding for protection of PBS and I-8 crossing	Peninsular bighorn sheep do not occur on Link 3; therefore, this mitigation measure is not applicable.
SS-CM-19: Fund removal of invasive species and install PBS water sources	Peninsular bighorn sheep do not occur on Link 3; therefore, this mitigation measure is not applicable.
SS-CM-19: Fund aerial surveys for PBS	Peninsular bighorn sheep do not occur on Link 3; therefore, this mitigation measure is not applicable.

Location: Link 3

Mitigation Measure and APM	Status
SS-CM-20: Implement avoidance, mitigation and compensation measures	Flat-tailed horned lizards are restricted to the first 23 miles of the Project (Link 1); therefore, this mitigation measure is not applicable.
SS-CM-20: Designate a field contact representative	Flat-tailed horned lizards are restricted to the first 23 miles of the Project (Link 1); therefore, this mitigation measure is not applicable.
SS-CM-20: Clearly define the limits of work limits	Flat-tailed horned lizards are restricted to the first 23 miles of the Project (Link 1); therefore, this mitigation measure is not applicable.
SS-CM-20: Minimize disturbance to soil and vegetation in FTHL habitat	Flat-tailed horned lizards are restricted to the first 23 miles of the Project (Link 1); therefore, this mitigation measure is not applicable.
SS-CM-20: Use existing roads whenever possible	Flat-tailed horned lizards are restricted to the first 23 miles of the Project (Link 1); therefore, this mitigation measure is not applicable.
SS-CM-20: Block newly created access routes as required by the lead agency	Flat-tailed horned lizards are restricted to the first 23 miles of the Project (Link 1); therefore, this mitigation measure is not applicable.
SS-CM-20: Monitor construction activities in FTHL habitat	Flat-tailed horned lizards are restricted to the first 23 miles of the Project (Link 1); therefore, this mitigation measure is not applicable.
SS-CM-20: Fence areas of permanent or long-term projects in FTHL management areas	Flat-tailed horned lizards are restricted to the first 23 miles of the Project (Link 1); therefore, this mitigation measure is not applicable.
SS-CM-20: Develop habitat restoration plan.	Flat-tailed horned lizards are restricted to the first 23 miles of the Project (Link 1); therefore, this mitigation measure is not applicable.
V-01a: Screen construction sites if visible from public areas	The preconstruction component of this measure is complete. The Construction Yard Visual Screening Plan, which was approved by the CPUC on October 19, 2010, will be implemented during construction.
V-01a: Submit final construction plans 60 days prior to construction	As shown in the Project Modification Report and Map Book, which as approved September 22, 2010 by the BLM and the CPUC, the Suncrest Substation and Wilson Construction Yard are not located in an area of high public visibility. Final Construction Plans for the Suncrest Substation were submitted on August 4, 2010. Grading plans for the Suncrest Substation were submitted to the CPUC on June 22, 2010 and July 28, 2010. A Surface Treatment Plan was submitted to the CPUC on August 3, 2010, revisions were submitted on October 25, 2010 to address comments received from the CPUC. The CPUC approved the Surface Treatment Plan on October 25, 2010.
V-01b: Design and install lighting to avoid night lighting impacts	SDG&E submitted a Suncrest Lighting Mitigation Plan September 24, 2010 as outlined in this mitigation. Comments were received from the agencies and incorporated into a final plan that was submitted October 25, 2010. The measures in this plan will be implemented during construction.
V-01b: Submit a Construction Lighting Mitigation Plan 90 days prior to construction	SDG&E submitted a Suncrest Lighting Mitigation Plan on September 24, 2010 as outlined in this mitigation. Comments were received from the agencies and incorporated into a final plan that was submitted October 25, 2010. The measures in this plan will be implemented during construction.
V-02a: Construct access and spur roads at appropriate angles	This mitigation measure is not applicable to construction activities at Suncrest Substation or Wilson Yard. Both areas will be accessed by existing roads. Upgrades to the Bell Bluff Truck trail are described in the Project Modification Report (PMR29), which was approved by the BLM and the CPUC on September 22, 2010; no increased visual impacts were identified with the access road upgrades.
V-02a: Consult with visual resources specialist to evaluate access road visibility prior to final design	This mitigation measure is not applicable to construction activities at Suncrest Substation or Wilson Yard. Both areas will be accessed by existing roads. Upgrades to the Bell Bluff Truck trail are described in the Project Modification Report (PMR29), which was approved by the BLM and the CPUC on September 22, 2010; no increased visual impacts were identified with the access road upgrades.
V-02a: Submit table 60 days prior to construction	No new access roads will be constructed; therefore, this mitigation measure is not applicable to construction activities at Suncrest Substation or Wilson Yard.
V-02a: Submit final construction plans 60 days prior to construction	Grading plans illustrating the use and expansion of the existing access road for Suncrest Substation were submitted on June 22, 2010.
V-02b: Create barriers for public access if opened as a construction route	No new public access will be opened by construction; therefore, this measure is not applicable.

Location: Link 3

Mitigation Measure and APM	Status
V-02b: Submit final construction and restoration plans 60 days prior to construction	The Project Modification Report (PMR) and Mapbook, submitted on May 14, 2010 and approved by the BLM and CPUC through a Determination Memorandum on September 22, 2010, illustrates changes to the final design that would reduce visual contrast from unnatural vegetation lines. Grading plans for Suncrest Substation were submitted on June 22, 2010. Landscape and drainage plans were submitted on June 22, 2010 and July 28, 2010. The Suncrest Surface Treatment Plan was submitted for review on August 3, 2010, the final Suncrest Surface Treatment Plan was approved by the CPUC on October 25, 2010.
V-02c: Treat disturbed soils visible from sensitive public viewing locations	The Surface Treatment Plan for the substation submitted on August 3, 2010 and approved by the CPUC on October 25, 2010, demonstrates that views of land scars will not be visible from sensitive viewing locations.
V-02c: Submit final construction and restoration plans 60 days prior to construction	Grading plans for Suncrest Substation were submitted on June 22, 2010 and July 28, 2010. Landscape and drainage plans were submitted to the CPUC on June 22, 2010. The Surface Treatment Plan was submitted to the CPUC on August 3, 2010 and approved by the CPUC on October 25, 2010.
V-02d: Consult regarding helicopter construction techniques	The Project Modification Report, which was submitted May 14, 2010, acknowledged by a Determination Memorandum from the CPUC dated September 22, 2010, discusses changes to the final design regarding the use of helicopter construction and prohibition of access and spur roads where construction would occur on slopes greater than 15 percent or near public viewing locations. The PMR indicates that the use of helicopters for construction of the substation will not be required. The substation is not located on slopes greater than 15 percent or near sensitive public views.
V-02d: Conduct Agency Consultations 120 days prior to construction	SDG&E has coordinated with the CPUC along with the CPUC's visual consultant regarding the use of helicopters for construction. This is demonstrated in the Project Modification Report submitted May 14, 2010 and approved by the CPUC and BLM through a Determination Memorandum dated September 22, 2010. The PMR indicates that the use of helicopters for construction of the substation will not be required.
V-07a: Submit Surface Treatment Plan 90 days prior to construction	SDG&E submitted a Surface Treatment Plan for review and approval to the CPUC on August 3, 2010 and a revised plan on October 25, 2010 to address comments provided by the CPUC. CPUC approved the final plan on October 25, 2010.
V-07a: Receive approval before vendor specification	SDG&E will perform treatment of any buildings or structures as described in the approved Suncrest Surface Treatment Plan. The Suncrest Surface Treatment Plan was approved by the CPUC on October 25, 2010.
V-07b: Submit a Screening Plan 90 days prior to screening installation	The Suncrest Substation Visual Screening Plan was submitted to the CPUC on November 8, 2010. A landscaping plan for the Suncrest Substation was submitted to the CPUC on June 22, 2010.
V-21a: Design and install lighting to avoid night lighting impacts	The Suncrest Lighting Mitigation Plan was submitted to CPUC on September 24, 2010. SDG&E resubmitted this plan on October 25, 2010 to incorporate all changes required by the CPUC. CPUC approved this plan on October 25, 2010.
V-21a: Submit a Lighting Mitigation Plan 90 days prior to construction	The Suncrest Lighting Mitigation Plan was submitted to CPUC on September 24, 2010. SDG&E resubmitted this plan on October 25, 2010 to incorporate all changes required by the CPUC. CPUC approved this plan on October 25, 2010.
VR-APM-04: Do not paint or discolor rocks or vegetation	The SWEAP video was approved by the CPUC on March 15, 2010. The SWEAP video will be shown to all project personnel prior to construction and enforced throughout all phases of the Project. The video includes instructions prohibiting application of paint or permanent discoloring agents on rocks or vegetation to indicate survey or construction limits.
VR-APM-05: Do not install structures in front or in line-of-sight of residences	The PMR Map Book (pages MS-105 and 106), which was submitted on May 24, 2010 and approved by the BLM and the CPUC on September 22, 2010, shows that the structures associated with the Suncrest Substation are not in direct line-of-sight with residences. A Surface Treatment Plan also shows that structures will not be constructed directly in front of residences or in direct line-of-sight from a residence and was submitted to the CPUC on August 3, 2010. The CPUC approved this plan on October 25, 2010.
L-01a: Submit Construction Notification Plan 45 days prior to construction	The Construction Notification Plan was approved by the CPUC on March 1, 2010.
L-01a: Mail a public notice 15 days prior to construction	The Construction Notification Plan that was approved by the CPUC on March 1, 2010 addresses mailing public notifications. Proof of Notification will be submitted to CPUC prior to start of construction.
L-01a: Advertise in newspapers and bulletins 15 days prior to construction	The Construction Notification Plan that was approved by the CPUC on March 1, 2010 addresses newspaper advertisement notifications. Proof of Notification will be submitted to CPUC prior to start of construction.

Location: Link 3

Mitigation Measure and APM	Status
L-01a: Post notices of construction at public venues 30 days prior to construction	The Construction Notification Plan that was approved by the CPUC on March 1, 2010 addresses posting of notices of construction at public venues. Proof of Notification will be submitted to CPUC prior to start of construction.
L-01a: Provide a public liaison person and toll-free hotline number before and during construction	The Construction Notification Plan identifies the public liaison person assigned to the project and the toll-free hotline. The Plan was approved by the CPUC on March 1, 2010.
L-02b: Notify landowners 90 days prior to completing final design of route	A memorandum submitted to CPUC on October 5, 2010 summarizes the landowner notification process. CPUC approved this memo on October 12, 2010. All landowners have been notified within 1000 feet of the project alignment. Landowners not directly affected by project facilities were sent a letter through certified mail in spring 2009 and given the opportunity to request changes. Landowners already in easement acquisition negotiations were notified through the acquisition process and provided the opportunity to request changes. These changes are also addressed in the Project Modification Report and Mapbook, which was submitted to CPUC on May 14, 2010 and approved by BLM and CPUC through a Determination Memorandum dated September 22, 2010.
L-02b: Provide notified parties 30 days to identify conflicts and potential reroutes	SDG&E provided affected landowners 30 days in which to respond to the project notification and discuss changes to the project to accommodate landowner requests. The L-2b Mitigation Measure memorandum (dated October 5, 2010) summarizes the criteria used to evaluate these requests. A summary of each landowner request received is also included with this memo. CPUC approved this memo on October 12, 2010. In addition, the PMR submitted on May 14, 2010 and approved by CPUC and BLM through a Determination Memorandum dated September 22, 2010 addresses several of these changes.
L-02b: Provide written report at or before the time property owners are identified	On March 18, 2009, SDG&E met with CPUC representatives to discuss the interpretation and notification requirements for mitigation measure L-2b. The notification and landowner requests processes were developed based on those discussions. SDG&E did not provide CPUC and BLM with a written report identifying properties that were suspected of having a land use conflict as described in the mitigation measures at or before the time property owners were notified, but SDG&E did consider these impacts in their initial evaluation of the project and with subsequent route changes as described in the Project Modification Report submitted to CPUC on May 14, 2010 and approved by BLM and CPUC through a Determination Memorandum dated September 22, 2010.
L-02b: Provide written report within 30 days of the public notice closing date for responses	A memorandum submitted to CPUC and BLM on October 5, 2010 summarizes the landowner notification process. CPUC approved this memorandum on October 12, 2010. All landowners have been notified within 1000 feet of the project alignment. Landowners not directly affected by project facilities were sent a letter through certified mail in spring 2009 and given the opportunity to request changes. Landowners already in easement acquisition negotiations were notified through the acquisition process and provided the opportunity to request changes. These changes are also addressed in the Project Modification Report and Mapbook submitted on May 14, 2010 and approved by the CPUC and BLM through a Determination Memorandum dated September 22, 2010.
L-02b: Develop specific reroute modifications	The modifications required by this task are located on Links 4 and 5. They are not applicable to Links 1,2 and 3.
LU-APM-01: Provide advance notice within 300 feet of construction activities	SDG&E will provide advance notice to residents, property owners, and tenants within 300 feet of construction activities and will appoint a public affairs officer to address public concerns or questions.
LU-APM-02: Place new structures more than 330 feet from residences	There are no residences within 330 feet of the substation; therefore, this mitigation measure is not applicable.
LU-APM-04: Provide notification prior to construction	To facilitate access to properties obstructed by construction activities, SDG&E will notify property owners and tenants in advance of construction activities and provide alternative access if feasible.
LU-APM-05: Coordinate construction activities with water management representatives	There are no irrigation canals or flood management structures impacted by construction activities at the Suncrest Substation or Wilson Yard; therefore, this mitigation measure is not applicable.
LU-APM-06: Restrict and confine activity within limits of construction	Grading plans were submitted to the CPUC on June 22, 2010 and July 28, 2010 describing the limits of construction. Activity will be restricted to and confined within those limits.
LU-APM-06: Provide flagging for environmentally sensitive areas	The ROW boundary and limits of construction activity inside and outside the ROW will be flagged in environmentally sensitive areas to alert construction personnel that those areas should be minimize or avoided.

Location: Link 3

Mitigation Measure and APM	Status
LU-APM-07: Install project facilities outside of private properties, parks, and other recreational areas	SDG&E designed project facilities to be located along the edges or borders of private property, open space parks, and recreation areas. When this was not possible, SDG&E consulted with affected property owners to reduce impacts and has paid just compensation to the property owners. SDG&E submitted a memo summarizing compliance with Mitigation Measure L-2b to the CPUC on October 5, 2010 documenting landownwer consultation and coordination. This memo was approved by CPUC on October 12, 2010. The final alignment is shown on the PMR Mapbook, which was submitted May 14, 2010 and acknowledged by a Determination Memo from CPUC dated September 22, 2010.
LU-APM-08: Coordinate to include Project in General Plans	SDG&E has been coordinating with the County of San Diego and Imperial County to determine whether there are any General Plan updates anticipated during the life of the project that could conflict with construction or operation of the transmission line. SDG&E spoke with LeAnn Carmichael (858-694-3739) at the County of San Diego and Andy Home, Deputy County Executive Officer for Natural Resources Development (760) 482-4727 at Imperial County. No General Plan updates are planned for Imperial County or the City of San Diego in the near future.
LU-APM-09: Obtain ministerial land use permits	Bell Bluff Truck Trail modification plans have been submitted to the County of San Diego for consultation and review; however, no permit is required. During construction, an electrical permit will be obtained from San Diego County for temporary power during construction. No activities associated with temporary power at the construction site will occur until this permit has been obtained.
R-APM-02c: Coordinate construction activities affecting parkland and trails prior to construction	SDG&E consulted with the County of San Diego on August 25, 2010 regarding the County-owned portion of Bell Bluff Truck Trail; no requests for additional gates or signage were made. A copy of the meeting minutes with the County of San Diego was submitted on October 1, 2010.
R-APM-03a: Restrict construction-related traffic to approved routes	This mitigation measure will be monitored during construction. The project no longer crosses ABDSP lands; therefore, this portion of the mitigation measure is no longer applicable.
AG-01c: Coordinate with grazing operators 60 days prior to construction and 30 days after construction	SDG&E has coordinated with landowners to discuss construction activities and address concerns related to agricultural productivity and animal welfare. A memo summarizing this coordination was submitted to CPUC on October 15, 2010. On Link 3, SDG&E coordinated with a private landowner on August 17 and 26, 2010 to discuss construction activities and requirements to minimize impacts to horses on his property. SDG&E also met with another private landowner on August 26, 2009 to discuss impacts to cattle operations and requirements during construction to minimize impacts to grazing operations.
C-01a: Submit cultural resources inventory prior to construction	A Final Class III Inventory was approved by the CPUC and BLM on June 2, 2010.
C-01a: Stake tower locations prior to cultural resource field surveys	The substation project area was staked and surveyed prior to conducting cultural resource field surveys.
C-01b: Protect potential and register-eligible resources from direct project impacts	The Project Modification Report and Mapbook, submitted on May 14, 2010 and approved by the CPUC and BLM through a Determination Memorandum on September 22, 2010, illustrates that the final design of the alignment incorporates changes to avoid impacts to potentially register-eligible and register-eligible resources based on preliminary National Register of Historic Places and consultation with the SHPO. A Final Class III Inventory was completed and approved by the CPUC and BLM on June 2, 2010. Two sites, one pre-historic and one historic, were documented on Link 3 within the substation pad work area. The cultural resources sites on Link 3 have been evaluated by SDG&E's cultural resources consultant for eligibility and both have been determined to be ineligible. A draft eligibility report with a Treatment Plan section presenting this information was submitted to the BLM, the CPUC, the SHPO and Native American Tribes for concurrence. Recommendations for treatment of features were developed in consultation with the interested Native American Tribes. There will be no earth disturbance allowed within the foot print of the Suncrest Substation until the evaluation report is finalized by the BLM in consultation with the CA SHPO. Work on the Bull Bluff Truck Trail and the Wilson Construction Yard will be allowed after the installation and inspection of identified ESAs.

Location: Link 3

Mitigation Measure and APM	Status
C-01b: Undertake additional studies if resources cannot be protected from direct impacts	The Project Modification Report and Mapbook, submitted on May 14, 2010 and approved by the CPUC and BLM through a Determination Memorandum on September 22, 2010, illustrates that the final design of the alignment incorporates changes to avoid impacts to potentially register-eligible and register-eligible resources based on preliminary National Register of Historic Places and consultation with the SHPO. A Final Class III Inventory was completed and approved by the CPUC and BLM on June 2, 2010. Two sites, one pre-historic and one historic, were documented on Link 3 within the substation pad work area. The cultural resources sites on Link 3 have been evaluated for eligibility by SDG&E's cultural resources consultant and both have been determined to be ineligible. A draft eligibility report with a Treatment Plan section presenting this information was submitted to the BLM, the CPUC, the SHPO and Native American Tribes for concurrence. Recommendations for treatment of features were developed in consultation with the interested Native American Tribes. Additional studies are not required for proposed actions along the Bell Bluff Truck Trail or the Wilson Construction Yard. If the need for additional studies for the cultural resource sites within the footprint of the Suncrest Substation, is identified by the BLM in consultation with the CA SHPO or interested Tribes, these studies will be completed before ground disturbance can occur within the Suncrest Substation work area.
C-01b: Incorporate results of studies in HPTP	The two cultural sites identified on Link 3 have been determined to be ineligible by SDG&E's cultural resources consultant and therefore would not be included in the Historic Properties Treatment Plan (HPTP). If the SHPO or Native American Tribes do not concur that these sites are ineligible, these sites will be included in the HPTP. No cultural sites are located along Bell Bluff Truck Trail or in the Wilson Yard. If additional studies are required and completed for the cultural resource sites within the Suncrest Substation, the results of those studies will be incorporated into the project HPTP.
C-01b: Designate NRHP and/or CRHR resources as ESA if within 50 feet of direct impact	If the SHPO or Native American Tribes determine that the two sites identified on Link 3 are NRHP- and/or CRHR-eligible, SDG&E will designate NRHP and/or CRHR-eligible resources within 50 feet of direct impact areas as an ESA if the resource can be avoided. These ESAs will be monitored by cultural monitors during construction and observations will be summarized and submitted to the CPUC in the weekly report. If the prehistoric or historic resource areas within the Substation footprint are determined to be eligible for the NRHP or CRHR, these sites will be subjected to data recovery efforts, as they can't be protected from direct impact from the development of the Suncrest Substation. The data recovery efforts will be detailed in a Historic Properties Treatment Plan that is reviewed and accepted prior to initiation of data recovery efforts or any other mitigation directed at these two cultural resources. There are no NRHP or CRHR eligible resources within the work areas for the Bull Bluff Truck Trail or the Wilson Construction Yard. The resources that are within 50 feet of work on these segments will be protected in established ESAs that will be in place prior to the initiation of ground disturbance.
C-01b: Erect protective flagging or other markers for ESA	The two sites in the Suncrest Substation development area will be protected during work on the Bell Bluff Truck Trail and the Wilson Construction Yard. The Suncrest Substation work area will be off limits to all ground disturbance until the evaluation report for these two sites has been approved by the BLM in consultation with the SHPO and interested Tribes. Work on the Bell Bluff Truck Trail and the Wilson Construction Yard will not be initiated until ESAs are established at the two cultural resource sites that have been identified to be present within 50 feet of the proposed work areas.
C-01b: Develop and implement monitoring program as part of HPTP	A monitoring program was incorporated into the Historic Properties Management Plan. The HPMP was submitted to the CPUC, BLM, USFS, ACOE and Native American Tribes on May 3, 2010. As required under the Programmatic Agreement, this plan was approved by the CPUC, BLM and USFS on July 13, 2010. This plan will be implemented during construction.
C-01c: Submit Historic Properties Treatment Plan	A Final Class III Inventory was completed and approved by the CPUC and BLM on June 2, 2010. Two sites, one pre-historic and one historic, were documented on Link 3 within the substation pad work area. The cultural resources sites on Link 3 have been evaluated for eligibility by SDG&E's cultural resources consultant and both have been determined to be ineligible. A draft eligibility report with a Treatment Plan section presenting this information was submitted to the BLM, the CPUC, the SHPO and Native American Tribes for concurrence. Recommendations for treatment of features were developed in consultation with the interested Native American Tribes. If the SHPO or the Native American Tribes determine that either of these sites are NRHP- and/or CRHR-eligible, they will be included in the HPTP.

Location: Link 3

Mitigation Measure and APM	Status
C-01d: Conduct data recovery investigations to reduce adverse effects	A Final Class III Inventory was completed and approved by the CPUC and BLM on June 2, 2010. Two sites, one pre-historic and one historic, were documented on Link 3 within the substation pad work area. The cultural resources sites on Link 3 have been evaluated for eligibility by SDG&E's cultural resources consultant and both have been determined to be ineligible. A draft eligibility report with a Treatment Plan section presenting this information was submitted to the BLM, the CPUC, the SHPO and Native American Tribes for concurrence. Recommendations for treatment of features were developed in consultation with the interested Native American Tribes. If the SHPO or the Native American Tribes determine that either of these sites are NRHP- and/or CRHR-eligible, they will be included in the HPTP and data recovery will be conducted as recommended in the HPTP. There is no data recovery required for sites that will be avoided and protected within or adjacent to the Bell Bluff Truck Trail or the Wilson Construction Yard.
C-01d: Submit field closure report prior to construction within 100 feet of affected resource	A Final Class III Inventory was completed and approved by the CPUC and BLM on June 2, 2010. Two sites, one pre-historic and one historic, were documented on Link 3 within the substation pad work area. The cultural resources sites on Link 3 have been evaluated for eligibility by SDG&E's cultural resources consultant and both have been determined to be ineligible. A draft eligibility report with a Treatment Plan section presenting this information was submitted to the BLM, the CPUC, the SHPO and Native American Tribes for concurrence. Recommendations for treatment of features were developed in consultation with the interested Native American Tribes. If the SHPO or the Native American Tribes determine that either of these sites are NRHP- and/or CRHR-eligible, and data recovery is required, a field closure report will be submitted. There is no data recovery required for sites that will be avoided and protected within or adjacent to the Bell Bluff Truck Trail or the Wilson Construction Yard.
C-01d: Submit final report of data-recovery investigations within 1 year of completing fieldwork	A final report is being prepared and will be submitted once available. This mitigation measure will be fulfilled during or after construction.
C-01e: Implement archaeological monitoring at cultural ESAs	A Historic Properties Treatment Plan (HPTP) is being prepared that will include locations of ESAs and protection boundaries. The HPTP will provide recommendations for further management and monitoring during construction. Construction at the substation pad will not commence until the HPTP is approved. Archeological monitors will be present during the establishment of the ESAs at sites within 50 feet of the Bell Bluff Truck Trail and Wilson Construction Yard. These ESAs will be inspected and maintained over the duration of work on either of these aspects of the project. An ESA will be established around the Suncrest Substation until the evaluation report for the two sites within the Suncrest Substation work area is approved by the BLM in consultation with the BLM and interested Tribes. No work will be allowed in the Suncrest Substation work area until the evaluation report is approved and after approval the entire Suncrest Substation work area will be monitored by a qualified cultural resource and Native American monitor beginning with vegetation removal and concluded when rough grading has been completed.
C-01e: Qualification of archaeologists must be approved	The qualifications of the principal archaeologist and archaeological monitors were submitted to the BLM and CPUC for approval on July 20, 2010. Cultural monitor resumes have been approved by the BLM on September 30, 2010. Only monitors approved by the CPUC and BLM will work on the project. A list of all approved monitors will be updated throughout the project. A qualified Native American monitor will be present for all ground disturbance within the Suncrest Substation work area.
C-01e: Retain and schedule any required Native American monitoring	A Historic Properties Management Plan (HPMP) was approved by the CPUC and BLM on July 15, 2010. The HPMP includes locations where Native American monitoring will be required. The Historic Properties Treatment Plan, which is under development, will provide recommendations for further management and monitoring during construction.
C-01e: Submit cultural resources monitoring monthly reports during construction	This mitigation measure will be fulfilled during construction.
C-01e: Notify if any damage to cultural resource ESAs and divert work to a buffer distance	This mitigation measure will be fulfilled during construction.

Location: Link 3

Mitigation Measure and APM	Status
C-01f: Train construction personnel to recognize and protect cultural resources	The SWEAP video, approved by the CPUC on March 15, 2010, includes instructions regarding the recognition of possible buried cultural remains and protection of all cultural resources. The SWEAP video will be shown to all project personnel prior to construction and enforced throughout all phases of the Project.
C-02a: Avoid known Native American remains and protect with ESA designation	Government-to-government consultations have been ongoing. SDG&E has avoided direct impacts to known locations of Native American human remains and will continue to avoid direct impacts to Native American human remains. Records of consultations are being held with the BLM. No known locations of Native American remains occur along Link 3. If Native American remains are encountered during construction, this mitigation measure will be implemented.
C-02a: Contact agencies if sites will be affected	SDG&E has avoided direct impacts to known locations of Native American human remains and will continue to avoid direct impacts to Native American human remains.
C-02a: Assist and support MLD with reinterment location	SDG&E will provide all necessary support to the MLD if Native American human remains are encountered during construction.
C-02a: Follow laws that govern treatment of human remains	SDG&E will follow all laws, statues and regulations as appropriate if Native American human remains are encountered during construction.
C-02a: Support in consultations with Native Americans and implement required actions and studies	Government-to-government consultations are ongoing. Records of consultations are being held with the BLM.
C-02a: Divert work if human remains are discovered and inform officer	This measure will be implemented as defined if human remains are discovered during construction.
C-03a: Implement archaeological monitoring	Archaeological and Native American monitors will be on-site during subsurface construction disturbance at all locations identified for buried archaeological deposits. The Historic Properties Management Plan, approved by the CPUC and BLM on July 15, 2010, states that monitoring will be at highly sensitive areas defined during Buried Site Testing (BST). It also states that if BST is not feasible in areas classified as high sensitivity for buried sites, those areas will be monitored during ground-disturbing construction activities. No work will be allowed at the Suncrest Substation work area until the evaluation report for the two identified cultural resouce sites is approved. After approval, the entire Suncrest Substation work area will be monitored by qualified cultural resource and Native American monitors beginning with vegetation removal and concluding when rough grading has been completed. Monitoring observations will be summarized and submitted to the CPUC in the weekly report.
C-03a: Divert work if buried cultural material discovered and notify archaeologist	This mitigation measure will be fulfilled during construction.
C-04a: Assist and support BLM in consultations with Native Americans to assess impacts	The preconstruction component of this measure is complete; however, government-to-government consultations are ongoing. Records of consultations are being held with the BLM.
C-04a: Submit documentation of all pre-construction actions 30 days prior to construction	Written documentation of all preconstruction consultation actions completed to date was included in the HPMP, approved on July 15, 2010, and the Final Class III Inventory. The written documentation required for work on the Bell Bluff Truck Trail and the Wilson Construction yard was presented in the HPMP. The additional documentation related to Native American consultation for the Suncrest Substation will be included as an Attachment to the approved Final Eligibility Evaluation Report. The preconstruction component of this mitigation measure is complete. Additional information will be provided to the BLM as the consultation process continues prior to and during construction. Actions that are required during or after construction will be defined, detailed, and scheduled in the Historic Properties Treatment Plan and implemented by the Applicant, consistent with Mitigation Measure C-1c.
C-05a: Design a long-term plan to protect NRHP and/or CRHR eligible sites 30 days prior to project operation	There are no NRHP- and/or CRHR-eligible sites on Link 3; therefore, no direct or indirect impacts will occur during project operation and maintenance.

Location: Link 3

Mitigation Measure and APM	Status
CR-APM-01: Instruct and provide a contract addressing protection and avoidance of cultural resources	The SWEAP video, approved by the CPUC on March 15, 2010, includes instructions regarding the recognition of possible buried cultural remains and protection of all cultural resources. A construction contract addressing state and federal laws regarding antiquities, fossils, and plants and wildlife, including the collection and removal, as well as the importance of these resources and the purpose and necessity of protecting them will be signed by each individual. Records of these contracts will be kept with the monitor. The SWEAP video will be shown to all project personnel prior to construction and enforced throughout all phases of the Project.
CR-APM-02: Flag archaeological sites eligible for National Register	The Project Modification Report and Mapbook, submitted on May 14, 2010 and approved by the CPUC and BLM through a Determination Memorandum on September 22, 2010, illustrates that the final design of the alignment incorporates changes, to the extent feasible, to avoid impacts to potentially register-eligible and register-eligible resources based on preliminary National Register of Historic Places and consultation with the SHPO. The two cultural resources sites identified on Link 3 are assumed to be ineligible based the field surveys, but SHPO and the Native American Tribes concurrence is pending. If these sites are determined to be eligible, they will be flagged for avoidance if possible. A protective ESA will be established around the Suncrest Substation work area and will remain in place until the Final Eligibility Evaluation Report is final. ESAs will be established at the two sites that are within 50 feet of the Bull Bluff Truck Trail and the Wilson construction yard before ground disturbance can occur in these areas of the project.
CR-APM-02: Implement impact avoidance and APMs during construction	SDG&E consulted with the appropriate land management agencies to avoid impacts to cultural resources where feasible. The Project Modification Report and Mapbook, submitted on May 14, 2010 and approved by the CPUC and BLM through a Determination Memorandum on September 22, 2010, illustrates that the final design of the alignment incorporates changes based on these consultations. Impact avoidance and APMs described in the approved HPMP and HPTP, which is under development, will be implemented during construction, if the two cultural resources sites on the substation pad work area are determined to be eligible by SHPO or the Native American Tribes. A protective ESA will be established around the Suncrest Substation work area and will remain in place until the Final Eligibility Evaluation Report is final. ESAs will be established at the two sites that are within 50 feet of the Bull Bluff Truck Trail and the Wilson construction yard before ground disturbance can occur in these areas of the project.
CR-APM-04: Conduct maintenance and other activities in conformance with national standards	This mitigation measure will be fulfilled during construction.
CR-APM-05: Follow guidelines for cultural resources	The Historic Properties Management Plan approved on July 15, 2010 incorporates the guidance provided in this measure. SDG&E will continue to comply with cultural resources mitigation measures as outlined in the MMCRP.
CR-APM-06: Avoid historic properties by fencing or barricading	A Historic Properties Management Plan (HPMP) was approved by the CPUC on July 15, 2010. The HPMP identifies historic properties along the Project route. No historic properties were identified within the construction area for the Suncrest Substation or Wilson Yard.
CR-APM-06: Implement a plan if historic properties cannot be avoided	A Historic Properties Management Plan (HPMP) was approved by the CPUC on July 15, 2010 and identifies historic properties along the Project route. No historic properties were identified within the construction area for the Suncrest Substation or Wilson Yard.
CR-APM-07: Control impacts that can deteriorate historic	No historic properties have been identified on Link 3; therefore this mitigation measure is not applicable.
CR-APM-07: Implement protective measures to minimize erosion and weeds	No historic properties have been identified on Link 3; therefore this mitigation measure is not applicable.
CR-APM-07: Implement control measures to minimize vibration, dust, and fumes	No historic properties have been identified on Link 3; therefore this mitigation measure is not applicable.
CR-APM-07: Minimize deterioration to buildings and structures	No historic properties have been identified on Link 3; therefore this mitigation measure is not applicable.
CR-APM-07: Implement a plan if deterioration cannot be avoided	No historic properties have been identified on Link 3; therefore this mitigation measure is not applicable.

Location: Link 3

Mitigation Measure and APM	Status
CR-APM-08: Avoid and protect landscaping essential to historic property	No historic properties have been identified on Link 3; therefore this mitigation measure is not applicable.
CR-APM-08: Minimize intrusion to the historic setting	No historic properties have been identified on Link 3; therefore this mitigation measure is not applicable.
CR-APM-09: Restrict construction and operation access	No historic properties have been identified on Link 3; therefore this mitigation measure is not applicable.
CR-APM-09: Instruct construction and maintenance personnel to protect sensitive properties	There are no historic properties that will be affected by construction activities at Suncrest Substation or use of the Wilson Yard; therefore, this measure is not applicable.
CR-APM-10: Span conductors over historic property	No historic properties have been identified on Link 3; therefore this mitigation measure is not applicable.
CR-APM-10: Boring shall avoid disturbance to historic property	No historic properties have been identified on Link 3; therefore this mitigation measure is not applicable.
CR-APM-11: Implement standard practices on private land	A memo was submitted to the CPUC on September 13, 2010 documenting compliance with this mitigation measure.
CR-APM-12: Conduct cultural surveys for staging areas not yet identified	SDG&E has conducted cultural surveys for staging areas not identified in the FEIR/EIS, including the Wilson Yard. The PMR and Mapbook, submitted on May 14, 2010 and approved by the CPUC and BLM through a Determination Memorandum on September 22, 2010, illustrates changes to the final design of the alignment based on these surveys.
PAL-01a: Submit an inventory of significant paleontological resources	SDG&E submitted the Paleontological Records Report, dated February 25, 2010 and the Sunrise Powerlink Paleontological Monitoring and Discovery Treatment Plan, dated April 7, 2010. These documents were approved by the CPUC, BLM and other involved land-managing agencies on July 30, 2010.
PAL-01b: Submit a Paleontological Monitoring Treatment Plan	The Paleontological Monitoring and Treatment Plan was developed by a qualified paleontologist and based on Society of Vertebrate Paleontology guidelines. The plan was approved by the BLM, CPUC and other agencies with jurisdiction on July 20, 2010. The approved plan indicates that no paleontological monitoring will be needed on Link 3 because the geology at the site in non-paleo producing.
PAL-01c: Conduct full-time paleontological construction monitoring	The Paleontological Monitoring and Treatment Plan, approved on July 20, 2010, indicates that no paleontological monitoring will be required on Link 3 because the geology at the site is non-paleo producing.
PAL-01c: Conduct part-time monitoring of sediments with low marginal undetermined sensitivity	The Paleontological Monitoring and Treatment Plan, approved on July 20, 2010, indicates that no paleontological monitoring will be required on Link 3 because the geology at the site is non-paleo producing.
PAL-01c: Divert construction activities when significant fossils are recovered	The Paleontological Monitoring and Treatment Plan, approved on July 20, 2010, indicates that no paleontological monitoring will be required on Link 3 because the geology at the site is non-paleo producing.
PAL-01d: Implement Treatment Plan if significant paleontological resources are unavoidable	The Paleontological Monitoring and Treatment Plan, approved on July 20, 2010, indicates that paleontological resources are unlikely to occur on Link 3 because the geology at the site is non-paleo producing. Therefore, the approved Treatment Plan for paleontological resources is not applicable to Link 3.
PAL-01e: Train construction personnel on paleontological resources	The SWEAP video, which was approved by the CPUC on March 15, 2010, will be shown to all project personnel and enforced throughout all phases of the Project. The SWEAP video includes instructions on the recognition of possible subsurface paleontological resources and protection of all paleontological resources during construction.
N-01a: Obtain a variance for night construction or 200 feet from sensitive receptors 45 days prior to construction	Limited construction activities may be required to occur outside of daytime hours at the Suncrest Substation. Construction activities along the access road and at the Wilson yard will occur in accordance with the local noise ordinance. If during construction an activity is required that would deviate from the local noise ordinance, SDG&E will obtain a variance from the local noise officer prior to initiating the activity.
N-01a: Employ noise suppression techniques	This meausure will be implemented during construction.
N-02a: Manage blasting with a plan for each site 45 days prior to construction	There are no vulnerable structures that could be damaged by blasting at the site; however, if blasting is required, a site-specific blasting plan will be prepared during construction as required by H-4b.

Location: Link 3

Mitigation Measure and APM	Status
N-02a: Restore damaged structure and compensate owner	There are no vulnerable structures that could be damaged by construction vibration at the substation; however if a structure is inadvertently adversely affected, SDG&E shall then fairly compensate the owner.
NOI-APM-01: Provide notice to sensitive receptors and residences within 300 feet of construction	The Construction Notification Plan addresses providing notice to sensitive receptors within 300 feet of construction sites, staging areas, and access roads. The Plan was approved by the CPUC on March 1, 2010. SDG&E will provide verification that notifications were made prior to start of construction.
NOI-APM-01: Provide a public liaison person before and during construction.	The Construction Notification Plan approved by the CPUC on March 1, 2010 identifies a public liaison person that can respond to concerns of neighboring receptors about noise disturbances.
NOI-APM-01: Establish a toll free number for questions and complaints	The Construction Notification Plan, which was approved by the CPUC on March 1, 2010, identifies the toll free telephone number established by SDG&E for receiving questions or complaints during construction. The Construction Notification Plan also identifies procedures for responding to callers.
T-05a: Coordinate road repairs with public agencies	This measure will be implemented post construction.
T-05a: Protect drainage structures and incorporate measures into access agreement/easement	The Landscaping and Drainage plans were submitted to the CPUC on June 22, 2010. The Suncrest Substation Drainage Study was approved on October 13, 2010. This plan illustrates how road drainage features will be protected. Consultations with the County of San Diego regarding protecting drainage features has been ongoing. As noted in LU-APM-9, an access agreement/easement with San Diego County is not required for Link 3 activities.
T-09a: Prepare a Construction Transportation Management Plan	A project-wide Traffic Study was submitted on April 28, 2010 and approved by San Diego County on September 29, 2010. The Study revealed that there are no significant traffic impacts at the Suncrest Substation site as a result of project activities. Therefore, a CTMP will not be required.
T-11b: Provide notification when and where the line will be erected prior to construction	Construction at the substation and yard does not involve installation of new transmission lines and towers over 200 feet in height; however, SDG&E has consulted with U.S. Customs and Border Patrol regarding the location of the alignment. SDG&E met with U.S. Customs and Border Patrol representatives on December 17, 2009, February 8, 2010, and April 20, 2010. A memo documenting this coordination was provided to CPUC for the administrative record on October 15, 2010.
T-11b: Provide maps of the alignment near the U.S./Mexico border	The April 30, 2010 Mapbook includes aerial images that clearly show the new lines and towers in relation to the U.S./Mexico border within San Diego and Imperial Counties. SDG&E provided a copy of this Mapbook to border patrol aircraft, the U.S. Customs and Border Patrol, and the CPUC on May 14, 2010. SDG&E consulted with the U.S. Customs and Border Patrol on December 17, 2009, February 8, 2010, and April 20, 2010.
T-APM-02a: Obtain permits for temporary lane closures	As determined by the Traffic Study approved by San Diego County on September 29, 2010, lane closures along public transportation routes to the Substation are not anticipated. However, if during construction, temporary lane closures are necessary, SDG&E will obtain required permits from the County of San Diego and CALTRANS for any temporary lane closures.
T-APM-02b: Submit Detour Plans	As determined by the Traffic Study approved by San Diego County on September 29, 2010, it is not anticipated that detours along public transportation routes will be necessary. During construction, if detours are required, SDG&E will submit detour plans to the County of San Diego and CALTRANS.
T-APM-02b: Right-of-Entry permit required for construction and maintenance activities outside of easements in the ABDSP	No project activities will occur within ABDSP; therefore, this measure is not applicable.
T-APM-02b: Provide a request for maintenance or other earth-disturbing activities within California State Parks	No project activities will occur on California State Park land; therefore, this measure is not applicable.
T-APM-04a: Coordinate in advance with emergency service providers	As determined by the Traffic Study approved by San Diego County on September 29, 2010, it is not anticipated that construction activities will restrict movements of emergency service providers. However, if necessary, during construction SDG&E will coordinate with emergency service providers prior to initiation of construction activities that would restrict movements of emergency vehicles.

Location: Link 3

Mitigation Measure and APM	Status
T-APM-04a: Notify cities and counties regarding construction activities	As determined by the Traffic Study approved by San Diego County on September 29, 2010, it is not anticipated that construction activities will impact police, fire, ambulance and paramedic services. However, if necessary, during construction SDG&E shall notify and provide required information to counties and cities prior to initiation of construction activities that could impact local authorities.
T-APM-05a: Coordinate construction activities adjacent to school bus stops with school districts 1 month prior to construction	SDG&E met with the Alpine Unified School District regarding impacts to school bus stops on August 26, 2010 at 1:00 pm and with Jamul-Dulzura School District on September 1, 2010 at 3:00 pm. No concerns were raised regarding construction areas associated with the Suncrest Substation or Wilson Yard.
T-APM-05a: Consult with transit authorities 1 month prior to construction	SDG&E met with Metropolitan Transit System representatives Mike Daney and Devin Braun on September 2, 2010. No concerns were raised regarding construction activities associated with the Suncrest Substation or Wilson Yard.
T-APM-06b: Parking in San Diego County shall comply with County regulations and per an approved traffic control plan	A CTMP is not required for the Suncrest Substation or the Wilson Yard, as described in measure T-09a. Therefore, this measure is not applicable to Link 3.
T-APM-09a: Underground utility facilities within 1,000 feet of an Officially Designated Scenic Highway	Link 3 does not include any new or relocated utility facilities within 1,000 feet of an Officially Designated Scenic Highway; therefore, this mitigation measure is not applicable.
T-APM-10a: Ensure continuous access to properties	Underground cable alignment installation is not part of construction at the Suncrest Substation or Wilson yard; therefore, this measure is not applicable.
HS-APM-01: Train personnel using hazardous materials	The SWEAP video that was approved by the CPUC on March 15, 2010 includes training on hazardous materials management procedures. This SWEAP will be shown to all project personnel and enforced throughout all phases of the Project.
HS-APM-01: Develop a Hazardous Communication Plan	The Sunrise Powerlink Hazard Communication (HazCom) Plan was approved by the CPUC on April 2, 2010. The HazCom Plan includes site-specific information and the location of MSDS.
HS-APM-02: Trained personnel to perform refueling	Refueling will only be performed by operators trained in refueling of vehicles or equipment.
HS-APM-02: Conduct refueling in designated areas or by assigned vehicles	Refueling will be performed in designated areas or by a mobile refueling tanker with appropriate secondary containment.
HS-APM-03: Develop applicable safety plans	The Sunrise Powerlink Hazard Communication (HazCom) Plan was approved by the CPUC on April 2, 2010. The HazCom Plan includes site-specific information and the location of MSDSs. The SWPPP was submitted on September 15, 2010. The HMBP and SPCC Plan will be developed during construction as required by applicable regulations.
HS-APM-05: Investigate impacts of all contaminated sites	The Soil Management Plan was approved by the CPUC on September 9, 2010 and addresses the requirements of this measure. The Suncrest Substation site is not a Section 65962.5 site or known contamination site.
HS-APM-07: Train personnel to recognize UXO	The SWEAP video was approved by the CPUC on March 15, 2010 and discusses training of personnel involved in excavation regarding recognition of UXO.
HS-APM-08: Assign Environmental or Health & Safety Representative	SDG&E has assigned Steve Riggs, Field Monitoring Manager with Burns & McDonnell, as the Environmental Field Representative project-wide.
HS-APM-09: Contact airport representatives within 2 miles	There are no structures over 200 feet in height that trigger FAA review associated with construction activities at the substation; therefore, this measure is not applcable.
HS-APM-10: Store and dispose of hazardous waste per regulations	If hazardous wastes are generated, they will be properly disposed of and stored in accordance with all applicable federal and state regulations. Hazardous material minimization measures shall be employed whenever possible.
HS-APM-11: Develop Fire Prevention and Response Plan	The Fire Plan, signed by the CAL Fire Chief, was approved by the CPUC on February 2, 2010.
HS-APM-11: Assign Fire Marshal to enforce fire prevention provisions	The Fire Plan, acknowledged by the CAL Fire Chief, was submitted to the CPUC on December 14, 2009 and approved by the CPUC on February 2, 2010. A project Fire Marshall was hired onto the project and is assigned to enforce the FPRP.

Location: Link 3

Mitigation Measure and APM	Status
HS-APM-12: Develop a Traffic Control Plan	A project-wide Traffic Study was submitted on April 28, 2010 and approved by San Diego County on September 29, 2010. The Study revealed that there are no significant traffic impacts at the Suncrest Substation site as a result of project activities. Roadway crossings are not part of construction activities at the Suncrest Substation or Wilson Yard. All measures required in any required encroachment permit will be implemented during construction.
HS-APM-14: Conduct environmental training to construction workers	The SWEAP video, which was approved by the CPUC on March 15, 2010, provides environmental training to construction workers regarding potential exposure. This SWEAP will be shown to all project personnel and enforced throughout all phases of the Project.
HS-APM-15: Stop work if soil or groundwater contamination is suspected	This mitigation measure will be fulfilled during construction if suspected contaminated soil or water is discovered.
HS-APM-16: Terminate work and implement health and safety procedures if contamination is suspected	This mitigation measure will be fulfilled during construction if suspected contaminated soil or water is discovered.
HS-APM-16: Take preliminary samples and send to lab for testing	This mitigation measure will be fulfilled during construction if suspected contaminated soil or water is discovered.
HS-APM-17: Work may proceed if no contamination	This mitigation measure will be fulfilled during construction.
HS-APM-17: Notify agencies if contamination is above regulatory limits	This mitigation measure will be fulfilled during construction.
P-01a: Implement an environmental monitoring plan	The Environmental Monitoring Plan was submitted to the CPUC on May 10, 2010. In addition, the SWEAP video, approved by the CPUC on March 15, 2010, discusses implementation of the Environmental Monitoring Program; maintenance of emergency spill supplies and equipment; the proper use of hazardous materials, development of a Hazardous Communication Plan; development of applicable environmental safety plans associated with hazardous materials; assignment of an Environmental Field Representative and/or General Contractor to the Health & Safety Office for the project; proper disposal/storage of hazardous and solid wastes in accordance with federal, state, and local regulations; and environmental training regarding potential exposure. The SWEAP video will be shown to all project personnel and enforced throughout all phases of the Project.
P-01a: Designate an Environmental Field Representative	The Environmental Monitoring Plan was submitted to CPUC on May 10, 2010. The Plan states that the Environmental Field Representative/ Lead Monitoring Manager for this Project is Steve Riggs.
P-01b: Maintain hazardous material spill kits onsite	This measure will be implemented during construction.
P-03a: Collect soil or groundwater samples if contaminated	This measure will be implemented during construction.
P-03a: Coordinate with regulatory agencies if contaminated soil or groundwater confirmed by laboratory data	This measure will be implemented during construction.
P-03b: Submit report to agencies of contaminated soil within 30 days of laboratory data receipt	This measure will be implemented during construction.
PS-01a: Limit conductor surface gradient	Following current industry substation design practices, the Suncrest Substation 500 and 230kV buses were designed to meet the conductor surface voltage gradients as specified in the "IEEE Guide for design of substation rigid bus structures" (IEEE standard 605-1998) and calculated following the procedures outlined in "Electric Power Connection for Substations" (ANSI/NEMA CC1-2009). The calculated maximum conductor surface voltage gradients for both the 500 and 230 kV conductors for Suncrest Substation are below the maximum allowable voltage gradients as defined by these current standards. In addition, the calculated maximum conductor surface voltage gradients for both the 500 and 230kV conductors for Suncrest Substation were compared to the maximum gradient values presented in Figure 4 of the IEEE Radio Noise Design Guide – 1971 as "good engineering design practices." The calculated maximum surface voltage gradients for Suncrest were below the values presented in the 1971 design guide.

Location: Link 3

Mitigation Measure and APM	Status
PS-02a: Identify objects within and near ROW for induced voltages and implement electrical grounding	A grounding study was performed to ensure that the substation and the area immediately outside of the proposed substation fenceline meets all applicable standards for step and touch voltage potential. The Ground Grid study, dated June 30, 2010, did not identify any objects near the substation with the potential for induced voltages. The entire substation will be fenced and all equipment, including the fence, will be grounded to the substation ground grid in accordance with SDG&E's standards. A memorandum addressing completion of this measure was submitted to the CPUC on October 6, 2010.
AQ-01a: Pave, apply water 3 times daily, or apply soil stabilizers	A Dust Control Plan was approved by the CPUC on January 20, 2010. The Dust Control Plan will be implemented during project construction.
AQ-01a: Pre-water sites 48 hours prior to clearing	This mitigation measure will be fulfilled during construction pursuant to the approved Dust Control Plan.
AQ-01a: Reduce amount of disturbed area	This mitigation measure will be fulfilled during construction pursuant to the approved Dust Control Plan.
AQ-01a: Spray stock-piles daily or as needed	This mitigation measure will be fulfilled during construction pursuant to the approved Dust Control Plan.
AQ-01a: Cover loads in trucks or maintain 6 inches of free-board	This mitigation measure will be fulfilled during construction pursuant to the approved Dust Control Plan.
AQ-01a: Pre-moisten import and export dirt prior to transport	This mitigation measure will be fulfilled during construction pursuant to the approved Dust Control Plan.
AQ-01a: Sweep public streets daily if soil tracking visible	This mitigation measure will be fulfilled during construction pursuant to the approved Dust Control Plan.
AQ-01a: Apply soil stabilizers or water on inactive work areas	This mitigation measure will be fulfilled during construction pursuant to the approved Dust Control Plan.
AQ-01a: File a Dust Control Plan 30 days prior to construction	The Dust Control Plan was submitted to the CPUC and approved on January 20, 2010 and the Wildlife Agencies on November 10, 2010.
AQ-01b: Maintain construction equipment and use low-emission equipment	SDG&E will use available Tier 3 equipment, minimizing the use of Tier 2 equipment. Any portable equipment over 50 hp will be permitted with the local Air Pollution Control District (APCD) or the California Air Resources Control Board as required by applicable regulations. Equipment run logs will be maintained on a daily basis and periodically submitted to the CPUC.
AQ-01h: Obtain NOx emission reduction credits or fund incentive programs prior to construction	Mitigation measure AQ-01h, which was required to achieve emission reductions to levels below the federal thresholds is no longer applicable. The emissions expected based on the PMR are less than the federal General Conformity de minimus thresholds for San Diego Air Basin as determined in the Memorandum of Determination issued by the CPUC in September 2010. For additional information refer to page 9 of the memorandum.
AQ-04a: Report quarterly the status of carbon credits	SDG&E sent an email regarding greenhouse gas emissions off-sets to the CPUC on August 27, 2009. The emissions off-sets approach was conditionally approved on September 7, 2009. The CPUC sent an email approving the proposed off-set purchases on November 9, 2009 and SDG&E purchased CRTs to satisfy this measure. SDG&E will report the quarterly status of efforts to create reductions or obtain banked credit and the quantity of construction-phase greenhouse gas emissions offset by credits. The preconstruction component of this measure is complete. The other requirements will be implemented during construction.
AQ-04c: Submit SF6 leak detection and repair program 90 days prior to construction	On April 2, 2010, the CPUC approved the submittals provided by SDG&E that documented its partnership with the U.S. EPA and development of a SF6 Leak Detection and Repair Program, which addressed the requirements included in this measure. The CPUC approval acknowledged satisfaction of this measure.
AQ-04c: Become a Partner in EPA's SF6 Partnership prior to construction.	The Partnership MOU between SDG&E and the U.S. EPA was established on February 24, 2010.
AQ-04c: Report SF6 emissions to CCAR	A SF6 Leak Detection and Repair Program was approved on March 12, 2010 and discusses the reporting procedures to the CCAR. SDG&E will implement the program and submit reports as required,
AQ-APM-02: Prohibit grading when wind exceeds 25 mph	This mitigation measure will be fulfilled during construction. SDG&E will prohibit construction grading on days when the wind gusts exceed 25 mph.
AQ-APM-02: Cover loads in trucks or maintain 2 feet of freeboard	This mitigation measure will be fulfilled during construction.

Location: Link 3

Mitigation Measure and APM	Status
AQ-APM-02: Install snow fence-type windbreaks	This mitigation measure will be fulfilled during construction.
AQ-APM-02: Limit vehicle speeds to 15 mph on unpaved roads	This mitigation measure will be fulfilled during construction.
AQ-APM-02: Water unpaved roads	This mitigation measure will be fulfilled during construction.
AQ-APM-02: Apply soil stabilizers	This mitigation measure will be fulfilled during construction.
AQ-APM-02: Contain exposed stockpiles of soil and other material	This mitigation measure will be fulfilled during construction.
AQ-APM-03: Use methods to minimize mud and dust tracking on paved roads	This mitigation measure will be fulfilled during construction. The Dust Control Plan approved by the CPUC on January 20, 2010 will be implemented and enforced during construction.
AQ-APM-04: Encourage carpooling to job sites	The SWEAP video, approved by the CPUC on March 15, 2010, encourages carpooling. This video will be shown to all Project Personnel and enforced throughout all phases of the Project.
AQ-APM-05: Minimize vehicle idling time with common sense approach	The SWEAP video was approved by the CPUC on March 15, 2010. The video addresses vehicle idling. The video will be shown to all Project personnel and enforced throughout all phases of the Project.
AQ-APM-05: Conduct briefings on common sense vehicle use	This mitigation measure will be implemented during construction.
H-01a: Submit a grading and drainage plan prior to construction	Grading, drainage and landscaping plans for the Suncrest Substation were submitted on June 22, 2010. The SWPPP for the substation was submitted on September 15, 2010. CPUC approved the the Suncrest Substation Drainage Study on October 13, 2010.
H-01a: Grade at substations during dry season months	This mitigation measure will be fulfilled during construction as per the SWPPP submitted on September 15, 2010.
H-01a: Cease construction during rainfall when rutting occurs	This mitigation measure will be fulfilled during construction as per the SWPPP submitted on September 15, 2010.
H-01a: Install drainage and erosion control BMPs prior to winter rains	This mitigation measure will be fulfilled during construction as per the SWPPP submitted on September 15, 2010.
H-02d: Provide vehicle and equipment maintenance log monthly	This mitigation measure will be implemented during construction. A vehicle and equipment maintenance log will be provided to the CPUC and BLM once monthly during project construction.
H-04b: Manage blasting near wells or springs with a Blasting Plan for each site	Two existing water wells occur on Link 3. Protection of these wells will be addressed in site-specific blasting plan that will be developed during construction as needed. Blasting plans will be submitted to the CPUC prior to blasting at the site.
H-05a: Construct substation pads with pervious surfaces	The substation pad will be constructed with a gravel surface in appropriate areas as depicted in the approved grading plans to ensure maximum percolation of rainfall after construction.
H-05a: Install detention/retention basins	Detention/retention basins shall be installed as shown in the landscaping and drainage plans submitted to the CPUC on June 22, 2010 and approved on October 13, 2010.
H-05a: Provide erosion protection to downstream drainage discharge points	Erosion protection for downstream drainage points will be installed as shown in the landscaping and drainage plans submitted to the CPUC on June 22, 2010. These plans were approved by CPUC on October 13, 2010.
H-05a: Submit drainage design hydrologic and hydraulic analysis prior to construction	Grading plans for Suncrest Substation were submitted on June 22, 2010. Landscape and drainage plans were submitted on June 22, 2010. SDG&E submitted a copy of the Drainage Study to the CPUC in response to comments regarding the hydrologic and hydraulic analysis on October 5, 2010. CPUC approved the Suncrest Substation Drainage Study on October 13, 2010.
H-07a: Submit a Hazardous Substance Control and Emergency Response Plan 60 days prior to construction	A memo was submitted to the CPUC on Wednesday September 15, 2010 documenting compliance with this mitigation measure and Waste Discharge Identification numbers assigned by the California State Water Resources Control Board. Compliance with this mitigation measure was fulfilled by development of the SWPPP submitted to the CPUC on September 15, 2010. WDID#937C357500 was assigned to the Suncrest Substation.

Location: Link 3

Mitigation Measure and APM	Status
WQ-APM-01: Minimize disturbance to water resources	This mitigation measure will be fulfilled during construction. Grading plans for Suncrest Substation were submitted on June 22, 2010. Landscape and drainage plans were submitted on June 22, 2010. The Suncrest Drainage Study was approved by the CPUC on October 13, 2010. These plans demonstrate how disturbance to water resources will be minimized.
WQ-APM-02: Avoid sensitive water features	A memo was submitted to the CPUC documenting compliance with Mitigation Measure WQ-APM-2, Task 1, on August 30, 2010. The April 30, 2010 Mapbook illustrates changes to the final design incorporating relocation of structures to avoid sensitive features to the maximum extent possible. A revised Mapbook and PMR was submitted to the CPUC on May 14, 2010 and approved on September 22, 2010.
WQ-APM-03: Clearly mark restricted sites prior to construction	Specific sites as identified by authorized agencies will be staked and flagged by a qualified biologist prior to construction and documented in the weekly monitoring report.
WQ-APM-03: Train construction personnel to recognize markers	The SWEAP video, which was approved by the CPUC on March 15, 2010, includes recognition of markers and equipment movement restrictions. This SWEAP will be shown to all project personnel and enforced throughout all phases of the Project.
WQ-APM-04: Maintain adequate distance from stream banks	This mitigation measure will be fulfilled during construction.
WQ-APM-04: Use existing bridges to cross major streams	This mitigation measure will be fulfilled during construction.
WQ-APM-04: Span riparian areas where feasible	Impacts to surface water, riparian areas, and floodplains, were considered during design of the project and have been avoided or will be spanned, to the extent feasible. The Project Modification Report, which was submitted on May 14, 2010 and acknowledged by a Determination Memorandum from the CPUC dated September 22, 2010, describes changes to the Suncrest Substation (PMR29). A small intermittent drainage crosses the northern portion of the substation footprint. This area is addressed in the Suncrest Substation Drainage Study approved by the CPUC on October 13, 2010.
WQ-APM-04: Prepare and implement erosion control BMPs per the SWPPP	The preconstruction component of this measure is complete. SDG&E has obtained a WDID #937C357500 for Link 3 and the SWPPP was submitted to the CPUC on September 15, 2010 for the administrative record. Implementation of the SWPPP will be performed during construction. Qualified Stormwater monitors will be on-site during construction monitoring erosion control. This will be documented in the weekly monitoring report.
WQ-APM-04: Select upland pull sites to minimize disturbance to water resources	There are no pull sites included as part of construction activities for the substation; therefore, this measure does not apply.
WQ-APM-04: Do not place structures in streambeds or drainage channels	To the extent feasible, structures were not designed to be located within streambeds and drainage features. Construction areas are shown in the Project Modification Report Map Book which was submitted to the CPUC on May 14, 2010 and approved by the CPUC and BLM in the Determination Memorandum on September 22, 2010. Construction activities at the Suncrest Station will include construction of a box culvert at the Bell Bluff Truck Trail and Peterson Creek crossing.
WQ-APM-05: Construct stream crossings and develop a mitigation and restoration plan	Stream crossings will be constructed at low flow periods when feasible. The Habitat Mitigation and Monitoring Plan (HMMP) addresses mitigation and restoration associated with construction activities that affect stream crossings. The HMMP was submitted on July 14, 2010 and resubmitted on October 8, 2010 to address agency comments. The HMMP has been accepted by the ACOE, CDFG and SWRCB in concept; however, the agencies have asked that the report be reformatted to break out each mitigation property separately. SDG&E will not impact jurisdictional areas prior to approval of the final HMMP.
WQ-APM-06: Avoid designated surface water protection areas	The final project alignment is in the vicinity of the following source water; Lake Morena, Barrett Lake, El Capitan Reservoir, and San Vicente Reservoir. All these source waters will be avoided. The nearest source water to a project facility is the El Capitan Reservoir (Link 5). Structure CP72-2 (PMR mapbook page MS-119) is within 350 feet of the reservoir. The pullsite adjacent to the structure is approximately 100 feet from the reservoir. The next nearest source water to a project facility is the San Vincente Reservoir (Link 5), which is approximately 1650 feet from structure CP39 (PMR mapbook page MS-132). All other source waters are at least 1 mile from a project facility.
WQ-APM-06: No diversions, detention, retention, or consumption of surface waters	No diversions, detention, retention or consumption of surface waters will be performed unless specifically authorized by appropriate agencies and necessary permits are obtained.

Location: Link 3

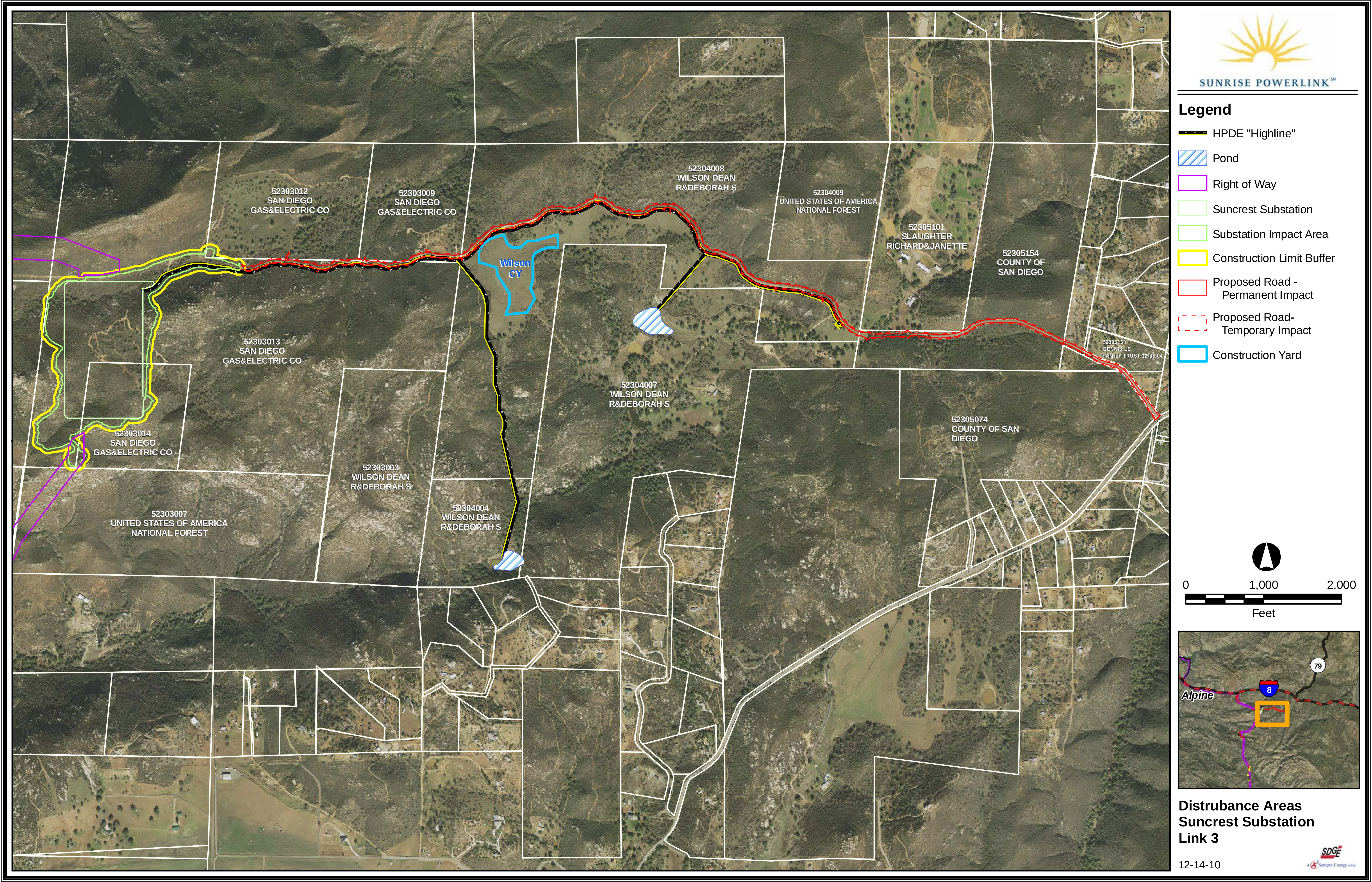
Mitigation Measure and APM	Status
WQ-APM-06: Conduct interviews with affected landowners prior to construction	Consultations with affected landowners have taken place and water wells have been identified.
WQ-APM-06: Negotiate with landowners to provide alternative water supplies	SDG&E has consulted with affected landowners regarding protection of groundwater supplies; no groundwater supplies will be used during construction therefore this mitigation measure is not applicable.
WQ-APM-08: Obtain permits prior to discharging groundwater into storm drains	Groundwater supplies will not be discharged into storm drains during project construction; therefore this mitigation measure is not applicable.
WQ-APM-08: Contain and sample if dewatering and then release water according to test results	Discharge of groundwater will not be required during construction. If dewatering is necessary during construction, the requirements of this measure will be implemented.
WQ-APM-09: Storing fuels and hazardous materials prohibited near wells	Two wells have been identified on Link 3. The well located within the 200-foot buffer along the road will be closed and the well in the center of the substation will be appropriately protected to prevent fuels and hazardous materials from entering it. The well in the center of the substation will be used post construction for fire protection and irrigation. This mitigation measure will be fulfilled during construction.
WQ-APM-10: Minimize stream bank erosion	Substation equipment would not be installed in areas that cross below or pass adjacent to streams with erodible bed or banks; therefore, this measure is not applicable.
WQ-APM-13: Dispose trash into enclosed containment	A trash enclosure will be provided during construciton.
WQ-APM-13: Remove hazardous materials to a hazardous waste facility and promptly clean up if released onto ground	This mitigation measure will be fulfilled during construction.
WQ-APM-14: Obtain NPDES permit and implement a SWPPP	The SWPPP and NPDES permits associated with WDID #937C357500 were submitted to the CPUC on September 15, 2010. The conditions of the permit and SWPPP will be implemented and enforced during the Project to prevent and avoid hydrologic impacts.
WQ-APM-15: Adjust route of access roads to avoid sensitive features	To the extent possible, access roads were designed to be constructed as outlined in this mitigation measure. The Project Modification Report and Mapbook, which was submitted May 14, 2010 and approved by the BLM and the CPUC through a Determination Memorandum on September 22, 2010, identified modifications to the Project that reduce impacts to "waters of the U.S." or waters of the state. Revised 401, 404 and 1602 permit applications were submitted for review and approval on August 18, 2010 and March 30, 2010. SDG&E received the signed 401 Water Quality Certification on November 15, 2010. The California Department of Fish and Game issued a Streambed Alteration Agreement (SAA) on November 17, 2010. SDG&E will not impact streambeds until the remaining permit is issued. (see BIO-APM-05)
WQ-APM-15: Use existing roads or cross-country access routes	Construction and maintenance traffic will use existing roads where feasible. This mitigation measure will be fulfilled during construction.
WQ-APM-15: Clearly mark approved construction traffic routes	Construction traffic routes associated with Link 3 have been identified as Japutal Valley Road to Bell Bluff Truck Trail. These construction routes were approved by the County of San Diego during the August 24, 2010 meeting and with affected landowners.
WQ-APM-16: Conduct site-specific assessment where sensitive water resources cannot be avoided	Biological, hydrology and cultural resource assessments were completed in accordance with the ACOE and CDFG guidelines. Permit applications for ACOE 404 Nationwide 12, CDFG 1600 Streambed Alteration Agreement and Regional Water Quality Control Board 401 Water Quality Certification were submitted on March 30, 2010.
WQ-APM-16: Locate staging/storage areas outside of riparian areas	Staging and storage areas for equipment and materials have been located outside of riparian areas.
WQ-APM-16: Obtain a Streambed Alteration Agreement when constructing new access through streambeds	The California Department of Fish and Game issued a Streambed Alteration Agreement (SAA) on November 17, 2010. A copy of the SAA will be maintained onsite during construction.
G-03a: Submit design-level geotechnical studies 60 day prior to final project design	A Geotechnical Investigation Report for Suncrest Substation dated December 21, 2009 was approved by the CPUC on September 2, 2010. The final project design is based on the findings of this report.

Location: Link 3

Mitigation Measure and APM	Status
GEO-APM-01: No widening or grading of existing access roads if soil is sensitive to disturbance	The FEIR/EIS identified sensitive soils as "natural sand sources that supply the material for sand dune systems throughout the ABDSP." The project no longer impacts ABDSP and there are no sand dune systems along the project route; therefore, this mitigation measure does not apply.
GEO-APM-02: Minimize soil disturbance or return to pre-construction contours and condition	This mitigation measure will be fulfilled during and post construction.
GEO-APM-03: Avoid placing structures in areas of high shrink/swell potential	A report titled, "Geotechnical and Geologic Hazards Investigation Report" was submitted to CPUC for review and approval on April 19, 2010. The report determined that no areas of high shrink/swell are present. The CPUC geotechnical consultant issued a memorandum on June 18, 2010 confirming concurrence with this finding. Therefore, this measure does not apply.
GEO-APM-04: Place structures in geologically stable areas	A Geotechnical Investigation Report for the Suncrest Substation dated December 21, 2009 was submitted on April 19, 2010 and approved by the CPUC on September 2, 2010. The final project design is based on the findings of this report.
GEO-APM-05: Implement construction to avoid or minimize new soil disturbance	Project construction activities have been designed to avoid or minimize new disturbance, erosion on manufactured slopes, and off-site degradation from accelerated sedimentation. During construction, impacts from accelerated sedimentation will also be minimized through implementation of the SWPPP.
GEO-APM-05: Maintain cut and fill slopes with erosion control and repair	This mitigation measure will be fulfilled during construction.
GEO-APM-06: Perform surface restoration for erosion control and re-vegetation	This mitigation measure will be fulfilled during construction as per the Grading and Landscaping and Draining plans submitted to the CPUC on March 24, 2010 and June 22, 2010.
GEO-APM-08: Remove or stabilize boulders and span structures over landslide areas	This mitigation measure will be fulfilled during construction.
GEO-APM-09: Implement field mitigation efforts if paleontological resources are encountered	If paleontological resources are encountered during construction, this mitigation measure will be implemented.
GEO-APM-09: Consult with agencies if paleontological resources cannot be avoided	If paleontological resources are encountered during construction, this mitigation measure will be implemented.
PSU-APM-01: Coordinate with utility providers	There are no third party utilities that will be affected by the project; therefore, this mitigation measure does not apply.
PSU-APM-02: Notify Underground Service Alert 48 hours prior to earth-disturbing activities	This mitigation measure will be implemented immediately prior to construction.
PSU-APM-03: Minimize disruption to response times and access for emergency and police services	The FEIR/EIS and a Traffic Impact Analysis performed by SDG&E indicated that construction of the substation should not cause lane closures or impact emergency and polices services. However, SDG&E will coordinate activities with emergency responders during construction.
S-03a: Provide documentation to show amount of waste recycled	This mitigation measure will be implemented during and following the completion of construction.
S-03b: Coordinate with water districts	A Water Use Study that discussed coordination efforts with local water districts was submitted for review on February 22, 2010. Potable water will be used during construction until approval is received to use reclaimed water.
S-03b: Provide letter 60 days prior to construction describing availability of reclaimed water and efforts to obtain for use	A Water Use Study describing the availability of reclaimed water was submitted on February 22, 2010. In addition, the Project Modification Report submitted to CPUC on May 14, 2010 and approved September 22, 2010 addressed the use of reclaimed water for the project.
F-01a: Submit draft Construction Fire Prevention Plan 90 days prior to construction	A Construction Fire Plan was acknowledged by the CAL FIRE Chief and was approved by the CPUC on February 2, 2010. Coordination with Cal FIRE will continue during construction to assess and mitigate any additional fire hazards associated with substation construction activities.

Location: Link 3

Mitigation Measure and APM	Status
F-01a: Receive approval of final Plan 30 days prior to construction	A Construction Fire Plan was acknowledged by the CAL FIRE Chief and was approved by the CPUC on February 2, 2010. Coordination with Cal FIRE will continue during construction to assess and mitigate any additional fire hazards associated with substation construction activities.
F-01a: Implement Fire Plan during construction and maintenance	A Construction Fire Plan was acknowledged by the CAL FIRE Chief and was approved by the CPUC on February 2, 2010. Coordination with Cal FIRE will continue during construction to assess and mitigate any additional fire hazards associated with substation construction activities.
F-01c: Do not obstruct firefighting equipment or crews	The Traffic Study, which was approved by San Diego County on September 29, 2010, illustrated that construction will not obstruct emergency response operations. During construction, SDG&E will ensure that construction does not obstruct firefighting operations.
F-01c: Coordinate fire suppression activities and unobstruct access roads at all times	This measure will be implemented during construction.
F-01c: Cease construction in work areas if fire within 1,000 feet	This measure will be implemented during construction.
F-01c: Contact dispatch centers 2 days prior to helicopter use	Helicopters will not be used during construction at the Suncrest Substation. This mitigation measure will be implemented regarding helicopter operations at Wilson Yard.
F-01d: Clear and spread onsite dead and decaying vegetation prior to construction and maintenance	SDG&E will clear dead and decaying vegetation from work areas prior to initiating grading activities and/or maintenance work. Clearing of dead and decaying vegetation will be monitored during construction and observations will be summarized and submitted to the CPUC in the weekly report.



SUNRISE POWERLINK℠
Legend
HPDE "Highline"
Pond
Right of Way
Suncrest Substation
Substation Impact Area
Construction Limit Buffer
Proposed Road - Permanent Impact
Proposed Road- Temporary Impact
Construction Yard
52303012 SAN DIEGO GAS&ELECTRIC CO
52303009 SAN DIEGO GAS&ELECTRIC CO
52304008 WILSON DEAN R&DEBORAH S
52304009 UNITED STATES OF AMERICA NATIONAL FOREST
52305101 SLAUGHTER RICHARD&JANETTE
52305154 COUNTY OF SAN DIEGO
Wilson CY
52303013 SAN DIEGO GAS&ELECTRIC CO
52304007 WILSON DEAN R&DEBORAH S
52305074 COUNTY OF SAN DIEGO
52303014 SAN DIEGO GAS&ELECTRIC CO
52303003 WILSON DEAN R&DEBORAH S
52304004 WILSON DEAN R&DEBORAH S
52303007 UNITED STATES OF AMERICA NATIONAL FOREST
0
1,000
2,000
Feet
79
8
Alpine
Distrubance Areas
Suncrest Substation
Link 3
12-14-10
SDG&E
A Sempra Energy utility

ES EXECUTIVE SUMMARY

This Environmental Impact Report/Environmental Impact Study (EIR/EIS) does not make a recommendation regarding the approval or denial of the project. It is purely informational in content and will be used by the permitting agencies (including California Public Utilities Commission (CPUC) and Bureau of Land Management (BLM)) in considering whether to approve the East County (ECO) Substation, Tule Wind, and Energia Sierra Juarez U.S. Generator-Tie (ESJ Gen-Tie) projects (collectively referred to as the Proposed PROJECT), or any of the alternatives analyzed in this EIR/EIS.

The CPUC is the state lead agency, responsible for compliance with the California Environmental Quality Act (CEQA). The BLM, the federal lead agency, is responsible for compliance with the National Environmental Policy Act (NEPA). A Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS) was prepared by the CPUC and BLM in compliance with CEQA and NEPA Guidelines and published in December 2010 with a 70-day comment period that ended on March 4, 2011. The Final EIR/EIS consists of four volumes. Volumes 1 and 2 are completely reprinted from the Draft EIR/EIS and changes made since public review are signified as a replacement, addition, or revision to existing text. Revisions to existing text are signified by strikeout (i.e., ~~strikeout~~) where text is removed, and by underlined text (i.e., underline) where text is added for clarification. Volumes 3 and 4 of the Final EIR/EIS contain all responses to comments received on the Draft EIR/EIS as well as comment letters received during the public review period.

This executive summary is organized as follows:

- ES.1, Introduction
- ES.2, Agency Use of the Document
- ES.3, Project Overview ~~and Objectives~~
- ES.4, Areas of Controversy/~~Public Scoping~~ Issues
- ES.5, Project Alternatives
- ES.6, Summary of the Environmental Analysis
- ES.7, Anza-Borrego Desert State Park
- ES.8, Environmentally Superior Alternative/Agency-Preferred Alternative
- ES.9~~8~~, Issues to be Resolved.

ES.1 Introduction

San Diego Gas & Electric Company (SDG&E) has filed an application (A.09-08-003) for a Permit to Construct (PTC) with the CPUC for the proposed ECO Substation Project. The proposed ECO Substation Project would be located near the unincorporated communities of Jacumba and Boulevard, approximately 70 miles east of downtown San Diego, in the southeastern portion of San Diego County, California. The proposed ECO Substation Project would primarily be located on private lands with a 1.5-mile portion of the proposed 138-kilovolt (kV) transmission line project component located on federal lands ~~administered~~ managed by the BLM; therefore, SDG&E has also requested a right-of-way (ROW) grant from the BLM for the 1.5-mile portion of the proposed 138 kV transmission line component.

In considering the proposed ECO Substation Project, the CPUC and BLM have evaluated a range of projects, including active generator applications that have been submitted to the California Independent System Operator (CAISO) for connections to the Southwest Powerlink (SWPL) through the proposed SDG&E ECO Substation Project. The CPUC and BLM have evaluated these projects to determine whether they are so closely related to the proposed ECO Substation Project as to be considered “connected actions” under the National Environmental Policy Act (NEPA) and “whole of the action” under the California Environmental Quality Act (CEQA). The CPUC (as the state lead agency under CEQA) and the BLM (as the federal lead agency under NEPA) have identified two projects in these categories:

- Tule Wind Project, as proposed by ~~Pacific Wind Development~~Tule Wind, LLC (a subsidiary of Iberdrola Renewables, Inc.), which would tie into the proposed Boulevard Substation rebuild component of the ECO Substation Project
- Energia Sierra Juarez U.S. Generator-Tie Project, as proposed by Energia Sierra Juarez U.S. Transmission, LLC, which would connect to the proposed ECO Substation.

These two projects, along with the proposed ECO Substation Project, are collectively referred to as the Proposed PROJECT. In addition, the proposed Invenergy and SDG&E Campo Wind Project, as well as the Manzanita Wind Project and Jordan Wind Project, which would connect to the Boulevard Substation Rebuild are viewed as reasonably foreseeable. The CPUC and BLM have determined that these three wind energy projects are sufficiently developed to analyze impacts where feasible. Therefore, for purposes of this EIR/EIS, the Campo, Manzanita, and Jordan projects are qualitatively evaluated at a programmatic level because sufficient project-level information has yet to be developed. The proposed Campo, Manzanita, and Jordan wind energy projects will still require project-specific environmental review and evaluation under all applicable environmental regulations once sufficient project-level information is developed. By including these nascent wind projects as components of the proposed wider PROJECT, it allows the lead agencies to further consider broad impacts, mitigation and consequences of the ECO substation project specifically, and the wider PROJECT as a whole.

This EIR/EIS has been prepared jointly by the CPUC and BLM to evaluate the environmental impacts that would be expected to result from construction and operation of the Proposed PROJECT, including the Campo, Manzanita, and Jordan wind energy projects. This EIR/EIS provides mitigation measures, which, if adopted, would avoid or minimize many of the significant environmental impacts identified and in accordance with CEQA and NEPA requirements, identifies and evaluates the environmental impacts of alternatives to the Proposed PROJECT.

ES.1.1 Changes made to the Draft EIR/EIS

In response to comments on the Draft EIR/EIS and through consultation with government agencies, changes have been made in the Final EIR/EIS. The following information has been added to or revised in this Final EIR/EIS and is listed by EIR/EIS section.

Section B Project Description

1. **Tule Wind, LLC Modified Project Layout.** After the Draft EIR/EIS was released for public review in December 2010, Tule Wind, LLC modified the Tule Wind Project layout to reduce the overall size of the project. The modified project as presented and analyzed in the Final EIR/EIS reduces the number of turbines and adjusts the transmission line route and access roads, as well as slightly modifies the layout of some of the turbine locations, as depicted in the Draft EIR/EIS. Table ES-1 provides a comparison of the Tule Wind Project analyzed in the Draft EIR/EIS with the Tule Wind modified project. The analysis supporting the evaluation of these modifications for each environmental topic is provided under the "Direct and Indirect Effects" heading under the "Tule Wind Project" discussion in Sections D.2 through D.18, in this Final EIR/EIS.

Table ES-1
Comparison of the Draft EIR/EIS versus Modified Tule Wind Project

Component	Draft EIR/EIS Project	Modified Project
Turbines	134 (200 MW)	128 (201 MW)
Met Towers	2 (197 feet)	3 (219 – 328 feet) new tower on northwest ridge on Ewiiaapaayp lands near turbine L-6
SODAR unit	SODAR	May include LIDAR unit (same location as SODAR)
Batch Plant[1]	on BLM	Location on BLM land moved slightly to the northeast from the location shown in the Draft EIR/EIS

Table ES-1 (Continued)

Component	Draft EIR/EIS Project	Modified Project
Underground collector system	42 – 50 inch deep trench	44 – 50 inch deep trench
Overhead collector system	232 poles Temporary Impact: 108.2 acres	250 poles Temporary Impact: 127 acres
138 kV transmission	100 feet ROW Single circuit 108 poles 9.7 miles	125 feet ROW Double circuit 80 poles 9.2 miles
Access Roads	New: 36.4 miles Improved: 27.6 miles Total land requirement: 250.3 acres	New: 36.8 miles Improved: 23.4 miles Total land requirement: 236.1 acres
Laydown area locations	38 Temporary fencing would occur	38 – no change in number but some locations are modified Temporary fencing may occur

Notes:
[1] Of the two alternative batch plant locations provided in the modified project layout, the alternative Rough Acres Ranch location for the batch plant is carried forward and considered in Tule Wind Project Alternatives 1 through 4.

These modifications to the Tule Wind Project are not the types of changes that would require analysis through supplementation or recirculation of the Draft EIR/EIS because the modifications reduce the overall size of the project. Therefore, these modifications to the Tule Wind Project are within the scope of the original Draft EIR/EIS analysis and such changes are insignificant as the term is used in Section 15088.5(b) of the CEQA Guidelines. Under NEPA, these changes do not result in new significant circumstances or information relevant to environmental concerns, or require analysis of a new alternative (40 CFR 1502.9(c)(1)(ii)).

2. **ESJ Gen-Tie Project Water Well Access Road.** In order to access well water for use during construction, approximately 4 miles east of ESJ Gen-Tie site, a new access route (150 feet by 20 feet) is proposed from Old Highway 80 to an existing well site. The new access road would facilitate access to an existing water well on property owned by the Jacumba Community Services District. This modification is addressed in Section B and its effects are analyzed in Section D.

Section C Alternatives

1. **SDG&E ECO Substation Project Alternatives.** After release of the Draft EIR/EIS for public review in December 2010, a modification to the ECO Partial Underground 138 kV Transmission Route Alternative was developed through government-to-government Section 106 consultation to reduce potential impacts to cultural resources in the proposed Jacumba National Register

District between milepost (MP) 0.3 and 2.4. In addition, through consultation with the U.S. Army Corps of Engineers (ACOE), a modification to the ECO Substation Alternative Site was developed to reduce environmental effects to jurisdictional wetlands and cultural resources.

The proposed modifications to the ECO Partial Underground 138 kV Transmission Route Alternative and ECO Substation Alternative Site are summarized below in Section ES.5.2.1 and are described in detail in Section C, Alternatives, in this Final EIR/EIS. The analysis supporting the evaluation of the modifications of these alternatives for each environmental topic is provided under the headings "ECO Substation Alternative Site" and "ECO Partial Underground 138 kV Transmission Route Alternative" in Sections D.2 through D.18 of this Final EIR/EIS.

The modifications to the ECO Partial Underground 138 kV Transmission Route Alternative and ECO Substation Alternative Site are not the types of changes in circumstance that would require analysis through supplementation of the Draft EIR/EIS because the modifications minimize or avoid effects on the environment. Therefore, these modifications to the ECO Partial Underground 138 kV Transmission Route Alternative and ECO Substation Alternative Site are within the scope of the original Draft EIR/EIS analysis and such changes are insignificant as the term is used in Section 15088.5(b) of the CEQA Guidelines. Under NEPA, these changes do not result in new significant circumstances or information relevant to environmental concerns or require analysis of a new alternative (40 CFR 1502.9(c)(1)(ii)).

2. **Tule Wind Project Alternatives (Alternatives 1 through 4 (Gen-Tie Routes 2 and 3 with Collector Station and O&M Facility on Rough Acres Ranch).** During public review of the Draft EIR/EIS, Tule Wind, LLC proposed an alternative location for the temporary 5-acre batch plant on Rough Acres Ranch. In addition, during the Section 106 government-to-government consultation, a concern was raised by Indian tribes regarding the location of the overhead collector line to the west of Lost Valley Rock (or its Kumeyaay name, "wekatoekush"), a geological feature located to the west of McCain Valley Road that holds value to the tribes. These alternatives address moving the overhead collector line to the east side of Lost Valley Rock to the 138 kV transmission line corridor that is vacated by moving the collector substation and O&M facility to Rough Acres Ranch. These modifications are summarized below in Section ES.5.2.2 and are addressed in Section C. Their effects are described in Section D.

   These modifications to the Tule Wind Project Alternatives (Alternatives 1 through 4) are not the types of changes in circumstance that would require analysis through supplementation of the Draft EIR/EIS because the modifications minimize effects on the environment. Therefore, these modifications to the Tule Wind Project Alternatives (Alternatives 1 through 4) are within the scope of the original Draft EIR/EIS analysis and such changes are insignificant as the term is used in Section 15088.5(b) of the CEQA Guidelines. Under

NEPA, these changes do not result in new significant circumstances or information relevant to environmental concerns, or require analysis of a new alternative (40 CFR 1502.9(c)(1)(ii)).

3. **Tule Wind Project Alternatives (Alternative 5, Reduction in Turbines).** Under this alternative, the proposed Tule Wind Project would consist of 65 turbines with the removal of 63 specific turbines to include six (6) turbines adjacent to the In-Ko-Pah Mountains Area of Environmental Concern (ACEC) being S1, R4, (R8), R8, R9, and R10 and 57 turbines on the western side of the project site including all turbines in the J, K, L, M, N, P, and Q strings. These modifications are described in Section C and their effects are analyzed in Section D.

Section D Environmental Analysis

1. **Revised Analysis and Mitigation Measures.** Various text sections have been modified in Section D, Environmental Analysis, or clarified in response to comments (see Section ES.4.2 for summary of comments received during public review of the Draft EIR/EIS). In addition, impact category FF-1 in Section D.15, Fire and Fuels Management, was clarified to distinguish this impact from Impact FF-2 and several mitigation measures have been modified for clarity or to ensure their feasibility (see various issue areas in Section D).

2. **Consideration of BLM Lands with Wilderness Characteristics.** Pursuant to the Federal Land Policy and Management Act, the BLM is required to conduct and maintain resources inventories for all public lands under its jurisdiction. BLM Instruction Memorandum (IM) 2011-154 reiterates the requirement for offices to conduct and maintain inventories regarding the presence and absence of wilderness characteristics, and to consider identified lands with wilderness characteristics when analyzing projects under NEPA. The BLM conducted an inventory for the Tule Wind Project site and determined that lands with wilderness characteristics are present (see Figure D.5-3, BLM Lands with Wilderness Characteristics). The wilderness characteristics inventory is summarized in EIR/EIS Section D.5, Wilderness and Recreation (see Section D.5.1.1). Impact WR-3a (presence of a project component in BLM lands with wilderness characteristics would substantially compromise wilderness characteristics), has been added to the Final EIR/EIS for the proposed Tule Wind Project and Tule Wind Project alternatives (see Section D.5.3.3, Impact WR-3a and subsections D.5.5.1 through D.5.5.5, Impact WR-3a).

ES.2 Agency Use of the Document

This EIR/EIS will be used by the permitting agencies (including CPUC and BLM) in considering whether to approve the ECO Substation, Tule Wind, and ESJ Gen-Tie projects, or any of the alternatives analyzed in this EIR/EIS. This EIR/EIS will not be used by the permitting agencies as the primary NEPA/CEQA document in consideration of the proposed Campo, Manzanita, and

Jordan wind energy projects, which will require project-specific environmental review and evaluation under all applicable environmental regulations once sufficient project-level information has been developed. By considering the Campo, Manzanita, and Jordan wind energy projects on a broad programmatic level earlier in the planning process, the permitting agencies are able to undertake a more comprehensive evaluation of all of the potential significant effects, including cumulative impacts, related to the overall Proposed PROJECT.

ES.2.1 California Public Utilities Commission

This EIR/EIS will be used by the CPUC, in conjunction with other information developed in the CPUC's formal record, to act only on SDG&E's application for a PTC and permission to operate the proposed ECO Substation. After the Final EIR/EIS is completed and certified, the CPUC will make a final decision on the ECO Substation Project. The Administrative Law Judge (ALJ) overseeing the PTC will prepare the proposed decision based on the environmental documentation and testimony from parties to the proceeding. The ALJ and CPUC will consider the final environmental document, along with other issues, during preparation of the decision on the PTC application.

ES.2.2 Bureau of Land Management

BLM is the federal lead agency for preparation of this EIR/EIS in compliance with the requirements of NEPA, the Council on Environmental Quality (CEQ) regulation for implementing NEPA (40 CFR 1500 et seq.), and the BLM NEPA Handbook (H-1790-1) in the evaluation of SDG&E's proposed ECO Substation Project and ~~Pacific Wind Development's~~Tule Wind, LLC's proposed Tule Wind Project.

The BLM's purpose and need for the ECO Substation and Tule Wind projects is to respond to SDG&E's and ~~Pacific Wind Development's~~Tule Wind, LLC's applications under Title V of the Federal Land Policy and Management Act (FLPMA,43 U.S.C. 1701 et seq.) for an ROW grant to construct, operate, maintain, and decommission a wind energy facility (Tule Wind Project) and a 138 kV transmission line on public lands (ECO Substation Project) in compliance with FLPMA, BLM ROW regulations, and other applicable federal laws. The BLM will consider the Final EIR/EIS and decide whether to approve, approve with modification, or deny issuance of an ROW grant to the applicants for their proposed projects.

ES.2.3 Responsible/Cooperating Agencies

Responsible/cooperating agencies, including the County of San Diego, California State Lands Commission, Bureau of Indian Affairs (BIA), Ewiiaapaayp Band of Kumeyaay Indians, and the ~~U.S. Army Corps of Engineers (~~ACOE~~)~~, will also use the EIR/EIS for their approval processes. Following certification of the EIR/EIS by the CPUC, the County of San Diego will use the

EIR/EIS for its discretionary action under CEQA in consideration of issuing two separate major-use permits, one for the Tule Wind Project and one for the ESJ Gen-Tie Project, because portions of those projects are within the County's jurisdiction. Because portions of the Tule Wind Project will occur on lands under the jurisdiction of the California State Lands Commission (CSLC) and the Ewiiaapaayp Band of Kumeyaay Indians, the BIA, Ewiiaapaayp Band of Kumeyaay Indians, and CSLC will also use the EIR/EIS for consideration of their required discretionary actions. Table ES-2~~1~~ lists agency jurisdiction by Proposed PROJECT component.

Following issuance of the Final EIR/EIS by the BLM, ACOE, depending on the total amount of waters of the U.S. impacted by the BLM-approved project, may ~~will~~ consider adoption of the document as a means of satisfying its NEPA requirements ~~and will use the EIR/EIS~~ in consideration of issuance of two separate Clean Water Act Section 404 permits, one for the Tule Wind Project and one for the ECO Substation Project.

Table ES-2~~1~~
Agency Jurisdiction of Project Components

Proposed PROJECT	Project Component	Jurisdiction	Miles/Acres[2] under Jurisdiction
ECO Substation Project	ECO Substation 500 kilovolt (kV) and 230/138 kV Yards	California Public Utilities Commission (CPUC)[1]	85.9 acres
	Southwest Powerlink (SWPL) Loop-In	CPUC [1]	1.74 acres
	138 kV Transmission Line	CPUC[1]	11.8 miles
		BLM	1.5 miles
	Boulevard Substation Rebuild	CPUC [1]	3.2 acres
Tule Wind Project	Wind Turbines and 34.5 kV Overhead and Underground Collector Cable System	Ewiiaapaayp Band of Kumeyaay Indians / BIA (18~~7~~ wind turbines)	~~20.2~~51.6 acres
		BLM (96~~7~~ wind turbines)	~~280~~ 277.9 acres
		CSLC (7 wind turbines)	~~37.5~~20.7 acres
		County of San Diego (7~~13~~ wind turbines)	~~49~~ 19.1 acres
	Collector Substation	BLM	5 acres
	Operations and Maintenance Facility	BLM	5 acres
	Meteorological Towers & SODAR/LIDAR unit	BLM	0.083~~62~~ acres
	138 kV Transmission Line	BLM	5.91~~7.42~~ miles
		County of San Diego	3.05~~1.96~~ miles
		State of California[3]	0.2~~3~~6 miles

Table ES-21 (Continued)

Proposed PROJECT	Project Component	Jurisdiction	Miles/Acres[2] under Jurisdiction
	New Roadways / Existing Roadways	Ewiiaapaayp Band of Kumeyaay Indians / BIA / Campo / Manzanita	12.3 miles
		BLM	36.2 miles
		County of San Diego	8.4 miles
		State of California	3.3 miles
ESJ Gen-Tie Project	500 kV Transmission Line (Steel Lattice Towers and Monopole Structures)	County of San Diego	10.65 acres
	230 kV Transmission Line (Steel Lattice Towers and Monopole Structures)	County of San Diego	9.6 acres
	Access Road to Existing Water Well	County of San Diego	0.06 acre (150 x 20 feet)
Campo Wind Project	Wind Turbines	Campo Band of Mission Indians and ~~CPUC~~BIA	unknown
	Switchyard and138 kV Transmission Line	BIA and / or CPUC[1]	unknown
Manzanita Wind Project	Wind Turbines	Manzanita Band of ~~in~~ Mission Indians and ~~CPUC~~BIA	unknown
	Switchyard and138 kV Transmission Line	BIA and / or CPUC[1]	unknown
Jordan Wind Project	Wind Turbines	County of San Diego	unknown
	Switchyard and interconnection transmission line	County of San Diego and / or CPUC	unknown

[1] Although these components of the ECO Substation, Campo, and Manzanita wind energy projects would be located on, or traverse, County of San Diego land, the County does not have jurisdiction of utility facilities. The CPUC has jurisdiction over these utilities according to California Constitution Article 12, Section 8.

[2] Acreage provided is permanent impact acreage. Temporary impact acreage for each project component is identified in Section B, Project Description, of this EIR/EIS. Mileage and acreage provided in table is approximate.

[3] The Tule Wind 138 kV transmission line would traverse State of California (Conservation Camp) lands and would cross Caltrans ROW at the Interstate 8 crossing.

As listed in Section A, Introduction/Overview, of this EIR/EIS, several other state and federal agencies may rely on information in this EIR/EIS to inform them in their decisions regarding issuance of specific permits related to project construction or operation: the Department of Transportation, California Department of Fish and Game, Regional Water Quality Control Board, and Office of Historic Preservation.

ES.3 Project Overview/~~Objectives~~

The Proposed PROJECT would be located in southeastern San Diego County, approximately 70 miles east of downtown San Diego, near the unincorporated communities of Jacumba and Boulevard (Figures ES-1, Regional Map, and ES-2, Vicinity Map/Overview Map). The following provides an overview of the Proposed PROJECT. A detailed project description is provided in Section B of this EIR/EIS.

ECO Substation Project

The ECO Substation Project, as proposed by SDG&E, includes the following major components:

- Construction of a 500/230/138 kV substation in eastern San Diego County
- Construction of the SWPL Loop-In, a short loop-in of the existing SWPL transmission line to the proposed ECO Substation
- Construction of a 138 kV transmission line, approximately 13.3 miles in length, running between the proposed ECO Substation and the rebuilt Boulevard Substation
- Rebuild of the existing Boulevard Substation.

The proposed ECO Substation Project would provide an interconnection hub for renewable generation along SDG&E's existing SWPL 500 kV transmission line. In addition to accommodating the region's planned renewable energy generation, the project would also provide a second source for the southeastern 138 kV transmission system that avoids the vulnerability of common structure outages, which would increase the reliability of electrical service for Boulevard, Jacumba, and surrounding communities.

Tule Wind Project

The Tule Wind Project, as proposed by ~~Pacific Wind Development~~Tule Wind, LLC, would include the following major components:

- Up to ~~134~~ 128 wind turbines, generating capacity ~~ranging in size~~ between 1.5-megawatt (MW) ~~(328 feet in height)~~ and 3.0 MW, ~~(492 feet in height)~~and ranging in height from 219 to 328 feet to the wind turbine hub (or nacelle), and 327 feet to 492 feet to the top-most blade tip, generating up to 201 MW of electricity
- A 34.5 kV overhead and underground collector cable system linking the wind turbines to the collector substation
- A 5-acre collector substation site and a 5-acre operations and maintenance (O&M) building site
- ~~Two~~ Three permanent meteorological towers and one sonic detecting and ranging (SODAR) unit or one light detecting and ranging (LIDAR) unit
- A 138 kV overhead transmission line running south from the collector substation to be interconnected with the rebuilt SDG&E Boulevard Substation.

The proposed Tule Wind Project would generate 201~~0~~ MW of electricity and would connect to the proposed Boulevard Substation rebuild component of SDG&E's ECO Substation Project where the electricity generated would feed into the existing SWPL 500 kV transmission line.

ESJ Gen-Tie Project

As proposed, the ESJ Gen-Tie Project would have the capacity to import up to 1,250 MW of renewable energy generated in northern Baja California, Mexico, and transmit to the existing SWPL transmission line in southeastern San Diego County, California. The selected route would interconnect with SDG&E's proposed ECO Substation and would be constructed on three to five 150-foot lattice towers or 170-foot steel monopoles, extending south from the point of interconnection for about 0.5 mile to the U.S. – Mexico international border. Only renewable energy would be transmitted via the gen-tie line. Although Energia Sierra Juarez U.S. Transmission, LLC, has proposed a 500 kV and a 230 kV Gen-Tie, only one of these would be built, with the 230 kV option being the preferred alternative. This EIR/EIS addresses both the 500 kV and 230 kV gen-tie lines, as well as potential biological, visual resource, and fire hazard impacts to the U.S. associated with wind turbines constructed in Mexico. In addition, approximately 4 miles east of the ESJ Gen-Tie site, a new access route (150 feet by 20 feet) is proposed from Old Highway 80 to an existing well site. Both the access route and well site are owned by the Jacumba Community Services District.

Campo Wind Project

SDG&E proposes to construct and operate approximately 106 turbines capable of generating 160 MW of electricity on its reservation lands. The project would be located south of the Tule Wind Project and west of the Boulevard Substation on the Campo Indian Reservation. Construction of the project is expected to occur over a single phase. Turbines (approximately 450 feet tall from ground to tip of the fully extended turbine blade) would be located on available ridgelines on the reservation. In addition to the 160 MW of generating capacity proposed for this project, the Campo Tribe has requested that an additional 140 MW of generation be analyzed in the BIA's NEPA review of the project for future development purposes. The proposed Invenergy and SDG&E Campo Wind Project would connect with the Boulevard Substation Rebuild component of the ECO Substation Project.

Manzanita Wind Project

The Manzanita Tribe proposes a project capable of generating up to 57.5 MW, which could include up to 25 wind turbines depending on the turbine size selected. These wind turbines are proposed to be located on the same ridgeline as the existing Kumeyaay Wind facility. Turbines are proposed to be approximately 414 feet tall from ground to tip of the turbine blade fully extended. The Manzanita Wind Project would connect with the Boulevard Substation Rebuild component of the ECO Substation Project.

It is expected that the Campo and Manzanita wind energy projects would develop a switchyard for both facilities on non-tribal lands and a new 138 kV transmission line would be constructed along the existing ROW of the 69 kV transmission corridor that currently connects to the existing Boulevard Substation. The new 138 kV transmission line would interconnect with the proposed Boulevard Substation Rebuild component of the ECO Substation Project.

Jordan Wind Project

The developers of the Jordan Wind Project have completed a preliminary wind energy assessment to construct and operate 40 2.3 MW turbines (total generating capacity of 92 MW) west of Boulevard in unincorporated San Diego County. The towers of the proposed wind turbines would be approximately 260 feet tall (height from ground to tip of fully extended blade would be approximately 430 feet). As proposed, construction of the project would occur between February and October 2013, and commercial operations are scheduled to begin in November 2013. The preferred point of interconnection for the Jordan Wind Project is the Boulevard Substation Rebuild component of the ECO Substation Project.

ES.4 Areas of Controversy/~~Public Scoping~~ Issues

ES.4.1 Scoping

In compliance with NEPA, the BLM posted a Notice of Intent (NOI) in the Federal Register on December 29, 2009, and in accordance with CEQA Guidelines, a Notice of Preparation (NOP) was prepared by the CPUC and mailed to the State Clearinghouse and other recipients on December 28, 2009, posted in the San Diego Union Tribune on December 28, 2009, and published in the Back County Messenger in their January edition. These actions initiated the 30-day public scoping period for the project. The comment period for the NOP ended on February 10, 2010, and on February 12, 2010, for the NOI. Comments were accepted until February 19, 2010. The scoping process provides an opportunity for governmental agencies and the public to provide comments on the issues and scope of the EIR/EIS. The CPUC and BLM held two public scoping meetings (January 27 and 28, 2010), to provide the public and governmental agencies information on the CEQA and NEPA process and to give them opportunities to identify environmental issues and alternatives for consideration in the EIR/EIS.

In total, 60 letters were received: 24 from federal, state, and local agencies and organizations; 35 from individuals; and 1 from the Campo Band of Mission Indians during the public scoping process. All comments received during the public scoping process are summarized in Section I of this EIR/EIS and included in the Public Scoping Report posted on the CPUC's website (see http://www.cpuc.ca.gov/environment/info/dudek/ECOSUB/ECOSUB.htm for Scoping Report).

Major issues discussed during this process included evaluation of alternatives, including project design alternatives such as undergrounding; alternative systems; and alternative energy technologies, such as distributed generation (DG), including rooftop solar panels. Environmental and social issues that were raised during scoping included impacts on a variety of sensitive resources, including impacts to natural scenery; biologically sensitive areas, including golden eagle (*Aquila chrysaetos)* and Q~~q~~uino checkerspot butterfly (*Euphydryas editha quino*) habitat; residential and recreational areas; areas susceptible to unstable conditions due to geology; increased risk of wildfire hazards; public health and safety; effects on local groundwater resources; as well as cumulative effects from other energy projects in the region in addition to all past, present, and reasonably foreseeable projects within the geographic range of the project.

According to the CEQA Guidelines, Section 15205(d), and NEPA (40 CFR 1506.10), the customary review period of a Draft EIR/EIS is 45 days. In accordance with CEQA and NEPA, the Notice of Availability (NOA) of the Draft EIR/EIS was distributed to more than 1,500 federal and state agencies; county and local jurisdictions; regional and local agencies, including local libraries; Native Americans; attorneys; private citizens; and the State Clearinghouse. The NOA, distributed on December 22, 2010, notified agencies, interested parties, and the public of the public review period of the Draft EIR/EIS, which began on December 24, 2010, and ended 54 days later on February 16, 2011. Recognizing that the public review period began during the holidays, the public comment period was extended past the typical 45-day public review period for a total of 54 days.

In addition to mailing the notice, the NOA was published in a regional newspaper, the *San Diego Union Tribune*, on December 24, 2010, as well as in a local newspaper, the *Back Country Messenger*, in the January 2011 monthly edition. On behalf of the BLM, the Environmental Protection Agency (EPA) also published an NOA in the Federal Register on December 23, 2010. BLM issued a news release on December 23, 2010, announcing availability of the Draft EIR/EIS on their project website at http://www.blm.gov/ca/st/en/fo/elcentro/nepa/tule.html. The NOA was also published on the CPUC website for the project at http://www.cpuc.ca.gov/environment/info/dudek/ECOSUB/ECOSUB.htm. During this period, the CPUC and BLM invited the public and interested groups to comment on the content of the Draft EIR/EIS. Furthermore, public information meetings on the Draft EIR/EIS were held at the Jacumba Highland Center on January 26, 2011, and the Boulevard Volunteer Fire Department on February 2, 2011. The NOA of the Draft EIR/EIS and the date of the public meetings were published concurrently with distribution of the Draft EIR/EIS.

In early February, the CPUC and BLM, at the request of EPA, announced another extension of the public comment period from February 16, 2011, to March 4, 2011—an additional 16 days beyond the original 54 days, for a total of 70 days. The extension notice was mailed on February 10, 2011, to the 1,500 + distribution list and was also published on the CPUC and BLM project websites. In addition, a one-page notice was prepared and sent to the Jacumba and Boulevard postmasters for posting on community boards within local post offices; the Highland Senior Center in Jacumba; as well as the three area libraries, including the Jacumba Public Library, Campo-Morena Village Branch Library, and Potrero Branch Library. The *Back Country Messenger* posted the extension notice on their community calendar as well (http://plus.calendars.net/backcountry).

ES.4.2 Comments on the Draft EIR/EIS

A 70-day public comment period followed the issuance of the Draft EIR/EIS in December 2010. More than 235 people and organizations participated in the public comment process by providing comments via email or post. Approximately 1,711 individual comments were received. The CPUC and BLM reviewed all comments and made changes to the EIR/EIS as appropriate. Responses to comments are provided in Volume 3 of the Final EIR/EIS.

The specific issues raised during the public scoping and Draft EIR/EIS review process are summarized in Table ES-3, Summary of Comments Received on the Draft EIR/EIS, and organized by section of the Draft EIR/EIS. Table ES-3 also indicates where major issues are addressed in the Final EIR/EIS.

Table ES-3
Summary of Comments Received on the Draft EIR/EIS

Draft EIR/EIS Section	Comments	Where Addressed in Final EIR/EIS
Section B, Project Description	Adequacy of project description	Volume 3, Common Response PD1
	Import of renewable energy only on ESJ Gen-Tie Line/permitting requirements for projects in Mexico	Volume 3, Common Response PD2
	Potential for future expansion of the ECO Substation	Volume 3, Common Response PD3
Section C, Alternatives	Adequacy of the range of alternatives	Volume 3, Common Response ALT1
	Consideration of a distributed generation alternative to the Proposed PROJECT	Volume 3, Common Response ALT2
Section D.2, Biological Resources	Impacts to special-status wildlife species including (but not limited to) golden eagle, California condor, bats, peninsular bighorn sheep, and Quino checkerspot butterfly.	Volumes 1 and 2, Final EIR/EIS, Section D.2 (Subsection D.2.3.3, Impact BIO-7 for all projects) Volume 3, Common Responses BIO1,

Table ES-3 (Continued)

Draft EIR/EIS Section	Comments	Where Addressed in Final EIR/EIS
		NOI2, BIO3, BIO4, BIO5
	Adequacy of impact analysis regarding wildlife corridors	Volumes 1 and 2, Final EIR/EIS, Section D.2 (Subsections D.2.1 (within the Regional Wildlife Corridor discussion) and D.2.3.3, Impact BIO-9 for the Tule Wind Project) Volume 3, Common Response BIO6
	Adequacy of biological resources mitigation and cumulative analysis	Volume 3, Common Responses BIO7, BIO8
	Impacts on designated management areas	Volumes 1 and 2, Final EIR/EIS, Section D.2 (Subsections D.2.2) and Section D.4 (Subsection D.4.2 and D.4.3, Impact LU-3 for the Tule Wind Project).
Section D.3, Visual Resources	Adequacy of visual simulations	Volumes 1 and 2, Final EIR/EIS, Section D.3 (Subsections D.3.1 (within the Visual Simulations discussion) Volume 3, Common Response VIS1
	Consideration of the Sunrise Powerlink in the existing visual setting	Volume 3, Common Response VIS2
	Visual impacts to Anza-Borrego Desert State Park	Volumes 1 and 2, Final EIR/EIS, Section D.3 (Subsections D.3.1.3 (see KOPs 14a, 14b, and 14c), D.3.3.3 (Impact VIS-1, Impact VIS-3, and Impact VIS-5 for the Tule Wind Project) Volume 3, Common Response VIS3
	Visual impacts from new lighting sources	Volumes 1 and 2, Final EIR/EIS, Section D.3 (Subsection D.3.3.3 (Impact VIS-4 for all projects)
Section D.4, Land Use	Impacts to existing community character resulting from large scale and visibility of project components	Volumes 1 and 2, Final EIR/EIS, Section D.4 (Subsection D.4.3.3, Impact LU-3 for all projects) Volume 2, Final EIR/EIS, Appendix 7 (Land Use Consistency Tables) Volumes 1 and 2, Final EIR/EIS, Section D.3 (Subsection D.3.3.3, Impact VIS-3 for all projects)
Section D.5, Wilderness and Recreation	Project impacts to wilderness and recreation areas (including reduced visitation)	Volumes 1 and 2, Final EIR/EIS, Section D.5 (Subsection D.5.3.3, Impact WR-1 through WR-4 for all projects)
Section D.7, Cultural and Paleontological Resources	Sufficiency of Native American consultation process	Volumes 1 and 2, Final EIR/EIS, Section D.7 (Subsection D.7.1.2 within Traditional Cultural Properties and Resources of Religious of Cultural Significance discussion and D.7.3.1 within the

Table ES-3 (Continued)

Draft EIR/EIS Section	Comments	Where Addressed in Final EIR/EIS
		Traditional Cultural Properties discussion) Volume 3, Common Response CUL1
	Adequacy of EIR/EIS identification and avoidance of Kumeyaay sites	Volumes 1 and 2, Final EIR/EIS, Section D.7 (Subsection D.7.1.2 for the ECO, Tule, and ESJ Gen-Tie Projects, as well as Section D.7.3.3, Impact CUL-1 through CUL-3 for all projects) Volume 3, Common Response CUL2
	Adequacy of cumulative cultural resource impact analysis	Volumes 1 and 2, Final EIR/EIS, Section D.7 (Subsection D.8.3.3, Impact CUL-3 for the Proposed PROJECT) Volumes 1 and 2, Final EIR/EIS, Section F (Subsection F.3.6, Impact CUL-1 through CUL-4 for All Reasonably Foreseeable Projects) Volume 3, Common Response CUL3
Section D.8, Noise	Adequacy of existing ambient sound level calculations	Volume 3, Common Response NOI1
	Need for analysis of audible and inaudible sound during operations of Tule Wind Turbines	Volume 3, Common Response NOI2
	Need for analysis of low-frequency noise and infrasound associated with operation of the Tule Wind Project	Volume 3, Common Responses NOI4, NOI5, NOI6
	Adequacy of calculation of operational noise generated by proposed wind turbines/inadequate analysis of impacts to sensitive receptors	Volume 3, Common Responses NOI7, NOI8, NOI9, NOI10, NOI11
	Appropriateness of 1,000-foot setback from wind turbines to residences and other sensitive receptors	Volume 3, Common Responses NOI5, NOI12
	Turbines not designed with appropriate noise control considerations (including controls to ensure consistency with future acceptable noise and sound thresholds)	Volume 3, Common Responses NOI13, NOI14
Section D.10, Public Health and Safety	Lack of analysis of health impacts (including shadow flicker, EMF) resulting from operation of proposed wind turbines	Volume 3, Common Responses PHS1, PHS3 ,PHS-5, PHS6, NOI5, NOI2
	Lack of analysis of stray voltage or "dirty electricity"	Volume 3, Common Response PHS2
Section D.12, Water Resources	Water demand and resources for construction	Volumes 1 and 2, Final EIR/EIS, Section D.12 (Subsection D.12.3.3, Impact HYD-4 for all projects), Section D.14 (Subsection D.14.3.3, Impact PSU-3 for all projects) Volume 3, Common Response WR1

Table ES-3 (Continued)

Draft EIR/EIS Section	Comments	Where Addressed in Final EIR/EIS
Section D.15, Fire and Fuels Management	Local fire station staffing and capability to adequately respond to a fire generated by a Proposed PROJECT and/or location of project in high hazard area	Volumes 1 and 2, Final EIR/EIS, Section D.15 (Subsection D.15.1 Existing Setting) Volume 3, Common Responses FIRE1, FIRE4
	Increased fire hazards and wildfire hazards can be reduced with undergrounding project alternative	Volume 3, Common Responses FIRE2, FIRE-5
	Increased insurance premiums or decline of coverage as a result of the Proposed PROJECT	Volume 3, Common Responses FIRE3, FIRE2
	Updated project information and fire impacts	Volumes 1 and 2, Final EIR/EIS, Section D.15 (Subsection D.15.3.3, Impact FF-2 and FF-3 for all projects) Volume 3, Common Response FIRE5
	Confusion regarding Mitigation Measure FF-6, FireSafe Council Funding	Volumes 1 and 2, Final EIR/EIS, Section D.15 (Subsection D.15.3.3, Impact FF-3, Mitigation Measure FF-6 as applicable for all projects) Volume 3, Common Response FIRE6
Section D.16, Social and Economic Conditions	Loss of property values resulting from the Proposed PROJECT	Volumes 1 and 2, Final EIR/EIS, Section D.16 (Subsection D.16.3.3, Impact SOC-3 for all projects) Volume 3, Common Response SOC1
	Loss of revenue for businesses in the project area	Volumes 1 and 2, Final EIR/EIS, Section D.16 (Subsection D.16.3.3, Impact SOC-2 for all projects)
Section D.18, Climate Change	Lack of quantification of greenhouse emission reduction achieved	Volume 3, Common Response CC1
	Lack of analysis regarding the effects of climate change on the Proposed PROJECT	Volume 3, Common Response CC2
Section F, Cumulative Impacts	Adequacy of cumulative impact analysis/lack of consideration in EIR/EIS od project throughout the southwestern U.S.	Volume 3, Common Response CUM1

As shown in Table ES-3, areas of concern/issues identified during the Draft EIR/EIS review process are addressed in the appropriate sections of the Final EIR/EIS. Responses to concerns raised during public review of the Draft EIR/EIS are provided in Volume 3 of the Final EIR/EIS.

Recurring comments on the Draft EIR/EIS are addressed through common responses that are provided in Section 2 of Volume 3 of the Final EIR/EIS.

ES.5 Project Alternatives

ES.5.1 Range of Alternatives Considered

Alternatives considered in this EIR/EIS include those considered by the applicants, the CPUC, and the BLM, as well as those identified by the general public and other agencies during the public scoping period (December 28, 2009, through February 15, 2010).

The alternatives screening process is described in greater detail in Section C of this EIR/EIS. This process culminated in the identification and screening of over 40 potential alternatives to the Proposed PROJECT in the following categories:

Alternatives to the ECO Substation Project: Twenty-one alternatives to the ECO Substation Project were evaluated, including nine alternative locations for the ECO Substation; one alternative location for the Boulevard Substation; five 138 kV transmission design, routing, and undergrounding alternatives; and six system alternatives.

Alternatives to the Tule Wind Project: Twelve alternatives to the Tule Wind Project were evaluated, including seven alternative location/configurations and five design alternatives.

Alternatives to the ESJ Gen-Tie Project: Five alternatives to the ESJ Gen-Tie Project were evaluated, including undergrounding of the 230 kV gen-tie, undergrounding of the 500 kV gen-tie (both at the same location as the proposed aboveground options), overhead alternative alignment routes for the 230 kV and 500 kV gen-ties toward the east, and an undergrounding alternative alignment route for the 230 kV gen-tie toward the east.

Alternatives to the Campo, Manzanita, and Jordan Wind Energy Projects: The Campo, Manzanita, and Jordan wind energy projects are evaluated under the other energy alternative and the No Project/No Action Alternative. Project-specific information has not been developed in order to provide for a full evaluation of these wind energy projects and any alternatives developed in respect to these projects would be speculative. Once sufficient project-specific information has been developed, alternatives will be discussed in detail in further environmental review of these projects.

Energy Alternatives: Three energy alternatives were considered, including energy efficiency, DG including rooftop solar panels, and alternative fuels.

Of the more than 40 alternatives considered, 12 project alternatives and 4 no project/no action alternatives are carried forward for full analysis in this EIR/EIS. As described in Section C of this EIR/EIS, alternatives that were eliminated from further consideration were not carried forward for full analysis as they did not meet project objectives, feasibility or environmental effectiveness criteria.

ES.5.2 Alternatives Carried Forward

The following alternatives are those selected through the alternative screening process (described in Section C of this EIR/EIS) for detailed EIR/EIS analysis. Each of these alternatives meets most or all of the basic project objectives as identified by the CPUC and fulfills the purpose and need as identified by the BLM, is feasible, and potentially avoids or reduces environmental effects of the Proposed PROJECT.

ES.5.2.1 ECO Substation Project Alternatives

Of the 21 alternatives considered, an alternative to the ECO Substation Site, as well as three transmission design, routing, and undergrounding alternatives have been selected for detailed analysis in this EIR/EIS. The CPUC has the sole responsibility in making a decision on the proposed ECO Substation Project, including which, if any, of the four alternatives or variations and/or combination of those alternatives evaluated in this EIR/EIS should be adopted, with the exception of a 1.5-mile portion of the proposed 138 kV transmission line between ~~milepost (~~MP~~)~~ 0.1 and 1.6, for which the BLM has sole responsibility.

ECO Substation Alternative Site. Under this alternative, the proposed ECO Substation would be located 700 feet east of the proposed ECO Substation Site with the northwest corner of the western ECO Substation pad removed, the SWPL Loop-In configuration would be changed, and the 138 kV transmission line would be extended to a total length of 13.4 miles. In addition, the access road to the ECO Substation would go along the west and southern side of the substation site, rather than along the north. Furthermore, the location of steel poles 76, 77, 91, 99, 102, 104, and 105 along the 138 kV transmission line would be shifted to avoid impacts to cultural resources. Other changes include one additional staging area, three additional pole sites, minor additions in new access roads, and permanent maintenance pads, as well as one retention pond instead of two. All other elements of the proposed ECO Substation Project would remain as described in Section B, Project Description, of this EIR/EIS.

ECO Partial Underground 138 kV Transmission Route Alternative. For this alternative, the proposed ECO Substation Project would be the same as proposed with the exception of undergrounding two segments ~~that the approximately 4-mile-long portion~~ of the proposed 138 kV transmission line, including an approximate 4-mile-long portion between the SWPL and

Boulevard Substation (from MP 9 to Boulevard Substation) and an approximate 2.7-mile portion along Old Highway 80 and Carrizo Gorge Road (from MP 0.3 to 2.4) ~~would be installed underground~~ rather than overhead on transmission line poles. The segment would then rejoin with the proposed overhead 138 kV transmission line route adjacent to SWPL.

ECO Highway 80 138 kV Transmission Route Alternative. For this alternative, the proposed ECO Substation Project would be the same as described in Section B, Project Description, of this EIR/EIS, with the exception that this alternative replaces the proposed 138 kV transmission line route from approximately MP 5.8 to 13.3 and instead would install the proposed 138 kV transmission line along Old Highway 80 where it would follow and overbuild an existing electrical distribution line. The proposed Old Highway 80 segment would connect the 138 kV transmission line from near the intersection of Highway 80 and the SWPL ROW to the Boulevard Substation. Overbuilding along the distribution line would require the removal and replacement of wooden poles with taller, steel poles. Total length of the proposed 138 kV transmission line would be 10.6 miles, compared with the proposed 13.3-mile-long, 138 kV transmission line.

ECO Highway 80 Underground 138 kV Transmission Route Alternative. This alternative would be the same as described for the ECO Highway 80 138 kV Transmission Route Alternative with the exception that the proposed 138 kV transmission line would be installed underground within the existing ROW along Old Highway 80.

ES.5.2.2 Tule Wind Project Alternatives

Of the 12 alternatives considered, the following 5 configuration and design alternatives have been selected for detailed analysis in the EIR/EIS. The BLM, BIA, Ewiiaapaayp Band of Kumeyaay Indians, California State Lands Commission, and County of San Diego have responsibility in making a decision on the proposed Tule Wind Project, including which, if any, of the five alternatives or variations and/or combinations of those alternatives evaluated in this EIR/EIS should be adopted.

Tule Wind Alternative 1, Gen-Tie Route 2 with Collector Substation/Operations and Maintenance (O&M) Facility on Rough Acres Ranch. Under this alternative, the proposed Tule Wind Project would consist of 128 turbines ~~be the same as proposed with the exception that~~and the proposed O&M and collector substation facilities would be co-located on Rough Acres Ranch (T17S R7E Sec. 9), approximately 5 miles south of the originally proposed site. In addition, under this alternative the temporary concrete batch plant would be moved from its proposed location on BLM jurisdictional lands to Rough Acres Ranch and the proposed overhead collector line located west of Lost Valley Rock would be relocated to east of Lost Valley Rock and constructed within the proposed Tule Wind Project 138 kV alignment that would be vacated as a result of the O&M facility and collector substation location shift. Moving the O&M and collector substation facilities to this alternative location would result in an increase in the length of the 34.5 kV overhead collector lines to connect the wind turbines to the substation, from 9.3 miles (proposed) to 17 miles. However, the underground collector lines would decrease in distance from approximately 35.1 miles to 28.9 miles. ~~(proposed) to 27 miles, t~~The 138 kV transmission line would decrease in distance as a result of this alternative from 9.2 miles (proposed) to ~~4~~ 3.8 miles, and the number of transmission line poles would decrease from ~~126~~ 80 poles (proposed) to ~~49~~ 44 poles. Under this alternative, the 138 kV gen-tie transmission line would run from the alternative collector substation approximately 1 mile east, south along McCain Valley Road, and then west along Old Highway 80 until connecting to the proposed Boulevard Substation rebuild component of the ECO Substation Project. This alternative would increase the land disturbance by ~~12~~ 49.3 acres, from ~~712~~ 725.3 acres (proposed) to ~~724~~ 774.6 acres.

Tule Wind Alternative 2, Gen-Tie Route 2 Underground with Collector Substation/O&M Facility on Rough Acres Ranch. This alternative would consist of 128 turbines and would essentially be the same as described in Tule Alternative 1 for the Tule Wind Alternative 2, Gen-Tie Route 2 with Collector Substation/O&M Facility on Rough Acres Ranch, with the exception that the proposed 138 kV gen-tie transmission line would run underground from the alternative collector substation approximately 1 mile east, south underground along McCain Valley Road, and then west underground along Old Highway 80 until reaching the Boulevard Substation rebuild component of the ECO Substation Project.

Tule Wind Alternative 3, Gen-Tie Route 3 with Collector Substation/O&M Facility on Rough Acres Ranch. This alternative would consist of 128 turbines and would essentially be the same as described in Tule Wind Alternative 1,Gen-Tie Route 2 with Collector Substation/O&M Facility on Rough Acres Ranch, with the exception that the proposed 138 kV gen-tie transmission line would run from the alternative collector substation approximately 3 miles west to Ribbonwood Road, continue south along Ribbonwood Road, and then east along Old Highway 80 until connecting to the proposed Boulevard Substation rebuild component of the ECO Substation Project. As a result of this alternative, the 138 kV gen-tie transmission line would decrease in distance from 9.2 miles (proposed) to 5.4 miles. The length of the overhead collector line system would increase in distance by 7.7 miles from 9.3 to 17 miles. Additionally, under this alternative, transmission line poles would decrease from ~~126~~ 80 poles (proposed) to ~~59~~ 60 poles, and the number of collector line poles would increase from 250 to 452 poles. This alternative would increase the land disturbance by ~~16~~ 54.7 acres, from ~~712~~ 725.3 acres (proposed) to ~~728~~ 780 acres.

Tule Wind Alternative 4, Gen-Tie Route 3 Underground with Collector Substation/O&M Facility on Rough Acres Ranch. This alternative would consist of 128 turbines and would essentially be the same as described in Tule Alternative 3, Gen-Tie Route 3 with Collector Substation/O&M Facility on Rough Acres Ranch, with the exception that the proposed 138 kV transmission line would run underground from the alternative collector substation approximately 3 miles west to Ribbonwood Road, continue south underground along Ribbonwood Road, and then east underground along Old Highway 80 until reaching the Boulevard Substation.

Tule Wind Alternative 5, Reduction in Turbines. Under this alternative, the proposed Tule Wind Project would consist of 65 turbines ~~be the same as proposed~~ with the ~~exception that this alternative would~~ removal of~~e~~ ~~62~~ 63 specific turbines to include ~~locations out of the 134 turbines proposed. The proposed action would erect 11~~ six turbines adjacent to the ~~BLM~~ In-Ko-Pah Mountains Area of Critical Environmental Concern (ACEC) being S1, R4, (R8), R8, R9, and R10 and 57~~1~~ turbines ~~adjacent to wilderness areas~~ on the western side of the project site including all turbines in the J, K, L, M, N, P, and Q strings. Figure C-2B, Tule Wind Project Alternatives Map, depicts the locations of proposed wind turbines.

ES.5.2.3 Alternatives to the ESJ Gen-Tie Project

Of the five alternatives considered, the following three alternatives have been selected for detailed analysis in the EIR/EIS. The County of San Diego will have the sole responsibility in making a decision on the proposed ESJ Gen-Tie Project, including which, if any, of the alternatives evaluated in this EIR/EIS should be adopted in consideration of a major-use permit. It should be noted that in making a decision, it is recommended that the County of San Diego consult with the U.S. Department of Energy (DOE) and the DOE's decision-making process regarding the issuance of a Presidential Permit for the ESJ Gen-Tie Project and the CPUC in the CPUC's decision-making process regarding the ECO Substation Project.

ESJ 230 kV Gen-Tie Underground Alternative. Under this alternative, the 230 kV gen-tie line would be placed underground rather than aboveground. It would follow the same proposed path as described for the Proposed PROJECT.

ESJ Gen-Tie Overhead Alternative Alignment. Under this alternative, both the 230 kV and 500 kV gen-tie options would shift approximately 700 feet east of the Proposed PROJECT to connect with the ECO Substation Alternative Site.

ESJ Gen-Tie Underground Alternative Alignment. Under this alternative, the 230 kV gen-tie line would shift approximately 700 feet east and be undergrounded to connect with the ECO Substation Alternative Site.

ES.5.2.4 No Project/No Action Alternatives

No Project Alternative 1–No ECO Substation, Tule Wind, ESJ Gen-Tie, Campo, Manzanita, or Jorda~~o~~n Wind Energy Projects. This alternative would result in the ECO

Substation, Tule Wind, and ESJ Gen-Tie, as well as the Campo, Manzanita, and Jorda~~o~~n wind energy projects not being constructed.

No Project Alternative 2–No ECO Substation Project. This alternative would result in the ECO Substation Project not being constructed. The proposed Tule Wind and ESJ Gen-Tie projects would be constructed; however, each of these projects would be required to interconnect to existing substations elsewhere in the project area or to construct their own transmission substations.

No Project Alternative 3–No Tule Wind Project. Under this alternative, the ROW would not be granted by the BLM and the Tule Wind Project would not be constructed. The ECO Substation and ESJ Gen-Tie projects would be constructed.

No Project Alternative 4–No ESJ Gen-Tie Project. Under this alternative, the ESJ Gen-Tie Project would not be constructed, and the renewable energy generated in Baja California, Mexico, would not reach the U.S. market via the ECO Substation. The ECO Substation and Tule Wind projects would be constructed.

ES.6 Summary of Environmental Analysis

A joint EIR/EIS must comply with both federal NEPA and state CEQA Guidelines. CEQA requires that each effect having a significant impact be identified in the EIR. Therefore, reference to "significant" or "less-than-significant" environmental effects in this EIR/EIS is considered a CEQA-related finding consistent with CEQA Guidelines, Section 21082.2 (14 CCR 15000 et seq.). NEPA does not require such a finding for an EIS; rather, it requires that an agency avoid or minimize adverse effects to the extent practicable. Under NEPA, a Record of Decision supported by an EIS may include a determination by the lead agency that the project may have a "significant effect" on the quality of the environment. Consequently, references to significant impacts in this document are made to fulfill the requirements of CEQA pursuant to the standards of California law. Under NEPA, impacts, whether significant or not, are disclosed and analyzed. No representation as to significance is made that represents an assessment as to the magnitude or intensity of an individual resource impact under the requirement of federal law. The following classifications were uniformly applied to denote the significance of environmental impacts under CEQA. NEPA does not require such a finding. Under NEPA, since significance is evidenced by the preparation of an EIS, impacts are either adverse or not. Impacts under CEQA are classified as follows:

Class I: Significant – cannot be mitigated to a level that is less than significant
Class II: Significant – can be mitigated to a level that is less than significant
Class III: Less than significant, no mitigation required

Class IV: Beneficial impact
No Impact: No impact identified.

Table ES-5~~2~~ ~~located at the end of this executive summary~~ provides a summary of Proposed PROJECT impacts and classification of impacts under CEQA, mitigation measures, and residual impacts. As shown in Table ES-5~~2~~, the Proposed PROJECT, including the Campo, Manzanita, and Jordan wind energy projects, as a whole would have adverse impacts that cannot be mitigated and under CEQA would be significant and unmitigable (Class I) impacts to biological resources, visual resources, cultural resources, noise, air quality, water resources, and fire and fuels management. Following is a summary of the environmental impact conclusions for the project and each of the project alternatives.

ES.6.1 ECO Substation Project

As summarized in Table ES-5~~3~~, the proposed ECO Substation Project would have unavoidable adverse impacts under NEPA ~~that cannot be mitigated~~ and under CEQA would be significant and unmitigable (Class I) impacts to the following issue areas: biological resources (direct loss of Quino checkerspot butterfly habitat), visual resources (impacts to scenic vistas and existing visual character), cultural resources (potential adverse change to traditional cultural properties), short-term construction noise, air emissions (NOx emissions), and fire and fuels management (increased fire probability from project facilities). Impacts in the remaining 11 issue areas were either found to be not adverse under NEPA and under CEQA less than significant (Class III), and/or following the implementation of applicant proposed measures (APMs) and mitigation measures presented in this EIR/EIS, to be adverse but mitigable under NEPA and under CEQA less than significant with mitigation implemented (Class II).

The ECO Substation Project including project alternatives was determined to be consistent with all applicable federal plans and policies. The County of San Diego has no jurisdiction over the ECO Substation Project and, therefore, local policies, plans, and regulations do not apply.

Four alternatives to the ECO Substation Project, in addition to the No Project/No Action Alternative, were identified for evaluation in this EIR/EIS. A comparison of the environmental effects for the proposed ECO Substation Project and each of the alternatives is provided in Table ES-6~~3~~ located at the end of the Executive Summary.

As summarized in Table ES-~~3~~4, the ECO Substation Alternative Site, combined with the ECO Partial Underground 138 kV Transmission Route Alternative, would cause the least environmental impact.

Similar to the proposed ECO Substation Project and other project alternatives considered, this alternative would have unavoidable adverse impacts under NEPA and significant and unmitigable (Class I) impacts under CEQA in the following issue areas: biological resources, visual resources, cultural resources, short-term construction noise, and air emissions, and fire and fuels management. Impacts in the remaining 11 issue areas would either be not adverse under NEPA and under CEQA would be considered less than significant (Class III); and/or following implementation of mitigation measures presented in this EIR/EIS, would be adverse but mitigable under NEPA, and under CEQA considered less than significant with mitigation implemented (Class II).

While this alternative would increase short-term construction-related impacts to air, noise, water, erosion, and biological resources, short-term impacts to these resources would occur within the same area as the proposed ECO Substation Project and would be mitigable in that adverse impacts were avoided or minimized under NEPA, and under CEQA can be mitigated to less than significant (Class II). This alternative would reduce some impacts to cultural resources from Class II to Class III through avoidance and would reduce visual resource and fire impacts associated with undergrounding two segments ~~an approximate 4-mile portion~~ of the proposed 138 kV transmission line project component, an approximate 4-mile portion between MP 9 and the Boulevard Substation as well as an approximate 2.7-mile portion along Old Highway 80 and Carrizo Gorge Road, from unavoidable adverse under NEPA and significant and unavoidable (Class I) under CEQA, to not adverse under NEPA and less than significant (Class III) under CEQA.

While the two 138 kV transmission line alternatives utilizing an existing utility ROW along Old Highway 80 would reduce the overall length of the proposed 138 kV transmission line from 13.3 miles (as proposed) to 10.6 miles and would potentially reduce some of the Proposed PROJECT impacts as described previously, they would also create more substantial impacts due to the proximity to Old Highway 80, a greater number of sensitive residences, additional critical habitat for the Quino checkerspot butterfly, and siting/slope constraints requiring additional construction impacts when compared to the Proposed PROJECT and, therefore, were not determined to be environmentally superior or preferable.

Under the No Project Alternative 2, No ECO Substation Project, the ECO Substation Project would not be built, and the conditions in the existing energy grid and local environment would remain the same. Without the ECO Substation Project, there would not be an interconnection hub that would enable renewable generation such as the ESJ Gen-Tie or Tule Wind projects to connect to the grid. Additionally, energy transmission would remain unreliable in Boulevard, Jacumba, and the surrounding communities. Planned generation facilities in the project area would require additional miles of transmission line to reach an interconnection point and possibly multiple connection points on SDG&E's existing transmission system. In addition, new substations to be constructed by each generator might be required to connect the generation facilities to the grid. Development of these facilities under the No Project Alternative 2 may actually increase impacts when compared to the ECO Substation Project; therefore, it was determined not to be environmentally superior or preferable.

ES.6.2 Tule Wind Project

The proposed Tule Wind Project would have unavoidable adverse impacts under NEPA ~~that cannot be mitigated~~ and under CEQA would be significant and unmitigable (Class I) impacts in the following issue areas: biological resources (bird/golden eagle strikes with turbines), visual resources (impacts to scenic vistas, existing visual character, light/glare, and inconsistency with policies/plans), cultural resources (potential adverse change to traditional cultural properties), and short-term construction noise and air emissions~~,~~ ~~and wildland fire and fuels management~~. Impacts to the remaining ~~11~~ 12 issue areas were either found to be not adverse under NEPA and under CEQA less than significant (Class III); and/or following implementation of APMs and mitigation measures presented in this EIR/EIS, to be adverse but mitigable under NEPA and under CEQA less ~~that~~ than significant with mitigation implemented (Class II).

The Tule Wind Project and alternatives ~~was~~ were determined to be consistent with the County of San Diego Existing General Plan ~~Land Use Element and~~ Energy Element, Zoning Ordinance, and all applicable federal plans and policies. With implementation of mitigation measures identified in Section D of this EIR/EIS and with approval of pending amendments discussed in Appendix 7 of this EIR/EIS, the Tule Wind Project was determined to be consistent with the County of San Diego Existing General Plan Land Use, Conservation, Public Facility, and Seismic Elements, and the Mountain Empire Subregional Plan.

Five alternatives to the Tule Wind Project, in addition to the No Project/No Action Alternative, were identified for evaluation in this EIR/EIS. A comparison of the environmental effects for the proposed Tule Wind Project and each of the alternatives is provided in Table ES-7~~3~~ located at the end of the Executive Summary.

As summarized in Table ES-4, the Tule Wind Alternative 5, Reduction in Turbines, combined with Tule Wind Alternative 2, Gen-Tie Route 2 Underground with Collector Substation/O&M Facility on Rough Acres Ranch, would cause the least environmental impact. This alternative would reduce the overall length of the proposed 138 kV gen-tie transmission line from 9.~~6~~ 2 miles to ~~4~~ 3.8 miles and would develop the O&M and collector substation on a more disturbed site. Similar to the proposed Tule Wind Project, this alternative would have unavoidable adverse impacts under NEPA and significant and unmitigable (Class I) impacts under CEQA in the following issue areas: short-term construction noise and air emissions, cultural resources, long-term visual impacts, ~~fire and fuels management,~~ and biological impacts (golden eagle/bird collisions with turbines).

Unavoidable adverse impact under NEPA and significant unavoidable (Class I) impacts under CEQA to golden eagles would be reduced with the removal of turbines within areas considered high risk of any known active golden eagle nest. Although this alternative would substantially reduce the risk of golden eagle mortality, the risk of mortality due to collision with operating turbines by golden eagle remains an unavoidable adverse impact under NEPA and a significant and unmitigable impact under CEQA due to the fact that the remaining turbines would continue to present risk, albeit with lower risk of collision to golden eagles foraging in the vicinity of the project. Impacts in the remaining ~~11~~ 12 issue areas ~~would~~ were found to be either not adverse under NEPA and under CEQA less than significant (Class III); and/or following implementation of APMs and mitigation measures presented in this EIR/EIS, would be adverse but mitigable under NEPA, and under CEQA less than significant with mitigation implemented (Class II).

While this alternative would increase short-term construction-related impacts to air, noise, water, and erosion due to trenching and boring of the 138 kV gen-tie, short-term impacts to these resources would occur within the same area as the Proposed Tule Project and can be mitigated to less than significant. This alternative would reduce impacts to golden eagles by siting turbines farther away from nesting eagles and would reduce long-term visual ~~and fire~~ impacts associated with the undergrounding of the 138 kV gen-tie project component from significant and unavoidable (Class I) to less than significant (Class III) and, therefore, from a strictly environmental perspective, ranks as the environmentally superior alternative. However, this alternative would remove the ~~17~~ 18 turbines proposed on the Ewiiaapaayp Indian Reservation; thereby affecting the Ewiiaapaayp Band of Kumeyaay Indians' wind and solar energy resources policies to develop renewable energy projects to serve economic and social needs of the reservation. In addition, ~~27~~ 35 turbines would be removed from lands ~~administered~~ managed by the BLM, 7 turbines would be removed from lands administered by the CSLC, and ~~11~~ 5 from lands under the jurisdiction of the County of San Diego.

The Tule Wind Alternatives 3 and 4 (aboveground and underground Gen-Tie Route 3) would reduce the overall length of the proposed 138 kV transmission line from 9.~~6~~2 to 5.4 miles when compared to the proposed Tule Wind Project and would potentially reduce some of the Proposed Tule Project impacts, as described previously. These alternatives would also create more impacts due to the increased length of the gen-tie required when compared to Tule Wind Alternatives 1 and 2 (Gen-Tie Route 2); therefore, these alternatives were not determined to be environmentally superior or preferable.

Under the No Project Alternative 3, No Tule Wind Project, the Tule Wind Project would not be built and the existing conditions on the project site would remain. However, the ECO Substation Project and ESJ Gen-Tie Project would be developed. Without the Tule Wind Project, approximately ~~200~~ 201 MW of proposed renewable energy production would not be developed on lands in the southeastern portion of San Diego County. While the construction and operations impacts would be reduced under this alternative, the unavoidable adverse (Class I under CEQA) impacts associated with the ECO Substation and ESJ Gen-Tie projects would occur under this alternative. Given that the No Project Alternative 3, No Tule Wind Project, would not reduce impacts associated with the ECO Substation and ESJ Gen-Tie projects and would not realize the proposed ~~200~~ 201 MW of renewable energy production, thereby negatively affecting ~~the region's~~SDG&E's ability to meet California's renewable portfolio standard (RPS) ~~program and associated Executive Order requirements~~targets to increase renewable energy and reduce greenhouse emissions, it was determined not to be environmentally superior or preferable.

ES.6.3 ESJ Gen-Tie Project

The proposed ESJ Gen-Tie Project would have unavoidable adverse impacts under NEPA ~~that cannot be mitigated~~ and under CEQA would be significant unmitigable impacts (Class I) in the following issue areas: visual resources (although visual impacts from the ESJ Gen-Tie Project are found to be less than significant, visual impacts from the ESJ Phase I Wind development in Mexico are significant and unavoidable)~~, cultural resources (potential adverse change to traditional cultural properties)~~ and short-term construction air emissions~~, and fire and fuels management~~. Impacts in the remaining 15~~3~~ issue areas where either found to be not adverse under NEPA and under CEQA less than significant (Class III); and/or following implementation of APMs and mitigation measures presented in this EIR/EIS, to be adverse but mitigable under NEPA, and under CEQA would be considered less than significant with mitigation implemented (Class II).

The ESJ Gen-Tie Project and alternatives were determined to be consistent with the County of San Diego Existing General Plan Land Use Element and Energy Element, and the County's Zoning Ordinance. With implementation of mitigation measures identified in Section D of this EIR/EIS, the ESJ Gen-Tie Project was determined to be consistent with the County of San Diego Existing General Plan Conservation, Public Facility, and Seismic elements, and the Mountain Empire Subregional Plan.

Three alternatives to the ESJ Gen-Tie Project, in addition to the No Project/No Action Alternative, were identified for evaluation in this EIR/EIS. A comparison of the environmental effects for the Proposed ESJ Gen-Tie Project and alternatives is provided in Table ES-8~~5~~.

As summarized in Table ES-8~~5~~, the ESJ Gen-Tie Overhead Alternative Alignment would cause the least environmental impact. This alternative would have similar impacts to the proposed ESJ Gen-Tie Project; therefore, it would rank equally with the Proposed ESJ Gen-Tie Project. This alternative ranks as the environmentally superior alternative for the ESJ Gen-Tie as it would be required to connect the environmentally superior alternative for the ECO Substation Project, which shifts the ECO Substation 700 feet to the east, as summarized in Section ES.5.2.1. Similar to the proposed ESJ Gen-Tie Project, this alternative would have unavoidable adverse impacts under NEPA and significant unmitigable (Class I) impacts under CEQA to visual resources (for the ESJ Phase I Wind development in Mexico), cultural resources, and short-term construction air emissions, and fire and fuels management. Impacts to the remaining 153 issue areas would be either not adverse under NEPA and under CEQA considered less than significant (Class III),; and/or following implementation of mitigation measures presented in this EIR/EIS, would be adverse but mitigable under NEPA, and considered less than significant under CEQA with mitigation implemented (Class II).

~~While the ESJ 230 kV Gen-Tie Underground Alternative and ESJ Gen-Tie Underground Alternative Alignment would reduce long-term impacts related to fire hazard, this reduction would only occur for the less-than-one-mile gen-tie line. In the context of developing the ECO Substation and the Phase I ESJ Gen-Tie Wind development in Mexico, these impacts would remain significant and unavoidable (Class I) even with the undergrounding of the gen-tie line.~~ While these undergrounding alternatives would reduce the already less-than-significant visual impacts resulting from the ESJ Gen-Tie Project, they would not reduce the significant and unavoidable visual impacts associated with the Phase I ESJ Gen-Tie Wind development in Mexico. Therefore, the minimal reduction in impacts associated with the undergrounding of the less-than-one-mile gen-tie (and removal of five poles/lattice towers) is not warranted given the increased short-term construction impacts and long-term impacts associated with the ECO Substation and Phase I ESJ Gen-Tie Wind development, both of which are connected by the ESJ gen-tie. Therefore, when compared to the proposed ESJ Gen-Tie Project and ESJ Gen-Tie Overhead Alternative Alignment, the undergrounding alternatives were not determined to be environmentally superior.

Under the No Project Alternative 4, No ESJ Gen-Tie Project, the ESJ Gen-Tie Project would not be built, and the existing conditions on the project site would remain the same. Construction-related impacts associated with the proposed ECO Substation and Tule Wind projects would occur under this alternative, as well as the indirect impacts associated with the Phase I ESJ Gen-Tie Wind development in Mexico. Under this alternative, it is likely that an alternative gen-tie would be constructed to connect the Phase I ESJ Gen-Tie Wind development to SDG&E's system. The impacts associated with this alternative gen-tie would be expected to be similar to those described for the proposed ESJ Gen-Tie Project and alternatives evaluated, but could vary depending on length of the gen-tie line and the location pursued. As it is unknown whether the No Project Alternative 4, No ESJ Gen-Tie Project, would actually reduce impacts and it may in fact increase impacts, it was determined not to be environmentally superior.

ES.7 Anza-Borrego Desert State Park

The largest state park in California, Anza-Borrego Desert State Park is located in the eastern part of the Proposed PROJECT study area and State Park lands including three state wilderness areas are located adjacent to BLM jurisdictional lands in the McCain Valley and Table Mountain areas. The topics listed below are of specific concern to Anza-Borrego Desert State Park and were identified in comment letters on the Notice of Intent and on the Draft EIR/EIS submitted by the California Department of Parks and Recreation. The environmental issues listed below have been addressed in this EIR/EIS.

Biological Resources

***Impacts to Migratory Birds*.** Potential adverse impacts to migratory birds in the vicinity of Anza-Borrego Desert State Park during construction and operation activities associated with the Proposed PROJECT have been addressed in EIR/EIS Section D.2, Biological Resources (see Section D.2.3.3, Impact BIO-8 for the Proposed PROJECT) and were determined to adverse but mitigable under NEPA/less than significant with implementation of mitigation under CEQA (Class II).

***Golden Eagles*.** Potential adverse impacts to golden eagles in the vicinity of Anza-Borrego Desert State Park during construction activities have been addressed in EIR/EIS Section D.2, Biological Resources (see Section D.2.3.3, Impact BIO-7 for the Proposed PROJECT) and were determined to be adverse but mitigable under NEPA/less than significant with implementation of mitigation under CEQA. Collision risks for golden eagles with proposed wind turbines have been addressed in Section D.2, Biological Resources (see Section D.2.3.3, Impact BIO-10 for the Tule Wind Project and the Proposed PROJECT) and were determined to be an unavoidable adverse impact under NEPA and a significant unmitigable impact under CEQA. The EIR/EIS golden eagle impact evaluation is based on a helicopter survey within a 10-mile radius of the proposed Tule Wind Project conducted by Wildlife Research Institute in spring 2010.

***Sensitive and Species of Special Concern*.** Potential adverse impacts to sensitive and species of special concern in the vicinity of Anza-Borrego Desert State Park, including northern red diamond rattlesnake (*Crotalus ruber*), barefoot banded-gecko (*Coleonyx switaki*), Blainville's horned lizard (*Phrynosoma blainvillii*, previously coast horned lizard), and orange-throated whiptail (*Aspidoscelis hyperythra beldingi*), resulting from construction of the ECO Substation, Tule Wind, and ESJ Gen-Tie Projects have been addressed in EIR/EIS Section D.2, Biological Resources (see Section D.2.3.3, Impact BIO-7, *Reptiles* for the three projects). A determination of no impact was made for the barefoot banded gecko and impacts to the red-diamond rattlesnake, Blainville's horned lizard, and orange-throated whiptail were mitigable under NEPA and less than significant with implementation of mitigation under CEQA.

Quino Checkerspot Butterfly. Potential adverse impacts to Quino checkerspot butterfly designated critical habitat in the vicinity of Anza-Borrego Desert State Park have been addressed in EIR/EIS Section D.2 (see Section D.2.3.3, Impact BIO-7, Quino Checkerspot Butterfly for the Proposed PROJECT) and were determined to be an unavoidable adverse impact under NEPA and a significant unmitigable impact under CEQA. Potential adverse impacts to Quino checkerspot butterfly habitat within the one-kilometer movement radius of the 2010 observation on the Tule Wind Project site have been addressed in EIR/EIS Section D.2, Biological Resources (see Section D.2.3.3, Impact BIO-7, Tule Wind Project, Quino Checkerspot Butterfly) and were determined to be adverse but mitigable under NEPA/less than significant with implementation of mitigation under CEQA (Class II).

Bats. Potential adverse impacts to bats from operating wind turbines (including impacts associated with collision and barotrauma) in the vicinity of Anza-Borrego Desert State Park have been addressed in EIR/EIS Section D.2, Biological Resources (see Section D.2.3.3, Impact BIO-10 for the Tule Wind Project) and were determined to be mitigable under NEPA/less than significant with implementation of mitigation under CEQA.

Peninsular Bighorn Sheep. Potential adverse impacts to peninsular bighorn sheep in the vicinity of Anza-Borrego Desert State Park resulting from construction activities have been addressed in EIR/EIS Section D.2, Biological Resources (see Section D.2.3.3, Impact BIO-7 (all projects), Peninsular Bighorn Sheep). A determination of no impact to peninsular bighorn sheep as a result of the ECO Substation and ESJ Gen-Tie Project was made and an impact determination of not adverse under NEPA/less than significant under CEQA was made for the Tule Wind Project. Also, construction and operational impacts to general wildlife movement and linkages are described in Section D.2.3.3, Impact BIO-9 for the Proposed PROJECT. The proximity of the ECO Substation, Tule Wind, and ESJ Gen-Tie Projects to designated critical habitat for peninsular bighorn sheep in the project area is described in EIR/EIS Section D.2, Biological Resources (see Section D.2.1.1 Regional Overview, Critical Habitat).

Viewsheds

The Final EIR/EIS includes three additional representative key observation points (KOPs 14a (Carrizo Badlands Overlook), 14b (Palm Spring), and 14c (Sombrero Peak)) located within Anza-Borrego Desert State Park to further describe the potential visual effects to State Park lands resulting from construction and operation of the Tule Wind Project. The existing conditions present at the identified representative KOPs, as well as a discussion regarding anticipated visual contrasts resulting from the visibility of proposed wind turbines from representative KOPs, is described in EIR/EIS Section D.3, Visual Resources (see Section D.3.1.1, Key Observation Points; Section D.3.1.3, Tule Wind Project; Section D.3.3.3, Impact VIS-1, VIS-3, and VIS-4 for the Tule Wind Project; and Sections D.3.5.1 through D.3.5.5 for the Tule Wind Project Alternatives). Visual resource impacts to KOPs within Anza-Borrego Desert State Park were determined to be an unavoidable adverse impact under NEPA and an unmitigable impact under CEQA due to moderate-to-high levels of color, line, and form contrasts anticipated between wind turbines and surrounding intact natural environment and due to the high visual sensitivity of State Park users.

Wilderness and Recreation

Potential adverse impacts to State Park wilderness and recreation areas have been addressed in EIR/EIS Section D.5, Wilderness and Recreation (see Section D.5.3.3, Impact WR-3, Tule Wind Project, *State Parks*) and were determined to be not adverse under NEPA/less than significant under CEQA.

Noise

Potential adverse impacts to sensitive receptors in the project area resulting from construction and operational activities have been addressed in EIR/EIS Section D.8, Noise (see Section D.8.3.3, Impact NOI-1 through Impact NOI-4 for the ECO Substation, Tule Wind, and ESJ Gen-Tie Projects). Section D.8.4 through Section D.8.6 describes the potential adverse noise impacts to sensitive receptors resulting from construction and operation of the ECO Substation, Tule Wind, and ESJ Gen-Tie Project Alternatives. Based on the calculations provided in EIR/EIS Section D.8 (see Section D.8.3.3, Impact NOI-3, Tule Wind Project (Table D.8-11)) which provides anticipated wind turbine noise levels at McCain Valley area residences within 1 mile of a proposed wind turbine, the noise levels within the State Park during project operations are anticipated to be similar to the fluctuating noise levels present the existing McCain Valley environmental setting.

Social and Economic Impacts

Potential adverse social and economic impacts including loss of revenues for project area businesses have been addressed in EIR/EIS Section D.16, Social and Economic Impacts (see Section D.16.3.3, Impact SOC-2 for the ECO Substation, Tule Wind, and ESJ Gen-Tie Projects as well for the Proposed PROJECT). As stated in Section D.16, the potential loss of revenue from business operations would be offset by economic benefits resulting from project construction, operation, and decommissioning and therefore, under NEPA, the Proposed PROJECT would be beneficial.

Cumulative Impacts

Potential adverse cumulative impacts to all environmental resources areas, including potential impacts to resources identified by Anza-Borrego Desert State Park, have been addressed in the this EIR/EIS (see Section F, Cumulative Scenario and Impacts. subsections Sections F.3.1 through F.3.17).

ES.8 Environmentally Superior Alternative/ Agency-Preferred Alternative

ES.78.1 CEQA Environmentally Superior Alternative/Agency-Preferred Alternative

CEQA requires that the environmentally superior alternative be selected from a range of reasonable alternatives that could feasibly attain the basic objectives of the project. Based on the analysis presented in Sections D.2 through D.18 of this EIR/EIS, the environmentally superior alternative was determined to be the No Project Alternative 1, No ECO Substation, Tule Wind, ESJ Gen-Tie, Campo, Manzanita, or Jordan wind energy projects (see Table ES-4). Under the No Project Alternative 1, the Proposed PROJECT (including the ECO Substation, Tule Wind, ESJ Gen-Tie, Campo, Manzanita, and Jordan wind energy projects) would not be constructed. All environmental impacts associated with the construction and operation of the Proposed Project would be eliminated and existing environmental conditions would be unaffected. There would be no new renewable energy source in the southeastern portion of San Diego County, and consequently, the regionSDG&E may not meet its California RPS program and associated Executive Order requirementstargets or to develop renewable energy on federal lands in complianceto comply with the Energy Policy Act of 2005. The southeastern energy transmission system servicing the Boulevard, Jacumba, and other surrounding communities would remain unstable.

CEQA Guidelines Section 15126(d)(2) further stipulates that "if the environmentally superior alternative is the No Project Alternative, the EIR shall also identify an environmentally superior alternative among the other alternatives." Based on the analysis for each alternative presented in Sections D.2 through D.18, and as summarized in Section E of this EIR/EIS, the environmentally superior alternative is defined as follows:

Table ES-4
Environmentally Superior Alternative

Alternative	Jurisdiction
ECO Substation Project	
ECO Substation Alternative Site, combined with:	CPUC to consider in consultation with the County of San Diego and DOE's decision-making process on the ESJ Gen-Tie Project
ECO Partial Underground 138 kV Transmission Route Alternative, combined with	CPUC and BLM to consider
Boulevard Substation Rebuild	CPUC to consider
Remaining components same as described for the proposed ECO Substation Project	CPUC to consider all remaining components. BLM to consider ROW Grant for proposed 138 kV transmission line from MP 0.1 to MP 1.6

Table ES-4 (Continued)

Alternative	Jurisdiction
Tule Wind Project	
Tule Wind Alternative 5, Reduction in Turbines, combined with:	County, BLM, BIA, CSLC, and Ewiiaapaayp Band of Kumeyaay Indians to consider reduction of turbines on County, BLM, CSLC, and tribal lands
Tule Wind Alternative 2, Gen-Tie Route 2 Underground with Collector Substation/O&M Facility on Rough Acres Ranch	County of San Diego to consider in consultation with BLM, CSLC, and BIA
ESJ Gen-Tie Project	
ESJ Gen-Tie Overhead Alternative Alignment	County of San Diego to consider in consultation with DOE and CPUC

It should be noted that since the Campo, Manzanita, and Jordan wind energy projects are not defined at a project level (due to insufficient detail at this time) and are instead addressed at a program level in this EIR/EIS, these projects are not included in the environmentally superior alternative and will be considered in detail in future environmental analysis conducted for these projects. Similar to the Proposed PROJECT, the environmentally superior alternative would result in the following unavoidable adverse impacts under NEPA and unmitigable (Class I) impacts under CEQA:

~~As with the Proposed Project, the environmentally superior alternative would result in the following Class I impacts~~:

Air Quality: Short-term construction VOC, NOx, and dust emissions associated with the Tule Wind Project, short-term construction NOx and dust emissions associated with the ECO Substation Project, and short-term construction dust emissions associated with the ESJ Gen-Tie Project.

Noise: Short-term construction noise associated with the ECO Substation Project and Tule Wind Project.

Biological Resources: Direct loss of quino checkerspot butterfly habitat associated with the ECO Substation Project and bird/golden eagle strikes from wind turbines

Visual Character: Scenic vistas~~,~~ and visual character impacts associated ~~, and new sources of light associated~~ with the ECO Substation, Tule Wind, and ESJ Wind Phase I projects and new sources of light associated with the Tule Wind and ESJ Wind Phase I projects.

Fire Fuels: Possibility of fire ignition from transmission lines and interference with firefighting associated with the ECO Substation Project~~, Tule Wind Project, and ESJ Gen-Tie Project~~.

Cultural Resources: Without confirmation that that Traditional Cultural Properties are not in the project area, impacts to cultural resources would remain adverse and unavoidable for the ECO Substation, and Tule Wind, and ESJ Gen-Tie projects.

The environmentally superior alternative would result in greater short-term and temporary air quality emissions and noise effects compared to the Proposed PROJECT, but these would be during construction and would be only short term. This alternative's long-term reduction in visual resource impacts and fire and fuels impacts (for the Tule Wind Project extending 25 years until project decommissioning), while still unmitigable, would result in a greater overall reduction in impacts when compared to the Proposed PROJECT. This alternative would reduce unavoidable adverse impacts under NEPA and unmitigable (Class I) impacts under CEQA associated with bird/golden eagle strikes from wind turbines and would reduce avian collision and electrocution risk, and, therefore, from a strictly environmental perspective, ranks as the environmentally superior alternative. However, this alternative would remove the 17 18 wind turbines proposed on the Ewiiaapaayp Indian Reservation, thereby affecting the Ewiiaapaayp Band of Kumeyaay Indians wind and solar energy resources policies to develop renewable energy projects to serve economic and social needs of their reservation. In addition, 27 33 turbines would be removed from lands administered managed by the BLM, 7 turbines would be removed from lands administered by the CSLC, and 11 5 from lands under the jurisdiction of the County of San Diego.

It should be noted that no other feasible mitigation measures or alternatives have been identified that would further reduce project impacts.

ES.78.2 BLM-Preferred Alternative

The BLM's preferred alternative per NEPA requirements and pending public comment on the Draft EIS for the ECO Substation project component is the ECO Substation Alternative Site, combined with ECO Partial Underground 138 kV Transmission Route Alternative, combined with Boulevard Substation Rebuild, and for the Tule Wind Project component is the Tule Wind Alternative 5, Reduction in Turbines, combined with Tule Wind Alternative 2, Gen-Tie Route 2 Underground with Collector Substation/O&M Facility on Rough Acres Ranch. This conclusion is based on the analysis presented in Sections D.2 through D.18.

The identification of a preferred alternative does not constitute a commitment or decision, and there is no requirement to select the preferred alternative in the record of decision. The identification of the preferred alternative may change between a draft EIS and final EIS. Various parts of separate alternatives that are analyzed in the draft can also be "mixed and matched" to develop a complete alternative in the final EIS as long as the reasons for doing so are explained.

Selection in the record of decision of an alternative other than the preferred alternative does not require preparation of a supplemental EIS.

ES.~~8~~9 Issues to be Resolved

This EIR/EIS considers the full range of potential environmental impacts and issues for the Proposed PROJECT. The environmental issues addressed in the EIR/EIS have been resolved in accordance with CEQA and NEPA. As previously discussed in this section, an environmentally superior alternative under CEQA and a BLM preferred alternative under NEPA have been presented. Final selection of the Proposed ECO Substation Project, Tule Wind Project, and ESJ Gen-Tie Project, and each of the project alternatives evaluated in the EIR/EIS, will be predicated by the final decisions made by each of the lead jurisdictions, CPUC, BLM, County of San Diego, California State Lands Commission, BIA, and Ewiiaapaayp Band of Kumeyaay Indians in their consideration of information presented in this EIR/EIS, as well as other factors, including purpose and need, engineering, economic cost/benefit, and public input. The proposed Campo, Manzanita, and Jordan wind energy projects would require project-specific environmental review and evaluation under all applicable environmental regulations once sufficient project-level information has been developed. A meaningful review beyond a programmatic level review would be inappropriate at this time.

Other issues will be resolved during the permitting and agency review process described in Section A, Introduction/Overview of this EIR/EIS, which will need to be resolved prior to project construction. Such permitting includes consultation with the U.S. Fish and Wildlife Service (USFWS) under Section 7 of the Endangered Species Act for the ECO Substation and Tule Wind projects (see Appendix 9 of the Final EIR/EIS for copies of the Tule and ECO Substation Biological Opinions); USFWS determination of consistency with the Bald and Golden Eagle Protection Act for the Tule Wind Project (the USFWS-approved Avian and Bat Protection Plan and their determination of consistency for the Tule Wind Project is available for review on the CPUC project website); ACOE issuance of Clean Water Act Section 404 permits for the ECO Substation and Tule Wind projects; Section 106 consultation with the Office of Historic Preservation (see Appendix 10 of the Final EIR/EIS for copies of the Tule Wind and ECO Substation Section 106 Draft Memorandum of Agreements); California Department of Fish and Game issuance of a Fish and Game Code Section 1602 streambed alteration agreement for the ECO Substation and Tule Wind projects; Regional Water Quality Control Board issuance of Clean Water Act Section 401 water quality certifications for the ECO Substation and Tule Wind projects; issuance of two separate major-use permits from the County of San Diego; federal, state, and local fire agency approval of applicant prepared Fire Protection Plans; and DOE's consideration of a Presidential Permit for the ESJ Gen-Tie Project.

Table ES-~~2~~5
Summary of Impacts and Mitigation for the Proposed Project

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	*Tule Wind Project*	*ESJ Gen-Tie Project*	*Proposed PROJECT[1]*		
Biological Resources						
Impact BIO-1: Construction activities would result in temporary and permanent losses of native vegetation.	Class II	Class II	Class II	Class II	BIO-1a: Confine all construction and construction-related activities to the minimum necessary area as defined by the final engineering plans. BIO-1b: Conduct contractor training for all construction staff. BIO-1c: Conduct biological construction monitoring. BIO-1d: Restore all temporary construction areas pursuant to a Habitat Restoration Plan. BIO-1e: Provide habitat compensation or restoration for permanent impacts to native vegetation communities. BIO-1f: Implement fire prevention best management practices during construction and operation activities. BIO-1g: Prepare and implement a Stormwater Pollution Prevention Plan.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact BIO-2: Construction activities would result in adverse effects to jurisdictional waters and wetlands through vegetation removal, placement of fill, erosion, sedimentation, and degradation of water quality.	Class II	Class II	Class II ~~No Impact~~	Class II	BIO-2a: Limit temporary and permanent impacts to jurisdictional features to the minimum necessary as defined by the final engineering plans. BIO-2b: Implement habitat creation, enhancement, preservation, and/or restoration pursuant to a wetland mitigation plan to ensure no net loss of jurisdictional waters and wetlands. BIO-2c: Where drainage crossings are unavoidable, construct access roads at right angles to drainages.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.

Table ES-52 (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	*Tule Wind Project*	*ESJ Gen-Tie Project*	*Proposed PROJECT*[1]		
Impact BIO-3: Construction and operation/maintenance activities would result in the introduction of invasive, non-native, or noxious plant species.	Class II	Class II	Class II	Class II	BIO-3a: Prepare and implement a Noxious Weeds and Invasive Species Control Plan.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact BIO-4: Construction activities would create dust that would result in degradation of vegetation.	Class II	Class II	Class II	Class II	BIO-4a: Prepare and implement a Dust Control Plan.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact BIO-5: Construction activities would result in direct or indirect loss of listed or sensitive plants or a direct loss of habitat for listed or sensitive plants.	Class II	Class II	Class II	Class II	BIO-5a: Install fencing or flagging around identified special-status plant species populations in the construction areas. BIO-5b: Implement special-status plant species compensation.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact BIO-6: Construction, including the use of access roads, would result in disturbance to wildlife and result in wildlife mortality.	Class III	Class III	Class III	Class III	No mitigation required.	No residual impacts would occur.
Impact BIO-7: Construction activities would result in direct or indirect loss of listed or sensitive wildlife or a direct loss of habitat for listed or sensitive wildlife.	Class I	Class II	Class II	Class I	BIO-7a: Cover and/or provide escape routes for wildlife from excavated areas and monitor these areas daily. BIO-7b: Enforce speed limits in and around all construction areas. BIO-7c: Minimize night construction lighting adjacent to native habitats. BIO-7d: Prohibit littering and remove trash from construction areas daily. BIO-7e: Prohibit the harm, harassment, collection of, or feeding of wildlife.	With avoidance, minimization, and compensatory mitigation, impacts to Quino checkerspot butterfly critical habitat would occur and would remain adverse and unavoidable.

Table ES-52 (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	*Tule Wind Project*	*ESJ Gen-Tie Project*	*Proposed PROJECT*[1]		
					BIO-7f: Obtain and implement the terms of agency permit(s) with jurisdiction federal or state listed species. BIO-7g: Conduct protocol surveys for Quino checkerspot butterfly within 1 year prior to project construction activities in occupied habitat. BIO-7h: Provide compensation for temporary and permanent impacts to Quino checkerspot butterfly habitat through conservation and/or restoration. BIO-7i: Final design of transmission towers and access roads through Quino checkerspot butterfly critical habitat shall maximally avoid host plants for Quino checkerspot butterfly. BIO-7j: Conduct pre-construction nesting bird surveys and implement appropriate avoidance measures for identified nesting birds.	
Impact BIO-8: Construction activities would result in a potential loss of nesting birds (violation of the Migratory Bird Treaty Act).	Class II	Class II	Class II	Class II	See MMs BIO-1a through BIO-1c, BIO-4a, BIO-7b through BIO-7e, and BIO-7j.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact BIO-9: Construction or operational activities would adversely affect linkages or wildlife movement corridors, the movement of fish, and/or native wildlife nursery sites.	Class III	Class III	Class III	Class III	No mitigation required.	No residual impacts would occur.
Impact BIO-10: Presence of transmission lines and wind turbines may result in electrocution of, and/or collisions by, listed or sensitive bird or	Class II	Class I	Class II	Class I	BIO-10a: Design all transmission towers and lines to conform with Avian Power Line Interaction Committee standards. BIO-10b: Develop and implement project-specific	With avoidance, minimization, and mitigation, operation of turbines would pose a

Table ES-5~~2~~ (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	***Tule Wind Project***	***ESJ Gen-Tie Project***	***Proposed PROJECT[1]***		
bat species.					Avian Protection Plans. BIO-10c: Design and configure wind turbines to maximally avoid and minimize bird and bat resources. BIO-10d: Minimize turbine lighting. BIO-10e: Conduct post-construction bird and bat species mortality monitoring and reporting pursuant to an approved monitoring program. BIO-10f: Authorize construction of portions of the project based on the results of behavioral and population studies of local golden eagles. BIO-10g: Monitor golden eagles nests in the area to track productivity. BIO-10h: Implement an adaptive management program in an Avian and Bat Protection Plan that provides triggers for required operational modifications (seasonality, radar, turbine-specific modifications, and cut-in speed). BIO-10i: Obtain written agency approval of the Avian and Bat Protection Plan ~~concurrence documenting compliance with regulations governing golden eagle~~.	significant and unmitigable risk of collision for golden eagles due to the proximity of known active nests near the Proposed PROJECT; therefore, this impact would yield residual effects.
Impact BIO-11: Maintenance activities would result in disturbance to wildlife and could result in wildlife mortality.	Class II	Class II	Class II	Class II	BIO-11a: Conduct maintenance activities resulting in vegetation disturbance outside of the bird nesting season or conduct pre-construction nesting bird surveys.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Visual Resources						
Impact VIS-1: The project would have a substantial adverse effect on a	Class I	Class I	Class III (although	Class I	VIS-1a: Reduce impacts at scenic highway and trail crossings.	With mitigation listed at left, adverse impacts to scenic

Table ES-~~2~~5 (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	***Tule Wind Project***	***ESJ Gen-Tie Project***	***Proposed PROJECT[1]***		
scenic vista.			Class I for ESJ Phase I Wind develop-ment in Mexico)		VIS-1b: Reduce impacts at scenic view areas. VIS-1c: Avoid potential visibility of transmission structures and related facilities from sensitive viewing locations.	vistas would remain adverse and unavoidable.
Impact VIS-2: The project would substantially damage scenic resources, including trees, rock outcroppings, and historic buildings within a state scenic highway.	No Impact	No Impact	No Impact	No Impact	No mitigation required	No residual impacts would occur.
Impact VIS-3: The project would substantially degrade the existing visual character or quality of the site and its surroundings.	Class I	Class I	Class II (although Class I for ESJ Phase I Wind develop-ment in Mexico)	Class I	VIS-3a: Reduce visibility of construction activities and equipment. VIS-3b: Reduce construction night-lighting impacts. VIS-3c: Reduce construction impacts to natural features. VIS-3d: Reduce in-line views of land scars. VIS-3e: Reduce visual contrast from unnatural vegetation lines. VIS-3f: Minimize vegetation removal. VIS-3g: Reduce visual contrast associated with substation and ancillary facilities. VIS-3h: Screen substations and ancillary facilities. VIS-3i: Reduce potential visual contrast of transmission structures. VIS-3j: Reduce potential transmission conductor visibility and visual contrast. VIS-3k: Reduce potential visual contrast from transmission structure spacing.	With mitigation listed at left, impacts to existing visual character would remain adverse and unavoidable.

Table ES-5~~2~~ (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	***Tule Wind Project***	***ESJ Gen-Tie Project***	***Proposed PROJECT[1]***		
					VIS-3l: Reduce potential view blockage and visual contrasts of structures. VIS-3m: Reduce visual impacts resulting from ~~landscaping and~~ native tree removal. VIS-3n: Reduce potential visual impacts of wind turbines and ancillary facilities.	
Impact VIS-4: The project would create a substantial new source of light or glare that would adversely affect day or nighttime views in the area. Impact VIS-4 pertains to long-term effects to nighttime views that would last the life of the project.	Class II	Class I	No Impact (although Class I for ESJ Phase I Wind develop-ment in Mexico)	Class I	VIS-4a: Reduce long-term night-lighting impacts from substations and ancillary facilities. VIS-4b: Incorporate Obstacle Collision Avoidance System (OCAS) onto Tule Wind Project wind turbines.	With mitigation listed at left, impacts related to light or glare from project facilities would remain adverse and unavoidable.
Impact VIS-5: Construction of the project or the presence of project components would result in an inconsistency with federal, state, or local regulations, plans, and standards applicable to the protection of visual resources.	Class II	Class I	Class II	Class I	MMs VIS-1a, 1b, and 1c. MMs VIS-3h, 3i, 3j, 3k, 3l, 3m, and 3n. MMs VIS-4a and 4b.	With mitigation listed at left, impacts related to project facilities and inconsistency with policies and plans protecting visual resources would remain adverse and unavoidable.
Land Use and Planning						
Impact LU-1: Construction would temporarily disturb land uses at or near project components.	Class II	Class II	Class III	Class II	LU-1a: Prepare Construction Notification Plan. LU-1b: Notify property owners and provide access.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.

Table ES-52 (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	*Tule Wind Project*	*ESJ Gen-Tie Project*	*Proposed PROJECT*[1]		
Impact LU-2: Presence of a project component would divide an established community or disrupt land uses at or near project components.	Class II	Class II	Class III	Class II	LU-2 (ECO) and LU-3 (Tule): Revise project elements to minimize land use conflicts.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact LU-3: The project would conflict with applicable land use plans, policies, or regulation of an agency with jurisdiction over the project adopted for the purpose of avoiding or mitigating an environmental effect.	Class III	Class II	Class II	Class II	Mitigation Measures in other specific impact categories in this EIR/EIS would mitigate adverse impacts associated with conflicts with applicable land use plans and policies.	With applicable mitigation residual impacts would not be adverse.
Wilderness and Recreation						
Impact WR-1: Construction activities would temporarily reduce access and visitation to wilderness or recreation areas.	Class II	Class II	Class III	Class II	WR-1: Provide notice for access restrictions or anticipated closures to wilderness and recreation areas WR-2: Maintain access along McCain Valley Road	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact WR-2: Presence of a project component would permanently preclude recreational activities.	Class III	Class III	No Impact	Class III	No mitigation required.	No residual impacts would occur.
Impact WR-3: Presence of a project component in a designated wilderness or wilderness study would result in loss of wilderness land.	No Impact	No Impact	No Impact	No Impact	No mitigation required.	No residual impacts would occur.
Impact WR-3a: Presence of a project component in BLM lands with wilderness characteristics would substantially compromise wilderness characteristics.	—	Not adverse[2]	—	Not adverse[2]	No mitigation required.	No residual impacts would occur.
Impact WR-4: Presence of a project component would result in increased	Class III	Class III	Class III	Class III	No mitigation required.	No residual impacts would occur.

Table ES-52 (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	*Tule Wind Project*	*ESJ Gen-Tie Project*	*Proposed PROJECT*[1]		
unauthorized access to specially designated or restricted areas.						
Agriculture						
Impact AG-1: Construction and operation activities would interfere with active agricultural operations.	Class III	No Impact	No Impact	Class III	No mitigation required.	No residual impacts would occur.
Impact AG-2: Operation would permanently convert DOC Farmland to non-agricultural use.	Class III	No Impact	No Impact	Class III	No mitigation required.	No residual impacts would occur.
Impact AG-3: Operation would conflict with existing zoning for agricultural use or permanently convert Williamson Act lands to non-agricultural use.	No Impact	Class III (existing zoning)/ No Impact (Williamson Act)	No Impact	Class III	No mitigation required.	No residual impacts would occur.
Impact AG-4: Operation would conflict with existing zoning for, or cause rezoning of, forest land, timberland, or timberland zoned Timberland Production.	No Impact	No Impact	No Impact	No Impact	No mitigation required.	Since no adverse impacts would occur, no residual impacts would occur.
Impact AG-5: Operation would result in the loss of forest land or conversion of forest land to non-forest use.	No Impact	No Impact	No Impact	No Impact	No mitigation required.	Since no adverse impacts would occur, no residual impacts would occur.
Cultural and Paleontological Resources						
Impact CUL-1: Construction of the project would cause an adverse change to known significant prehistoric ~~and~~ or historic	Class II	Class II	Class II	Class II	CUL-1A: Develop and Implement a Historic Properties Treatment Plan-Cultural Resources ~~Treatment Program~~Management Plan CUL-1B: Avoid and Protect Significant Resources	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.

Table ES-52 (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	*Tule Wind Project*	*ESJ Gen-Tie Project*	*Proposed PROJECT[1]*		
archaeological resources.					(Environmentally Sensitive Areas Demarcated and Avoided). CUL-1C: Train Contractor CUL-1D: Construction Monitoring CUL-1E: Discovery of Unknown Resources CUL-1F: Control Unauthorized Access CUL-1G: Funding of Law Enforcement Patrols CUL-1H: Continue Consultation with Native Americans and Other Traditional Groups	
Impact CUL-2: Construction of the project would cause an adverse change to sites known to contain human remains either in formal cemeteries or buried Native American remains.	Class II	Class II	Class II	Class II	CUL-2: Human Remains Procedures	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact CUL-3: Construction of the project would have a potential to cause an adverse change to Traditional Cultural Properties (TCP).	Class I	Class I	Class III	Class I	See MMs CUL-1A through CUL-1H and CUL-2CUL-3: Complete Consultation with Native American and other Tribal Groups	Without confirmation that TCPs are not in the project area, impacts would remain adverse and unavoidable for the ECO and Tule projects.
Impact CUL-4: Operation and long-term presence of the project would cause an adverse change to known significant historic architectural (built environment) resources.	Class III	Class II	No Impact	Class II	CUL-1A: Develop and Implement a Historic Properties Treatment Plan-Cultural Resources Treatment Program Management Plan	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact PALEO-1: Construction of the project would destroy or disturb significant paleontological resources.	Class II	Class II	Class II	Class II	PALEO-1: Avoid Paleontological Resources or Reduce Impacts to Less Than Significant PALEO-1A: Inventory and evaluate	The measures listed at left would mitigate this impact. Residual impacts would not

Table ES-52 (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	*Tule Wind Project*	*ESJ Gen-Tie Project*	*Proposed PROJECT[1]*		
					paleontological resources in the Final APE. PALEO-1B: Develop Paleontological Monitoring and Treatment Plan. PALEO-1C: Monitor Construction for Paleontology. PALEO-1D: Conduct paleontological data recovery. PALEO-1E: Train construction personnel.	be adverse.
Noise						
Impact NOI-1: Construction noise would substantially disturb sensitive receptors and violate local rules, standards, and/or ordinances.	Class I	Class I	Class III	Class I	NOI-1: Blasting Plan.	With mitigation listed at left, impacts related to nighttime noise would remain adverse and unavoidable. Noise impacts from helicopter and blasting noise would be adverse and unavoidable if impacted residents do not agree to temporarily relocate.
Impact NOI-2: Construction activity would temporarily cause groundborne vibration.	Class III	Class I	Class III	Class I	See MM NOI-1.	Since it is not known whether impacted residents would agree to temporarily relocate, with mitigation listed at left, vibration impacts from blasting would remain adverse and unavoidable.
Impact NOI-3: Permanent noise levels would increase due to corona noise from operations of the transmission lines and noise from other project components.	Class II	Class II	Class II	Class II	NOI-2: Conductor configuration selection to address noise impacts. NOI-3: Site-specific noise mitigation plan.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.

Table ES-5~~2~~ (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	***Tule Wind Project***	***ESJ Gen-Tie Project***	***Proposed PROJECT[1]***		
Impact NOI-4: Routine inspection and maintenance activities would increase ambient noise levels.	Class III	Class III	Class III	Class III	No mitigation required.	No residual impacts would occur.
Transportation and Traffic						
Impact TRA-1: Construction would cause temporary road and lane closures that would temporarily disrupt traffic flow.	Class II	Class II	Class II	Class II	TRA-1: Prepare and implement a traffic control plan.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact TRA-2: Construction activities would restrict the movements of emergency vehicles (police cars, fire trucks, ambulances, and paramedic units), and there are no reasonable alternative access routes available.	Class II	Class II	Class III	Class II	See MM TRA-1.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact TRA-3: Construction activities would result in unstable flow, or fluctuations in volumes of traffic that temporarily restrict flow; or in an unacceptable reduction in performance of the circulation system, as defined by an applicable plan (including a congestion management program), ordinance, or policy establishing measures of effectiveness for the performance of the circulation system.	Class II	Class II	Class III	Class II	See MM TRA-1.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact TRA-4: The project would substantially increase hazards due to a design feature (e.g., sharp curves or	Class III	Class III	Class III	Class III	No mitigation is required.	No residual impacts would occur.

Table ES-52 (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	*Tule Wind Project*	*ESJ Gen-Tie Project*	*Proposed PROJECT*[1]		
dangerous intersections) or incompatible uses (e.g., farm equipment).						
Impact TRA-5: Construction would substantially disrupt bus or rail transit service, and there would be no suitable alternative routes or stops; or would impede pedestrian movements or bike trails, and there are no suitable alternative pedestrian/bicycle access routes or accommodation through construction zones; or would conflict with planned transportation projects in the project area.	Class II	Class II	Class III	Class II	See MM TRA-1.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact TRA-6: Construction or staging activities would increase the demand for and/or reduce the supply of parking spaces, and there would be no provisions for accommodating the resulting parking deficiencies.	Class III	Class III	No Impact	Class III	No mitigation is required.	No residual impacts would occur.
Impact TRA-7: A noticeable increase in deterioration of roadway surfaces used for the construction zone would occur as a result of heavy truck or construction equipment movements.	Class II	Class II	Class III	Class II	TRA-2: Repair roadways damaged by construction activities	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact TRA-8: A project structure, crane, or wires would be positioned such that it could adversely affect aviation activities, or a proposed land	Class II	Class II	Class II	Class II	TRA-3: Consult with and inform FAA, DOD, and U.S. Customs and Border Protection	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.

Table ES-5~~2~~ (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	*Tule Wind Project*	*ESJ Gen-Tie Project*	*Proposed PROJECT*[1]		
use would conflict with the applicable Airport Land Use Compatibility Plan.						
Public Health and Safety						
Impact HAZ-1: Impacts to soil or groundwater could result from an accidental spill or release of hazardous materials due to improper handling or storage of hazardous materials during construction activities.	Class II	Class II	Class II	Class II	HAZ-1a: Hazardous Materials Management Plan. HAZ-1b: Health and Safety Program. HAZ-1c: Waste Management Plan. HAZ-1d: Testing for environmental hazards associated with demolition.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact HAZ-2: Residual pesticides and/or herbicides could be encountered during grading or excavation.	Class II	Class II	Class III	Class II	HAZ-2a: Test for pesticides/herbicides on currently or historically farmed land. HAZ-2b: Contingency plan for encountering contaminated soils.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact HAZ-3: Previously unknown soil and/ or groundwater contamination could be encountered during grading or excavation.	Class II	Class II	Class II	Class II	HAZ-3: Soil testing for lead contamination.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact HAZ-4: Potential safety hazards could adversely affect construction workers or the general public accessing the project site during construction, operation, or decommissioning.	Class II	Class II	Class II	Class II	HAZ-4a: Safety Assessment. HAZ-4b: Blasting Plan.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact HAZ-5: Impacts to soil or groundwater could result from an accidental spill or release of hazardous materials during operations and maintenance.	Class II	Class II	Class II	Class II	HAZ-5a: Spill Prevention Control and Countermeasure Plan. HAZ-5b: Hazardous Materials Business Plan.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.

Table ES-52 (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	*Tule Wind Project*	*ESJ Gen-Tie Project*	*Proposed PROJECT*[1]		
Impact HAZ-6: Herbicides used for vegetation control around towers and other project facilities could result in adverse health effects to the public or maintenance workers.	Class III	Class III	Class III	Class III	No mitigation required.	No residual impacts would occur.
Impact HAZ-7: Undue risks could result due to the breaking of a rotor blade, also called "blade throw."	N/A	Class II	N/A	Class II	HAZ-6: Wind Turbine Safety Zone and Setbacks.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact HAZ-8: Undue risks could result due to the potential collapse of a wind turbine.	N/A	Class III	N/A	Class III	See MM HAZ-6.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact PS-1 Operation could result in EMI, including interference with radar, radio, television, and electrical equipment.	Class II	Class II	Class II	Class II	PS-1a: Minimize electromagnetic and public safety communications. PS-1b: Limit conductor surface potential. PS-1c: Document complaints of broadcast interference. PS-1d: Aeronautical study. (Tule Wind)	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact PS-2: Operation could result in induced currents and shock hazards in joint use corridors.	Class II	Class II	Class II	Class II	PS-2: Determine proper grounding procedures and implement appropriate grounding measures.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact PS-3: Electric fields could affect cardiac pacemakers.	Class III	Class III	Class III	Class III	No mitigation required.	No residual impacts would occur

Table ES-5~~2~~ (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	***Tule Wind Project***	***ESJ Gen-Tie Project***	***Proposed PROJECT[1]***		
Impact PS-4: Project structures could be affected by wind or lightning hazards.	Class III	Class III	Class III	Class III	No mitigation required.	No residual impacts would occur
Impact PS-5: Facilities could suffer an outage from intentional destruction or terrorism.	Class III	Class III	Class III	Class III	No mitigation required.	No residual impacts would occur
Air Quality						
Impact AIR-1: Construction would generate dust and exhaust emissions of criteria pollutants and toxic air contaminants.	Class I	Class I	Class I	Class I	AQ-1: Measures (listed in Section D.11) shall be incorporated in order to reduce fugitive dust and other criteria pollutant emissions during construction activities. AQ-2: Off-road diesel engine standards.	With mitigation listed in Section D.11, impacts to air quality would remain adverse and unavoidable.
Impact AIR-2: Operation, maintenance, and inspections would generate dust and exhaust emissions of criteria pollutants and toxic air contaminants.	Class III	Class III	Class III	Class III	No mitigation required.	No residual impacts would occur
Impact AIR-3: Construction and decommissioning would not generate exhaust emissions of VOC and NOx that would exceed the general conformity de minimis thresholds.	Class III	Class III	N/A	N/A	No mitigation required.	No residual impacts would occur.
Impact AIR-4: Construction and operational activities would not conflict with or obstruct the implementation of applicable local air quality plans.	Class III	Class III	Class III	Class III	No mitigation required.	No residual impacts would occur.
Impact AIR-5: Construction and operational activities would not	Class II	Class II	Class III	Class II	See MMs AQ-1 and AQ-2.	No residual impacts would occur.

Table ES-5~~2~~ (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	*Tule Wind Project*	*ESJ Gen-Tie Project*	*Proposed PROJECT*[1]		
expose sensitive receptors to substantial pollutant concentrations.						
Impact AIR-6: Construction and operational activities would not create objectionable odors affecting a substantial number of people.	Class III	Class III	Class III	Class III	No mitigation required.	No residual impacts would occur.
Water Resources						
Impact HYD-1: Construction activity could degrade water quality due to erosion and sedimentation.	Class II	Class II	Class II	Class II	HYD-1: A Stormwater Pollution Prevention Plan shall be prepared to reduce soil erosion during construction. See MM GEO-1.	The measure listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact HYD-2: Construction activity could degrade water quality through spills of potentially harmful materials.	Class II	Class II	Class II	Class II	See MM HYD-1. See MM GEO-1.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact HYD-3: Excavation could degrade groundwater quality in areas of shallow groundwater.	Class II	Class II	Class II	Class II	HYD-2: Avoidance and preventative measures to protect local groundwater during excavation. See MMs HAZ-1a through HAZ-1d, HAZ-2a, and HAZ-2b.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact HYD-4: The project could deplete local water supplies.	Class II	Class II	Class III	Class II	HYD-3: Identification of sufficient water supply.	The measure listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact HYD-5: Creation of new impervious areas could cause increased runoff, resulting in flooding or increased erosion downstream.	Class II	Class II	Class II	Class II	HYD-4: Stormwater Management Plan.	The measure listed at left would mitigate this impact. Residual impacts would not be adverse.

Table ES-52 (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	*Tule Wind Project*	*ESJ Gen-Tie Project*	*Proposed PROJECT*[1]		
Impact HYD-6: Project features located in a floodplain or watercourse could result in flooding, flood diversions, or erosion, or expose people or structures to significant risk.	Class II	Class II	Class III	Class II	See MMs HYD-1, HYD-4, BIO-1a through BIO-1d, BIO-1f, and BIO-2a through BIO-2c.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact HYD-7: Accidental releases of contaminants from project facilities could degrade water quality.	Class II	Class II	Class II	Class II	See MMs HAZ-5a and HAZ-5b.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact HYD-8: Where septic tanks are proposed, such facilities could impact local water quality.	No Impact	Class III	No Impact	Class III	No mitigation required.	No residual impacts would occur.
Geology, Mineral Resources, and Soils						
Impact GEO-1: Erosion would be triggered or accelerated due to construction activities.	Class II	Class II	Class II	Class II	GEO-1: Erosion Control and Sediment Transport Control Plan. See MM HYD-1.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact GEO-2: Project would expose people or structures to potential substantial adverse effects as a result of problematic soils.	Class II	Class II	Class II	Class II	GEO-2: Conduct geotechnical studies for soils to assess characteristics and aid in appropriate foundation design.	The measure listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact GEO-3: Project would expose people or structures to potential substantial adverse effects as a result of seismically induced ground shaking, ground failure, or fault rupture.	Class II	Class II	Class II	Class II	See MM GEO-2 GEO-3: Conduct geotechnical investigations. GEO-4: Facilities inspections conducted following major seismic event.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.

Table ES-5~~2~~ (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	***Tule Wind Project***	***ESJ Gen-Tie Project***	***Proposed PROJECT[1]***		
Impact GEO-4: Project would expose people or structures to potential substantial adverse effects as a result of landslides, earthflows, rockfall, and/or subsidence.	Class III	Class II	Class III	Class II	See MM HYD-3 GEO-5: Conduct geotechnical surveys for landslides and mines.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact GEO-5: Project would impact mineral resources.	Class III	Class III	Class III	Class III	No mitigation required.	Since no adverse impacts would occur, no residual impacts would occur.
Public Services and Utilities						
Impact PSU-1: Construction of the project would disrupt the existing utility systems or cause a co-location accident.	Class II	Class II	Class III	Class II	PSU-1a: Notification of utility service interruption. PSU-1b: Protect underground utilities. PSU-1c: Coordinate with utility providers.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact PSU-2: Project construction and operation would increase the need for public services and facilities.	Class III	Class III	Class III	Class III	No mitigation required.	There would be no adverse residual impacts.
Impact PSU-3: Sufficient water supplies are not available to serve the project from existing entitlements, and resources and new or expanded entitlements would be needed.	Class II	Class II	Class III	Class II	See MM HYD-3.	The measure listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact PSU-4: The applicable wastewater treatment provider that serves or may serve the project determines that adequate capacity to serve the project's projected demand (in addition to the provider's existing commitments) is not available.	No Impact	Class III	No Impact	Class III	No mitigation required.	There would be no adverse residual impacts.

Table ES-52 (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	*Tule Wind Project*	*ESJ Gen-Tie Project*	*Proposed PROJECT*[1]		
Impact PSU-5: The project would not be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs.	Class III	Class III	Class III	Class III	No mitigation required.	There would be no adverse residual impacts.
Fire and Fuel						
Impact FF-1: Construction and/or operational and maintenance and decommissioning (Tule Wind Project only) activities would significantly increase the probability of a wildfire.	Class II	Class II	Class II	Class II	FF-1: Develop and implement a Construction Fire Prevention/Protection Plan. FF-2: Revise the Wildland Fire Prevention and Fire Safety Electric Standard Practice Plan (2009) to Create the Wildland Fire Prevention and Fire Safety Electric Standard Practice Operational Maintenance Plan. FF-3: Development Agreement with Rural Fire Protection District and San Diego County Fire Authority. FF-4: Customized Fire Protection Plan for Project.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Impact FF-2: Presence of project facilities including overhead transmission line would increase the probability of a wildfire.	Class I	Class II	Class II	Class I	See MMs FF-1 through FF-4. FF-3: Provide Assistance to San Diego Rural Fire Protection District and San Diego County Fire Authority. FF-4: Customized Fire Protection Plan for Project. FF-5: Wind Turbine Generator Fire Protection Systems. Tule Wind APMs PDF-1, PDF-4, PDF-6, and PDFs8-26. Tule Wind Fire Protection Plan Mitigation Measures FPP-4 through FPP-7 (implemented through the Tule Wind Fire Protection Plan). ESJ APMs FIRE-1 through FIRE-3.	Because final approval of SDG&E's Fire Protection Plan (Mitigation Measure FF-4) has yet to be received and assistance to SDRFPD and SDCFA has yet to be provided in the form of supporting fire code specialist positions (Mitigation Measure FF-3) to SDRFPD and SDCFA, mitigation effectiveness for the ECO Substation Project

Table ES-5~~2~~ (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	*Tule Wind Project*	*ESJ Gen-Tie Project*	*Proposed PROJECT*[1]		
						is not known and, therefore, for purposes of the analysis conducted these impacts unavoidable~~With mitigation listed at left, impacts related to increased fire probability from project facilities~~ would remain adverse and unavoidable.
Impact FF-3: Presence of the overhead transmission line/facilities would reduce the effectiveness of firefighting.	Class I	Class II	Class II	Class I	See MMs FF-1 through FF-3 and FF-5. FF-6: Funding for FireSafe Council.	Because final approval of SDG&E's Fire Protection Plan (Mitigation Measure FF-4) has yet to be received and assistance to SDRFPD and SDCFA has yet to be provided in the form of supporting fire code specialist positions (Mitigation Measure FF-3) to SDRFPD and SDCFA, mitigation effectiveness for the ECO Substation Project is not known and, therefore, for purposes of the analysis conducted~~With mitigation listed at left, impacts related to reduced effectiveness of firefighting due to the presence of~~

Table ES-52 (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	*Tule Wind Project*	*ESJ Gen-Tie Project*	*Proposed PROJECT*[1]		
						project facilities would remain adverse and unavoidable.
Impact FF-4: Project activities would introduce non-native plants, which would contribute to an increased ignition potential and rate of fire spread.	Class II	Class II	Class II	Class II	See MM FF-2. FF-7: Preparation of Disturbed Area Revegetation Plan.	The measures listed at left would mitigate this impact. Residual impacts would not be adverse.
Social and Economic Conditions						
Impact SOC-1: The project would displace substantial numbers of people or existing housing.	Class III	No Impact	No Impact	Class III	No mitigation required.	There would be no adverse residual impacts.
Impact SOC-2: Project construction and/or presence would cause a change in revenue for businesses, tribes, or governments and would cause a substantial change in local employment.	Beneficial	Beneficial	Beneficial	Beneficial	No mitigation required.	Impacts would be beneficial with no adverse residual impacts.
Impact SOC-3: Project construction and operation would cause a decrease in property values.	Not Adverse	Not Adverse	Not Adverse	Not Adverse	No mitigation required.	There would be no adverse residual impacts.
Impact SOC-4: Property tax revenues and/or fees from project presence would substantially benefit public agencies.	Beneficial	Beneficial	Beneficial	Beneficial	No mitigation required.	Impacts would be beneficial with no adverse residual impacts.
Environmental Justice						
Impact EJ-1: Construction and operation would not result in disproportionately high or adverse effects on minority or low-income	No Impact	No Impact	No Impact	No Impact	No mitigation required.	Since no impacts would occur, no residual impacts would occur.

Table ES-52 (Continued)

Impact	CEQA Impact Class				Mitigation Measures	Residual Impact
	ECO Substation Project	*Tule Wind Project*	*ESJ Gen-Tie Project*	*Proposed PROJECT*[1]		
populations.						
Climate Change						
Impact GHG-1: Project construction would cause a net increase of greenhouse gas emissions.	Class III	Class III	Class III	Class III	No mitigation required.	There would be no adverse residual impacts.
Impact GHG-2: Project operation would cause a net increase of greenhouse gas emissions.	Class III	Class III	Class III	Class III	No mitigation required.	There would be no adverse residual impacts.
Impact GHG-3: Project activities would not conflict with an applicable plan, policy, or regulation adopted for the purpose of reducing the emissions of greenhouse gases.	Class III	Class III	Class III	Class III	No mitigation required.	There would be no adverse residual impacts.

[1] Includes Campo, Manzanita, and Jordan Wind Energy Projects.
[2] This impact is solely applicable to BLM jurisdictional lands and therefore, only a NEPA impact determination is provided.

Table ES-6~~3~~
Comparison of Impacts for the Proposed ECO Substation Project and Alternatives

Proposed ECO Substation Project	ECO Substation Site Alternative	ECO Partial Underground 138 kV Transmission Route	ECO Highway 80 138 kV Transmission Route	ECO Highway 80 Underground 138 kV Transmission Route
Biological Resources (see Section D.2 for full analysis)				
Adverse and unmitigable impacts (Class I) would occur to QCB critical habitat. Other adverse mitigable impacts (Class II) would occur for other sensitive species/habitat.	Adverse and unmitigable impacts (Class I) would be nearly identical to the Proposed Project.	Adverse and unmitigable impacts (Class I) would remain significant and would be greater than the Proposed Project due to increased ground disturbance during construction.	Adverse and unmitigable impacts (Class I) would remain significant and would be greater than the Proposed Project due to an increase in sensitive riparian habitat as well as QCB habitat.	Adverse and unmitigable impacts (Class I) would remain significant and would be greater than the Proposed Project due to increased ground disturbance during construction and an increase in sensitive riparian habitat and QCB habitat.
Visual Resources (see Section D.3 for full analysis)				
Adverse and unmitigable impacts (Class I) would occur as the Project would have adverse impacts on scenic vistas and substantially degrade existing visual character.	Adverse and unmitigable impacts (Class I) would be nearly identical to the Proposed Project.	Adverse and unmitigable impacts (Class I) would occur. Although undergrounding a portion of the transmission line would reduce and avoid some of the visual impacts, the overall impact levels would be similar to those identified for the proposed Project.	Adverse and unmitigable impacts (Class I) would be greater than the Proposed Project due to installation of a new transmission line along a more visible corridor (more residences in the area and along a highway).	Adverse and unmitigable impacts (Class I) would occur. Although undergrounding a portion of the transmission line would reduce and avoid some of the visual impacts, the overall impact levels would be similar to those identified for the Proposed Project.
Land Use **(see Section D.4 for full analysis)**				
Short- and long-term land use impacts associated with the Project would generally be adverse mitigable impacts (Class II). The Project would be consistent with all applicable federal land use plans, and because the County has no land use jurisdiction over the Project, local plans are not applicable	Impacts would be nearly identical to those of the Proposed Project.	Impacts would be nearly identical to those of the Proposed Project, temporary impacts would be slightly greater, and long-term impacts where the transmission line is undergrounded would be less.	Impacts would be nearly identical to those of the Proposed Project, temporary impacts and some long-term impacts would be slightly greater due to a greater number of residences along the alternate 4.8-mile route.	Impacts would be nearly identical to those of the Proposed Project, temporary impacts would be slightly greater, and long-term impacts where the transmission line is undergrounded would be less.

Table ES-63 (Continued)

Proposed ECO Substation Project	ECO Substation Site Alternative	ECO Partial Underground 138 kV Transmission Route	ECO Highway 80 138 kV Transmission Route	ECO Highway 80 Underground 138 kV Transmission Route
and impacts would not be adverse (Class III).				
Wilderness and Recreation **(see Section D.5 for full analysis)**				
Project would not directly impact wilderness or recreation areas. Temporary impacts to access to recreation and wilderness areas would be adverse but mitigable (Class II).	Impacts would be nearly identical to those of the Proposed Project.	Adverse mitigable impacts (Class II) would be slightly greater than those of the Proposed Project, but would also be mitigable.	Impacts would not be adverse (Class III) as under this alternative the project would not interfere with access to a wilderness or recreation area.	Impacts would not be adverse (Class III) as under this alternative the project would not interfere with access to a wilderness or recreation area.
Agricultural Resources **(see Section D.6 for full analysis)**				
Impacts would not be adverse (Class III), due to small impacts at Ketchum Ranch.	Impacts would not be adverse (Class III); impacts would be identical to those of the Proposed Project.	Impacts would not be adverse (Class III), impacts would be identical to those of the Proposed Project.	Impacts would not be adverse (Class III). Impacts would be less than those of the Proposed Project.	Impacts would not be adverse (Class III), impacts would be less than those of the Proposed Project.
Cultural and Paleontological Resources **(see Section D.7 for full analysis)**				
Adverse and unmitigable impacts (Class I) may occur to Traditional Cultural Property (TCP). Adverse and mitigable impacts (Class II) would occur to archaeological resources.	This alternative avoids a significant prehistoric archaeological site. Therefore, impacts would be reduced, but overall impacts would remain adverse and unmitigable (Class I) due to potential impacts to TCP.	Impacts to cultural resources would increase under this alternative due to open trenching along the undergrounded route. Overall impacts would remain adverse and unmitigable (Class I) due to potential impacts to TCP.	Impacts would be similar to the proposed project and would remain adverse and unmitigable (Class I).	Impacts to cultural resources would increase under this alternative due to open trenching along the undergrounded route. Overall impacts would remain adverse and unmitigable (Class I) due to potential impacts to TCP.

Table ES-63 (Continued)

Proposed ECO Substation Project	ECO Substation Site Alternative	ECO Partial Underground 138 kV Transmission Route	ECO Highway 80 138 kV Transmission Route	ECO Highway 80 Underground 138 kV Transmission Route
Noise **(see Section D.8 for full analysis)**				
Adverse and unmitigable noise impacts (Class I) would occur temporarily due to construction related nighttime noise, helicopters and blasting .Other noise impacts would be adverse and mitigable (Class II) and/or not adverse (Class III).	Impacts would be similar to but less than those of the Proposed Project. due to an increase distance to residences. Adverse and unmitigable noise impacts (Class I) would occur temporarily due to construction related nighttime noise, helicopters and blasting.	Construction related adverse impacts would be similar to the proposed project, and would remain adverse and unmitigable (Class I). Operations noise impacts would be reduced where the transmission line is undergrounded, but would remain adverse and mitigable (Class II).	Construction related adverse impacts would be similar to the proposed project, and would remain adverse and unmitigable (Class I). Operations noise impacts would be similar to the proposed project and would remain adverse and mitigable (Class II).	Construction related adverse impacts would be similar to the proposed project, and would remain adverse and unmitigable (Class I). Operations noise impacts would be reduced where the transmission line is undergrounded, but would remain adverse and mitigable (Class II).
Transportation and Traffic **(see Section D.9 for full analysis)**				
Short-term construction activities would cause adverse mitigable impacts (Class II) to traffic and roadways.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.
Public Health and Safety **(see Section D.10 for full analysis)**				
Hazardous materials encountered during construction and electromagnetic interference during operations would result in adverse mitigable impacts Class II impacts.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be greater than the Proposed Project due to trenching for underground installation, but would remain less than significant with mitigation.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be greater than the Proposed Project due to trenching for underground installation, but would remain less than significant with mitigation.

Table ES-6~~3~~ (Continued)

Proposed ECO Substation Project	ECO Substation Site Alternative	ECO Partial Underground 138 kV Transmission Route	ECO Highway 80 138 kV Transmission Route	ECO Highway 80 Underground 138 kV Transmission Route
Air Quality **(see Section D.11 for full analysis)**				
Short-term construction related NO_x and PM_{10} air emissions would remain adverse with mitigation (Class I), other short-term air quality impacts would be Adverse mitigable impacts (Class II) and long-term impacts would not be adverse (Class III).	Impacts would be similar to the Proposed Project and would include adverse and unmitigable impacts (Class I).	Significant and unmitigable impacts (Class I). Due to a section of the transmission line being placed underground, air quality impacts associated with helicopter delivery of aboveground tower components would not occur, but greater impacts related to trenching would occur. Ultimately, impacts would be similar to the Proposed Project.	Impacts would be similar to the Proposed Project and would include adverse and unmitigable impacts (Class I).	Significant and unmitigable impacts (Class I). Due to a section of the transmission line being placed underground, air quality impacts associated with helicopter delivery of aboveground tower components would not occur, but greater impacts related to trenching would occur. Ultimately, impacts would be similar to the Proposed Project.
Water Resources **(see Section D.12 for full analysis)**				
Short-term construction activities would degrade water resources and impact water supply, resulting in adverse but mitigable impacts (Class II).	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be greater than the Proposed Project, but remain less than significant with mitigation.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be greater than the Proposed Project, but remain less than significant with mitigation.
Geology, Mineral Resources, and Soils **(see Section D.13 for full analysis)**				
Short-term construction activities would cause erosion and project facilities would be located in seismically active area with liquefaction risk resulting in adverse mitigable impacts (Class II).	Adverse mitigable impacts (Class II) would be almost identical to those of the Proposed Project.	Adverse mitigable impacts (Class II) would be temporary and greater than those of the Proposed Project, but would be mitigable. Permanent impacts would be less than the Proposed Project where the transmission line would be placed underground but would remain adverse with mitigation.	Adverse mitigable impacts (Class II) would be similar to those of the Proposed Project.	Adverse mitigable impacts (Class II) would be temporary and greater than those of the Proposed Project, but with mitigation, remain less than significant. Permanent impacts would be less than the Proposed Project where the transmission line would be placed underground but would remain adverse with mitigation.

Table ES-6~~3~~ (Continued)

Proposed ECO Substation Project	ECO Substation Site Alternative	ECO Partial Underground 138 kV Transmission Route	ECO Highway 80 138 kV Transmission Route	ECO Highway 80 Underground 138 kV Transmission Route
***Public Services and Utilities* (see Section D.14 for full analysis)**				
Adverse mitigable impacts (Class II) during construction would disrupt existing utilities and require substantial amounts of water.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.
Fire and Fuels Management (see Section D.15 for full analysis)				
Adverse and unmitigable impacts (Class I) would occur as with partial mitigation, certain risks remain. The possibility that a transmission line fault would start a fire remains. Transmission lines also reduce firefighter effectiveness. Therefore, impacts are considered adverse and unmitigable.	Adverse and unmitigable impacts (Class I) would be similar to the Proposed Project.	Adverse and unmitigable impacts (Class I) would be less than the Proposed Project, but would remain adverse.	Adverse and unmitigable impacts (Class I) would be similar to the Proposed Project.	Adverse and unmitigable impacts (Class I) would be less than the Proposed Project, but would remain adverse.
Social and Economic Conditions (see Section D.16 for full analysis)				
No adverse impacts (Class III) and beneficial impacts would occur. The Project would not displace people or housing, and would stimulate the local economy.	No adverse impacts (Class III) and beneficial impacts would occur as impacts would be similar to the Proposed Project.	No adverse impacts (Class III) and beneficial impacts would occur as impacts would be similar to the Proposed Project.	No adverse impacts (Class III) and beneficial impacts would occur as impacts would be similar to the Proposed Project.	No adverse impacts (Class III) and beneficial impacts would occur as impacts would be similar to the Proposed Project.

Table ES-63 (Continued)

Proposed ECO Substation Project	ECO Substation Site Alternative	ECO Partial Underground 138 kV Transmission Route	ECO Highway 80 138 kV Transmission Route	ECO Highway 80 Underground 138 kV Transmission Route
Environmental Justice (see Section D.17 for full analysis)				
Construction and operation of the project would not result in disproportionately high or adverse effects on minority or low-income populations.	Construction and operation of the project would not result in disproportionately high or adverse effects on minority or low-income populations.	Construction and operation of the project would not result in disproportionately high or adverse effects on minority or low-income populations.	Construction and operation of the project would not result in disproportionately high or adverse effects on minority or low-income populations.	Construction and operation of the project would not result in disproportionately high or adverse effects on minority or low-income populations.
***Climate Change* (see Section D.18 for full analysis)**				
No adverse impacts (Class III) and beneficial impacts (Class IV) would occur as the Project would assist the State in achieving its renewable energy goals.	No adverse impacts (Class III) and beneficial impacts (Class IV) impacts would occur and would be similar to the Proposed Project.	No adverse impacts (Class III) and beneficial impacts (Class IV) impacts would occur and would be similar to the Proposed Project.	No adverse impacts (Class III) and beneficial impacts (Class IV) impacts would occur and would be similar to the Proposed Project.	No adverse impacts (Class III) and beneficial impacts (Class IV) impacts would occur and would be similar to the Proposed Project.

Table ES-74
Comparison of Impacts for the Proposed Tule Wind Project and Alternatives

Proposed Tule Wind Project	Tule Alternative Gen-Tie Route 2 with Collector Substation/ O&M Facility on Rough Acres Ranch	Tule Alternative Gen-Tie Route 2 Underground with Collector Substation/ O&M Facility on Rough Acres Ranch	Alternative Gen-Tie Route 3 with Collector Substation/O&M Facility on Rough Acres Ranch	Tule Alternative Gen-Tie Route 3 Underground with Collector Substation/ O&M Facility on Rough Acres Ranch	Tule Reduction in Turbines
Biological Resources **(see Section D.2 for full analysis)**					
Adverse and unmitigable impacts (Class I) would be caused by wind turbines to birds, such as golden eagles. Impacts to other sensitive species and habitats would be adverse but mitigable (Class II).	Adverse and unmitigable impacts (Class I) would be similar. Adverse mitigable impacts (Class II) to vegetation and habitat would be slightly greater. Adverse mitigable impacts (Class II) due to electrocution would be slightly reduced due to a reduction in overhead lines.	Adverse and unmitigable impacts (Class I) would be similar. Adverse mitigable impacts (Class II) to vegetation and habitat would be slightly greater. Adverse mitigable impacts (Class II) due to electrocution would be slightly reduced due to a reduction in overhead lines.	Adverse and unmitigable impacts (Class I) would be similar. Adverse mitigable impacts (Class II) to vegetation and habitat would be slightly greater. Adverse mitigable impacts (Class II) due to electrocution would be slightly reduced due to a reduction in overhead lines.	Adverse and unmitigable impacts (Class I) would be similar. Adverse mitigable impacts (Class II) to vegetation and habitat would be slightly greater. Adverse mitigable impacts (Class II) due to electrocution would be slightly reduced due to a reduction in overhead lines.	Adverse and unmitigable impacts (Class I) to special status bird species would be substantially reduced (based on the ~~62~~ 65 turbines removed under this alternative that are in areas of high risk of collision for golden eagles based on topography, landforms, and distance to known active nests). However adverse and unmitigable impacts (Class I) to golden eagles would remain due to the risk of mortality from collision with operating turbines. Adverse mitigable impacts (Class II) to vegetation and habitat would be slightly reduced. Adverse mitigable impacts (Class II) due to electrocution would be the same as the proposed project.

Table ES-74 (Continued)

Proposed Tule Wind Project	Tule Alternative Gen-Tie Route 2 with Collector Substation/ O&M Facility on Rough Acres Ranch	Tule Alternative Gen-Tie Route 2 Underground with Collector Substation/ O&M Facility on Rough Acres Ranch	Alternative Gen-Tie Route 3 with Collector Substation/O&M Facility on Rough Acres Ranch	Tule Alternative Gen-Tie Route 3 Underground with Collector Substation/ O&M Facility on Rough Acres Ranch	Tule Reduction in Turbines
***Visual Resources* (see Section D.3 for full analysis)**					
Adverse and unmitigable impacts (Class I) would occur as the Project would have adverse impacts on scenic vistas, would substantially degrade existing visual character, would create a substantial new source of light, and would temporarily cause inconsistency with visual impact regulations due to construction.	Adverse and unmitigable impacts (Class I) would be nearly identical to the Proposed Project.	Adverse and unmitigable impacts (Class I) would occur, although undergrounding a portion of the transmission line would reduce and avoid some of the visual impacts, the overall impact would remain adverse and unmitigable (Class I).	Adverse and unmitigable impacts (Class I) would be nearly identical to the Proposed Project.	Adverse and unmitigable impacts (Class I) would occur, although undergrounding a portion of the transmission line would reduce and avoid some of the visual impacts, the overall impact would remain adverse and unmitigable (Class I).	Adverse and unmitigable impacts (Class I) would be reduced as turbines would be removed from highest ridgelines; however turbines would remain on elevated ridgelines in the project area.
***Land Use* (see Section D.4 for full analysis)**					
Short-term construction and long-term land use impacts would be adverse of mitigable (Class II). The project would be consistent with all applicable federal and Ewiiaapaayp Band land use plans. A portion of the project on county lands would not be consistent with all applicable county plans and policies pertaining to maintenance of rural character;	Impacts would be similar to the Proposed Project.	Impacts would be reduced but would remain similar to the Proposed Project.	Impacts would be similar to the Proposed Project and would remain similar to the Proposed Project.	Impacts would be reduced but would remain similar to the Proposed Project.	Impacts would be similar to the Proposed Project.

Table ES-74 (Continued)

Proposed Tule Wind Project	Tule Alternative Gen-Tie Route 2 with Collector Substation/ O&M Facility on Rough Acres Ranch	Tule Alternative Gen-Tie Route 2 Underground with Collector Substation/ O&M Facility on Rough Acres Ranch	Alternative Gen-Tie Route 3 with Collector Substation/O&M Facility on Rough Acres Ranch	Tule Alternative Gen-Tie Route 3 Underground with Collector Substation/ O&M Facility on Rough Acres Ranch	Tule Reduction in Turbines
however, with implementation of mitigation measures provided under land use and visual resources (and with the granting of the Major Use Permits required for wind turbines and the 138 kV transmission line) this impact is considered to be adverse and mitigable Class II).					
Wilderness and Recreation **(see Section D.5 for full analysis)**					
Mitigable adverse impacts (Class II) would occur as the Project would directly impact recreation areas, and would not directly impact wilderness areas. Project components would impact inventoried lands with wilderness characteristics; however, portions of the project site not directly impacted by project components would retain wilderness characteristics.	Mitigable adverse impacts (Class II) would be slightly less than the Proposed Project, due to alternate Rough Acres Ranch site. Similar affects to lands with wilderness characteristics as the Proposed Project.	Mitigable adverse impacts (Class II) would be slightly less than the Proposed Project, due to alternate Rough Acres Ranch site. Similar affects to lands with wilderness characteristics as the Proposed Project.	Mitigable adverse impacts (Class II) would be slightly less than the Proposed Project, due to alternate Rough Acres Ranch site. Similar affects to lands with wilderness characteristics as the Proposed Project.	Mitigable adverse impacts (Class II) would be slightly less than the Proposed Project, due to alternate Rough Acres Ranch site. Similar affects to lands with wilderness characteristics as the Proposed Project.	Mitigable adverse impacts (Class II) would be less than the Proposed Project, due to fewer turbines and a bigger buffer adjacent to wilderness areas in the northwest. Affects to lands with wilderness characteristics would be reduced compared to the Proposed Project due to fewer turbines.

Table ES-74 (Continued)

Proposed Tule Wind Project	Tule Alternative Gen-Tie Route 2 with Collector Substation/ O&M Facility on Rough Acres Ranch	Tule Alternative Gen-Tie Route 2 Underground with Collector Substation/ O&M Facility on Rough Acres Ranch	Alternative Gen-Tie Route 3 with Collector Substation/O&M Facility on Rough Acres Ranch	Tule Alternative Gen-Tie Route 3 Underground with Collector Substation/ O&M Facility on Rough Acres Ranch	Tule Reduction in Turbines
***Agricultural Resources* (see Section D.6 for full analysis)**					
Adverse impacts would not occur (Class III) as the Project would not directly impact agricultural area, and would place a utility, an allowable use, in areas zoned for agriculture.	Adverse impacts would not occur (Class III). Impacts would be greater than those of the Proposed Project, but remain not adverse.	Adverse impacts would not occur (Class III). Impacts would be greater than those of the Proposed Project, but remain not adverse.	Adverse impacts would not occur (Class III). Impacts would be greater than those of the Proposed Project, but remain not adverse.	Adverse impacts would not occur (Class III). Impacts would be greater than those of the Proposed Project, but remain not adverse.	Adverse impacts would not occur (Class III). Impacts would be identical to those of the Proposed Project.
***Cultural and Paleontological Resources* (see Section D.7 for full analysis)**					
Adverse and unmitigable impacts (Class I) may occur to Traditional Cultural Property (TCP).	Impacts would be reduced due to the O&M/Substation facility being located in a more disturbed area. Overall impacts would remain adverse and unmitigable (Class I) due to potential impacts to TCP.	Impacts would be reduced due to the O&M/Substation facility being located in a more disturbed area, but would increase where trenching would occur. Overall impacts would remain adverse and unmitigable (Class I) due to potential impacts to TCP.	Impacts would be reduced due to the O&M/Substation facility being located in a more disturbed area. Overall impacts would remain adverse and unmitigable (Class I) due to potential impacts to TCP.	Impacts would be reduced due to the O&M/Substation facility being located in a more disturbed area, but would increase where trenching would occur. Overall impacts would remain adverse and unmitigable (Class I) due to potential impacts to TCP.	Impacts would be reduced with fewer turbine locations due to less ground disturbance. Overall impacts would remain adverse and unmitigable (Class I) due to potential impacts to TCP.
***Noise* (see Section D.8 for full analysis)**					
Adverse and unmitigable noise and vibration impacts (Class I) would temporarily occur from construction related blasting and drilling activities, Operations noise would be adverse	Impacts would be similar to the Proposed Project and would remain adverse with mitigation (Class I).	Adverse and unmitigable impacts (Class I) would be greater than the Proposed Project due to trenching activities along the underground portion of the transmission line.	Adverse and unmitigable impacts (Class I) would occur during construction that would be greater than the Proposed Project due to an increase in sensitive receptors along the alternate route, and would remain adverse with	Adverse and unmitigable impacts (Class I) would occur during construction that would be greater than the Proposed Project and other Alternatives due to an increase in sensitive receptors along the	Impacts would be similar to the Proposed Project and would remain adverse with mitigation (Class I).

Table ES-74 (Continued)

Proposed Tule Wind Project	Tule Alternative Gen-Tie Route 2 with Collector Substation/ O&M Facility on Rough Acres Ranch	Tule Alternative Gen-Tie Route 2 Underground with Collector Substation/ O&M Facility on Rough Acres Ranch	Alternative Gen-Tie Route 3 with Collector Substation/O&M Facility on Rough Acres Ranch	Tule Alternative Gen-Tie Route 3 Underground with Collector Substation/ O&M Facility on Rough Acres Ranch	Tule Reduction in Turbines
and mitigable (Class II).			mitigation.	alternate route and open trenching, and would remain adverse with mitigation.	
***Transportation and Traffic* (see Section D.9 for full analysis)**					
Short-term construction activities would cause adverse but mitigable impacts (Class II) to traffic and roadways.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.
***Public Health and Safety* (see Section D.10 for full analysis)**					
Hazardous materials encountered during construction and electromagnetic interference during operations would result in mitigable adverse impacts (Class II).	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be greater than the Proposed Project and aboveground Alternatives due to trenching for underground installation, but would remain less than significant.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be greater than the Proposed Project and aboveground Alternatives due to trenching for underground installation, but would remain less than significant.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.
***Air Quality* (see Section D.11 for full analysis)**					
Short-term construction related VOC, NOx, PM_{10}, and $PM_{2.5}$ air emissions would remain adverse with mitigation (Class I), other short-term air quality impacts would be mitigable adverse impacts	Adverse and unmitigable impacts (Class I) would be similar to the Proposed Project.	Significant and unmitigable impacts (Class I) would occur. Due to a section of the transmission line being placed underground, air quality impacts associated with helicopter delivery of	Adverse and unmitigable impacts (Class I) would be similar to the Proposed Project.	Significant and unmitigable impacts (Class I) would occur. Due to a section of the transmission line being placed underground, air quality impacts associated with helicopter delivery of	Adverse and unmitigable impacts (Class I) would be slightly less than but similar to the Proposed Project.

Table ES-74 (Continued)

Proposed Tule Wind Project	Tule Alternative Gen-Tie Route 2 with Collector Substation/ O&M Facility on Rough Acres Ranch	Tule Alternative Gen-Tie Route 2 Underground with Collector Substation/ O&M Facility on Rough Acres Ranch	Alternative Gen-Tie Route 3 with Collector Substation/O&M Facility on Rough Acres Ranch	Tule Alternative Gen-Tie Route 3 Underground with Collector Substation/ O&M Facility on Rough Acres Ranch	Tule Reduction in Turbines
(Class II), and long-term impacts would not be adverse (Class III).		aboveground tower components would not occur, but greater impacts related to trenching would occur. Ultimately, impacts would be similar to the Proposed Project.		aboveground tower components would not occur, but greater impacts related to trenching would occur. Ultimately, impacts would be similar to the Proposed Project.	
Water Resources **(see Section D.12 for full analysis)**					
Short-term construction activities would degrade water resources and impact water supply, resulting in adverse but mitigable impacts (Class II).	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be greater than to the Proposed Project, but would remain less than significant with mitigation.	Adverse mitigable impacts (Class II) would be similar to the Proposed Project.	Adverse mitigable impacts (Class II) would be greater than to the Proposed Project, but would remain less than significant with mitigation.	Adverse mitigable impacts (Class II) would be slightly less than the Proposed Project.
Geology, Mineral Resources, and Soils **(see Section D.13 for full analysis)**					
Short-term construction activities would cause erosion and project facilities would be located in seismically active area with potentially active faults, steep slopes, and active/inactive mines, resulting in mitigable adverse impacts (Class II).	Mitigable adverse impacts (Class II) would be similar to those of the Proposed Project.	Mitigable adverse impacts (Class II) would occur Where the transmission line is placed underground, temporary impacts would increase and permanent impacts would decrease compared to those of the Proposed Project. However, overall impacts would remain adverse but mitigable.	Mitigable adverse impacts (Class II) would be similar to those of the Proposed Project.	Mitigable adverse impacts (Class II) would occur Where the transmission line is placed underground, temporary impacts would increase and permanent impacts would increase compared to those of the Proposed Project. However, overall impacts would remain less than adverse but mitigable.	Mitigable adverse impacts (Class II) would be less the than Proposed Project due to removal of turbine locations near a potential active fault; risks of landslides, earthflows, rockfall are reduced due to the elimination of turbine locations within steeper slope areas; and risks of subsidence are reduced due to the elimination of turbine locations in an area of past mining operations.

Table ES-74 (Continued)

Proposed Tule Wind Project	Tule Alternative Gen-Tie Route 2 with Collector Substation/ O&M Facility on Rough Acres Ranch	Tule Alternative Gen-Tie Route 2 Underground with Collector Substation/ O&M Facility on Rough Acres Ranch	Alternative Gen-Tie Route 3 with Collector Substation/O&M Facility on Rough Acres Ranch	Tule Alternative Gen-Tie Route 3 Underground with Collector Substation/ O&M Facility on Rough Acres Ranch	Tule Reduction in Turbines
***Public Services and Utilities* (see Section D.14 for full analysis)**					
Construction activities would cause temporary adverse impacts to utility services and water supplies that would be mitigable (Class II).	Mitigable adverse impacts (Class II) would be similar to the Proposed Project.	Mitigable adverse impacts (Class II) would be similar to the Proposed Project.	Mitigable adverse impacts (Class II) would be similar to the Proposed Project.	Mitigable adverse impacts (Class II) would be similar to the Proposed Project.	Mitigable adverse impacts (Class II) would be slightly less than the Proposed Project.
***Fire and Fuels Management* (see Section D.15 for full analysis)**					
Mitigable adverse impacts (Class II) with implementation of mitigation measures and fire protection plans. ~~Adverse and unmitigable impacts (Class I) would occur as with partial mitigation, certain risks remain. The possibility that a transmission line fault would start a fire remains. Transmission lines also reduce firefighter effectiveness. Therefore, impacts are considered adverse and unmitigable.~~	Mitigable adverse impacts (Class II) would be similar to the Proposed Project.~~Adverse and unmitigable impacts (Class I) would be similar to the Proposed Project~~	Mitigable adverse impacts (Class II) would be similar to the Proposed Project.~~Adverse and unmitigable impacts (Class I) would be less than the Proposed Project, but would remain adverse.~~	Mitigable adverse impacts (Class II) would be similar to the Proposed Project.~~Adverse and unmitigable impacts (Class I) would be similar to the Proposed Project.~~	Mitigable adverse impacts (Class II) would be similar to the Proposed Project.~~Adverse and unmitigable impacts (Class I) would be less than the Proposed Project, but would remain adverse.~~	Mitigable adverse impacts (Class II) would be similar to the Proposed Project.~~Adverse and unmitigable impacts (Class I) would be similar to the Proposed Project.~~
***Social and Economic Conditions* (see Section D.16 for full analysis)**					
The Project would not have an adverse impact, would not displace people or housing, and would	Impacts would be similar to the Proposed Project.	Impacts would be similar to the Proposed Project.	Impacts would be similar to the Proposed Project.	Impacts would be similar to the Proposed Project.	Similar to the Proposed Project, the Project under this alternative would not have an adverse impact,

Table ES-74 (Continued)

Proposed Tule Wind Project	Tule Alternative Gen-Tie Route 2 with Collector Substation/ O&M Facility on Rough Acres Ranch	Tule Alternative Gen-Tie Route 2 Underground with Collector Substation/ O&M Facility on Rough Acres Ranch	Alternative Gen-Tie Route 3 with Collector Substation/O&M Facility on Rough Acres Ranch	Tule Alternative Gen-Tie Route 3 Underground with Collector Substation/ O&M Facility on Rough Acres Ranch	Tule Reduction in Turbines
stimulate the local economy.					would not displace people or housing, and would stimulate the local economy. However, under this alternative revenues from all turbines that would otherwise have been on the Ewiiaapaayp Indian Reservation would be eliminated. Revenues for BLM, California State Lands Commission (CSLC), and the County of San Diego would also be reduced.
***Environmental Justice* (see Section D.17 for full analysis)**					
No impact	No impact	No impact	No impact	No impact	No impact
***Climate Change* (see Section D.18 for full analysis)**					
No adverse impacts (Class III) would occur as the Project would assist the State in achieving its renewable energy goals.	No adverse impacts (Class III) would occur, as this alternative would be similar to the Proposed Project.	No adverse impacts (Class III) would occur, as this alternative would be similar to the Proposed Project.	No adverse impacts (Class III) would occur, as this alternative would be similar to the Proposed Project.	No adverse impacts (Class III) would occur, as this alternative would be similar to the Proposed Project.	No adverse impacts (Class III) would occur, as under this alternative impacts would be slightly less than but similar to the Proposed Project.

Table ES-85
Comparison of Impacts for the Proposed ESJ Gen-Tie Project and Alternatives

Proposed ESJ Gen-Tie Project	ESJ 230 kV Gen-Tie Underground Alternative	ESJ Gen-Tie Overhead Alternative Alignment	ESJ Gen-Tie Underground Alternative Alignment
***Biological Resources* (see Section D.2 for full analysis)**			
Mitigable adverse impacts (Class II) that would be temporary and permanent would occur to native vegetation, and sensitive species and their habitat.	Mitigable adverse impacts (Class II) would be greater than the Proposed Project due to increased ground disturbance, but would remain mitigable.	Mitigable adverse impacts (Class II) would be nearly identical to the Proposed Project.	Mitigable adverse impacts (Class II) would be greater than the Proposed Project, but would remain mitigable.
***Visual Resources* (see Section D.3 for full analysis)**			
The ESJ Gen-Tie would have impacts on scenic vistas that would not be adverse (Class III); impacts on visual quality and consistency with visual resource plans and policies would be adverse but mitigable (Class II). The ESJ Wind Phase I Project component in Mexico would cause adverse and unmitigable impacts (Class I) to scenic vistas, visual character, and night-time views.	Adverse and unmitigable impacts (Class I) would remain due to the ESJ Wind Phase I Project, undergrounding the ESJ Gen-Tie line would reduce some impacts already classified as Class II and III.	Impacts would be similar to the proposed project.	Adverse and unmitigable impacts (Class I) would remain due to the ESJ Wind Phase I Project, undergrounding the ESJ Gen-Tie line would reduce some impacts already classified as Class II and III.
***Land Use* (see Section D.4 for full analysis)**			
Short- and long-term land use impacts would not be adverse (Class III) and with implementation of mitigation measures provided under land use, visual resources, and fire and fuels management the project was found to be consistent with all land use plans and policies (impacts would be adverse but mitigable (Class II)).	Impacts would be less than those of the Proposed Project and would not be adverse (Class III).	Impacts would be nearly identical to those of the Proposed Project.	Impacts would be less than those of the Proposed Project and would not be adverse (Class III).
***Wilderness and Recreation* (see Section D.5 for full analysis)**			
Impacts would not be adverse (Class III)	Temporary impacts would be slightly greater and operations impacts would be slightly less than those of the Proposed Project. However, impacts would remain not adverse (Class III).	Impacts would be nearly identical to those of the Proposed Project.	Temporary impacts would be slightly greater and operations impacts would be slightly less than those of the Proposed Project. However, impacts would remain not adverse (Class III).

Table ES-8~~5~~ (Continued)

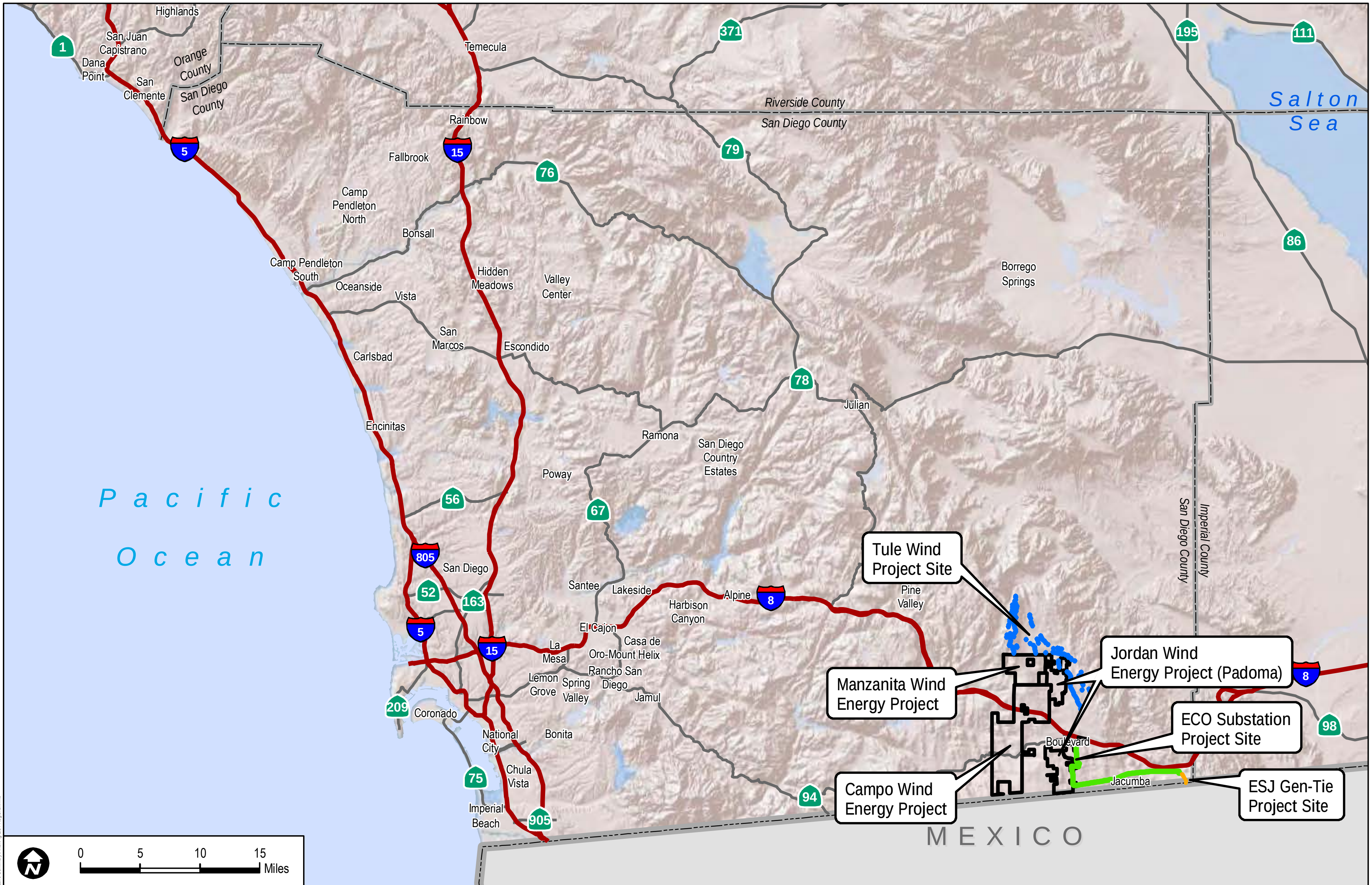
Proposed ESJ Gen-Tie Project	ESJ 230 kV Gen-Tie Underground Alternative	ESJ Gen-Tie Overhead Alternative Alignment	ESJ Gen-Tie Underground Alternative Alignment
***Agricultural Resources* (see Section D.6 for full analysis)**			
No impact	No impact	No impact	No impact
***Cultural and Paleontological Resources* (see Section D.7 for full analysis)**			
Impacts would be adverse and mitigable (Class II) due to potential impacts to human remains, archaeological sites, and cultural or paleontological resources during project construction. ~~Adverse and unmitigable i~~Impacts ~~(Class I) may occur~~ to Traditional Cultural Property (TCP) would not be adverse (Class III).	Impacts to cultural resources would increase under this alternative due to open trenching along the undergrounded route. ~~Overall impacts would remain adverse and unmitigable (Class I) due to potential i~~Impacts to TCP would not be adverse (Class III).	Impacts would be similar due to potential impacts to human remains, archaeological sites, and cultural or paleontological resources. (Class II). ~~Overall impacts would remain adverse and unmitigable (Class I) due to potential i~~Impacts to TCP would not be adverse (Class III).	Impacts would slightly increase due to open trenching along the undergrounded route. (Class II). ~~Overall impacts would remain adverse and unmitigable (Class I) due to potential i~~Impacts to TCP would not be adverse (Class III).
***Noise* (see Section D.8 for full analysis)**			
Mitigable adverse impacts (Class II) would occur from Corona noise from operations of the transmission lines and noise from other project components. All other Project related noise impacts would not be adverse (Class III).	Undergrounding the transmission lines would result in no adverse noise impacts (Class III) during operations. Construction noise would increase during open trenching, but would not be adverse (Class III).	Mitigable adverse impacts (Class II) would occur and be similar to the Proposed Project. All other Project related noise would not be adverse (Class III).	Undergrounding the transmission lines would result in no adverse noise impacts (Class III) during operations. Construction noise would increase during open trenching, but would not be adverse (Class III).
***Transportation and Traffic* (see Section D.9 for full analysis)**			
Mitigable adverse impacts (Class II) would occur that would be short-term and related to construction traffic and roadways.	Mitigable adverse impacts (Class II) would be similar to the Proposed Project.	Mitigable adverse impacts (Class II) would be similar to the Proposed Project.	Mitigable adverse impacts (Class II) would be similar to the Proposed Project.
***Public Health and Safety* (see Section D.10 for full analysis)**			
Hazardous materials encountered during construction and electromagnetic interference during operations would result in adverse mitigable impacts (Class II) .	Mitigable adverse impacts (Class II) would be greater than the Proposed Project due to trenching for underground installation, but would remain less than significant.	Mitigable adverse impacts (Class II) would be similar to the Proposed Project.	Mitigable adverse impacts (Class II) would be greater than the Proposed Project due to trenching for underground installation, but would remain less than significant.

Table ES-85 (Continued)

Proposed ESJ Gen-Tie Project	ESJ 230 kV Gen-Tie Underground Alternative	ESJ Gen-Tie Overhead Alternative Alignment	ESJ Gen-Tie Underground Alternative Alignment
Air Quality **(see Section D.11 for full analysis)**			
Short-term construction related PM_{10} air emissions would remain adverse with mitigation (Class I). Other short-term air quality impacts would be adverse mitigable (Class II), and long-term impacts would not be adverse (Class III).	Adverse unmitigable impacts (Class I), due to a section of the transmission line being placed underground, air quality impacts associated with helicopter delivery of aboveground tower components would not occur, but greater impacts related to trenching would occur. Ultimately, impacts would be similar to the Proposed Project.	Adverse unmitigable impacts (Class I) would be similar to the Proposed Project.	Adverse unmitigable impacts (Class I), due to a section of the transmission line being placed underground, air quality impacts associated with helicopter delivery of aboveground tower components would not occur, but greater impacts related to trenching would occur. Ultimately, impacts would be similar to the Proposed Project.
Water Resources (see Section D.12 for full analysis)			
Short-term construction activities would degrade water resources and impact water supply, resulting in adverse but mitigable impacts (Class II).	Mitigable adverse impacts (Class II) would be greater than the Proposed Project, but would be mitigable.	Mitigable adverse impacts (Class II) would be similar to the Proposed Project.	Mitigable adverse impacts (Class II) would be greater than the Proposed Project, but would be mitigable.
Geology, Mineral Resources, and Soils **(see Section D.13 for full analysis)**			
Short-term construction activities would cause erosion and project facilities would be located in seismically active area, resulting in adverse mitigable impacts (Class II).	Mitigable adverse impacts (Class II) would occur. Temporary impacts would be greater and permanent impacts would be less than those of the Proposed Project. However, overall impacts would remain adverse but mitigable.	Mitigable adverse impacts (Class II),would be similar to those of the Proposed Project.	Mitigable adverse impacts (Class II) would occur. Temporary impacts would be greater and permanent impacts would be less than those of the Proposed Project. However, overall impacts would remain adverse but mitigable.
Public Services and Utilities **(see Section D.14 for full analysis)**			
Construction related impacts would occur but would not be adverse (Class III).	Adverse impacts would not occur (Class III), impacts would be similar to those of the Proposed Project.	Adverse impacts would not occur (Class III), impacts would be similar to those of the Proposed Project.	Adverse impacts would not occur (Class III), impacts would be similar to those of the Proposed Project.

Table ES-85 (Continued)

Proposed ESJ Gen-Tie Project	ESJ 230 kV Gen-Tie Underground Alternative	ESJ Gen-Tie Overhead Alternative Alignment	ESJ Gen-Tie Underground Alternative Alignment
Fire and Fuels Management **(see Section D.15 for full analysis)**			
Adverse mitigable impacts (Class II). A transmission line fault could start a fire and reduce firefighter effectiveness; however, with implementation of mitigation, impacts would be adverse but mitigable (Class II). Adverse unmitigable impacts (Class I) would occur as with partial mitigation, certain risks remain. The possibility that a transmission line fault would start a fire remains. Transmission lines also reduce firefighter effectiveness. Therefore, impacts are considered adverse and unmitigable.	Mitigable adverse impacts (Class II) would occur and, therefore would, be less than the proposed project by undergrounding the transmission line.	Adverse unmitigable impacts (Class II) . would be nearly identical to the proposed project.	Mitigable adverse impacts (Class II) would occur and, therefore, would be less than the proposed project by undergrounding the transmission line.
Social and Economic Conditions **(see Section D.16 for full analysis)**			
The Project would not displace people or housing, and would stimulate the local economy.	Impacts would be similar to the Proposed Project.	Impacts would be similar to the Proposed Project.	Impacts would be similar to the Proposed Project.
Environmental Justice **(see Section D.17 for full analysis)**			
No impact	No impact	No impact	No impact
Climate Change **(see Section D.18 for full analysis)**			
No adverse impacts (Class III) would occur because the Project would assist the State in achieving its renewable energy goals.	No adverse impacts (Class III) would occur, as impacts would be similar to the Proposed Project.	No adverse impacts (Class III) would occur, as impacts would be similar to the Proposed Project.	No adverse impacts (Class III) would occur, as impacts would be similar to the Proposed Project.


Pacific Ocean
Salton Sea
MEXICO
Riverside County
San Diego County
Orange County
Imperial County
Tule Wind Project Site
Jordan Wind Energy Project (Padoma)
Manzanita Wind Energy Project
ECO Substation Project Site
Campo Wind Energy Project
ESJ Gen-Tie Project Site
Highlands
San Juan Capistrano
Dana Point
San Clemente
Temecula
Rainbow
Fallbrook
Camp Pendleton North
Bonsall
Camp Pendleton South
Oceanside
Vista
Hidden Meadows
Valley Center
San Marcos
Escondido
Carlsbad
Encinitas
Ramona
San Diego Country Estates
Julian
Borrego Springs
Poway
San Diego
Santee
Lakeside
Alpine
Pine Valley
Harbison Canyon
El Cajon
Casa de Oro-Mount Helix
La Mesa
Lemon Grove
Spring Valley
Rancho San Diego
Jamul
Coronado
National City
Bonita
Chula Vista
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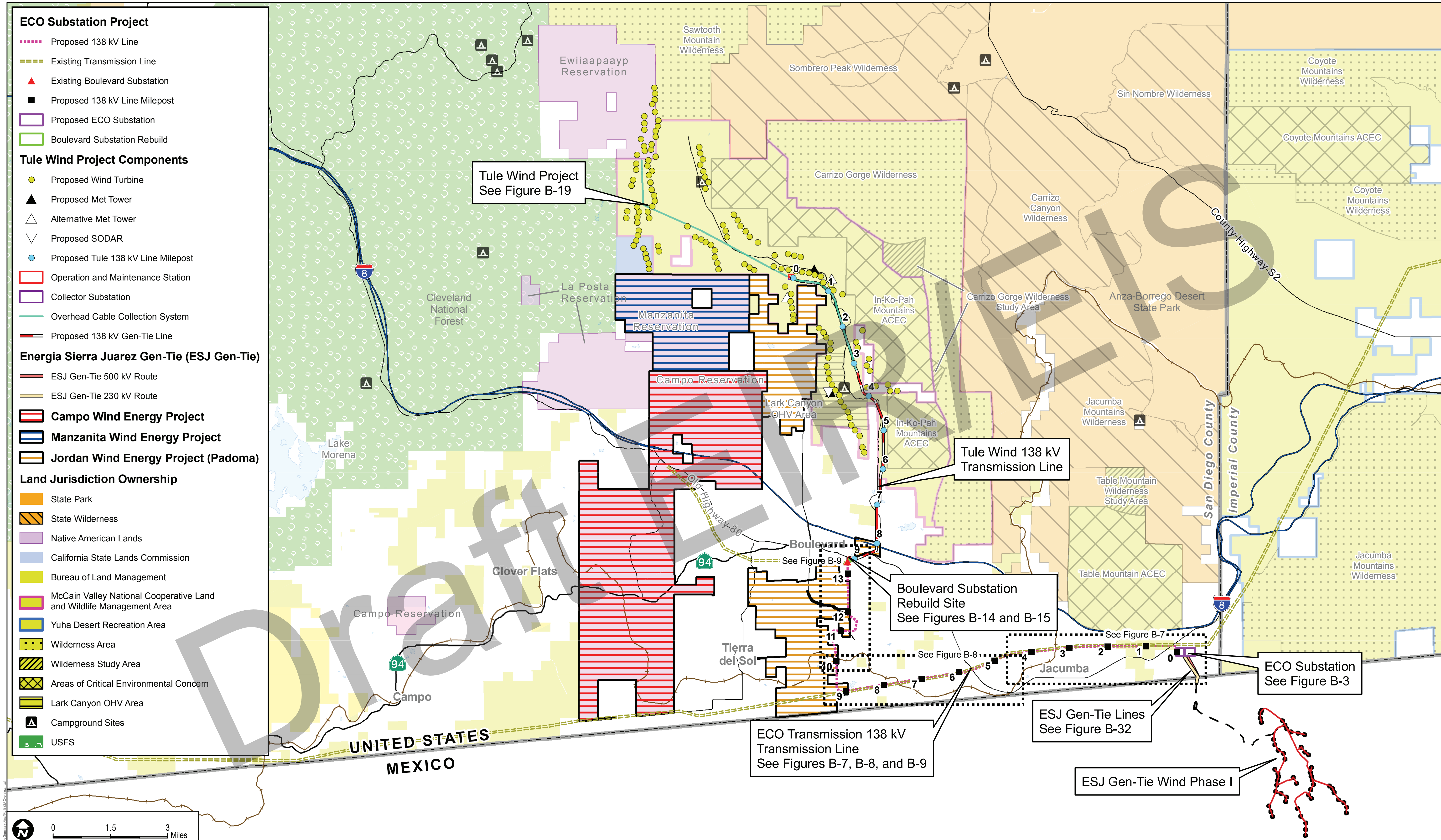

DUDEK

6168-01

SOURCE: BLM; SanGIS; SANDAG; USFS; Tule Wind Project: HDR Engineering 2010; ESJ U.S. Project: ENTRIX 2009; ESJ Wind Project: ENTRIX 2010; ECO Substation Project: SDG&E 2009

FIGURE ES-2A
Vicinity/Overview Map

East County Substation/Tule Wind/Energia Sierra Juarez Gen-Tie Projects - EIR/EIS

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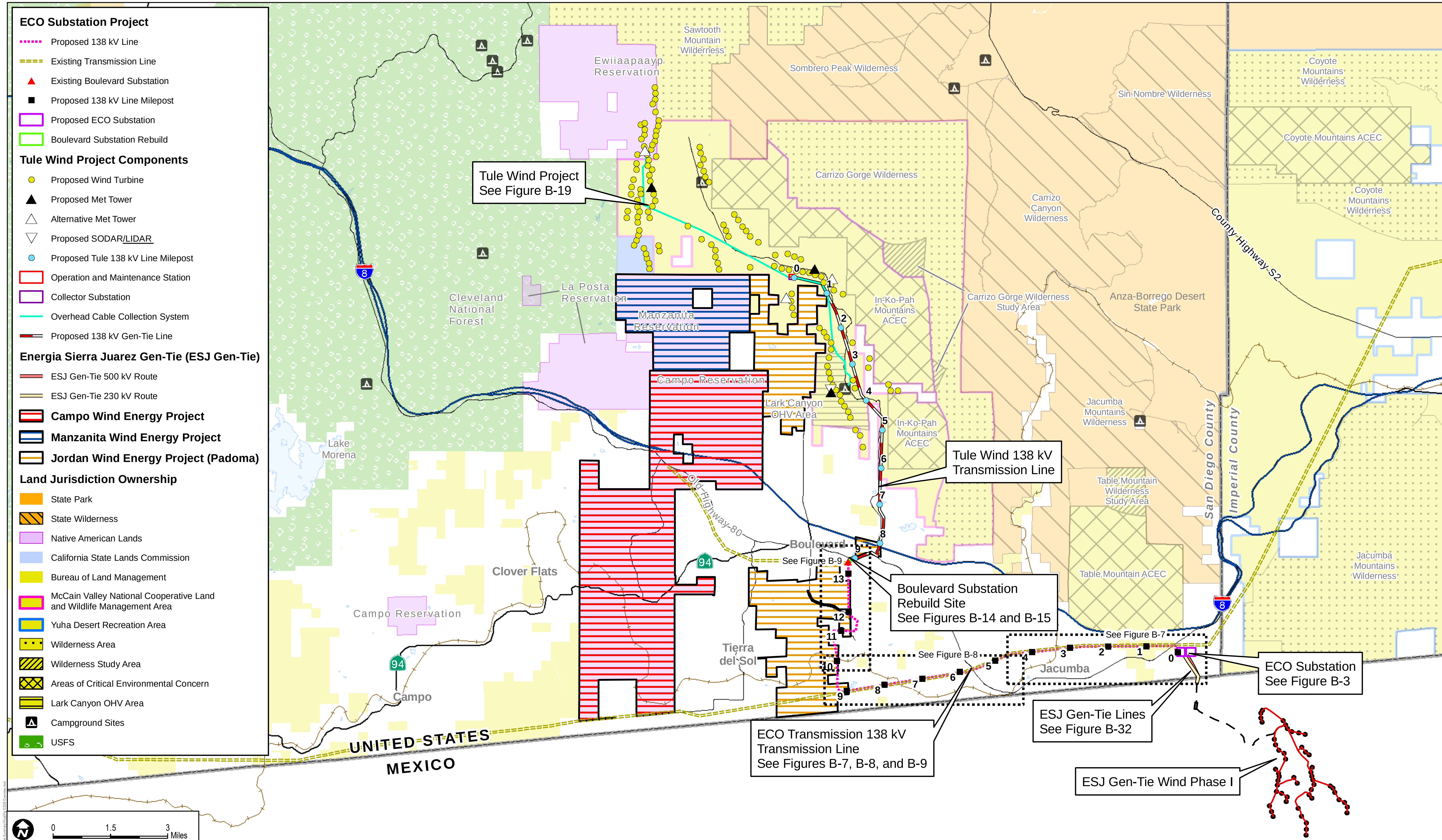

DUDEK

6168-01

SOURCE: BLM; SanGIS; SANDAG; USFS; Tule Wind Project: HDR Engineering 2010; Iberdrola Renewables 2011
ESJ U.S. Project: ENTRIX 2009; ESJ Wind Project: ENTRIX 2010;
ECO Substation Project: SDG&E 2009

FIGURE ES-2B

Vicinity/Overview Map

East County Substation/Tule Wind/Energia Sierra Juarez Gen-Tie Projects - EIR/EIS

Note: Figure depicts Tule Wind modified project layout

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not provide information indicating how climate change might potentially impact the prairie chub. The prairie chub has persisted for millennia with periods of extreme weather events, such as droughts and floods. If climate change causes more extreme weather events, there is no information to indicate that such events will have a negative impact on the prairie chub. At this time, we lack sufficient certainty to know specifically how climate change will affect the species. We are not aware of any data at an appropriate scale to evaluate habitat or population trends for the prairie chub within its range, make predictions about future trends, or determine whether the species will actually be impacted. Therefore, based on information presented by the petitioner and readily available in our files, we do not consider climate change to be a threat to the species; however, we intend to investigate this factor more thoroughly in our status review of the species.

In summary, we find that the petition, along with information readily available in our files, has not presented substantial information that the prairie chub may warrant listing due to other natural or manmade factors.

Finding

On the basis of our determination under section 4(b)(3)(A) of the Act, we have determined that the petition presents substantial scientific or commercial information indicating that listing the prairie chub throughout its entire range may be warranted. This finding is based on information provided under factors A and D about the potential threats from altered stream flows and degraded water quality, and inadequacy of existing regulatory mechanisms to protect prairie chubs from altered stream flows or degraded water quality. We determine that the information provided under factors B, C, and E is not substantial. In considering what factors might constitute threats, we must look beyond the mere exposure of the species to the factor to determine whether the species responds to the factor in a way that causes actual impacts to the species. If there is exposure to a factor, but no response, or only a positive response, that factor is not a threat. If there is exposure and the species responds negatively, the factor may be a threat and we then attempt to determine how significant a threat it is. If the threat is significant, it may drive or contribute to the risk of extinction of the species such that the species may warrant listing as threatened or endangered as those terms are defined by the Act. This does not necessarily require empirical proof of a threat. The combination of exposure and some corroborating evidence of how the species is likely impacted could suffice. The mere identification of factors that could impact a species negatively may not be sufficient to compel a finding that listing may be warranted. The information must contain evidence sufficient to suggest that these factors may be operative threats that act on the species to the point that the species may meet the definition of threatened or endangered under the Act.

Because we have found that the petition presents substantial information indicating that listing the prairie chub may be warranted, we are initiating a status review to determine whether listing the prairie chub as threatened or endangered under the Act is warranted.

The "substantial information" standard for a 90-day finding differs from the Act's "best scientific and commercial data" standard that applies to a status review to determine whether a petitioned action is warranted. A 90-day finding does not constitute a status review under the Act. In a 12-month finding, we will determine whether a petitioned action is warranted after we have completed a thorough status review of the species, which is conducted following a substantial 90-day finding. Because the Act's standards for 90-day and 12-month findings are different, as described above, a substantial 90-day finding does not mean that the 12-month finding will result in a warranted finding.

References Cited

A complete list of references cited is available on the Internet at *http://www.regulations.gov* and upon request from the Oklahoma Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**).

Author

The primary author of this notice is the staff of the Oklahoma Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**).

Authority

The authority for this action is the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

Dated: April 4, 2011.

Rowan W. Gould,

Acting Director, U.S. Fish and Wildlife Service.

[FR Doc. 2011–9089 Filed 4–13–11; 8:45 am]

BILLING CODE 4310–55–P

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

50 CFR Part 17

[Docket No. FWS–R8–ES–2010–0031; MO 92210–0–0008–B2]

Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition To List Hermes Copper Butterfly as Endangered or Threatened

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Notice of 12-month petition finding.

SUMMARY: We, the U.S. Fish and Wildlife Service (Service), announce a 12-month finding on a petition to list Hermes copper butterfly (*Hermelycaena [Lycaena] hermes*) as endangered and to designate critical habitat under the Endangered Species Act of 1973, as amended (Act).

After review of all available scientific and commercial information, we find that listing Hermes copper butterfly as endangered or threatened is warranted. Currently, however, listing Hermes copper butterfly is precluded by higher priority actions to amend the Lists of Endangered and Threatened Wildlife and Plants. Upon publication of this 12-month petition finding, we will add Hermes copper butterfly to our candidate species list. We will develop a proposed rule to list Hermes copper butterfly as our priorities allow. We will make any determination on critical habitat during development of the proposed listing rule. During any interim period, we will address the status of the candidate taxon through our annual Candidate Notice of Review (CNOR).

DATES: The finding announced in this document was made on April 14, 2011.

ADDRESSES: This finding is available on the Internet at *http://www.regulations.gov* at Docket Number FWS–R8–ES–2010–0031. Supporting documentation we used in preparing this finding is available for public inspection, by appointment, during normal business hours at the Carlsbad Fish and Wildlife Office, U.S. Fish and Wildlife Service, 6010 Hidden Valley Road, Suite 101, Carlsbad, CA 92011. Please submit any new information, materials, comments, or questions concerning this finding to the above internet address or the mailing address listed under **FOR FURTHER INFORMATION CONTACT**.

FOR FURTHER INFORMATION CONTACT: Jim Bartel, Field Supervisor, Carlsbad Fish and Wildlife Office, U.S. Fish and Wildlife Service, 6010 Hidden Valley Road, Suite 101, Carlsbad, CA 92011; by telephone at 760–431–9440; or by facsimile at 760–431–9624. If you use a telecommunications device for the deaf (TDD), please call the Federal Information Relay Service (FIRS) at 800–877–8339.

SUPPLEMENTARY INFORMATION:

Background

Section 4(b)(3)(B) of the Act (16 U.S.C. 1531 *et seq.*) requires that, for any petition to revise the Federal Lists of Threatened and Endangered Wildlife and Plants that contains substantial scientific or commercial information that listing a species may be warranted, we make a finding within 12 months of the date of receipt of the petition. In this finding, we determine whether the petitioned action is: (a) Not warranted, (b) warranted, or (c) warranted, but immediate proposal of a regulation implementing the petitioned action is precluded by other pending proposals to determine whether species are endangered or threatened, and expeditious progress is being made to add or remove qualified species from the Federal Lists of Endangered and Threatened Wildlife and Plants. Section 4(b)(3)(C) of the Act requires that we treat a petition for which the requested action is found to be warranted but precluded as though resubmitted on the date of such finding, that is, requiring a subsequent finding to be made within 12 months. We must publish these 12-month findings in the **Federal Register.**

Previous Federal Actions

On October 26, 2004, we received a petition dated October 25, 2004, from the Center for Biological Diversity (CBD) and David Hogan, requesting that Hermes copper butterfly be listed as endangered under the Act and that critical habitat be designated. Included in the petition was supporting information regarding the species' taxonomy, biology, ecology, historical and current distribution, status of population, and actual and potential threats affecting the species and its habitat.

On August 8, 2006, we published a 90-day finding for Hermes copper butterfly in the **Federal Register** (71 FR 44966). The finding concluded that the petition and information in our files did not present substantial scientific or commercial information indicating that listing Hermes copper butterfly may be warranted. For a detailed history of Federal actions involving Hermes copper butterfly prior to the 2006 90-day finding, please see the August 8, 2006, **Federal Register** finding (71 FR 44966).

On March 17, 2009, CBD and David Hogan filed a complaint for declaratory and injunctive relief challenging the Service's decision not to list Hermes copper butterfly as endangered or threatened under the Act. In a settlement agreement dated October 23, 2009, (Case No. 09–0533 S.D. Cal.), the Service agreed to submit a new 90-day petition finding to the **Federal Register** by May 13, 2010, for Hermes copper butterfly. As part of the settlement agreement, we agreed to evaluate the October 25, 2004, petition filed by CBD and David Hogan, supporting information submitted with the petition, and information available in the Service's files, including information that has become available since the August 8, 2006, publication of the negative 90-day finding (71 FR 44966). If the 90-day finding determined that listing may be warranted, we agreed to submit a 12-month finding for Hermes copper butterfly to the **Federal Register** by April 15, 2011.

On May 4, 2010, we published a 90-day finding in the **Federal Register** (75 FR 23654) that determined listing of Hermes copper butterfly as endangered or threatened may be warranted. This notice constitutes the 12-month finding on the October 25, 2004, petition to list Hermes copper butterfly as endangered.

Species Information

It is our intent to discuss only those topics directly relevant to the listing of Hermes copper butterfly under the Act in this 12-month finding. For more information on the taxonomy, biology, and ecology of Hermes copper butterfly, please refer to the 90-day finding published in the **Federal Register** on May 4, 2010 (75 FR 23654). That document is available on the Internet at *http://www.regulations.gov* under docket number FWS–R8–ES–2010–0031.

Taxonomy and Species Description

Hermes copper butterfly was first described as *Chrysophanus hermes* by Edwards (1870, p. 21). Scudder (1876, p. 125) placed this species in the genus *Tharsalea* based on the presence of hindwing tails. Freeman (1936, p. 279) placed Hermes copper butterfly in the genus *Lycaena* as *L. hermes* based on the assessment of the male genetalia, finding that *L. hermes* was distinctly a lycaenid and not typical of the other taxa of *Tharsalea.* Miller and Brown (1979, p. 22) erected a monotypic genus to accommodate Hermes copper butterfly as *Hermelycaena hermes.* This segregation appears to be supported by allozyme data presented by Pratt and Wright (2002, p. 223); although these authors did not recommend separate genus or subgenus placement (Pratt and Wright 2002, p. 225). The broadly based morphological assessment of Miller and Brown (1979) coupled with the more recent allozyme work of Pratt and Wright (2002) support recognition of Hermes copper butterfly as a distinct genus; however, *Lycaena hermes* is the name predominantly used in recent literature (Scott 1986, p. 392; Faulkner and Brown 1993, p. 120; Emmel 1998, p. 832; Opler and Warren 2005, p. 22), and we recognize it as such for the purposes of this finding. Any data or information relevant to the taxonomic status of Hermes copper butterfly will be fully addressed in any proposed rule, and as such will be available for public comment. However, there is no question that as a unique species, Hermes copper butterfly is a listable entity under the Act.

Hermes copper butterfly is a small, brightly-colored butterfly approximately 1 to 1.25 inches (2.5 to 3.2 centimeters (cm)) in length, with one tail on the hindwing. On the upperside, the forewing is brown with a yellow or orange area enclosing several black spots, and the hindwing has orange spots that may be merged into a band along the margin. On the underside, the forewing is yellow with four to six black spots, and the hindwing is bright yellow with three to six black spots (USGS 2006). Mean last instar (period between molts) larval body length is 0.6 inches (in) (15 millimeters (mm)) (Ballmer and Pratt 1988, p. 4). Emmel and Emmel (1973, pp. 62, 63) provide a full description of the early stages of the species (eggs, larvae, and pupae).

Biology

Females deposit single eggs on *Rhamnus crocea* (spiny redberry) in the early summer, often where a branch splits or on a leaf (Marschalek and Deutschman 2009, p. 401). Eggs overwinter, with larvae reported from mid-April to mid-May (Marschalek and Deutschman 2009, p. 400) followed by pupation on the host plant (Emmel and Emmel 1973, p. 63). Not much is known regarding larval biology, as this life stage is little-studied and extremely difficult to find in the field (Marschalek and Deutschman 2009, pp. 400, 401). Hermes copper butterflies have one flight period (termed univoltine) typically occurring in mid-May to early July, depending on weather conditions and elevation (Marschalek and Deutschman 2008, p. 100; Marschalek and Klein 2010, p. 5). Emergence appears to be influenced by weather;

however this relationship is not well understood. For example, weather conditions in the spring of 2010 were cool and moist and resulted in a late emergence; however, the spring of 2006 was hot and dry and also resulted in a late emergence period (Deutschman *et al.* 2010, p. 4). We have no information regarding the ability of immature life stages to undergo multiple-year diapause (a low metabolic rate resting stage) during years with poor conditions (Deutschman *et al.* 2010, p. 4). Multiple year diapause is rare and can occur in stages more advanced than the egg, such as pupae or larvae, after larvae have fed and accumulated energy reserves (Gullan and Cranston 2010, p. 169, Service 2003, p. 8); it is less likely to occur with Hermes copper butterflies because they overwinter (diapause) as eggs.

Deutschman *et al.* (2010, p. 8) used 145 Amplified Fragment Length Polymorphism (AFLP) markers to estimate fundamental Hermes copper butterfly population genetic parameters (i.e., polymorphism, expected heterozygosity, F_{ST} values, and private alleles) that allowed them to evaluate the magnitude of genetic differentiation within and among sampled populations, an indicator of dispersal ability (gene flow). The AFLP process was able to detect genetic differences among individuals, even those captured within several meters of each other. Deutschman *et al.* (2010, pp. 8–17) indicated that butterflies can show differentiation even when close in proximity, presumably due to physical barriers. Alternately, butterflies sampled at locations that are not close have shown little differentiation, indicating that butterflies can also disperse long distances under the right conditions. Deutschman *et al.* (2010, pp. 8–17) sampled at one location (Wildwood Glen) before and after a fire and found genetically differentiated groups, indicating that Hermes copper butterfly individuals are capable of movement between populations. Landscape features may enhance or restrict dispersal which overall, may have several implications regarding population structure and dynamics (Deutschman *et al.* 2010, p. 16). Genetic differentiation of individuals from proximal locations could be a result of dispersal barriers, genetic drift, original colonizers, or a combination of factors (Deutschman *et al.* 2010, p. 16). The genetic similarity of widely geographically separate sample locations indicates that recolonization events by females occur at much further distances than implied by previous studies that suggest most individuals move less than 656 ft (200 m) (Marschalek and Deutschman 2008, p. 102; Marschalek and Klein 2010, p. 7). Deutschman *et al.* (2010, p. 16) noted the majority of genetically similar individuals were territorial males, so it is possible Hermes copper butterfly exhibits sex-biased long-distance dispersal by females, as has been noted for other lycaenids (Robbins and Small 1981, pp. 312–313). In general, Hermes copper butterflies have limited directed movement ability (Marschalek and Klein 2010, p. 1), though lyceanids can be dispersed by the wind (Robbins and Small 1981 p. 312). Deutschman *et al.* (2010, p. 16) analysis also showed the genetic composition of individuals at any location exhibited a high degree of temporal variability, possibly due to biotic (drift, dispersal) and abiotic (landscape, fire regime) influences.

Habitat

Hermes copper butterfly inhabits coastal sage scrub and southern mixed chaparral (Marschalek and Deutschman 2008, p. 98). Hermes copper butterfly larvae use only *Rhamnus crocea* as a host plant (Thorne 1963, p. 143; Emmel and Emmel 1973, p. 62). The range of *R. crocea* extends throughout coastal northern California, as far north as San Francisco (Consortium of California Herbaria 2010); however, Hermes copper butterfly has never been documented north of San Diego County (Carlsbad Fish and Wildlife Office (CFWO) GIS database). Therefore, some factor other than host plant availability apparently has historically limited or currently limits the range of the species. Researchers report adults are rarely found far from *R. crocea* (Thorne 1963, p. 143) and take nectar almost exclusively from *Eriogonum fasciculatum* (California buckwheat) (Marschalek and Deutschman 2008, p. 5). The densities of host plants and nectar sources required to support a Hermes copper population are not known. Recent research has not added much to Thorne's (1963, p. 143) basic description of Hermes copper butterfly habitat: "It is very difficult to analyze the complex factors which determine why a certain plant has been successful in a given spot * * * In the case of *Rhamnus crocea,* the only consistent requirement seems to be a well-drained soil of better than average depth, yet not deep enough to support trees. Such soils occur along canyon bottoms and on hillsides with a northern exposure; therefore, it is in these situations that [Hermes copper butterfly] is generally found."

Hermes copper butterflies exhibit a preference for micro-sites within stands of *Rhamnus crocea,* which may be related to temperature because adults become active around 72 degrees Fahrenheit (°F) (22 degrees Celsius (°C)) (Marschalek and Deutschman 2008, p. 5). Marschalek and Deutschman (2008, p. 3) recorded densities of Hermes copper butterflies on paired transects along edges and within the interior of host plant stands in rural areas. Their study indicates that Hermes copper butterfly densities are significantly higher near host plant stand edges than in the interior (Marschalek and Deutschman 2008, p. 102). Adult males have a strong preference for openings in the vegetation, including roads and trails, specifically for the north and west sides of canopy openings (Marschalek and Deutschman 2008, p. 102). These areas capture the first morning light and reach the temperature threshold for activity more quickly than other areas (Deutschman *et al.* 2010, p. 4). Hermes copper butterflies tend to remain inactive under conditions of heavy cloud cover and cooler weather (Marschalek and Deutschman 2008, p. 5). Across all four sites sampled by Marschalek and Deutschman, Hermes copper butterfly presence was positively associated with *Eriogonum fasciculatum,* but negatively associated with *Adenostema fasciculatum* (chamise) (Marschalek and Deutschman 2008, p. 102). Therefore, woody canopy openings with a northern exposure in stands of *R. crocea* and adjacent stands of *Eriogonum fasciculatum* appear to be components of suitable habitat for Hermes copper butterfly.

Marschalek and Klein (2010) studied intra-habitat movement of Hermes copper butterflies using mark-release-recapture techniques. They found the highest median dispersal distance for a given site in a given year was 146 ft (44.5 m), and their maximum recapture distance was 0.7 miles (mi) (1.1 kilometers (km)) (Marschalek and Klein 2010, p. 1). They also found no adult movement across non-habitat areas, such as type-converted grassland or riparian woodland (Marschalek and Klein 2010, p. 6). Hermes copper butterfly is typically relatively sedentary (Marschalek and Klein 2010, p. 1), although winds may aid dispersal (Robbins and Small 1981, p. 312). Studies to date infer that most individuals typically move less than 656 ft. (200 m) (Marschalek and Deutschman 2008, p. 102, Marschalek and Klein 2010, pp. 725–726), supporting the assumption that Hermes copper butterflies are typically sedentary compared to other butterfly species such as painted ladies—(*Vanessa cardui*). However, as discussed above, genetic research indicates that females may disperse longer distances than males (Deutschman *et al.* 2010, p. 16) contradicting previous methods used such as mark-release-recapture (Marschalek and Deutschman 2008, p. 102) that may not detect the movement of females and over sample territorial males. More information is needed to fully understand movement patterns of Hermes copper butterfly; however, dispersal is likely inhibited by lack of available habitat in many areas (Deutschman et al. 2010, p. 17).

Range and Population Distribution Status

Hermes copper butterfly is endemic to the southern California region, primarily occurring in San Diego County, California (Thorne 1963, p. 143). All records of Hermes copper butterflies in the United States are within San Diego County, with most occurrences concentrated in the southwest portion of the County (Marschalek and Klein 2010, p. 4). Notable exceptions to the "southwestern distribution pattern" are two old museum specimens collected in north San Diego County, one from the vicinity of the community of Bonsall in 1934, and another from the vicinity of the community of Pala in 1932. Historical data indicate Hermes copper butterflies ranged from the vicinity of the community of Pala, California, in northern San Diego County (CFWO GIS database) to approximately 18 mi (29 km) south of Santo Tomas in Baja California, Mexico, and from Pine Valley in eastern San Diego County to Mira Mesa, Kearny Mesa, and Otay Mesa in western San Diego County (Thorne 1963, pp. 143, 147). They have never been recorded immediately adjacent to the coast, and have not been found east of the western slopes of the Cuyamaca Mountains above approximately 4,264 ft (1,300 m) (Marschalek and Klein 2010, p. 4).

The distribution of Hermes copper butterfly in Mexico is not well-known and researchers have not explored this area (Marschalek and Klein 2010, p. 4). Of the two museum specimens from Mexico, one collected in 1936 was labeled "12 miles north of Ensenada," and another collected in 1983 was labeled "Salsipuedes" (Marschalek and Klein 2010, p. 4). Assuming older specimens were usually collected relatively close to roads that existed at the time (Thorne 1963, p. 145), these Mexican locations probably were collected from approximately the same location, which is a popular surf destination known as Salsipuedes, located approximately 12 mi (19 km) north of Ensenada off the Esconica Tijuana-Ensenada (coastal highway to Ensenada). The known distribution in Mexico of *Rhamnus crocea* is relatively contiguous with that in the U.S., extending to approximately 190 mi (312 km) south of the border into Mexico along the western Baja California Peninsula (Little 1976, p. 150). Hermes copper butterflies have been recorded as far south into Mexico as 18 mi (29 km) south of Santo Tomas, which is approximately half the distance of the extent of *Rhamus crocea's* Mexican range; (Thorne 1963, p. 143). As stated in our 2006, 90-day finding (71 FR 44969; August 8, 2006), there have been recent discoveries (post-1993) of extant populations within the species' known historical range in the United States. These include Black Mountain, Crestridge and two populations on the San Diego National Wildlife Refuge. However, there is still uncertainty as to the distribution of Hermes copper butterfly within the known historical range because we have very little information on the status of the species in Mexico.

A species' range can be defined at varying relevant scales of resolution, from maximum geographic range capturing all areas within the outermost record locations (coarsest scale, hereafter called "known historical range"), to the scale of individual population distributions (finest scale, hereafter called "population distributions"). This concept was discussed by Thorne (1963, p. 143): "However within this range [Hermes copper butterfly] distribution is limited to pockets where the larval food plant occurs, so that the total area where the insect actually flies is probably not more than a fraction of one percent of the maximum area."

To more precisely determine the historical range of Hermes copper butterfly, we entered all Hermes copper butterfly observation records that had information about collection location in our GIS database, and mapped all observed and museum specimen records with an appropriate level of detail and location description. To better determine the geographic locations of historical Hermes copper butterfly records mapped by Thorne (1963, p. 147), we overlaid a transparent image of his map on Google Earth imagery, and scaled it appropriately to ensure that geographic features and community locations corresponded with those of the imagery. Examination of Thorne's (1963 p. 147) map expanded the known historical range as described by Deutschman *et al.* (2010, p. 3) to the southeast in the vicinity of the community of Pine Valley and Corte Madera Valley. The resulting known historical range of Hermes copper butterfly within the United States can be described as comprised of a narrow northern portion within the Central Valley and Central Coast ecoregions, north of Los Penasquitos Canyon and Scripps Poway Parkway (latitude midway between the northernmost record location and the international border), and a wider southern portion encompassing the Southern Coast, Southern Valley, and Southern Foothills ecoregions (see Figure 1 and Table 1 below; San Diego County Plant Atlas 2010). Although the distribution of Hermes copper butterfly populations in Mexico is not well understood, United States populations minimally encompass half the species' known historical latitudinal range. The results of our population distribution analysis indicate areas in the United States most likely to harbor possible extant undiscovered Hermes copper butterfly populations within the known historical range are primarily limited to a relatively narrow area within the southern portion of the range bordered on the north and south by the 2003 Cedar Fire and 2007 Harris Fire perimeters, and on the west and east roughly by Sycuan Peak and Long Valley (see Figure 1 and Table 1 below).

TABLE 1—ALL KNOWN HERMES COPPER BUTTERFLY POPULATIONS IN THE UNITED STATES AND MEXICO

Map No.	Population name (other names)	Last observed	Presumed status	Extant in 2000 *	Fire	Extirpated why?
1	Elfin Forest (Onyx Ridge).	2002	Unknown	Y	2007	
2	Rancho Santa Fe (Del Dios)	2004	Extirpated	Y	2007	Fire, Development.
3	Black Mountain	2004	Unknown	Y		
4	Van Dam Peak (Meadowbrook)	2003	Extirpated	Y	....	Isolation (Development).
5	Lopez Canyon	2008	Extant	Y		

TABLE 1—ALL KNOWN HERMES COPPER BUTTERFLY POPULATIONS IN THE UNITED STATES AND MEXICO—Continued

Map No.	Population name (other names)	Last observed	Presumed status	Extant in 2000 *	Fire	Extirpated why?
6	Sycamore Canyon	2003	Extirpated	Y	2003	Fire.
7	North Santee (Fanita Ranch)	2005	Unknown	Y	2003	
8	Mission Trails (Mission Gorge, Mission Dam).	2010	Extant	Y	2003	
9	Crestridge	2007	Extirpated ***	Y	2003	Fire.
10	Anderson Truck Trail	2003	Extirpated	Y	2003	Fire.
11	Alpine (Wright's Field)	2010	Extant	Y		
12	North McGinty Mountain	2010	Extant	Y		
13	South McGinty Mountain	2010	Extant	Y		
14	Los Montanas	2010	Extant	Y		
15	Rancho San Diego	2009	Extant	Y	2007	
16	San Miguel Mountain	2006	Extirpated	Y	2007	Fire.
17	Rancho Jamul	2007	Extirpated	Y	2003, 2007	Fire.
18	North Jamul	2004	Unknown	Y	2003	
19	East McGinty Mountain	2001	Unknown	Y		
20	Loveland Reservoir	2010	Extant	Y		
21	Sycuan Peak	2010	Extant	Y		
22	Skyline Truck Trail (Lawson Valley)	2010	Extant	Y		
23	Lyons Peak	2003	Unknown	Y	2007	
24	Hollenbeck Canyon	2007	Extirpated	Y	2003, 2007	Fire.
25	Dulzura (Near Marron Valley Road)	2005	Extirpated	Y	2003, 2007	Fire.
26	Lawson Valley (Lawson Peak)	2010	Extant	Y	2006, 2007	
27	Hidden Glen (Japutal Valley, Lyons Valley Road).	2008	Extant	Y		
28	Willows (Viejas Grade Road)	2003	Extirpated	Y	2003	Fire.
29	North Guatay Mountain	2004	Unknown	Y	2003	
30	North Descanso (Wildwood Glen, Descanso).	2010	Extant	Y	2003	
31	South Descanso (Roberts Ranch)	2010	Extant	Y	2003	
32	Japutal (Japutal Valley)	2009	Extant	Y		
33	South Guatay Mountain	2008	Extant	Y		
34	Hartley Peak (Portrero)	2010	Extant	Y	2007	
35	Pala	1932	Extirpated	...	...	Unknown.
36	Bonsall	1934	Extirpated	...	...	Unknown.
37	San Elijo Hills (San Marcos Creek, San Elijo Road and Questhaven Road).	1979	Extirpated	...	...	Development.
38	Lake Hodges	1982	Extirpated	...	2007	Fire.
39	Sabre Springs (Poway Road and 395).	2001	Extirpated	Y	...	Development.
40	Miramar	1996	Extirpated	...	...	Development.
41	Mira Mesa	Prior to 1963	Extirpated	...	...	Development.
42	Cowles Mountain (Big Rock Road Park).	1973	Extirpated	...	...	Isolation.
43	Kearny Mesa	1939	Extirpated	...	...	Development.
44	Mission Valley (Fairmont Canyon, Canyons near Mission Valley).	1908	Extirpated	...	...	Development.
45	San Diego State University (San Diego State College).	1957	Extirpated	...	...	Development.
46	El Monte (El Monte Park, El Monte Road).	1960	Extirpated	...	...	Fire, Development.
47	Pine Valley	Pre-1963	Unknown.			
48	Corte Madera	Pre-1963	Unknown.			
49	Tecate Peak	1980	Extirpated	...	2007	Fire.
50	Deerhorn Valley	1970	Extirpated	...	2007	Fire.
51	Dictionary Hill	1962	Extirpated	...	...	Isolation (Development).
52	Otay Mountain (Little Cedar Canyon, Otay foothill).	1979	Extirpated	...	2003, 2007	Fire.
53	South Otay Mesa	Pre-1920	Extirpated	...	...	Development.
54	Salsipuedes (12 miles North of Ensenada) **.	1983	Unknown.			
55	Santo Tomas (18 miles south of Santo Tomas) **.	Pre-1920	Unknown.			
56	South Santee	1967	Extirpated	...	...	Development.
57	North Ensenada (Bajamar) **	1936	Unknown.			

* Populations with last observation prior to 2000 have lower geographic accuracy.

** Map Nos. 54, 55, and 57 are populations in Mexico that are not represented on Figure 1 in this document.

*** Extirpation was a result of high mortality from fire, followed by reduced population density. Only one male was observed in 2007, and none after that.

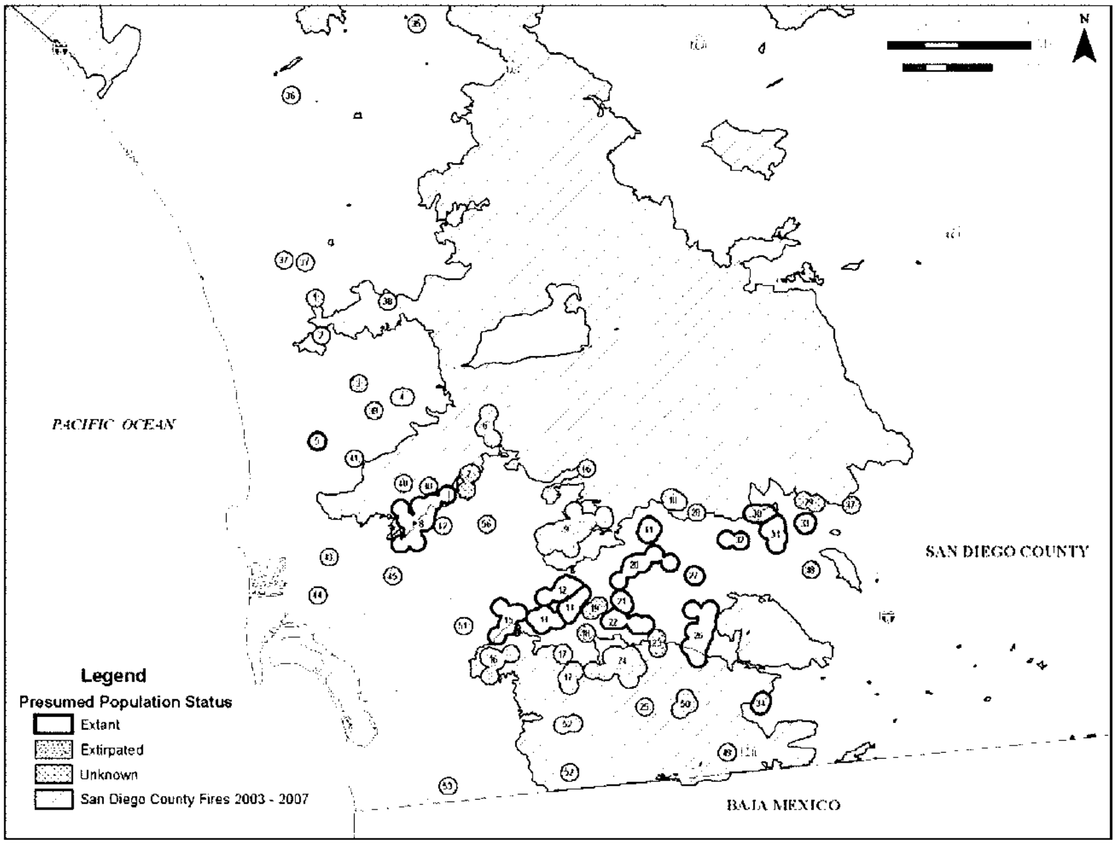

Figure 1. Hermes copper butterfly populations in the United States and their current presumed status.

To evaluate the status of Hermes copper butterfly's current range and populations, we considered all available historical data and recent research results, including record locations (CFWO GIS databases), monitoring data, (Marschalek and Deutschman 2008; Marschalek and Klein 2010), movement data (Marschalek and Deutschman 2009; Marschalek and Klein 2010), and data from a recent distribution study (Deutschman *et al.* 2010). To estimate the geographic population distribution of Hermes copper butterfly, we used all occurrence records and mapped areas within approximately 0.6 mi (1 km) of known observation sites. This distance is greater than the average recapture distance recorded by Marschalek and Klein (2010, p. 1), but just under the maximum recorded recapture distance, an approximate within-population movement distance further supported by Deutschman *et al.*'s (2010, p. 26) genetic data (see *Habitat* section above). Locations within approximately 1.2 mi (2 km) (where 0.6 mi (1 km) movement distances overlapped) were considered part of the same population, unless topographic or genetic information indicated the possibility of barriers to movement. We used recent fire footprint data and aerial GIS information, in addition to the information referenced above, to determine which Hermes copper butterfly populations may be extant, extirpated, or of unknown status. A Hermes copper population was considered to be "extant" if the species was recorded based on recent survey records and not affected by recent fires. A Hermes copper population was considered to be extirpated if the area had been developed and no habitat remained, a fire footprint encompassed the area and subsequent surveys were negative, or if the record was very old with no recent detections. In some instances, we had no recent information to make a determination on Hermes copper butterfly's current status and it was therefore classified as "unknown." See Figure 1 and Table 1 above for a list of populations and information used to determine population status.

In summarizing the results of our analysis of Hermes copper butterfly's current range and population distributions (see Figure 1 and Table 1 above), we estimated there were at least 57 known separate historical populations throughout the species' range since the species was first described. In the year 2000, 35 populations were thought to be extant. Since that time, 11 populations have been extirpated (2 by development, 1 by fire and development, 8 by fire alone) and 7 are of unknown status. As of 2011, of the 57 known populations, 17 Hermes copper butterfly populations are extant, 28 populations are believed to have been extirpated, and 12 populations are of unknown status. In the northern portion of the range, most remaining suitable habitat is limited to the relatively isolated and fragmented undeveloped lands between the cities of San Marcos, Carlsbad, and Escondido and the community of Rancho Santa Fe, and the habitat "islands" containing the Black Mountain and Van Dam Peak observation locations; however, no new populations have been discovered. In the southern portion of the range, all extant populations except Lopez Canyon and the southern portion of Mission Trails Park (both isolated from other extant populations by development and fire) are within relatively well-connected undeveloped lands east of the City of El Cajon between the 2003 Cedar Fire and 2007 Harris Fire perimeters (see Figure 1 and Table 1 above). The Mission Trails Park population remains extant even after approximately 74 percent of the population area burned in 2003, presumably because burned areas were recolonized (after host plant and nectar sources regrew) by Hermes copper butterflies from nearby unburned areas. The best information available leads us to conclude that the northern portion of the species' known historical range has contracted or may no longer exist, and we estimate that approximately 27 percent of the populations within the southern portion of the species' known historical U.S. range that were extant in 2000 have been extirpated (see Figure 1 and Table 1 above; Map #s 6, 9, 10, 16, 17, 24, 25, 28). Further investigation is needed to accurately determine the status of Hermes copper butterfly in Mexico (Marschalek and Klein 2010, p. 2). Klein (2010a, p. 1) visited the Salsipuedes location in the first week of June 2005 for approximately 30 minutes. He did not observe any Hermes copper butterflies; however, he described the habitat as having a "decent number of [*Rhamnus crocea*], a large amount of *Eriogonum fasciculatum,*" and said he felt the area was "very good" for Hermes copper butterfly (Klein 2010, p. 1).

Summary of Information Pertaining to Five Factors

Section 4 of the Act (16 U.S.C. 1533) and implementing regulations (50 CFR part 424) set forth procedures for adding species to, removing species from, or reclassifying species on the Federal Lists of Endangered and Threatened Wildlife and Plants. Under section 4(a)(1) of the Act, a species may be determined to be endangered or threatened based on any of the following five factors:

(A) The present or threatened destruction, modification, or curtailment of its habitat or range;

(B) Overutilization for commercial, recreational, scientific, or educational purposes;

(C) Disease or predation;

(D) The inadequacy of existing regulatory mechanisms; or

(E) Other natural or manmade factors affecting its continued existence.

In making this finding, information pertaining to Hermes copper butterfly in relation to the five factors provided in section 4(a)(1) of the Act is discussed below.

In considering whether a species warrants listing under any of the five factors, we look beyond the species' exposure to a potential threat or aggregation of threats under any of the factors, and evaluate whether the species responds to those potential threats in a way that causes actual impact to the species. The identification of threats that might impact a species negatively is not sufficient to compel a finding that the species warrants listing. The information must include evidence indicating that the threats are operative and, either singly or in aggregation, affect the status of the species. Threats are significant if they drive, or contribute to, the risk of extinction of the species, such that the species warrants listing as endangered or threatened, as those terms are defined in the Act.

Factor A. The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

Here we describe the primary threats that result in Hermes copper butterfly habitat destruction and modification, describe how those threats interact to cause long-term or permanent range curtailment, and provide an assessment of the likelihood of those threats continuing into the foreseeable future.

Development

The current distribution of Hermes copper butterfly habitat in San Diego County is largely due to previous urban development within coastal and interior San Diego County which resulted in the loss and fragmentation of Hermes copper butterfly habitat (CalFlora 2010; Consortium of California Herbaria 2010; San Diego Plant Atlas 2010). Of the 28 known extirpated Hermes copper butterfly populations, loss and fragmentation of habitat as a result of development has contributed to the extirpation of 14 populations (50 percent) (see **Background** section above and, Table 1 above, and Factor E discussion below). Since the year 2000, occupied habitats containing Hermes copper butterfly's host plant, *Rhamnus crocea,* in Rancho Santa Fe and Sabre Springs were lost due to urban development. In the City of San Marcos, one *R. crocea* stand near Jacks Pond was lost to development (Anderson 2010a, pp. 1, 2) and another *R. crocea* stand was significantly reduced in the vicinity of Palomar College (Anderson 2010b, pp. 1, 2). The *R. crocea* stand in Lopez Canyon is currently found within a relatively small preserve (roughly rectangular area 0.4 mi (0.6 km) by 0.5 mi (0.8 km)) that is contiguous with suitable Hermes copper butterfly habitat in Del Mar Mesa where development is ongoing. This stand of *R. crocea* is likely all that remains of what was once a wider distribution, encompassing the community of Mira Mesa and the western portion of Miramar Naval Air Station (per Thorne's 1963 map, p. 147).

Although a significant amount of habitat has been lost due to development throughout the range of Hermes copper butterfly within the United States, the remaining currently occupied population areas are protected from destruction by development due to their presence on federally owned lands, on lands conserved under regional habitat conservation plans, or on lands subject to local resource protection ordinances in San Diego County (approximately 66 percent of the total area currently occupied by Hermes copper butterfly populations occurs on federal and non-federal conserved lands; see Figure 1 above) and the remaining 34 percent of occupied habitat occurs on lands subject to local resource protection ordinances in San Diego County. Our GIS analysis indicates that of the total conserved area discussed above (66 percent of all occupied areas), approximately 27 percent (encompassing portions of 10 populations) is located within established regional habitat conservation plan preserve lands (see Factor D San Diego Multiple Species Conservation Program (MSCP) discussion below), approximately 38 percent (encompassing portions of 7 populations) falls within U.S. Forest Service lands, and approximately 1 percent (encompassing portions of 3 populations) falls within Bureau of Land Management (BLM) land. These lands are therefore afforded protection from development. Additionally, as described in Factor D below, the County of San Diego now has in place two ordinances that restrict new development or other proposed projects within sensitive habitats. The Biological Mitigation Ordinance of the County of San Diego Subarea Plan (County of San Diego, 1998b, Ord. Nos. 8845, 9246) regulates development within coastal sage scrub and mixed chaparral habitats that currently support portions of 10 extant Hermes copper butterfly populations on non-Federal land within the boundaries of the County's MSCP subarea plan. The County of San Diego Resource Protection Ordinance (County of San Diego 2007) restricts development within coastal sage scrub and mixed chaparral habitats that currently support all extant Hermes copper butterfly populations on non-Federal lands throughout the county. These ordinances provide some regulatory measures of protection for the remaining 34 percent of extant Hermes copper butterfly habitat throughout the species occupied range. Although past development in occupied Hermes copper butterfly habitat resulted in a substantial number of extirpations of Hermes copper butterfly populations, restrictions are in place to limit development and the corresponding destruction and modification of Hermes copper butterfly habitat in the future. Therefore, we do not believe future development alone will significantly reduce or fragment remaining Hermes copper butterfly habitat on non-federal lands. However, as discussed below under "Habitat Fragmentation," we believe that the combined impacts of existing development, limited future small-scale development, existing dispersal barriers, and megafires could further fragment Hermes copper butterfly habitat and threaten the species. Within U.S. Forest Service lands, we anticipate that future development, if any, will be limited, and the Forest Service has incorporated measures to address threats to Hermes copper butterfly and its habitat as it implements specific activities within forest lands (see Factor D below for additional discussion). The very limited number of Hermes copper butterfly populations within BLM lands are unlikely to face future development pressure. Therefore, we conclude that Hermes copper butterfly is not currently threatened by habitat loss due to future development alone.

Wildfire

The historical fire regime in southern California likely was characterized by many small lightning-ignited fires in the summer and a few, infrequent large fires in the fall of varying fire intensity (Keeley and Fotheringham 2003, p. 242–243). These infrequent, large, high-intensity wildfires, so-called "megafires" (greater than 123,553 ac (50,000 ha) in size), burned the landscape long before Europeans settled the Pacific coast (Keeley and Zedler 2009, p. 90). As such, modern fire regimes in southern California "have much in common with historical regimes" (Keeley and Zedler 2009, p. 69). While some researchers claim that the fire regime of chaparral growing in adjacent Baja California is not affected by megafires due to a lack of fire suppression activities (cf. Minnich and Chou 1997, Minnich 2001), Keeley and Zedler (2009, p. 86) believe that the fire regime in Baja California similarly consists of "small fires punctuated at periodic intervals by large fire events." The current fire regime in southern California consists of numerous small fires that are periodically impacted by megafires that are generally driven by extreme "Santa Ana" weather conditions of high temperatures, low humidity, and strong erratic winds (Keeley and Zedler 2009, p. 90). The primary difference between the current fire regime and historical fire regimes in southern California is that human-induced or anthropogenic ignitions have increased the frequency of fires, and in particular, megafires, far above historical levels. While this change may not have demonstrably affected the nectar sources of Hermes copper butterfly in San Diego County, especially within chaparral (Franklin *et al.* 2004, p. 701), frequent fires open up the landscape, particularly coastal sage scrub, making the habitat more vulnerable to invasive, nonnative plants (Keeley *et al.* 2005, p. 2117). However the primary concern with frequent megafires is the Hermes copper butterfly mortality associated with these extensive and intense events (see Factor E discussion below) which precludes recolonization of burned areas by Hermes copper butterfly.

The significance of this concern can be seen in the current distribution of the species in southern California. Analysis of GIS information indicates approximately 66 percent of the extant occurrences are found within the footprint of the 1970 Laguna Fire, which Minnich and Chou (1997, p. 240) reported last burned in 1920. In contrast, the areas north and south of the extant Hermes copper butterfly occurrences reburned several times between 2001 and 2007 (Keeley *et al.* 2009, pp. 287, 293). We examined maps of current high fire threat areas in San Diego County based on recent reports by the Forest Area Safety Task Force (Jones 2008, p. 1; SANDAG 2010, p. 1). Areas identified as most vulnerable include all occupied and potentially occupied Hermes copper butterfly habitats in San Diego County within the species' known historical range, with the exception of Black Mountain, Van Dam Peak, Lopez Canyon, and the unburned southern portion of Mission Trails Park. In light of the recent spate of drought-influenced wildfires in southern California, especially the 2007 fires, a future megafire affecting most or all of the area burned by the Laguna Fire in 1970 (40-year chaparral) is likely to occur and would pose a significant threat to Hermes copper butterfly in the United States because it would encompass the majority of extant populations (see Factor E below for direct mortality effects discussion).

As described in our August 8, 2006, 90-day finding (71 FR 44966), *Rhamnus crocea* are "obligate resprouters" after fires and are resilient to frequent burns (Keeley 1998, p. 258). Additionally, although Keeley and Fotheringham (2003, p. 244) indicated that continued habitat disturbance, such as fire, will result in conversion of native shrublands to nonnative grasslands, Keeley (2004, p. 7) also noted that invasive, nonnative plants will not typically displace obligate resprouting plant species in mesic shrublands that burn once every 10 years. Therefore, because *R. crocea* is an obligate resprouter, it will likely recover in those areas that retain this burn frequency. Specific information regarding Hermes copper butterfly's primary nectar source (*Eriogonum fasciculatum* (California buckwheat)) is less understood. *Eriogonum fasciculatum* is a facultative seeder and high proportions of this nectar source are likely killed by fire, and densities are reduced the following year within burned areas (Zedler *et al.* 1983, p. 814); however, *E. fasciculatum* does show minimal resprouting capability (approximately 10 percent) if individuals are young (Keeley 2006, p. 375). The extent of invasion of nonnative plants and type conversion in areas specifically inhabited by Hermes copper butterfly are unknown. However, information clearly indicates that wildfire results in at least temporary reductions in suitable habitat for Hermes copper butterfly and may result in lower densities of *E. fasciculatum* (Zedler *et al.* 1983, p. 814; Keeley 2006, p. 375; Marschalek and Klein 2010, p. 728). In areas where *R. crocea* is capable of resprouting, the quantity of *E. fasciculatum* nectar source necessary to support a persisting Hermes copper butterfly population may be temporarily unavailable due to recent fire impacts. If areas are repeatedly burned, *E. fasciculatum* will not have the time necessary to become reestablished, rendering the habitat unsuitable for Hermes copper butterfly (Marschalek and Klein 2010, p. 728). Increased fire frequency may also pose a threat to Hermes copper butterfly through loss of host plant and nectar source habitat, and fire management plans are not expected to provide protection from megafires such as those that occurred in 2003 and 2007. Based on the above, we consider wildfire, specifically megafires that encompass vast areas and are increasing in frequency, a significant threat to Hermes copper butterfly.

Habitat Fragmentation

Habitat fragmentation can result in smaller, more vulnerable Hermes copper butterfly populations (see Factor E discussion below). The presence of suitable habitat on which Hermes copper butterflies depend often determines the size and range of the local population. Wildfires and past development have caused habitat fragmentation that separates populations and inhibits movement by creating a gap in area that Hermes copper butterflies are not capable of traversing. The connectivity of habitat occupied by a butterfly population is not defined by host plant distribution at the scale of host plant stands or patches, but rather by adult butterfly movement that results in interbreeding (see Service 2003, pp. 22, 162–165). Any loss of resource contiguity on the ground that does not affect butterfly movement, such as burned vegetation, may degrade habitat, but may not fragment habitat. Therefore, in order for habitat to be fragmented, movement must be prevented by a barrier, or the distance between remaining host plants where larvae develop must be greater than adult butterflies will move to mate or deposit eggs. Genetic analysis (Deutschman *et al.* 2010; p. 16) indicates that butterflies can show differentiation even when close in proximity, presumably due to physical barriers that may be a result of development or a landscape feature (i.e., the three McGinty Mountain sites that are on opposite sides of the mountain may be separated by topography). Alternately, sampling locations that are not close have shown little genetic differentiation, indicating that butterflies can also disperse long distances under the right conditions. Sampling at one location before and after a fire found genetically differentiated groups. Deutschman *et al.* (2010, p. 16) concluded their findings supported the idea that Hermes copper butterfly individuals are capable of long-distance movement, but developed areas and natural landscape features may enhance or restrict dispersal. It is important to note that although movement may be possible, the habitat must be suitable at the time Hermes copper butterflies arrive to ensure successful recolonization.

As described in our 90-day finding published in 2010 (75 FR 23658, May 4, 2010) Hermes copper butterfly habitat has become fragmented by both past urban development (permanently) and wildfires. Comparison of Hermes copper butterfly occurrences and host plant distribution with mapped wildfire perimeters indicates that wildfires cause short-term fragmentation of habitat, and, historically, Hermes copper butterfly habitat in San Diego County has been fragmented and lost due to the progression of development over the last 50 years. Analysis of the Hermes copper butterfly populations indicates that in the northern portion of the U.S. range, the habitat has been fragmented (and lost) permanently by development and further fragmented temporally by wildfires, resulting in extirpation of at least four Hermes copper butterfly populations (see Table 1 above). As described in the Background section above and Factor E below, two historical Hermes copper butterfly populations (Rancho Santa Fe and Van Dam Peak) in the northern portion of the range have been lost since the year 2000, presumably because the habitat became isolated to an extent that connectivity with other populations was lost. Neither the Rancho Santa Fe habitat area nor Van Dam Peak habitat area is expected to be recolonized because the distance to the next nearest source population (13 mi (20 km) and 7 mi (11 km), respectively) exceeds the dispersal capability of the species. In the southern portion of the range, Lopez Canyon and the extant portion of Mission Trails Park are both isolated (7 mi (11 km) separation) from other extant populations by development and burned areas that are no longer likely occupied. Although the Mission Trails Park population remains extant this population was likely reduced up to 74 percent by the 2003 fire, and remaining unburned habitat is surrounded by development, functionally isolating it from any potential source populations thought to be extant (see Figure 1 above). While we do not expect future development alone to threaten Hermes copper butterfly habitat, we believe that the combined impacts attributable to wildfire and small scale development may fragment habitat further and hence, threaten the species' continued existence. Based on the above, we consider habitat fragmentation, due to the combined impact of existing development, possible future (limited) development, existing dispersal barriers, and megafires, a significant threat to Hermes copper butterfly.

Summary of Factor A

Based on the above information, we consider Hermes copper butterfly to be threatened by the present or threatened destruction, modification, or curtailment of the species habitat or range. Specifically, we consider Hermes copper butterfly threatened by habitat fragmentation and wildfire. The combination of habitat fragmentation (as a result of past and potential limited future urban development), existing dispersal barriers, and megafires (that encompass vast areas and are increasing in frequency) that fragment, limit, and degrade Hermes copper butterfly habitat threaten the species with extirpation throughout its range. These threats are evidenced by the loss and isolation of many populations throughout the range; those remaining extant populations fall within areas of high megafire risk. Thus, we consider threats under this factor to be significant.

Factor B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

We found two Internet postings (accessed in June 2004) offering to sell specimens of Hermes copper butterfly (Martin 2004, pers. comm.). We found no evidence that Hermes copper butterflies, whole or in parts, were being used in a commercial "butterfly essence" process (Morning Star Essences 2006, pers. comm.) and we have no other information to indicate that other commercial business activities are a threat to Hermes copper butterfly. Neither of these previously viewed Web sites offered Hermes copper butterfly for sale during a more recent search (November 22, 2010), nor did we locate any additional commercially available specimens. We found no other information to indicate Hermes copper butterfly is used for commercial, scientific, or educational purposes. Therefore, based on our review of the best available scientific and commercial information, we do not consider overutilization for commercial, recreational, scientific, or educational purposes a current threat to Hermes copper butterfly.

Factor C. Disease or Predation

Disease

We evaluated the potential of disease to threaten Hermes copper butterfly rangewide and found no information indicating disease to be current threat to Hermes copper butterfly.

Predation

Predation (including parasitism) is a factor that is known to cause mortality in butterflies, and therefore could potentially threaten any butterfly species. Faulkner and Klein (2005, p. 26) stated that "no papers have reported any parasites or predators for the Hermes copper butterfly, though they obviously exist." Birds may consume Hermes copper butterfly larvae, although we are not aware of any data that indicate bird predation is a significant threat to Hermes copper butterfly. Furthermore, heavy predation of adult insects and their progeny is a common ecological phenomenon, and most species have evolved under conditions where high mortality due to natural enemies has shaped their evolution (see Ehrlich *et al.* 1988). However, we found no information to indicate predation to be current threat to Hermes copper butterfly.

Therefore, based on our review of the best available scientific and commercial information, we do not consider disease or predation a current threat to Hermes copper butterfly.

Factor D. The Inadequacy of Existing Regulatory Mechanisms

The Act requires us to examine the adequacy of existing regulatory mechanisms, with respect to threats, that may ameliorate the danger of Hermes copper butterfly becoming either endangered or threatened. Existing regulatory mechanisms that may have an effect on potential threats to Hermes copper butterfly can be placed into two general categories: (1) Federal mechanisms, and (2) State and local mechanisms.

Federal Mechanisms

There are five primary Federal regulatory mechanisms that we discuss below: the National Forest Management Act (16 U.S.C. 1600 *et seq.*); the Federal Land Policy and Management Act; the Sikes Act as amended (16 U.S.C. 670a *et seq.*); the Healthy Forests Restoration Act of 2003 (16 U.S.C. 6501 *et seq.*); and the National Environmental Policy Act (NEPA; 42 U.S.C. 4321 *et seq.*).

Under the National Forest Management Act of 1976, the U.S. Forest Service (Forest Service) is required to prepare a comprehensive land and natural resource management plan for each unit of the Forest Service, in accordance with NEPA's procedural requirements, to guide the maintenance and use of resources within national forests. The plans require an interdisciplinary approach, including a provision providing for diversity for plant and animal communities (16 U.S.C. 1604(g)(3)(B)). The Forest Service is currently operating under the transition provisions of the 2000 Planning Rule (65 FR 67514; November 9, 2000) as an interim measure until a new planning rule is issued (see 74 FR 67059; December 18, 2009). The 2000 rule allows forests to develop, revise and amend forest plans using the procedures of the 1982 Rule (47 FR 43037; September 30, 1982). All existing forest plans have been developed using the 1982 Planning Rule procedures, including the Cleveland National Forest Plan.

In preparing the Cleveland National Forest (CNF) Plan, the Forest Service evaluated and identified Hermes copper butterfly as a species of concern and then evaluated this species relative to its potential of risk from Forest Service activities and plan decisions in its 2005 Final Environmental Impact Statement (USFS 2005). Hermes copper butterfly, along with 148 other species, was defined as a "species-at-risk" (USFS 2005, Appendix B, p. 36), requiring a further individual viability assessment. The subsequent threat category identified for Hermes copper butterfly was "5" or "Uncommon, narrow endemic, disjunct, or peripheral in the plan area with substantial threats to persistence or distribution from Forest Service activities" (USFS 2005, Appendix B, p. 43). The specific threat associated with Hermes copper butterfly and Forest Service management activities is described as "Prescribed fire or fuel reduction projects in habitat (affecting host plant, *Rhamnus crocea*)" (USFS 2005, Appendix B, p. 52). There are approximately 7,860 acres (ac) (3,181 hectares (ha)) of extant Hermes copper butterfly habitat (encompassing 7 populations) within the CNF and approximately 2,100 ac (850 ha) of Hermes copper butterfly habitat that has been extirpated or is of unknown status. The Forest Service incorporates measures into its planning efforts to address identified threats as it implements specific activities on forest lands. As an example, in 2007, measures were included to protect Hermes copper butterfly habitat ahead of the Horsethief Fuels Reduction Project (Jennings 2007, pers. comm.). Although the proposed project has not yet been implemented, the recommendations of flagging and avoidance of all *R. crocea* bushes are standard management measures for relevant CNF activities (Winter 2010, pers. comm.).

The CNF has also initiated two projects for restoration of habitat at Barber Mountain related to impacts from the Harris Fire (Metz 2010, pers. comm.). In an effort to restore nectar and host plants at this site, seeds from both *Eriogonum fasciculatum* and *Rhamnus crocea* plants have been collected locally and *E. fasciculatum* seeds have already been planted (Metz 2010, pers. comm.).

Because fires, particularly recent wildfires (megafires), have been identified as a factor affecting the distribution of this species, the CNF has been monitoring Hermes copper butterfly populations in burned and unburned areas of CNF to assist in monitoring the recovery and management of this species on its lands (HDR and E2M, 2009, p. 1). As part of the Forest Service's approach to management of Hermes copper butterfly and its habitat, the Forest Service commissioned a 2009 survey to determine the current status of Hermes copper butterfly populations at eight locations in the Descanso Ranger District of the CNF. A total of 16 Hermes copper butterflies were observed at 12 locations at 5 study sites (HDR and E2M, 2009, p. 11). The 2009 study concluded that the low number of observations were reflective of the on-going recovery of Hermes copper butterfly habitats from the effects of wildfires, the precipitation pattern in Hermes copper butterfly habitat in 2009, and host plant health (HDR and E2M, 2009, p. 25).

Previous monitoring surveys conducted on CNF lands include a 2005 survey for assessment of recolonization at Viejas Mountain, an area impacted by the Cedar Fire in 2003, in which no Hermes copper butterflies were observed (Klein 2005, pers. comm.). Additionally, a 2005 survey at Barber Mountain, an area that had not recently burned, revealed 95 specimens of Hermes copper butterflies (Faulkner 2005, pers. comm.), while a wider 2008 survey of the area after the Witch Fire in 2007 found scattered populations with only two sites containing more than a single specimen (Faulkner 2008 pers. comm.). Locations were marked for revegetation with *Eriogonum fasciculatum* and *Rhamnus crocea* in an attempt to extend the unburned chaparral habitat so as to expand the existing Hermes copper butterfly populations or establish new populations (Faulkner 2008, pers. comm.).

Recent fire events appear to have negatively affected the current occupancy of Hermes copper butterfly at the surveyed locations on CNF lands. The 2009 survey results indicate that of the study sites affected by fires in 2003 and 2007, Hermes copper butterfly was only found at one site (North Descanso), an area located on the southern edge of the area affected by the 2003 Cedar Fire and adjacent to unburned private lands, which the authors speculate contain a source population of Hermes copper butterflies (HDR and E2M, 2009, p. 25). The current monitoring, management efforts, and conservation measures implemented and planned by the Forest Service indicate that the CNF is actively working towards conservation of Hermes copper butterfly and its habitat.

The Federal Land Policy and Management Act of 1976 (FLPMA) governs the management of public lands under the jurisdiction of the BLM. The legislative goals of FLPMA are to establish public land policy; to establish guidelines for its [BLM's] administration; and to provide for the management, protection, development and enhancement of the public lands. While FLPMA generally directs that public lands be managed on the basis of multiple use, the statute also directs that such lands be managed to "protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological values; * * * [to] preserve and protect certain public lands in their natural condition; [and to] provide food and habitat for fish and wildlife * * *." (43 U.S.C. 1701(a)(8)). Although the BLM has a multiple-use mandate under the FLPMA which allows for grazing, mining, and off-road vehicle use, the BLM also has the ability under the FLPMA to establish and implement special management areas such as Areas of Critical Environmental Concern, wilderness areas, research areas, etc. BLM's South Coast Resource Management Plan covers the San Diego County area. Approximately 1 percent, or 411 ac (166 ha) of the total Hermes copper butterfly habitat occupied by extant populations (3 populations in this case) occur within the BLM owned lands. An additional approximately 289 ac (117 ha) of Hermes copper butterfly habitat that supported populations believed to have been extirpated or that are of unknown status (encompassing 3 populations) also occurs on BLM lands. Hermes copper butterfly was a species considered but not addressed in the BLM's South Coast Resource Management Plan (SCRMP; BLM 1994, p. 76) but many components of Hermes copper butterfly habitat (coastal sage scrub and chaparral) are contained within the SCRMP planning area, and receive some regulatory protection under the plan. Approximately half of Hermes copper butterfly habitat supporting extant populations on BLM lands, a 201 ac (81 ha) portion of the Descanso South population (see Table 1 and Figure 1 above; Map #31) falls within the Pine Creek Wilderness Area and therefore benefits from BLM's wilderness protection policies. The Pine Creek Wilderness Area is managed in accordance with the provisions of the Wilderness Act of 1964 (16 U.S.C. 1131 *et seq.*). The Wilderness Act of 1964 strictly limits use of wilderness areas, imposing restrictions on use of vehicles, new developments, chainsaw use, mountain bike use, leasing, and mining, in order to protect the natural habitats of the areas, maintain species diversity, and enhance biological values. Lands acquired by BLM within wilderness area boundaries become part of the designated wilderness area and are managed in accordance with all provisions of the Wilderness Act and applicable laws. We believe existing BLM regulations provide adequate protection from the threat of development described in Factor A above, but not from mortality and habitat fragmentation due to megafire as described in Factors A above and E below. However, megafire is not a threat that is susceptible to reduction or elimination by regulatory mechanisms.

The Sikes Act requires the Department of Defense to develop and implement integrated natural resources management plans (INRMPs) for military installations across the United States. We are not aware of any currently extant Hermes copper butterfly populations on military installations; however there are historical Hermes copper butterfly observation locations and potential Hermes copper butterfly habitat (see Table 1 and Figure 1 above, Map #40) on Miramar Naval Air Station and the adjacent Mission Gorge Recreational Facility (MGRF) (also known as Admiral Baker Field). Through the 2002 Naval Base San Diego INRMP, which is currently under revision, the Navy manages its open space areas using an ecosystem-level approach that includes invasive species removal, habitat restoration and enhancement, and natural resource inventories (Stathos 2010, pers. comm.). In the 2002 INRMP, the Navy identified the following focus areas for management actions: Wildlife conservation and management, rare wildlife species, exotic vegetation control, habitat restoration, and fire management (U.S. Navy 2002, section 3, pp. 37–40 and 45–47). Hermes copper butterfly is not identified as a rare species in the INRMP; however, some existing management recommendations and actions may also be beneficial to Hermes copper butterfly, if it is rediscovered on Navy lands. The INRMPs are reviewed every year by military installations and modified as needed, and are reviewed at least every 5 years with the Service and States.

The Healthy Forests Restoration Act of 2003 includes the first meaningful statutory incentive for the U.S. Forest Service and the Bureau of Land Management to give consideration to prioritized fuel reduction projects identified by local communities. In order for a community to take advantage of this opportunity, a Community Wildfire Protection Plan (CWPP) must be prepared. The process of developing a CWPP can help a community identify and clarify priorities for the protection of life, property and critical infrastructure in the wildland-urban interface (WUI) (Fire Safe Council of San Diego County 2011). See our discussion of CWPPs below under the State and Local Regulations subsection. Combined, the Healthy Forests Restoration Act and the Community Wildfire Protection Plan emphasize the need for federal, state and local agencies to work collaboratively with communities in developing hazardous fuel reduction projects, and place priority on treatment areas identified by the communities themselves in a CWPP (Fire Safe Council of San Diego County 2011). While these regulations reduce the impact of wildfire to some extent, especially with regard to human property and safety, the impact of megafires on wildlands is not a threat that is susceptible to elimination by such regulatory mechanisms.

All Federal agencies are required to adhere to the National Environmental Policy Act (NEPA) of 1970 for projects they fund, authorize, or carry out. The Council on Environmental Quality's regulations for implementing NEPA (40 CFR parts 1500–1518) state that in their environmental impact statements agencies shall include a discussion on the environmental impacts of the various project alternatives (including the proposed action), any adverse environmental effects which cannot be avoided, and any irreversible or irretrievable commitments of resources involved (40 CFR part 1502). NEPA itself is a disclosure law that provides an opportunity for the public to submit comments on the particular project and propose other conservation measures that may directly benefit listed species; however, it does not require subsequent minimization or mitigation measures by the Federal agency involved. Although Federal agencies may include conservation measures for listed species as a result of the NEPA process, Hermes copper butterfly may be provided indirect protections due to its co-occurrence with listed species. Any such measures are typically voluntary in nature and are not required by the statute. Additionally, activities on non-Federal lands are subject to NEPA if there is a Federal nexus.

As stated above, land and resource management plans prepared by the Forest Service and BLM must be developed in accordance with NEPA requirements and, as noted above, the Forest Service prepared an environmental impact statement for its 2005 Land Management Plans (including the Cleveland National Forest Plan) and will be required to meet NEPA requirements in preparing its revised plan. Similarly, the U.S. Navy must meet the procedural requirements of NEPA in developing its INRMPs.

State and Local Mechanisms

The California Environmental Quality Act (CEQA) (Public Resources Code 21000–21177) and the CEQA Guidelines (California Code of Regulations, Title 14, Division 6, Chapter 3, sections 15000–15387) requires State and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible. CEQA applies to projects proposed to be undertaken or requiring approval by State and local government agencies and the lead agency must complete the environmental review process required by CEQA, including conducting an initial study to identify the environmental impacts of the project and determine whether the identified impacts are "significant." If significant impacts are determined, then an environmental impact report must be prepared to provide State and local agencies and the general public with detailed information on the potentially significant environmental effects (CERES 2010). "Thresholds of Significance" are comprehensive criteria used to define environmental significant impacts based on quantitative and qualitative standards and include impacts to biological resources such as candidate, sensitive, or special status species identified in local or regional plans, policies, or regulations, or by the California Department of Fish and Game (CDFG) or the Service; or impacts to any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the CDFG or Service (Appendix G, CEQA 2010). Defining these significance thresholds helps ensure a "rational basis for significance determinations" and provides support to the final determination and appropriate revisions or mitigation actions to a project in order to develop a mitigated negative declaration rather than an environmental impact report (Governor's Office of Planning and Research, 1994, p. 5).

The County of San Diego has developed the *Guidelines for Determining Significance and Report Format and Content Requirements—Biological Resources* (Guidelines) (County of San Diego, 2010) to review discretionary projects and environmental documents pursuant to the CEQA. The Guidelines provide guidance for evaluating adverse environmental effects that a proposed project may have on biological resources and are consulted during the evaluation of any biological resource pursuant to CEQA. Included in the specific guidelines, under Special Species Status, is a determination as to whether a project will impact occupied Hermes copper butterfly habitat. Section 4.1 K (p. 14) of the guidelines states:

"Though not state or federally listed, the Hermes copper meets the definition of endangered under CEQA Sec. 15380 because its 'survival and reproduction in the wild are in immediate jeopardy from one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, disease, or other factors.' The County's determination that the Hermes copper meets the definition of endangered under CEQA is based on the loss of Hermes copper populations by development and wildfire, and the review of published and unpublished literature. Interim guidelines for surveying, assessing impacts, and designing mitigation for Hermes copper are provided in Attachment C of the Report Format and Content Requirements—Biological Resources." (County of San Diego, 2010, p. 14).

The newly added Hermes copper butterfly section of the guidelines offers a proactive requirement for project review under CEQA that can provide a specific protective measure to the species and its habitat.

The San Diego Multiple Species Conservation Program (MSCP) is a subregional habitat conservation plan (HCP) and Natural Community Conservation Plan (NCCP) made up of several subarea plans that have been in place for more than a decade. Under the umbrella of the MSCP, each of the 12 participating jurisdictions is required to prepare a subarea plan that implements the goals of the MSCP within that particular jurisdiction. The MSCP covers 582,243 ac (235,625 ha) and the County of San Diego Subarea Plan covers 252,132 ac (102,035 ha) of unincorporated county lands in the southwestern portion of the MSCP plan area. The County subarea plan is implemented in part by the Biological Mitigation Ordinance (BMO), which outlines specific project design criteria and species and habitat protection and mitigation requirements for projects within subarea boundaries (see MSCP Subarea Plan, County of San Diego 2007, and Biological Mitigation Ordinance (Ord. Nos. 8845, 9246), County of San Diego 1998b). All projects within the County's subarea plan boundaries must comply with both the MSCP requirements and the County's policies under CEQA. Hermes copper butterfly is not a covered species under any MSCP subarea plans; however, the protections afforded by the BMO indirectly benefit the species by establishing mitigation ratios and project development conditions that restrict development within coastal sage scrub and mixed chaparral habitats. Of the 17 currently extant Hermes copper butterfly populations, the BMO affords some indirect protection to the 10 that fall all or partially within the County's subarea plan boundaries.

The County of San Diego Resource Protection Ordinance (RPO) (County of San Diego 2007) applies to all non-federal lands within the County located within and outside of the County of San Diego subarea plan boundaries. The RPO imposes restrictions on development to reduce impacts to natural resources including sensitive habitat lands. Sensitive habitat lands are those that support unique vegetation communities or those that are either necessary to support a viable population of sensitive species, are critical to the proper functioning of a balanced natural ecosystem, or which serve as a functioning wildlife corridor (County of San Diego, 2007, p. 3). They can include areas that contain maritime succulent scrub, southern coastal bluff scrub, coastal and desert dunes, calcicolous scrub, and maritime chaparral, among others. Impacts to RPO sensitive habitat lands, which include lands with potential host and nectar plant habitat for Hermes copper butterfly (i.e., scrub and chaparral), are only allowed when all feasible measures have been applied to reduce impacts and when mitigation provides an equal or greater benefit to the affected species (County of San Diego, 2007, p. 13).

The California Department of Forestry and Fire Protection (CAL FIRE) is an emergency response and resource protection department. CAL FIRE protects lives, property and natural resources from fire, and protects and preserves timberlands, wildlands, and urban forests. The CAL FIRES's varied programs work together to plan protection strategies incorporating concepts of the National Fire Plan, the California Fire Plan, individual CAL FIRE Unit Fire Plans, and Community Wildfire Protection Plans (CWPPs). Fire Plans outline the fire situation within each CAL FIRE Unit, and CWPPs do the same for communities (CALFIRE 2011a, p. 1; County of San Diego 2011a). Each plan identifies prevention measures to reduce risks, informs and involves the local communities in the area, and provides a framework to diminish potential wildfire losses and implement all applicable fire management regulations and policies (CALFIRE 2011b; County of San Diego 2011a). Planning includes other state, federal and local government agencies as well as Fire Safe Councils (CALFIRE 2011a, p. 1). Cooperative efforts via contracts and agreements between state, federal, and local agencies are essential to respond to wildland fires (CALFIRE 2011a, p. 1). Because of these types of cooperative efforts, fire engines and crews from many different agencies may respond at the scene of an emergency (CALFIRE 2011a, p. 1); however CALFIRE typically takes the lead with regard to planning for megafire, prevention, management, and suppression, and CAL FIRE is in charge of incident command during a wildfire. The San Diego County Fire Authority (SDCFA), local governments, and CAL FIRE cooperatively protect 1.42 million acres of land with 54 fire stations throughout San Diego County (County of San Diego 2011b, p. 1). Wildfire management plans and associated actions can help to reduce the impacts of wildfire on natural resources, including Hermes copper butterfly, but their first priority is human health and safety. While these plans and associated measures ameliorate the impacts of wildfire to some extent, especially with regard to human property and safety, the impact of megafires on wildlands is not a threat that is susceptible to elimination by such regulatory mechanisms.

Summary of Factor D

In summary, we considered the adequacy of existing regulatory mechanisms to protect Hermes copper butterfly. On Forest Service lands, the Cleveland National Forest Plan addresses the conservation of natural resources, including Hermes copper butterfly, and specific management practices have been identified and are being implemented to conserve existing populations of Hermes copper butterfly and its habitat. Approximately 1 percent of Hermes copper butterfly habitat occurs on BLM lands and is afforded some protection through the South Coast Management Plan and Wilderness Area designation through management of habitat areas for listed and other sensitive species and land use limitation. Although the Navy has not recorded extant populations of Hermes copper butterfly on their lands in San Diego County, we believe the management measures identified in their INRMP for the Mission Gorge Recreational Facility provides an adequate protective mechanism for existing coastal sage habitat suitable for Hermes copper butterfly. Hermes copper butterfly and its habitat may also receive protection under NEPA as land management plans, INRMPs, and activity level plans are developed on Forest Service, BLM and U.S. Navy lands either occupied by or that contain suitable habitat for the species.

On State and county lands occupied by Hermes copper butterfly or containing its habitat, we believe the requirements of CEQA and the two County ordinances are adequate regulatory mechanisms that protect the species and its habitat from development related impacts. The Biological Mitigation Ordinance of the County of San Diego Subarea Plan and the County of San Diego Resource Protection Ordinance impose restrictions on development within coastal sage scrub and mixed chaparral habitats that support half of the historical distribution of Hermes copper butterfly populations. Although Federal, State, and local regulatory mechanisms help to reduce wildfire impacts, primarily to property and human safety, they do not adequately protect Hermes copper butterfly from direct mortality or habitat fragmentation due to megafires. However, we do not consider the impact of megafire on wildlands to be a threat that is susceptible to elimination by regulatory mechanisms.

Therefore, based on our review of the best available scientific and commercial information, we do not consider the inadequacy of existing regulatory mechanisms to be a threat to Hermes copper butterfly.

Factor E. Other Natural or Manmade Factors Affecting the Species' Continued Existence

Wildfire

As discussed in the **Background** section and Factor A discussions above, wildfire can result in temporal loss of Hermes copper butterfly habitat. However, the most significant threat posed by wildfire to Hermes copper butterfly is the direct loss (*i.e.,* mortality) of butterflies associated with extensive and intense fire events. The magnitude of this threat is increased by the periodic occurrence of megafires, which are typically created by extreme "Santa Ana" weather conditions of high temperatures, low humidity, and strong erratic winds (see **Background** section and Factor A's wildfire discussion above; Keeley and Zedler 2009, p. 90). Human-induced or anthropogenic ignitions have increased the frequency of fire far above historical levels (Keeley and Fotheringham 2003, p. 240). Recolonization of burned areas by Hermes copper butterfly can be precluded when fires, and particularly megafires, occur too frequently. The significance of this concern can be seen in the current distribution of the species in southern California; analysis of GIS information indicates approximately 66 percent of the extant occurrences are found within the footprint of the 1970 Laguna Fire, which Minnich and Chou (1997, p. 240) reported last burned in 1920. In contrast, the areas north and south of the extant Hermes copper butterfly occurrences burned several times from 2001 to 2007 (Keeley *et al.* 2009, pp. 287, 293). A single megafire burning most or all of the 40-year old chaparral in the footprint of the Laguna fire would likely imperil the species in the United States (see Figure 1 above). Additionally, as discussed in the **Background** section above, the 2003 Otay and Cedar fires and the 2007 Harris and Witch fires in particular have negatively impacted the species, resulting in or contributing to the extirpation of 9 of 35 populations (see Table 1 above).

It is well-documented that wildfires that occur in occupied Hermes copper butterfly habitat result in loss of Hermes copper butterflies (Klein and Faulkner 2003, pp. 96, 97; Marschalek and Klein 2010, pp. 4, 5). The butterflies rarely survive wildfire because life stages of the butterfly inhabit host plant foliage, and *Rhamnus crocea* typically burns to the ground and resprouts from stumps (Deutschman *et al.* 2010, p. 8; Marschalek and Klein 2010, p. 8). This results in at least the temporal loss of both the habitat (until the *R. crocea* and nectar source regrowth occurs) and the presence of butterflies (occupancy) in the area. Wildfires can also leave patches of unburned occupied habitat that are functionally isolated (e.g., further than the dispersal distance of the butterfly) from other occupied habitat. Furthermore, large fires can eliminate source populations before previously burned habitat can be recolonized, and can result in long-term or permanent loss of butterfly populations. For example, in Mission Trails Park the 7,303 ac (2596 ha) "Assist #59" Fire in 1981 and the smaller 126 ac (51 ha) "Assist #14" Fire in 1983 (no significant overlap between fires), resulted in an approximate 18-year extirpation of the Mission Trails Park Hermes copper butterfly population (Klein and Faulkner 2003, pp. 96, 97). More recent examples include extirpations of the monitored Crestridge, Rancho Jamul, Anderson Road, Hollenbeck Canyon, and San Miguel Mountain populations, as well as other less-monitored populations (Marschalek and Klein 2010, pp. 4, 5; Deutschman *et al.* 2010, p. 36). After the 2003 Cedar Fire, Hermes copper butterfly records at the regularly monitored Crestridge population, once considered the largest and most robust population within the species' range (Klein and Faulkner 2003, p. 86), were limited to presumably the same male for a 6-day period in 2005, and another single male observed in 2007 (Marschalek and Klein 2010, p. 4; Deutschman *et al.* 2010, p. 33). Marschalek (2010a, p. 2) described how when his study "colonies" in the Rancho Jamul population were extirpated by fire in 2003, he discovered additional occupied habitat on the other side of a nearby firebreak in 2004; however the remaining population distribution was extirpated in the 2007 Harris Fire (Marschalek 2010a, p. 1). Data indicate all historical populations burned in both the 2003 and 2007 fires were extirpated except North Descanso, where record locations were within a narrow extension of the fire perimeter surrounded on three sides by unburned habitat (see Table 1 and Figure 1 above). We know this habitat was recolonized because genetic research determined the colonizing individuals were not related to those collected before the fire (Deutschman *et al.* 2010, p. 26). These facts underscore the importance of having available Hermes copper butterfly source populations to recolonize habitat after fire. As discussed in the **Background** section above, of the 35 known Hermes copper butterfly populations in 2000, 1 northern Hermes copper butterfly population and 8 southern populations are believed to have been extirpated by fire or a combination of fire and development since 2003 (see Table 1 above).

As discussed above under Factor A, we examined maps of current high fire threat areas in San Diego County based on recent reports by the Forest Area Safety Task Force (Jones 2008; SANDAG 2010). Areas identified as most vulnerable include all occupied and potentially occupied Hermes copper butterfly habitats in San Diego County within the species' known historical range, with the exception of Black Mountain, Van Dam Peak, Lopez Canyon, and the unburned southern portion of Mission Trails Park. Nineteen potential source populations for recolonization of habitats burned in the past 10 years (extant or of unknown status) fall within a contiguous area that has not recently burned (southeastern populations in Figure 1), and where the threat of fire is considered high (SANDAG 2010). All except 3 of these potential source populations (North Descanso, Hartley Peak, and North Guatay Mountain) also fall within the 174,026 ac (70,426 ha) 1970 Laguna Fire perimeter (similar in size to the 2003 and 2007 fires), and the 3 that do not fall within the Laguna Fire perimeter fall partially within the 2003 and 2007 fire perimeters. This analysis of current fire danger and fire history illustrates the potential for permanent loss of the majority, if not all, remaining butterfly populations should another large fire occur prior to recolonization of burned habitats (per discussion above, recolonization may not occur for up to 18 years). As discussed by Marschalek and Klein (2010, p. 9) and Deutschman *et al.* (2010, p. 42), there is a risk that one or more wildfires could extirpate the majority of extant Hermes copper butterfly populations. Based on the above, we consider wildfire, specifically megafires that encompass vast areas and are increasing in frequency, a significant threat to Hermes copper butterfly.

Vulnerability of Small and Isolated Populations

Small population size, low population numbers, and population isolation are not necessarily independent factors that threaten a species. Typically, it is the combination of small size and number and isolation of populations in conjunction with other threats (such as the present or threatened destruction and modification of the species' habitat or range) that may significantly increase the probability of species' extinction.

Population isolation renders smaller populations more vulnerable to stochastic extirpation. Small populations and isolation could also subject Hermes copper butterfly to genetic drift and restricted gene flow that may decrease genetic variability over time and could adversely affect species' viability (Allee 1931, pp. 12–37; Stephens *et al.* 1999, pp. 185–190; Dennis 2002, pp. 389–401). The best available scientific information indicates adult Hermes copper butterfly densities have been reduced to low or no detectability, or occupancy has been entirely eliminated in some burned areas (for example Crestridge, see Factor A discussion above), and habitat has been fragmented and isolated by development (Deutschman *et al.* 2010, p. 33). As discussed in the Background section and Factor A discussion above, most remaining northern habitats are limited to the relatively isolated and fragmented undeveloped lands between the cities of San Marcos, Carlsbad, and Escondido and the community of Rancho Santa Fe. The nearest occupied Hermes copper butterfly location (Mission Trails) to the habitat "islands" containing the Black Mountain and Van Dam Peak observation locations are approximately 9 mi (14 km) and 7 mi (11 km) away, respectively, and separated by highly developed areas. Future recolonization of Hermes copper butterfly to these areas, which appear to contain suitable habitat, is not likely due to their isolation. One population isolated by development was extirpated due to the 2007 Witch Fire (Rancho Santa Fe), and a second isolated population was extirpated for unknown reasons (Van Dam Peak). As discussed above under Factor A, neither the Rancho Santa Fe habitat area nor the Van Dam Peak habitat area is expected to be recolonized because the distance to the next nearest source population exceeds the dispersal capability of the species. In the southern portion of the range, Lopez Canyon and the extant portion of Mission Trails Park are both isolated from other extant populations by development and burned areas that are no longer likely occupied. Although the Mission Trails Park population remains extant this population was likely reduced up to 74 percent by the 2003 fire, and remaining unburned habitat is surrounded by development, functionally isolating it from any potential source populations thought to be extant (see Figure 1 above). Therefore, we consider the effects of restricted geographical range, population isolation, and reduced population size a significant threat to Hermes copper butterfly.

Global Climate Change

Evaluations by Parmesan and Galbraith (2004, pp. 1–2, 29–33) indicate whole ecosystems may be shifting northward and upward in elevation, or are otherwise being altered by differing climate tolerance among species within communities. Climate change may be causing changes in the arrangement and community composition of occupied habitat patches. Current climate change predictions for terrestrial areas in the Northern Hemisphere and the southwestern United States indicate warmer air temperatures, more intense precipitation events, and increased summer drying (Field *et al.* 1999, pp. 1–3; Hayhoe *et al.* 2004, p. 12422; Cayan *et al.* 2005, p. 6; Intergovernmental Panel on Climate Change (IPCC) 2007, p. 11). However, predictions of climatic conditions for smaller subregions, such as San Diego County, remain less certain. Tabor and Williams (2010, p. 562) summarized the four major sources of uncertainty in downscaled climate projections: (1) Uncertainties in future greenhouse gas emissions and atmospheric composition (scenario uncertainty); (2) uncertainties in modeling the climate response (Global Circulation Model uncertainty); (3) uncertainties in the observational data sets used as the basemap for the debiasing procedure (historical observational uncertainty); and (4) uncertainty over the validity of assumptions underlying the change-factor approach (change-factor uncertainty). These uncertainties are a general phenomenon of climate model downscaling and they can be substantial, especially the first two (Tabor and Williams 2010, pp. 562, 564). Thus, discretion is necessary when using downscaled climate projections, because downscaling Global Circulation Models to the finest available resolution may produce misleading results (Tabor and Williams 2010, p. 564). Southern California has a unique and globally rare Mediterranean climate. Summers are typically dry and hot while winters are cool, with minimal rainfall averaging about 10 inches per year. The maritime influence of the Pacific Ocean combined with the coastal and inland mountain ranges creates an inversion layer typical of Mediterranean-like climates, particularly in southern California. These conditions also create microclimates, where the weather can be highly variable within small geographic areas at the same time. These microclimates are difficult to model and make it even more difficult to predict meaningful changes in climate for this region, specifically for small local areas, and the resultant impact on the Hermes copper butterfly and its habitat.

We evaluated the available historical weather data and the species biology to determine the likelihood of effects assuming the climate has been and will continue to change. The typical effect of a warmer climate, as observed with Hermes copper butterfly in lower, warmer elevation habitats compared to higher, cooler elevations, is an earlier flight season by several days (Thorne 1963, p. 146; Marschalek and Deutschman 2008, p. 98). Marschalek and Klein (2010, p. 2) noted that past records suggest a slightly earlier flight season in recent years compared to the 1960s. The earliest published day of flight prior to 1963, after "30 years of extensive collecting," was May 20 (Thorne 1963, pp. 143, 146), but adults began flying on May 16 and May 12 in 2003 and 2004, respectively (Marschalek and Deutschman 2008, p. 100), and were reported as early as April 29 in 2003, and May 14 in 2008 (CFWO GIS database). The record early observation on April 29, 2003, was from Fortuna Mountain in Mission Trails Park, a well-collected population with records dating back to 1958, including collections by Thorne (called "Mission Gorge" or "Mission Dam" on museum specimen labels) where May 21 was the earliest documented record from the 1960s and early 1970s (before climate change trends were reasonably detectable as described by the IPCC (2007, pp. 2, 4)). The historical temperature trend in Hermes copper butterfly habitats for the month of April (when larvae are typically developing and pupating) from 1957 to 2006 can be calculated with relatively high confidence (*p* values from 0.001 to 0.05). The rate of temperature change has been an increase of 0.04 to 0.07 °F (0.07 to 0.13 °C) per year (Climate Wizard 2010), a total increase of which could explain the earlier than average flight seasons. The latest published observation date (presumed end of flight season) of an adult prior to 1970 was on July 30, 1967 (museum specimen collected by Thorne at "Suncrest"); however, the latest observation date from monitoring and data and other records in the past 10 years was on July 2 in 2010, despite an uncharacteristically late start to the flight season (May 29). Shorter flight seasons are also consistent with higher average temperatures, as a higher metabolism in these exothermic short-lived invertebrates typically results in faster growth and earlier death. Nevertheless, given the temporal and geographical availability of their widespread perennial host plant, and exposure to extremes of climate throughout their known historical range (Thorne 1963, p. 144), Hermes copper butterfly and its host and nectar plants are not likely to be negatively affected throughout the majority of the species' range by phenological shifts in development of a few days (unlike species such as Edith's checkerspot (*Euphydryas editha*) that depend on annual host plants; Service 2003, pp. 63, 64). While it is possible the species' climatic tolerance, such as temperature thresholds for activity (see **Background** section above), could result in a change in the species niche and distribution of suitable habitat as the climate changes, predicting any such changes would be speculative because we do not understand what currently limits the species' range to a much smaller geographic area than its host plant. Based on the above, we do not consider global climate change a current threat to Hermes copper butterfly.

Mexico Populations

Although wildfire and isolation of small populations may be threats to Hermes copper butterfly and its habitat in Mexico, especially near the U.S. border where the human population and development is most concentrated (see for example National Aeronautics and Space Administration's 2010 October 24 update wildfire satellite imagery that includes Baja California, Mexico), these threats are likely of less magnitude because there is far less development in the more remote areas of Baja California that may support Hermes copper butterfly. We are not aware of any conservation activities related to Hermes copper butterfly in Mexico.

Summary of Factor E

In summary, we consider Hermes copper butterfly threatened by other natural or manmade factors affecting the species' continued existence. Specifically, Hermes copper butterfly is threatened with extirpation due to wildfire (megafire), restricted geographical range, and population isolation. The loss of populations, due to megafires and population fragmentation and isolation, inhibits the ability of Hermes copper butterfly to rebound from stochastic events such as megafires. These threats are evidenced by the loss of populations in the north and south of the U.S. range and subsequent isolation of other populations throughout the range. The remaining extant populations fall within a restricted area bounded by development and face high megafire risk. Thus, we consider threats under this factor to be significant.

Finding

As required by the Act, we conducted a review of the status of the species and considered the five factors in assessing whether Hermes copper butterfly is endangered or threatened throughout all or a significant portion of its range. We examined the best scientific and commercial information available regarding the past, present, and future threats faced by Hermes copper butterfly. We reviewed the petition, information available in our files, other available published and unpublished information, and we consulted with Hermes copper butterfly experts and other Federal, State, and local jurisdictions.

This status review identified threats to Hermes copper butterfly attributable primarily to "megafires" (large wildfires) and small and isolated populations (Factor E), and to a lesser extent, habitat loss due to increased wildfire frequency and due to fragmentation resulting from the combined impacts of existing development, possible future (limited) development, existing dispersal barriers, and megafires (Factor A). The primary threats to the species are mortality from wildfire and small population size. These threats increase the risk of extirpation of Hermes copper butterfly populations rangewide. Hermes copper butterfly occupies scattered areas of sage scrub and chaparral habitat in an arid region susceptible to wildfires of increasing frequency and size. The likelihood that the species will be burned by catastrophic wildfires, combined with the isolation and small size of extant populations makes Hermes copper butterfly particularly vulnerable to population extirpation rangewide. Therefore, we find that there are threats of sufficient imminence, intensity, or magnitude to indicate that Hermes copper butterfly is in danger of extinction (endangered), or likely to become endangered within the foreseeable future (threatened), throughout its range or a significant portion of its range based on the threats described above.

On the basis of the best scientific and commercial information available, we find that the petitioned action to list Hermes copper butterfly is warranted. We will make a determination on the status of the species as endangered or threatened when we do a proposed listing determination. However, as explained in more detail below, immediate proposal of a regulation to implement this finding is precluded by higher priority listing actions, and we are making expeditious progress to add or remove qualified species from the Lists of Endangered and Threatened Wildlife and Plants.

We reviewed the available information to determine if the existing and foreseeable threats render Hermes copper butterfly at risk of extinction now such that issuing an emergency regulation temporarily listing the species under section 4(b)(7) of the Act is warranted. We determined that issuing an emergency regulation temporarily listing the species is not warranted at this time, because the threat of extinction is not immediate. However, if at any time we determine that issuing an emergency regulation temporarily listing the species is warranted, we will initiate such action at that time.

Listing Priority Number

The Service adopted guidelines on September 21, 1983 (48 FR 43098) to establish a rational system for utilizing available resources for the highest priority species when adding species to the Lists of Endangered or Threatened Wildlife and Plants or reclassifying species listed as threatened to endangered status. The system places the greatest emphasis on taxonomic distinctiveness by assigning priority in descending order to monotypic genera (genus with one species), full species, and subspecies.

Using the Service's LPN guidance, we assign each candidate an LPN of 1 to 12, depending on the magnitude of threats (high vs. moderate to low), immediacy of threats (imminent or nonimminent), and taxonomic status of the species (in order of priority: Monotypic genus (a species that is the sole member of a genus), species, or part of a species (subspecies, distinct population segment, or significant portion of the range)). The lower the listing priority number, the higher the listing priority (that is, a species with an LPN of 1 would have the highest listing priority).

Under the Service's guidelines, the magnitude of threat is the first criterion we look at when establishing a listing priority. The guidance indicates that species with the highest magnitude of threat are those species facing the greatest threats to their continued existence. These species receive the highest listing priority. The threats that Hermes copper butterfly faces are high in magnitude because the major threats (particularly mortality due to wildfire and increased wildfire frequency) occur throughout all of the species' range and are likely to result in adverse impacts to the status of the species. Based on an evaluation of all known historical populations, approximately 49 percent are believed to have been extirpated. Historical records indicate that development has isolated and modified habitats in the northern portion of the U.S. range. The isolation of these habitats has inhibited the species' ability to recolonize after stochastic events such as wildfires. When a wildfire passes through an occupied area, it is highly likely that all individuals or eggs, if present, within the area are killed (see discussion under Factor E: Wildfire above). As populations become more isolated from other occupied areas, their ability to recolonize after such events is lost. As described in the discussions of wildlife under Factors A and E above, wildfires are increasing in frequency and magnitude which increases the potential for isolation of populations and, in turn, increases the risk of extirpation rangewide.

Under our LPN guidelines, the second criterion we consider in assigning a listing priority is the immediacy of threats. This criterion is intended to ensure that the species that face actual, identifiable threats are given priority over those for which threats are only potential or that are intrinsically vulnerable but are not known to be presently facing such threats. Hermes copper butterfly faces actual, identifiable threats as discussed under Factors A and E of this finding, including the threat of a large, high-intensity wildfire (megafire) capable of killing Hermes copper butterfly populations and destroying or modifying the species' habitat in a way that would cause a rangewide reduction in populations; however, the impact of wildfire to Hermes copper butterfly and its habitat occurs on a sporadic basis and we do not have the ability to predict when wildfires will occur. While we conclude that listing Hermes copper butterfly is warranted, an immediate proposal to list this species is precluded by other higher priority listings, which we address below.

The third criterion in our LPN guidance is intended to devote resources to those species representing highly distinctive or isolated gene pools as reflected by taxonomy. Hermes copper butterfly is a valid taxon at the species level. Hermes copper butterfly faces high magnitude, non-imminent threats, and is a valid taxon at the species level. Thus, in accordance with our LPN guidance (48 FR 43098, September 21, 1983), we have assigned Hermes copper butterfly an LPN of 5.

As a result of our analysis of the best available scientific and commercial information, we assigned Hermes copper butterfly a Listing Priority Number of 5, based on species level taxonomic classification and high magnitude but nonimminent threats. Hermes copper butterfly is threatened by megafires, habitat fragmentation, and the effects of restricted range and small population size throughout all of the known populations in the United States. The effect of past habitat fragmentation is considered irreversible and has continuing impacts over the range of the species. The threat of wildfire continues to exist throughout the species range; however, the impact of wildfire on Hermes copper butterfly and its habitat occurs on a sporadic basis and we do not have the ability to predict when wildfires will occur. While we conclude that listing Hermes copper butterfly is warranted, an immediate proposal to list this species is precluded by other higher priority listings, which we address below.

We will continue to monitor the threats to Hermes copper butterfly, and the species' status on an annual basis, and should the magnitude or the imminence of the threats change, we will revisit our assessment of the LPN.

Work on a proposed listing determination for Hermes copper butterfly is precluded by work on higher priority listing actions with absolute statutory, court-ordered, or court-approved deadlines and final listing determinations for those species that were proposed for listing with funds from Fiscal Year 2011. This work includes all the actions listed in the tables below under expeditious progress.

Preclusion and Expeditious Progress

Preclusion is a function of the listing priority of a species in relation to the resources that are available and the cost and relative priority of competing demands for those resources. Thus, in any given fiscal year (FY), multiple factors dictate whether it will be possible to undertake work on a listing proposal or whether promulgation of such a proposal is precluded by higher priority listing actions.

The resources available for listing actions are determined through the annual Congressional appropriations process. The appropriation for the Listing Program is available to support work involving the following listing actions: Proposed and final listing rules; 90-day and 12-month findings on petitions to add species to the Lists of Endangered and Threatened Wildlife and Plants (Lists) or to change the status of a species from threatened to endangered; annual "resubmitted" petition findings on prior warranted-but-precluded petition findings as required under section 4(b)(3)(C)(i) of the Act; critical habitat petition findings; proposed and final rules designating critical habitat; and litigation-related, administrative, and program-management functions (including preparing and allocating budgets, responding to Congressional and public inquiries, and conducting public outreach regarding listing and critical habitat). The work involved in preparing various listing documents can be extensive and may include, but is not limited to: Gathering and assessing the best scientific and commercial data available and conducting analyses used as the basis for our decisions; writing and publishing documents; and obtaining, reviewing, and evaluating public comments and peer review comments on proposed rules and incorporating relevant information into final rules. The number of listing actions that we can undertake in a given year also is influenced by the complexity of those listing actions; that is, more complex actions generally are more costly. The median cost for preparing and publishing a 90-day finding is $39,276; for a 12-month finding, $100,690; for a proposed rule with critical habitat, $345,000; and for a final listing rule with critical habitat, $305,000.

We cannot spend more than is appropriated for the Listing Program without violating the Anti-Deficiency Act (see 31 U.S.C. 1341(a)(1)(A)). In addition, in FY 1998 and for each fiscal year since then, Congress has placed a statutory cap on funds that may be expended for the Listing Program, equal to the amount expressly appropriated for that purpose in that fiscal year. This cap was designed to prevent funds appropriated for other functions under the Act (for example, recovery funds for removing species from the Lists), or for other Service programs, from being used for Listing Program actions (see House Report 105–163, 105th Congress, 1st Session, July 1, 1997).

Since FY 2002, the Service's budget has included a critical habitat subcap to ensure that some funds are available for other work in the Listing Program ("The critical habitat designation subcap will ensure that some funding is available to address other listing activities" (House Report No. 107–103, 107th Congress, 1st Session, June 19, 2001)). In FY 2002 and each year until FY 2006, the Service has had to use virtually the entire critical habitat subcap to address court-mandated designations of critical habitat, and consequently none of the critical habitat subcap funds have been available for other listing activities. In some FYs since 2006, we have been able to use some of the critical habitat subcap funds to fund proposed listing determinations for high-priority candidate species. In other FYs, while we were unable to use any of the critical habitat subcap funds to fund proposed listing determinations, we did use some of this money to fund the critical habitat portion of some proposed listing determinations so that the proposed listing determination and proposed critical habitat designation could be combined into one rule, thereby being more efficient in our work. At this time, for FY 2011, we do not know if we will be able to use some of the critical habitat subcap funds to fund proposed listing determinations.

We make our determinations of preclusion on a nationwide basis to ensure that the species most in need of listing will be addressed first and also because we allocate our listing budget on a nationwide basis. Through the listing cap, the critical habitat subcap, and the amount of funds needed to address court-mandated critical habitat designations, Congress and the courts have in effect determined the amount of money available for other listing activities nationwide. Therefore, the funds in the listing cap, other than those needed to address court-mandated critical habitat for already listed species, set the limits on our determinations of preclusion and expeditious progress.

Congress identified the availability of resources as the only basis for deferring the initiation of a rulemaking that is warranted. The Conference Report accompanying Public Law 97–304 (Endangered Species Act Amendments of 1982), which established the current statutory deadlines and the warranted-but-precluded finding, states that the amendments were "not intended to allow the Secretary to delay commencing the rulemaking process for any reason other than that the existence of pending or imminent proposals to list species subject to a greater degree of threat would make allocation of resources to such a petition [that is, for a lower-ranking species] unwise." Although that statement appeared to refer specifically to the "to the maximum extent practicable" limitation on the 90-day deadline for making a "substantial information" finding (see 16 U.S.C. 1533(b)(3)(A)), that finding is made at the point when the Service is deciding whether or not to commence a status review that will determine the degree of threats facing the species, and therefore the analysis underlying the statement is more relevant to the use of the warranted-but-precluded finding, which is made when the Service has already determined the degree of threats facing the species and is deciding whether or not to commence a rulemaking.

In FY 2011, on March 18, 2010, Congress passed a continuing resolution which provides funding at the FY 2010 enacted level through April 8, 2011. Until Congress appropriates funds for FY 2011 at a different level, we will fund listing work based on the FY 2010 amount. Thus, at this time in FY 2011, the Service anticipates an appropriation of $22,103,000 based on FY 2010 appropriations. Of that, the Service must dedicate $11,632,000 for determinations of critical habitat for already listed species. Also $500,000 is appropriated for foreign species listings under the Act. The Service thus has $9,971,000 available to fund work in the following categories: compliance with court orders and court-approved settlement agreements requiring that petition findings or listing determinations be completed by a specific date; section 4 (of the Act) listing actions with absolute statutory deadlines; essential litigation-related, administrative, and listing program-management functions; and high-priority listing actions for some of our candidate species. In FY 2010, the Service received many new petitions and a single petition to list 404 species. The receipt of petitions for a large number of species is consuming the Service's listing funding that is not dedicated to meeting court-ordered commitments. Absent some ability to balance effort among listing duties under existing funding levels, it is unlikely that the Service will be able to initiate any new listing determinations for candidate species in FY 2011.

In 2009, the responsibility for listing foreign species under the Act was transferred from the Division of Scientific Authority, International Affairs Program, to the Endangered Species Program. Therefore, starting in FY 2010, we used a portion of our funding to work on the actions described above for listing actions related to foreign species. In FY 2011, we anticipate using $1,500,000 for work on listing actions for foreign species, which reduces funding available for domestic listing actions; however, currently only $500,000 has been allocated for this function. Although there are no foreign species issues included in our high-priority listing actions at this time, many actions have statutory or court-approved settlement deadlines, thus increasing their priority. The budget allocations for each specific listing action are identified in the Service's FY 2011 Allocation Table (part of our administrative record).

For the above reasons, funding a proposed listing determination for the Hermes copper butterfly is precluded by court-ordered and court-approved settlement agreements, listing actions with absolute statutory deadlines, work on final listing determinations for those species that were proposed for listing with funds from FY 2011, and work on proposed listing determinations for those candidate species with a higher listing priority (i.e., candidate species with LPNs of 1 to 4).

Based on our September 21, 1983, guidelines for assigning an LPN for each candidate species (48 FR 43098), we have a significant number of species with a LPN of 2. Using these guidelines, we assign each candidate an LPN of 1 to 12, depending on the magnitude of threats (high or moderate to low), immediacy of threats (imminent or nonimminent), and taxonomic status of the species (in order of priority: monotypic genus (a species that is the sole member of a genus); species; or part of a species (subspecies, distinct population segment, or significant portion of the range)). The lower the listing priority number, the higher the listing priority (that is, a species with an LPN of 1 would have the highest listing priority).

Because of the large number of high-priority species, we have further ranked the candidate species with an LPN of 2 by using the following extinction-risk type criteria: International Union for the Conservation of Nature and Natural Resources (IUCN) Red list status/rank; Heritage rank (provided by NatureServe); Heritage threat rank (provided by NatureServe); and species currently with fewer than 50 individuals, or 4 or fewer populations. Those species with the highest IUCN rank (critically endangered); the highest Heritage rank (G1); the highest Heritage threat rank (substantial, imminent threats); and currently with fewer than 50 individuals, or fewer than 4 populations, originally comprised a group of approximately 40 candidate species ("Top 40"). These 40 candidate species have had the highest priority to receive funding to work on a proposed listing determination. As we work on proposed and final listing rules for those 40 candidates, we apply the ranking criteria to the next group of candidates with an LPN of 2 and 3 to determine the next set of highest priority candidate species. Finally, proposed rules for reclassification of threatened species to endangered are lower priority, because as listed species, they are already afforded the protections of the Act and implementing regulations. However, for efficiency reasons, we may choose to work on a proposed rule to reclassify a species to endangered if we can combine this with work that is subject to a court-determined deadline.

With our workload so much bigger than the amount of funds we have to accomplish it, it is important that we be as efficient as possible in our listing process. Therefore, as we work on proposed rules for the highest priority species in the next several years, we are preparing multi-species proposals when appropriate, and these may include species with lower priority if they overlap geographically or have the same threats as a species with an LPN of 2. In addition, we take into consideration the availability of staff resources when we determine which high-priority species will receive funding to minimize the amount of time and resources required to complete each listing action.

As explained above, a determination that listing is warranted but precluded must also demonstrate that expeditious progress is being made to add and remove qualified species to and from the Lists of Endangered and Threatened Wildlife and Plants. As with our "warranted-but-precluded" finding, the evaluation of whether progress in adding qualified species to the Lists has been expeditious is a function of the resources available for listing and the competing demands for those funds. (Although we do not discuss it in detail here, we are also making expeditious progress in removing species from the list under the Recovery program in light of the resource available for delisting, which is funded by a separate line item in the budget of the Endangered Species Program. So far during FY 2011, we have completed one delisting rule; see 76 FR 3029.) Given the limited resources available for listing, we find that we are making expeditious progress in FY 2011. This progress includes preparing and publishing the following determinations:

FY 2011 COMPLETED LISTING ACTIONS

Publication date	Title	Actions	FR pages
10/6/2010	Endangered Status for the Altamaha Spinymussel and Designation of Critical Habitat.	Proposed Listing, Endangered	75 FR 61664–61690.
10/7/2010	12-Month Finding on a Petition to list the Sacramento Splittail as Endangered or Threatened.	Notice of 12-month petition finding, Not warranted.	75 FR 62070–62095.
10/28/2010	Endangered Status and Designation of Critical Habitat for Spikedace and Loach Minnow.	Proposed Listing, Endangered (uplisting).	75 FR 66481–66552.
11/2/2010	90-Day Finding on a Petition to List the Bay Springs Salamander as Endangered.	Notice of 90-day Petition Finding, Not substantial.	75 FR 67341–67343.
11/2/2010	Determination of Endangered Status for the Georgia Pigtoe Mussel, Interrupted Rocksnail, and Rough Hornsnail and Designation of Critical Habitat.	Final Listing, Endangered	75 FR 67511–67550.

FY 2011 COMPLETED LISTING ACTIONS—Continued

Publication date	Title	Actions	FR pages
11/2/2010	Listing the Rayed Bean and Snuffbox as Endangered	Proposed Listing, Endangered	75 FR 67551–67583.
11/4/2010	12-Month Finding on a Petition to List Cirsium wrightii (Wright's Marsh Thistle) as Endangered or Threatened.	Notice of 12-month petition finding, Warranted but precluded.	75 FR 67925–67944.
12/14/2010	Endangered Status for Dunes Sagebrush Lizard	Proposed Listing, Endangered	75 FR 77801–77817.
12/14/2010	12-Month Finding on a Petition to List the North American Wolverine as Endangered or Threatened.	Notice of 12-month petition finding, Warranted but precluded.	75 FR 78029–78061.
12/14/2010	12-Month Finding on a Petition to List the Sonoran Population of the Desert Tortoise as Endangered or Threatened.	Notice of 12-month petition finding, Warranted but precluded.	75 FR 78093–78146.
12/15/2010	12-Month Finding on a Petition to List *Astragalus microcymbus* and *Astragalus schmolliae* as Endangered or Threatened.	Notice of 12-month petition finding, Warranted but precluded.	75 FR 78513–78556.
12/28/2010	Listing Seven Brazilian Bird Species as Endangered Throughout Their Range.	Final Listing, Endangered	75 FR 81793–81815.
1/4/2011	90-Day Finding on a Petition to List the Red Knot subspecies *Calidris canutus roselaari* as Endangered.	Notice of 90-day Petition Finding, Not substantial.	76 FR 304–311.
1/19/2011	Endangered Status for the Sheepnose and Spectaclecase Mussels	Proposed Listing, Endangered	76 FR 3392–3420.
2/10/2011	12-Month Finding on a Petition to List the Pacific Walrus as Endangered or Threatened.	Notice of 12-month petition finding, Warranted but precluded.	76 FR 7634–7679.
2/17/2011	90-Day Finding on a Petition to List the Sand Verbena Moth as Endangered or Threatened.	Notice of 90-day Petition Finding, Substantial.	76 FR 9309–9318.
2/22/2011	Determination of Threatened Status for the New Zealand-Australia Distinct Population Segment of the Southern Rockhopper Penguin.	Final Listing, Threatened	76 FR 9681–9692.
2/22/2011	12-Month Finding on a Petition to List *Solanum conocarpum* (marron bacora) as Endangered.	Notice of 12-month petition finding, Warranted but precluded.	76 FR 9722–9733.
2/23/2011	12-Month Finding on a Petition to List Thorne's Hairstreak Butterfly as Endangered.	Notice of 12-month petition finding, Not warranted.	76 FR 991–1003.
2/23/2011	12-Month Finding on a Petition to List *Astragalus hamiltonii, Penstemon flowersii, Eriogonum soredium, Lepidium ostleri,* and *Trifolium friscanum* as Endangered or Threatened.	Notice of 12-month petition finding, Warranted but precluded & Not Warranted.	76 FR 10166–10203.
2/24/2011	90-Day Finding on a Petition to List the Wild Plains Bison or Each of Four Distinct Population Segments as Threatened.	Notice of 90-day Petition Finding, Not substantial.	76 FR 10299–10310.
2/24/2011	90-Day Finding on a Petition to List the Unsilvered Fritillary Butterfly as Threatened or Endangered.	Notice of 90-day Petition Finding, Not substantial.	76 FR 10310–10319.
3/8/2011	12-Month Finding on a Petition to List the Mt. Charleston Blue Butterfly as Endangered or Threatened.	Notice of 12-month petition finding, Warranted but precluded.	76 FR 12667–12683.
3/8/2011	90-Day Finding on a Petition to List the Texas Kangaroo Rat as Endangered or Threatened.	Notice of 90-day Petition Finding, Substantial.	76 FR 12683–12690.
3/10/2011	Initiation of Status Review for Longfin Smelt	Notice of Status Review	76 FR 13121–31322.
3/15/2011	Withdrawal of Proposed Rule to List the Flat-tailed Horned Lizard as Threatened.	Proposed rule withdrawal	76 FR 14210–14268.
3/22/2011	12-Month Finding on a Petition to List the Berry Cave Salamander as Endangered.	Notice of 12-month petition finding, Warranted but precluded.	76 FR 15919–15932.
4/1/2011	90-Day Finding on a Petition to List the Spring Pygmy Sunfish as Endangered.	Notice of 90-day Petition Finding, Substantial.	76 FR 18138–18143.
4/5/2011	12-Month Finding on a Petition to List the Bearmouth Mountainsnail, Byrne Resort Mountainsnail, and Meltwater Lednian Stonefly as Endangered or Threatened.	Notice of 12-month petition finding, Not Warranted and Warranted but precluded.	76 FR 18684–18701.
4/5/2011	90-Day Finding on a Petition To List the Peary Caribou and Dolphin and Union population of the Barren-ground Caribou as Endangered or Threatened.	Notice of 90-day Petition Finding, Substantial.	76 FR 18701–18706.

Our expeditious progress also includes work on listing actions that we funded in FY 2010 and FY 2011 but have not yet been completed to date. These actions are listed below. Actions in the top section of the table are being conducted under a deadline set by a court. Actions in the middle section of the table are being conducted to meet statutory timelines, that is, timelines required under the Act. Actions in the bottom section of the table are high-priority listing actions. These actions include work primarily on species with an LPN of 2, and, as discussed above, selection of these species is partially based on available staff resources, and when appropriate, include species with a lower priority if they overlap geographically or have the same threats as the species with the high priority. Including these species together in the same proposed rule results in considerable savings in time and funding, when compared to preparing separate proposed rules for each of them in the future.

ACTIONS FUNDED IN FY 2010 AND FY 2011 BUT NOT YET COMPLETED

Species	Action
Actions Subject to Court Order/Settlement Agreement	
Mountain plover[4]	Final listing determination.

ACTIONS FUNDED IN FY 2010 AND FY 2011 BUT NOT YET COMPLETED—Continued

Species	Action
Hermes copper butterfly [3]	12-month petition finding.
4 parrot species (military macaw, yellow-billed parrot, red-crowned parrot, scarlet macaw) [5]	12-month petition finding.
4 parrot species (blue-headed macaw, great green macaw, grey-cheeked parakeet, hyacinth macaw) [5]	12-month petition finding.
4 parrots species (crimson shining parrot, white cockatoo, Philippine cockatoo, yellow-crested cockatoo) [5]	12-month petition finding.
Utah prairie dog (uplisting)	90-day petition finding.
Actions With Statutory Deadlines	
Casey's june beetle	Final listing determination.
6 Birds from Eurasia	Final listing determination.
5 Bird species from Colombia and Ecuador	Final listing determination.
Queen Charlotte goshawk	Final listing determination.
5 species southeast fish (Cumberland darter, rush darter, yellowcheek darter, chucky madtom, and laurel dace) [4]	Final listing determination.
Ozark hellbender [4]	Final listing determination.
Altamaha spinymussel [3]	Final listing determination.
3 Colorado plants (*Ipomopsis polyantha* (Pagosa Skyrocket), *Penstemon debilis* (Parachute Beardtongue), and *Phacelia submutica* (DeBeque Phacelia)) [4].	Final listing determination.
Salmon crested cockatoo	Final listing determination.
6 Birds from Peru & Bolivia	Final listing determination.
Loggerhead sea turtle (assist National Marine Fisheries Service) [5]	Final listing determination.
2 mussels (rayed bean (LPN = 2), snuffbox No LPN) [5]	Final listing determination.
CA golden trout [4]	12-month petition finding.
Black-footed albatross	12-month petition finding.
Mojave fringe-toed lizard [1]	12-month petition finding.
Kokanee—Lake Sammamish population [1]	12-month petition finding.
Cactus ferruginous pygmy-owl [1]	12-month petition finding.
Northern leopard frog	12-month petition finding.
Tehachapi slender salamander	12-month petition finding.
Coqui Llanero	12-month petition finding/ Proposed listing.
Dusky tree vole	12-month petition finding.
5 WY plants (*Abronia ammophila, Agrostis rossiae, Astragalus proimanthus, Boechere* (*Arabis*) *pusilla, Penstemon gibbensii*) from 206 species petition.	12-month petition finding.
Leatherside chub (from 206 species petition)	12-month petition finding.
Frigid ambersnail (from 206 species petition) [3]	12-month petition finding.
Platte River caddisfly (from 206 species petition) [5]	12-month petition finding.
Gopher tortoise—eastern population	12-month petition finding.
Grand Canyon scorpion (from 475 species petition)	12-month petition finding.
Anacroneuria wipukupa (a stonefly from 475 species petition) [4]	12-month petition finding.
3 Texas moths (*Ursia furtiva, Sphingicampa blanchardi, Agapema galbina*) (from 475 species petition)	12-month petition finding.
2 Texas shiners (*Cyprinella* sp., *Cyprinella lepida*) (from 475 species petition)	12-month petition finding.
3 South Arizona plants (*Erigeron piscaticus, Astragalus hypoxylus, Amoreuxia gonzalezii*) (from 475 species petition).	12-month petition finding.
5 Central Texas mussel species (3 from 475 species petition)	12-month petition finding.
14 parrots (foreign species)	12-month petition finding.
Striped newt [1]	12-month petition finding.
Fisher—Northern Rocky Mountain Range [1]	12-month petition finding.
Mohave ground squirrel [1]	12-month petition finding.
Puerto Rico harlequin butterfly [3]	12-month petition finding.
Western gull-billed tern	12-month petition finding.
Ozark chinquapin (*Castanea pumila* var. *ozarkensis*) [4]	12-month petition finding.
HI yellow-faced bees	12-month petition finding.
Giant Palouse earthworm	12-month petition finding.
Whitebark pine	12-month petition finding.
OK grass pink (*Calopogon oklahomensis*) [1]	12-month petition finding.
Ashy storm-petrel [5]	12-month petition finding.
Honduran emerald	12-month petition finding.
Southeastern pop snowy plover & wintering pop. of piping plover [1]	90-day petition finding.
Eagle Lake trout [1]	90-day petition finding.
Smooth-billed ani [1]	90-day petition finding.
32 Pacific Northwest mollusks species (snails and slugs) [1]	90-day petition finding.
42 snail species (Nevada & Utah)	90-day petition finding.
Peary caribou	90-day petition finding.
Spring Mountains checkerspot butterfly	90-day petition finding.
Spring pygmy sunfish	90-day petition finding.
Bay skipper	90-day petition finding.
Spot-tailed earless lizard	90-day petition finding.
Eastern small-footed bat	90-day petition finding.
Northern long-eared bat	90-day petition finding.
Prairie chub	90-day petition finding.
10 species of Great Basin butterfly	90-day petition finding.
6 sand dune (scarab) beetles	90-day petition finding.

ACTIONS FUNDED IN FY 2010 AND FY 2011 BUT NOT YET COMPLETED—Continued

Species	Action
Golden-winged warbler [4]	90-day petition finding.
404 Southeast species	90-day petition finding.
Franklin's bumble bee [4]	90-day petition finding.
2 Idaho snowflies (straight snowfly & Idaho snowfly) [4]	90-day petition finding.
American eel [4]	90-day petition finding.
Gila monster (Utah population) [4]	90-day petition finding.
Arapahoe snowfly [4]	90-day petition finding.
Leona's little blue [4]	90-day petition finding.
Aztec gilia [5]	90-day petition finding.
White-tailed ptarmigan [5]	90-day petition finding.
San Bernardino flying squirrel [5]	90-day petition finding.
Bicknell's thrush [5]	90-day petition finding.
Chimpanzee	90-day petition finding.
Sonoran talussnail [5]	90-day petition finding.
2 AZ Sky Island plants (*Graptopetalum bartrami* & *Pectis imberbis*) [5]	90-day petition finding.
I'iwi [5]	90-day petition finding.
High-Priority Listing Actions	
19 Oahu candidate species [2] (16 plants, 3 damselflies) (15 with LPN = 2, 3 with LPN = 3, 1 with LPN = 9)	Proposed listing.
19 Maui-Nui candidate species [2] (16 plants, 3 tree snails) (14 with LPN = 2, 2 with LPN = 3, 3 with LPN = 8)	Proposed listing.
2 Arizona springsnails [2] (*Pyrgulopsis bernadina* (LPN = 2), *Pyrgulopsis trivialis* (LPN = 2))	Proposed listing.
Chupadera springsnail [2] (*Pyrgulopsis chupaderae* (LPN = 2))	Proposed listing.
8 Gulf Coast mussels (southern kidneyshell (LPN = 2), round ebonyshell (LPN = 2), Alabama pearlshell (LPN = 2), southern sandshell (LPN = 5), fuzzy pigtoe (LPN = 5), Choctaw bean (LPN = 5), narrow pigtoe (LPN = 5), and tapered pigtoe (LPN = 11)) [4].	Proposed listing.
Umtanum buckwheat (LPN = 2) and white bluffs bladderpod (LPN = 9) [4]	Proposed listing.
Grotto sculpin (LPN = 2) [4]	Proposed listing.
2 Arkansas mussels (Neosho mucket (LPN = 2) & rabbitsfoot (LPN = 9)) [4]	Proposed listing.
Diamond darter (LPN = 2) [4]	Proposed listing.
Gunnison sage-grouse (LPN = 2) [4]	Proposed listing.
Coral Pink Sand Dunes Tiger Beetle (LPN = 2) [5]	Proposed listing.
Miami blue (LPN = 3) [3]	Proposed listing.
Lesser prairie chicken (LPN = 2)	Proposed listing.
4 Texas salamanders (Austin blind salamander (LPN = 2), Salado salamander (LPN = 2), Georgetown salamander (LPN = 8), Jollyville Plateau (LPN = 8)) [3].	Proposed listing.
5 SW aquatics (Gonzales Spring Snail (LPN = 2), Diamond Y springsnail (LPN = 2), Phantom springsnail (LPN = 2), Phantom Cave snail (LPN = 2), Diminutive amphipod (LPN = 2)) [3].	Proposed listing.
2 Texas plants (Texas golden gladecress (*Leavenworthia texana*) (LPN = 2), Neches River rose-mallow (*Hibiscus dasycalyx*) (LPN = 2)) [3].	Proposed listing.
4 AZ plants (Acuna cactus (*Echinomastus erectocentrus* var. *acunensis*) (LPN = 3), Fickeisen plains cactus (*Pediocactus peeblesianus fickeiseniae*) (LPN = 3), Lemmon fleabane (*Erigeron lemmonii*) (LPN = 8), Gierisch mallow (*Sphaeralcea gierischii*) (LPN = 2)) [5].	Proposed listing.
FL bonneted bat (LPN = 2) [3]	Proposed listing.
3 Southern FL plants (Florida semaphore cactus (*Consolea corallicola*) (LPN = 2), shellmound applecactus (*Harrisia* (=*Cereus*) *aboriginum* (=*gracilis*)) (LPN = 2), Cape Sable thoroughwort (*Chromolaena frustrata*) (LPN = 2)) [5].	Proposed listing.
21 Big Island (HI) species [5] (includes 8 candidate species—5 plants & 3 animals; 4 with LPN = 2, 1 with LPN = 3, 1 with LPN = 4, 2 with LPN = 8).	Proposed listing.
12 Puget Sound prairie species (9 subspecies of pocket gopher (*Thomomys mazama* ssp.) (LPN = 3), streaked horned lark (LPN = 3), Taylor's checkerspot (LPN = 3), Mardon skipper (LPN = 8)) [3].	Proposed listing.
2 TN River mussels (fluted kidneyshell (LPN = 2), slabside pearlymussel (LPN = 2)) [5]	Proposed listing.
Jemez Mountain salamander (LPN = 2) [5]	Proposed listing.

[1] Funds for listing actions for these species were provided in previous FYs.
[2] Although funds for these high-priority listing actions were provided in FY 2008 or 2009, due to the complexity of these actions and competing priorities, these actions are still being developed.
[3] Partially funded with FY 2010 funds and FY 2011 funds.
[4] Funded with FY 2010 funds.
[5] Funded with FY 2011 funds.

We have endeavored to make our listing actions as efficient and timely as possible, given the requirements of the relevant law and regulations, and constraints relating to workload and personnel. We are continually considering ways to streamline processes or achieve economies of scale, such as by batching related actions together. Given our limited budget for implementing section 4 of the Act, these actions described above collectively constitute expeditious progress.

The Hermes copper butterfly will be added to the list of candidate species upon publication of this 12-month finding. We will continue to monitor the status of this species as new information becomes available. This review will determine if a change in status is warranted, including the need to make prompt use of emergency listing procedures.

We intend that any proposed classification of the Hermes copper butterfly will be as accurate as possible. Therefore, we will continue to accept additional information and comments from all concerned governmental agencies, the scientific community, industry, or any other interested party concerning this finding.

References Cited

A complete list of references cited is available on the internet at *http://www.regulations.gov* and upon request from the Carlsbad Fish and Wildlife Office (see **ADDRESSES**).

Authors

The primary authors of this notice are the staff members of the Carlsbad Fish and Wildlife Office.

Authority

The authority for this action is section 4 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

Dated: March 29, 2011.

Rowan W. Gould,

Acting Director, Fish and Wildlife Service.

[FR Doc. 2011–9028 Filed 4–13–11; 8:45 am]

BILLING CODE 4310–55–P

Close

Underground vs. Overhead: Power Line Installation-Cost Comparison and Mitigation

BY FRANK ALONSO AND **CAROLYN A. E. GREENWELL**, SAIC

Hurricane Sandy left many electric utility executives, their customers, local and state government leaders and regulators contemplating placing overhead power lines underground. This desire surges into prominence whenever natural disasters cause destruction on the overhead distribution and transmission networks across the country. In the past, the largest obstacle to placing overhead power lines underground has been the higher cost of installation and maintenance for underground lines.

Although overhead power lines are typically more economical, they are susceptible to damage from wind-borne tree branches, debris and high wind and ice-loading conditions from extreme weather. The damages can cause extended power outages that in extreme cases cannot be restored for days or even weeks, as we have seen after Hurricane Sandy. The cost for repairing the physical damages can be in the billions of dollars. During long outages after a catastrophe, there are also associated intangible impacts to a utility's customers such as despair, discomfort, anxiety and helplessness. In addition to the intangible impacts, there are considerable direct economic impacts to customers resulting from lost economic activity, food spoilage, looting, etc. These tangible and intangible impacts challenge the electric utility industry's attempts to justify the installation of overhead electric distribution and transmission systems.

Cost Differentials

Whenever a major weather-related catastrophe occurs or land is being developed, the question of placing overhead power lines underground surges. The answer to the proverbial question, "Why can't overhead power lines be placed underground?" is, "They can be, but it's expensive."

Higher initial construction costs. According to the May 2011 paper "Underground Electric Transmission Lines" published by the Public Service Commission of Wisconsin, "The estimated cost for constructing underground transmission lines ranges from 4 to 14 times more expensive than overhead lines of the same voltage and same distance. A typical new 69 kV overhead single-circuit transmission line costs approximately $285,000 per mile as opposed to $1.5 million per mile for a new 69 kV underground line (without the terminals). A new 138 kV overhead line costs approximately $390,000 per mile as opposed to $2 million per mile for underground (without the terminals)."

These costs show a potential initial construction cost differential of more than five times for underground lines as opposed to overhead lines for construction in Wisconsin. Costs vary in other regions, but the relative difference between overhead and underground installation costs is similar from state to state.

Technical improvements in cable technology, wire placement, conduit sizing, grounding methods, directional boring techniques and other aspects of undergrounding power lines have advanced the reliability of underground power. They have not lowered their initial construction costs significantly, however, which are mostly associated with trenching through the earth along the entire line route.

Maintenance costs. The present worth of the maintenance costs associated with underground lines is difficult to assess. Many variables are involved, and many assumptions are required to arrive at what would be a guess at best. Predicting the performance of an underground line is difficult, yet the maintenance costs associated with an underground line are significant and one of the major impediments to the more extensive use of underground construction. Major factors that impact the maintenance costs for underground transmission lines include:

Cable repairs. Underground lines are better protected against weather and other conditions that can impact overhead lines, but they are susceptible to insulation deterioration because of the loading cycles the lines undergo during their lifetimes. As time passes, the cables' insulation weakens, which increases the potential for a line fault. If the cables are installed properly, this debilitating process can take years and might be avoided. If and when a fault occurs, however, the cost of finding its location, trenching, cable splicing, and re-embedment is sometimes five to 10 times more expensive than repairing a fault in an overhead line where the conductors are visible, readily accessible and easier to repair.

In addition, easement agreements might require a utility to compensate property owners for disruption in their property use and for property damage caused by the repairs to the underground cables.

Line outage durations. The durations of underground line outages vary widely depending on the operating voltage, site conditions, failure, material availability and experience of repair personnel.

The typical repair duration of cross-linked polyethelene (XLPE), a solid dielectric type of underground cable, ranges from five to nine days. Outages are longer for lines that use other nonsolid dielectric underground cables such as high-pressure, gas-filled (HPGF) pipe-type cable, high-pressure, fluid-filled (HPFF) pipe-type cable, and self-contained, fluid-filled (SCFF)-type cable. In comparison, a fault or break in an overhead conductor usually can be located almost immediately and repaired within hours or a day or two at most.

During the extended line outages required for underground line repairs, services to customers are disrupted. The length of customer outages can be mitigated using redundant feeders, but the duration of such outages is still longer than those associated with overhead lines, and they have additional costs associated with them.

Line modifications. Overhead power lines are easily tapped, rerouted or modified to serve customers; underground lines are more difficult to modify after the cables have been installed. Such modifications to underground power lines are more expensive because of the inability to readily access lines or relocate sections of lines.

For example, when a developer or homeowner requests electric service for a new home, if there's an overhead distribution line nearby, the service connection can be designed, constructed and made available for connection to the new home in a relatively short time. Service drops to new residences can be installed within a day or two after the service request is submitted to the utility.

If the utility is requested to provide underground service to the new home, however, the design and construction will take up to a week or two. This time differential increases the cost for Âunderground power.

Who Pays?

As the additional construction time, specialty cable costs and excavation costs continue to increase, the issue of who bears these differential costs remains unsolved. Typically the differential costs for new distribution services are paid by the developer according to a regulated tariff. The developer may then pass those costs to home buyers who purchase property fed by underground power lines. For example, in an Orlando, Fla., neighborhood, each home buyer must pay an additional $15,000 as his or her share of the costs for underground power service.

For transmission lines, it is difficult to determine how to allocate the differential costs associated with placing them underground to a specific developer, customer class or individual customer. These costs typically are absorbed by utilities, and if allowed by the regulatory agencies, the costs are included in the utilities' rate bases. Regulatory agencies usually do not allow utilities to differentiate between underground and overhead services in their rates. Service rates must be the same for each customer classification regardless how the service is provided.

There are signs that regulatory agencies are modifying their approach, however. For example, southeastern Connecticut, a generation resource-limited area, is also one of the wealthiest areas of Connecticut. A new 345-kV line was required to connect new generation facilities to the New England power grid. Because of large opposition from southeastern Connecticut citizens, portions of the line had to be built underground using HPFF and XLPE cables. Because the bulk power generated would benefit consumers throughout the region, the costs of those new generation facilities and associated overhead transmission tie line were shared by all New England ratepayers. The differential costs for undergrounding portions of the 345-kV tie line, however, were borne only by the southeastern Connecticut ratepayers. This rate differentiation must be the norm and not the exception.

Restrictions enforced by regulatory agencies try to ensure utility customers are not unduly burdened with system improvements that benefit a limited number of customers. In addition, nearly all regulatory agencies base their standard power delivery models using overhead line construction. Any proposed underground line installations that exceed the specified voltage, dollar or line length limit must be justified and approved by the regulatory agency prior to design and construction.

Investor-owned utilities (IOUs) face additional cost challenges. Unless special exceptions are obtained ahead of time, IOUs are not allowed to include their expenses for works-in-progress into their rate bases. A new power line-whether overhead or underground-cannot be included in the rate base until it is energized and serving customers. Therefore, lengthy and costly underground projects result in higher financing costs the utility must absorb without being able to Ârecover them until the project is completed and permitted by regulators.

In addition, most regulatory agencies require utilities to justify the need and costs of new facilities. The need for a new power line typically is supported by load growth. The cost of new facilities is justified by who benefits and by performing a typical industry cost comparison.

If a new facility cannot be justified to the regulatory agency, the utility must bear the costs or at least the differential costs of designing, constructing and operating the facility.

In the U.S., more than 97 percent of the transmission line miles are installed overhead, so it is difficult to justify installing underground power. Established standard design and construction practices are to place such lines overhead. Unless undergrounding is justified by physical constraints, the utility would be responsible for the differential cost between the overhead and underground installation of the line. That differential cost must be financed and will impact the utility's return on investments to their stockholders.

Changes Required

Regulatory reform. The first required change is a redefinition of who is responsible for the differential costs associated with building and maintaining power lines underground and converting overhead lines to underground. Currently for distribution lines, those costs are passed on to the land developers who request underground services who, in turn, pass the costs on to home buyers. This seems an equitable way to handle the initial construction costs. Under these Âarrangements, however, utilities remain responsible for the higher maintenance costs over the life of the lines. In addition, for those utilities without underground facilities on their systems, the initial costs for converting overhead lines to underground lines would require additional startup costs associated with staff training, stocking their warehouses with underground materials and equipment, developing new standards, and purchasing new equipment for underground installation and maintenance.

A more equitable approach might be to develop separate rates for customers served underground and overhead. Maintenance costs would be tracked and allocated according to the type of service provided to each customer. This would increase the utility's commitment to place distribution lines underground. Under the current system, the utilities have the means to recover initial construction costs. Their reluctance to undergrounding distribution lines stems from the higher maintenance costs they have to absorb when underground lines fail.

Independent assessment of differential costs. Another change needed is the development of an independent assessment of the differential costs associated with installing power lines underground. Utilities cannot take this on, first, because constructing overhead structures-let's say a few structures within a mile-is less expensive than trenching a mile's worth of land to 8 feet or more in depth, and second, because customers generally do not accept a utility's estimates or explanations as credible.

In addition, preparing the independent cost comparisons is fraught with Âchallenges. For example, when trying to average the costs of excavating a 10-foot deep trench to a width of 5 feet and include the necessary 2:1 sloping or appropriate shoring required to prevent cave-ins, it is difficult to provide a realistic average cost that considers the types of soils or rock encountered. This is because the cost of excavating is determined by the amount to be excavated and what is to be excavated. There is no average subsurface or soil type in the U.S. that would support such a calculation. The unknowns lead to variable excavating costs that are unrealistic to a U.S. utility and hard to justify to regulatory agencies and customers. This calls for local costs to be developed and examined.

Other changes already are taking place to consider underground power delivery more seriously. Engineers and planners are developing lists of costly obstacles to overcome while customers continue to demand underground power delivery. As storms leave behind damages that cost billions of dollars, everyone will focus more intently on the justification for undergrounding. This change is not revolutionary but reality.

The placement of power lines underground typically is driven by the lack of available right of way or aesthetics. Placing lines underground in heavily populated, urban areas is a decision readily justified to regulatory agencies. Typically, construction costs for those lines are approved by regulatory agencies to be added to the utilities' rate bases; however, for lines that are requested to be installed underground by a community concerned about the aesthetic, it is only just to have the community absorb a portion if not the full amount of the differential costs. This concept has been employed by several Florida utilities that needed to construct transmission lines through established, residential communities. In at least two cases, reasonable agreements were reached by the utility and government agency for sharing the differential costs of placing the transmission lines underground.

The Answer

"They can be, but it's expensive," is the proverbial answer concerning underground power delivery, but the time is quickly approaching when utility customers and government officials will demand an answer that provides a more in-depth, independent look at how much more expensive underground power delivery is compared with overhead power delivery. Changes will be precipitated by power outages associated with natural disasters, citizens who don't want their homes Âdevalued by nearby overhead lines, and competitive economic forces that drive utilities to consider placing power lines underground.

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Clairemont woman voices health concerns about new steel power pole

BY: Virginia Cha (mailto:virginia.cha@10news.com) (http://www.facebook.com/) (http://www.twitter.com/)
POSTED: Jun 9, 2013
UPDATED: 271 days ago

SAN DIEGO - A woman in Clairemont says she was alarmed when she saw a new, large-sized metal power pole going up in her neighborhood.

"I'm concerned about my health," said Jan Brown, who noticed the big metal utility pole going up in her Clairemont neighborhood recently. "There's a lot more wires and looks like a lot more voltage is coming off the top of those poles."

The new metal pole is at least 20 feet taller than common wooden poles. Some residents call the steel giants eyesores that will cost them money.

"It's going to kill our property values if these monsters keep going up in our neighborhood," said Brown.

Her neighbor says along with property values, he is worried about the health of his kids.

"I am concerned with that," said Kurt Meeder. "I have small children, 12 and 9 years old."

While the pole in question is one of several steel poles crossing through a section of Clairemont at Cole, it is still about a mile away from Brown's home where there is an older wooden power pole out front.

"The million dollar question is are they going to replace all the wood poles in this area with these?" asked Brown.

10News asked SDG&E that question.

"There's no plan to replace all the wooden poles in that area," said SDG&E spokeswoman Gina Jacobs. "The pole that was replaced was a transmission pole."

Those are fewer and farther between. As for whether the new pole has more lines and therefore more output?

"It's the same so there's no new output of electricity in that area," said Jacobs.

SDG&E says the steel poles are upgrades because they are stronger and able to withstand the elements better.

Brown still does not like them.

"They're ugly, they stand out, they're bigger," she said. "There's nothing good I can say about this thing."

SDG&E says steel poles improve reliability. About 3,000 wooden poles have been replaced so far, with many of those in high fire risk areas.

Microgrid powers Borrego during emergency

Presented by SDG&E

6 a.m.Nov. 10, 2013

On the afternoon of Sept. 6, 2013, intense thunderstorms blew into Borrego Springs, causing heavy rain, flash floods, high winds and severe lightning in the area. Lightning from the storm struck and shattered a power pole on the only transmission line serving the community, cutting electricity to all the town's 2,780 power customers.

SDG&E repair crews quickly arrived on the scene and worked throughout the night to restore power to all customers. But this wasn't a run-of-the-mill power restoration, as crews were able to make use of a special advantage: SDG&E's Borrego Springs Microgrid. A first of its kind in the area, this Microgrid uses new smart grid technology – including local power generation, local energy storage, and automated switching – to create a more robust, resilient grid that can dynamically react to the changing environmental and system conditions. The Microgrid is connected to the grid, but can disconnect and function independently during emergencies, supplying vital electricity to the local community through its on-site resources. The project is partially funded by the U.S. Department of Energy and the California Energy Commission.

As soon as the storm passed and utility patrols were able to determine the damage, the Microgrid began to provide power to customers. In total, 1,060 customers had their power restored automatically within hours by the Microgrid, using the on-site power. This included the essential downtown business area that contains several gas stations, stores and the local library, which is the designated "cool zone" for the community. The Microgrid continued to use on-site generation to power these customers while repairs were made to the damaged poles, allowing them to keep air conditioners and other vital appliances running during the intense heat. This is one of the first times in the nation that a Microgrid has been used to power a large portion of a community during an emergency situation.

While the Microgrid supplied power to many customers, SDG&E personnel made numerous phone calls or house visits to keep residents informed on the status of repairs and estimated restoration times for other customers. SDG&E also contacted customers with medical conditions and offered them a room in the Borrego Springs Resort, which SDG&E had turned into another "cool zone" by powering the facility with a backup generator. Eight customers with medical needs took SDG&E up on their offer to avoid the triple-digit heat.

By early afternoon on Sept. 7, all the repairs had been made and power was ready to be restored to the community. In total, nine transmission and 11 distribution wood poles were replaced with steel poles to strengthen the system against future adverse weather conditions. At 3:38 p.m., roughly 25 hours after the initial lightning strike, SDG&E restored power to all 2,780 customers in Borrego Springs.

“The Microgrid was really a crucial tool during this emergency situation,” said Linda Haddock, executive director of the Borrego Springs Chamber of Commerce. “It provided electricity to the essential areas of our town and kept vital air conditioners running during the extremely hot weather we saw that day. This innovative project, coupled with the hard work of SDG&E repair crews and their collaboration with local residents, helped Borrego Springs make it through this emergency unscathed. It truly made a difference in the lives of our residents in Borrego Springs.”

The Borrego Springs Microgrid offers a powerful example of what new smart grid technology can do. When this experimental project was used during an actual power emergency, it gave SDG&E and its customers a glimpse of a possible “utility of the future” – one in which the grid itself can respond to outages by routing and restoring power where it is most needed, bringing vitally needed energy to residents and quite possibly saving lives in the process.

Devin Brookhart

From: Bill Powers <bpowers@powersengineering.com>
Sent: Friday, March 07, 2014 7:42 PM
To: lisa.orsaba@cpuc.ca.gov; wmetz@fs.fed.us; CNFMSUP
Subject: large footnote reference #1 A.12-10-009: SDG&E's Master Special Use Permit - POC Supplemental Scoping Comments
Attachments: Footnote_RPOD.pdf

SAN DIEGO GAS & ELECTRIC COMPANY

MASTER SPECIAL USE PERMIT
CLEVELAND NATIONAL FOREST
ORANGE AND SAN DIEGO COUNTIES, CALIFORNIA
REVISED PLAN OF DEVELOPMENT

APRIL 2013

PREPARED BY:

INSIGNIA ENVIRONMENTAL

PREPARED FOR:

SDGE

A Sempra Energy utility℠

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1 – INTRODUCTION AND OVERVIEW OF PROPOSED ACTION

In September 2012, San Diego Gas & Electric Company (SDG&E) submitted a Preliminary Plan of Development (POD) to the United States (U.S.) Forest Service (USFS), along with a Standard Form (SF) 299 Application for Transportation and Utility Systems and Facilities on Federal Lands, to combine over 70 existing use permits and easements for 69 kilovolt (kV) power line and 12 kV distribution line (collectively, electric line) facilities and appurtenant facilities within the Cleveland National Forest (CNF) into one Master Special Use Permit (MSUP) to be issued by the USFS.

The purpose of the Preliminary POD was to provide additional detail and an assessment of the potential environmental impacts associated with the activities SDG&E proposes to undertake in connection with the SF 299 Application. After reviewing the Preliminary POD, the USFS and California Public Utilities Commission (CPUC) provided comments and requested additional information about SDG&E's proposal. In anticipation of public scoping, SDG&E has prepared this Revised POD to include responses to USFS and CPUC comments and data requests. The Revised POD is based on preliminary design and information available as of April 2013. Additional information regarding project design and environmental impacts is anticipated to be developed during the environmental review process and final project engineering.

In 2005, in consultation with the USFS, SDG&E submitted an initial application to obtain an MSUP. The purpose of the MSUP was to consolidate and memorialize SDG&E's rights and responsibilities in connection with the continued operation of its electric lines and other existing facilities located within the CNF. In 2009, the USFS circulated for public comment an Environmental Assessment (EA) prepared pursuant to the USFS' National Environmental Policy Act (NEPA) review process. In response to public comments received on that EA, the USFS determined that additional fire risk reduction measures within the CNF (including fire hardening) and additional undergrounding should be evaluated as part of the MSUP review process and that, as a result, an environmental impact statement (EIS) was required. SDG&E has been working with the USFS since that time to expand the scope of the proposed MSUP, as requested by the USFS, to include specific fire risk reduction measures. In addition, SDG&E has been analyzing the potential environmental effects of the proposed fire hardening activities and refining the scope where possible to avoid and minimize potential impacts. This Revised POD and the SF 299 Application provide an updated description and environmental analysis of the Proposed Action as it has evolved since 2005.

To incorporate the fire risk reduction measures recommended for inclusion, SDG&E has expanded the scope of the Proposed Action previously evaluated in the 2009 EA to include additional proposed activities beyond the administrative adoption of a consolidated MSUP. In addition to combining the previously issued use permits and easements for existing SDG&E facilities within the CNF into one MSUP, the Proposed Action as described in this Revised POD and SF 299 Application includes fire hardening along 11 existing 69 kV power lines and 12 kV distribution lines as well as the relocation and undergrounding of certain electric lines within the CNF. More specifically, the Proposed Action has been expanded to include:

- Consolidation of over 70 previously-issued special use permits and easements on lands within the administrative boundary[1] of the CNF into one MSUP to allow the continued maintenance and operation of SDG&E's existing 69 kV power lines and 12 kV distribution lines as listed in Attachment A: Facilities Included Under the MSUP and ancillary or appurtenant facilities (as described in Section 4.1.2 Installation of Other Facilities), as well as approximately 45 miles of existing access roads required to operate and maintain the existing electric lines located within the administrative boundary of the CNF

- Adoption of a Master Special Use Permit Operating Plan for SDG&E's existing facilities within the CNF

- Wood-to-steel conversion of approximately 50 miles of existing 69 kV power lines and 12 kV distribution lines, including the replacement of approximately 1,025 existing wood utility poles with steel poles for five existing 69 kV power lines and six existing 12 kV distribution lines on lands within the administrative boundary of the CNF

- Undergrounding of approximately nine miles of existing electric lines and removal of the corresponding existing wood utility poles on lands within the administrative boundary of the CNF

Figure 1: Facilities Included Under the MSUP shows the locations of the SDG&E facilities within the CNF that may be included in the MSUP. and Figure 2: Facilities to Be Reconstructed shows the location of the Proposed Action; Attachment B: Detailed Route Maps includes detailed information for each electric line. The draft MSUP Operating Plan is included as Attachment C: MSUP Operating Plan.

The electric lines proposed to be replaced as part of the Proposed Action extend outside of CNF-administered lands into private and tribal lands, as well as other state- and federally administered lands. To facilitate environmental review and approval of associated activities along these portions of the electric lines by the appropriate agencies with jurisdiction in these areas, these activities are analyzed in this Revised POD as Connected Actions and Similar Actions as defined in NEPA. NEPA defines Connected Actions as actions that are closely related and therefore

[1] The administrative boundary of the CNF includes only those lands under the jurisdiction of the USFS, and not the private lands adjacent to the CNF that are included within the Congressional boundary of the CNF.

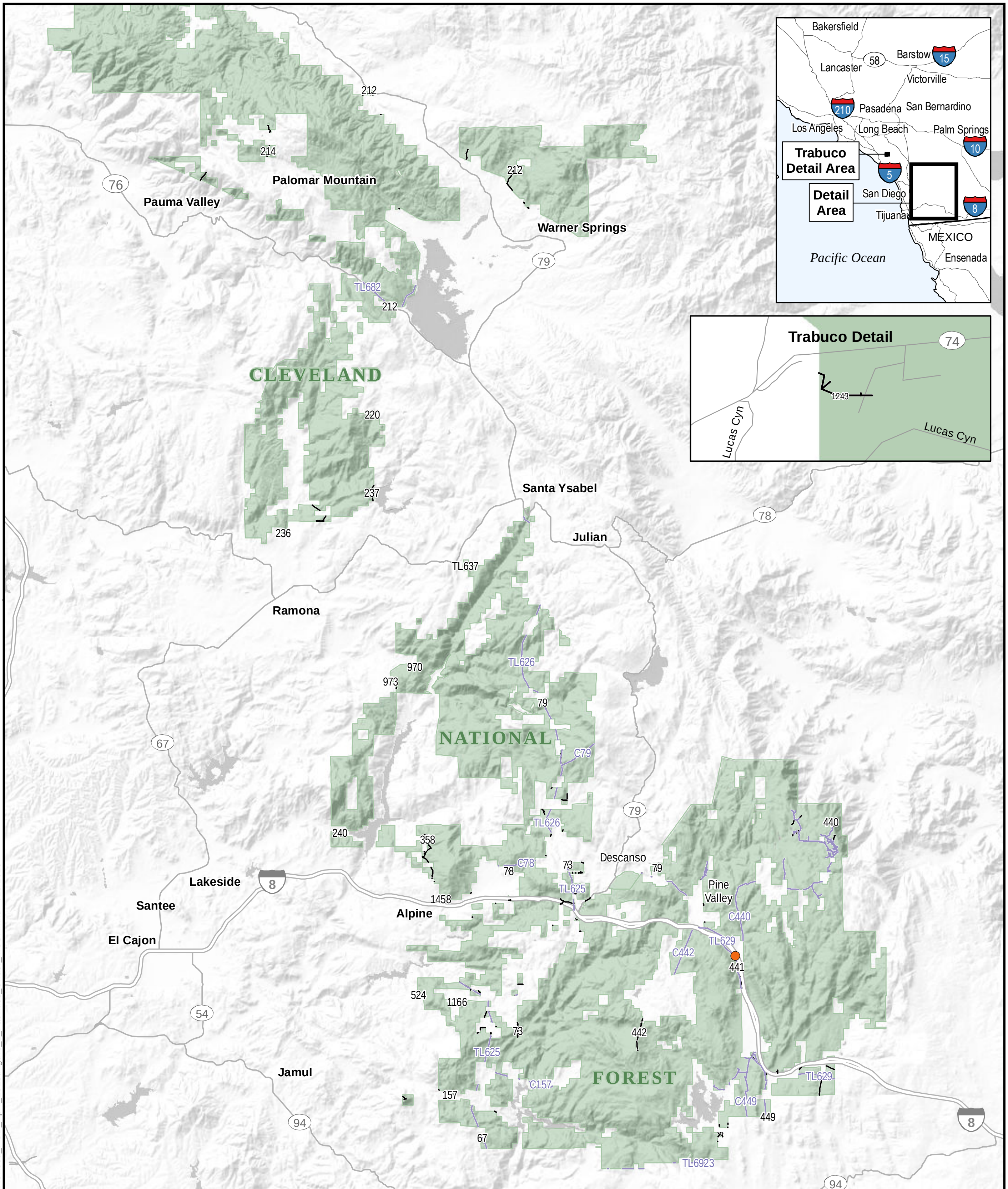

Figure 1: Facilities Included Under the MSUP

CNF Revised Plan of Development

- Facilities to be Reconstructed
- Other Facilities Included in the MSUP
- Substation
- United States Forest Service
- Interstate
- State Highway
- Lake/Reservoir

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1 inch = 6 miles

0 2 4 6 Miles

N

Z:\Projects\SDGE_CNF_ESRP\MXDs\POD\Revised_POD_April_2013\Figure_1_Facilities_Under_MSUP.mxd 4/19/2013

Source: SDG&E, 2013; USFS, 2012

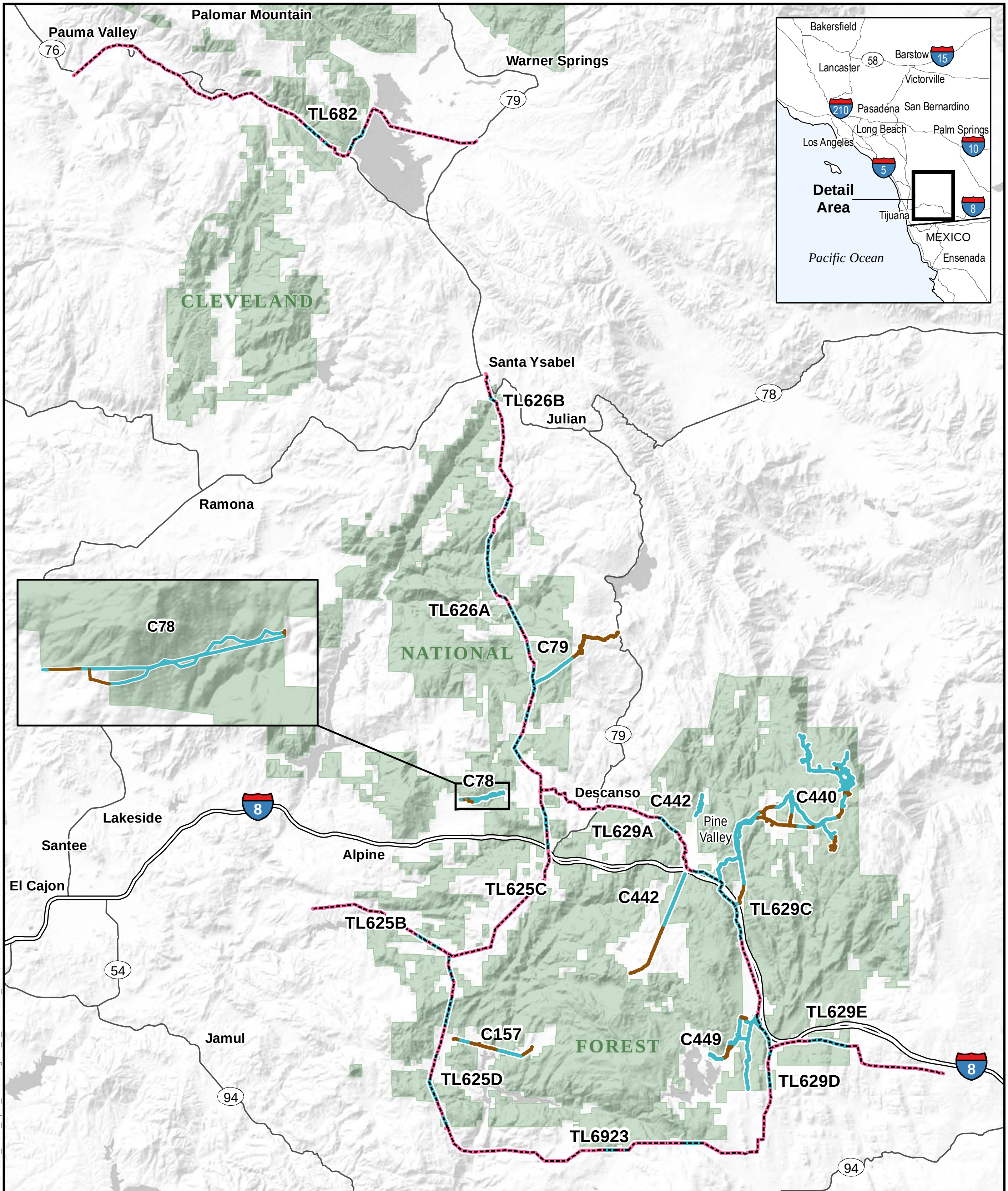

Figure 2: Facilities to be Reconstructed — **CNF Revised Plan of Development**

- Proposed Action
- Connected Actions
- Similar Actions
- *69 kV Power Line Shown with Dashed Line*
- United States Forest Service
- Interstate
- State Highway
- Lake/Reservoir

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1 inch = 6 miles

0 2 4 6 Miles

Source: SDG&E, 2012; USFS, 2012; CPAD 1.7 GreenInfo Network, 2011

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should be discussed in the same impact statement. NEPA further provides that actions are connected if they:

- automatically trigger other actions which may require an EIS
- cannot or will not proceed unless other actions are taken previously or simultaneously
- are interdependent parts of a larger action and depend on the larger action for their justification

Each of the 69 kV power line fire hardening projects are subject to review by the California Public Utilities Commission (CPUC) irrespective of whether the activity is taking place within or outside of the CNF. Relative to the Proposed Action, the 69 kV power line fire hardening projects outside the USFS-administrative boundary of the CNF are considered Connected Actions. These include replacement of approximately 1,011 existing wood utility poles with steel poles along the five existing 69 kV power lines at locations outside the administrative boundary of the CNF and the maintenance of approximately 0.9 mile of existing access roads required to operate and maintain the existing 69 kV power lines located outside of the CNF. Figure 2: Facilities to Be Reconstructed shows the location of Connected Actions.

NEPA defines Similar Actions as "actions, which when viewed with other reasonably foreseeable or proposed agency actions, have similarities that provide a basis for evaluating their environmental consequences together, such as common timing or geography." Because the USFS may wish to analyze the 12 kV distribution line activities outside of the CNF due to their geographic proximity, those activities are included in this Revised POD as Similar Actions.

The Similar Actions include replacement of approximately 238 existing wood utility poles with steel poles along the six existing 12 kV distribution lines at locations outside the administrative boundary of the CNF, the undergrounding of approximately four miles of existing 12 kV distribution lines and removal of corresponding existing wood utility poles, and the maintenance of approximately 0.7 mile of existing access roads required to operate and maintain the existing distribution lines located outside of the CNF. Figure 2: Facilities to Be Reconstructed shows the location of Similar Actions.

Notably, all of the power lines, distribution lines, and associated access roads included in the Proposed Action, as Connected Actions, and as Similar Actions are existing facilities that have been operated and maintained for decades. SDG&E currently operates and maintains these facilities consistent with SDG&E's standard protocols and procedures, including SDG&E's Natural Community Conservation Plan (NCCP). All aspects (construction, operation, and maintenance) of the Proposed Action, Connected Actions, and Similar Actions would comply with SDG&E's standard protocols and procedures, including the NCCP. The Proposed Action would not increase system capacity or open new areas to development, and there would be no growth-inducing impacts to the surrounding area as a result of the Proposed Action. SDG&E's operations and maintenance protocols and procedures have been incorporated into the design of the Proposed Action and compose the baseline from which environmental effects have been assessed.

During the MSUP review and approval process, SDG&E must continue to operate and maintain its existing facilities to ensure continued electric service and reliability. Operation and maintenance activities that would continue to occur during the pendency of the MSUP review and approval process may range from routine inspections and preventive maintenance to potential emergency repair or replacement work. Work conducted by SDG&E during the pendency of the MSUP review would comply with SDG&E's standard operation and maintenance practices and protocols, and would be subject to any required approvals or authorizations. Consistent with SDG&E's existing practice, SDG&E would continue to coordinate with and notify the USFS of work activities within the CNF.

This Revised POD includes the following sections:

- Purpose and Need
- Route Description
- Project Components
- Alternatives
- Right-of-Way
- Construction Activities
- Operation and Maintenance Activities
- Required Permits and Authorizations
- Preliminary Environmental Resource Evaluation

These sections describe the purpose of the Proposed Action, its physical setting, specific construction details and route locations for work being performed, potential alternatives considered by SDG&E in addition to the Proposed Action, and a preliminary evaluation of potential impacts to the environment that may result from construction as well as operation and maintenance of the power lines and distribution lines. Because the power lines, distribution lines, access roads, and other ancillary or appurtenant facilities (as described in Section 4.1.2 Installation of Other Facilities) included in the Proposed Action are existing facilities or would be within existing rights-of-way (ROWs), and because the Proposed Action would not increase system capacity or open new areas to development, there would be no growth-inducing impacts to the surrounding area as a result of the Proposed Action.

2 – PURPOSE AND NEED

The previously circulated EA contained the following Purpose and Need for the Proposed Action:

> *The purpose of this proposal is to authorize the powerlines and associated facilities needed to continue electric service to a variety of users within and adjacent to the Cleveland National Forest through a Master Special Use Permit. This action is needed because the 70 individual permits or easements for the existing facilities have expired, and a permit is required for the continued occupancy and use of National Forest System lands. This action responds to the goals and objectives outlined in the Cleveland Forest Plan, and helps move the project area towards desired conditions described in that plan.*

This fundamental purpose of the Proposed Action remains unchanged. The Proposed Action is needed because the approximately 70 individual permits and easements for the existing facilities have lapsed, and a master permit would enable SDG&E to continue to operate and maintain its facilities within the CNF subject to uniform use restrictions and conditions. SDG&E took into consideration all applicable federal, state, and local policies and plans, including the USFS CNF Land Management Plan (LMP) and its goals, objectives, strategies, and standards when developing the Proposed Action and evaluating its potential impacts in this Revised POD. The Proposed Action has been designed consistent with the goals and objectives outlined in the LMP. These goals, objectives, strategies, and standards include the following:

- *Goal 7.1 – Retain natural areas as a core for a regional network while focusing the built environment into the minimum land area needed to support growing public needs.* (LMP Part 1)

    - Facilities supporting urban infrastructure needs are clustered on existing sites or designated corridors, minimizing the number of acres encumbered by special-use authorizations. Special-uses serve public needs, provide public benefits, and conform to resource management and protection objectives. All uses are in full compliance with the terms and conditions of the authorization. There is a low level of increase in the developed portion of the landscape as measured by road densities; in fact, over time, the built environment is shifted away from or designed to better protect resource values.

- *Lands 2 – Non-Recreational Special Use Authorizations* (LMP Part 2)

    - Administer existing special-use authorizations in threatened, endangered, proposed and candidate species habitats to ensure they avoid or minimize impacts to threatened, endangered, proposed and candidate species and their habitats, cultural and scenic resources, and open space values.

    - Efficiently administer special-use authorizations (SUAs) on National Forest System lands.

    - Work with special-use authorization holders to better administer National Forest System land and to reduce administrative cost.

    - Require special-use authorizations to maximize opportunities to co-locate facilities and minimize the encumbrance on National Forest System land.

    - For special-use authorization holders operating within threatened, endangered, proposed and candidate species key and occupied habitats develop and provide information and education on the ways to avoid and minimize effects on their activities on occupied threatened, endangered, proposed and candidate species habitat.

    - Use signing, barriers, or other suitable measures to protect threatened, endangered, proposed and candidate species in key and occupied habitats within the special-use authorization areas.

- *Plan Standards* (LMP Part 3)
  - S42: Include provisions for raptor safety when issuing permits for new power lines and communication sites (see guidelines in [Forest Plan] Appendix G). Also implement these guidelines for existing permits within five years in other high-use raptor flyways. Coordinate with California Department of Fish and Game, U.S. Fish & Wildlife Service, and power agencies to identify high-use flyways.

Additional LMP goals, objectives, strategies, and standards identified as applicable to the Proposed Action, and the Proposed Action's consistency with those goals, objectives, strategies and standards, are described in greater detail in Attachment D: LMP Policy Consistency Analysis.

As previously described, the Proposed Action has been revised subsequent to the publication of the EA to include fire hardening activities along five existing 69 kV power lines and six existing 12 kV distribution lines, as well as the relocation and undergrounding of certain 12 kV distribution lines. These activities have been added to the Proposed Action as a result of public comments received during the EA review process as well as to continue implementing SDG&E's long-term fire hardening efforts. By incorporating these fire hardening activities, the Proposed Action would increase the fire safety and service reliability of the existing electric lines within and around the CNF. As described in Section 4 – Project Components, several key actions—including wood-to-steel pole conversion, single- to double-circuit conversion for two of the five Proposed Action 69 kV power lines, removal of portions of two 12 kV distribution lines, and undergrounding of portions of three 12 kV distribution lines and one 69 kV power line—are being proposed to improve their fire safety and service reliability. The Proposed Action would enable SDG&E to physically increase fire safety and service reliability of SDG&E 69 kV power lines and 12 kV distribution lines and facilities in and around the CNF, which includes areas that are subject to severe weather conditions—including extreme temperatures, high winds and ice—consistent with CPUC General Orders, North American Electric Reliability Corporation/Federal Energy Regulatory Commission (NERC/FERC) requirements, and SDG&E standards. Specifically, SDG&E is required to implement the Proposed Action to meet reliability requirements in accordance with CPUC General Order 95, which requires corrective actions for variable (non-immediate high to low) safety and/or reliability risks (e.g., High Risk Fire Areas). The Proposed Action is also required to meet California Independent System Operator (CAISO) Tariff provisions, which require operation and maintenance of facilities to avoid materially adverse impacts on the CAISO-Controlled Grid. NERC Reliability Standards for the Bulk Electric Systems of North America and FERC Standards of Conduct for Transmission Providers (Order No. 717), which define reliability requirements for planning and operating electric systems in North America to ensure electric systems operate reliably, are also applicable to the Proposed Action. These standards would also be adhered to consistent with SDG&E's Written Procedures and Compliance Plan and all associated compliance controls and procedures. In addition, the Proposed Action would avoid and minimize potential environmental effects by maximizing use of existing SDG&E electric line alignments and access roads and by following SDG&E's robust program of environmental compliance practices and protocols. Specifically, the Proposed Action involves the replacement of existing facilities within existing 69 kV power line and 12 kV distribution facility corridors. As described in Section 10 – Preliminary

Environmental Resource Evaluation, SDG&E has re-evaluated the potential environmental impacts that may result from the Proposed Action to support further NEPA review by the USFS. SDG&E has designed the Proposed Action to minimize electric line relocations—and the potential environmental impacts and safety risks that may arise from such relocations—by maximizing the use of existing roads and facility corridors. Wood-to-steel pole conversion would generally occur in close proximity to existing poles, and fly yards, staging areas, stringing sites, and other work areas would be placed, where possible, in previously disturbed areas to minimize impacts. SDG&E has also designed the Proposed Action to utilize existing access roads, where possible, improving them only as needed to perform safe and effective construction and operation and maintenance activities on the electric lines.

3 – ROUTE DESCRIPTION

The Proposed Action involves the replacement and operation and maintenance of SDG&E's electric lines and other facilities located within the USFS-administrative boundary for the CNF in the central portion of San Diego County, California. The Connected Actions and Similar Actions are located outside the USFS-administrative boundary for the CNF. The Proposed Action boundaries are approximately 4.5 miles north of the U.S.-Mexico border, 14.5 miles west of the Imperial County border, 8.5 miles south of the Riverside County border, and 14.5 miles east of the City of San Diego. Figure 2: Facilities to Be Reconstructed displays the location of the Proposed Action, Connected Actions, and Similar Actions.

The Proposed Action includes activities planned for portions of five 69 kV power lines and six 12 kV distribution lines that traverse the CNF. The 69 kV power lines and 12 kV distribution lines included as part of the Proposed Action are divided into the following components:

- 69 kV Power Line (TL) 625 – approximately 22.5 miles in total length, with approximately 6.5 miles located within the CNF boundary and approximately 16 miles located outside the CNF boundary; runs from Loveland Substation east to Barrett Tap, from Barrett Tap east to Descanso Substation, and from Barrett Tap south to Barrett Substation.

- TL626 – approximately 18.8 miles in total length, with approximately 8.2 miles located within the CNF boundary and approximately 10.6 miles located outside the CNF boundary; runs from Santa Ysabel Substation south to Descanso Substation.

- TL629 – approximately 29.8 miles in total length, with approximately 9.6 miles located within the CNF boundary and approximately 20.2 miles located outside the CNF boundary; runs from Descanso Substation east to Glencliff Substation, from Glencliff Substation southeast to Cameron Tap, from Cameron Tap south to Cameron Substation, and from Cameron Tap east to Crestwood Substation.

- TL682 – approximately 20.2 miles in total length, with approximately 2.5 miles located within the CNF boundary and approximately 17.7 miles located outside the CNF boundary; runs from Rincon Substation east to Warners Substation.

- TL6923 – approximately 13.4 miles in total length, with approximately 1.7 miles located within the CNF boundary and approximately 11.7 miles located outside the CNF boundary; runs from Barrett Substation east to Cameron Substation.
- 12 kV Distribution Line or Circuit (C) 78 – approximately 1.8 miles in total length, with approximately 1.5 miles located within the CNF boundary and approximately 0.3 mile located outside the CNF boundary; runs from east of Viejas Reservation, east along Viejas Grade Road, to Via Arturo Road.
- C79 – approximately 2.2 miles in total length, with approximately 1.8 miles located within the CNF boundary and approximately 0.4 mile located outside the CNF boundary; runs from Boulder Creek Road east to the Cuyamaca Peak communication site.
- C157 – approximately 3.5 miles in total length, with approximately 1.8 miles located within the CNF boundary and approximately 1.7 miles located outside the CNF boundary; runs from Skye Valley Road, near Lyons Valley Road, east to Skye Valley Ranch.
- C440 – approximately 24.0 miles in total length, with approximately 17.7 miles located within the CNF boundary and approximately 6.3 miles located outside the CNF boundary; runs from Glencliff Substation northeast to Mount Laguna along Sunrise Highway.
- C442 – approximately 6.2 miles in total length, with approximately 3.7 miles located within the CNF boundary and approximately 2.5 miles located outside the CNF boundary; runs south from Pine Valley Road to Los Pinos Peak Forest Station and along Pine Creek Road south toward the community of Pine Valley.
- C449 – approximately 6.7 miles in total length, with approximately 5.8 miles located within the CNF boundary and approximately 0.9 mile located outside the CNF boundary; runs from Old Highway 80 south along Buckman Springs Road to Oak Drive and southwest along Morena Stokes Valley Road to Camp Morena.

All of these lines are located within existing ROWs. As previously noted, the Proposed Action includes only the portions of these lines that are within the administrative boundary of the CNF. Connected Actions and Similar Actions for 69 kV power lines and 12 kV distribution lines, respectively, are those actions taking place along these lines, and outside the administrative boundary of the CNF, that SDG&E would undertake alongside the Proposed Action to reduce environmental impacts, the overall project time to completion, and total cost. The locations of these components are described in more detail in the following subsections.

3.0 69 KV POWER LINES

The Proposed Action involves work along the following five existing 69 kV power lines. Proposed activities on these lines outside of the CNF are analyzed as Connected Actions.

3.0.0 TL625

TL625 is located near the unincorporated communities of Alpine and Descanso in central San Diego County. As shown in Attachment B: Detailed Route Maps, TL625 consists of the following three segments:

- The Loveland Substation to Barrett Tap segment (TL625B) travels east out of Loveland Substation, located on Sequan Truck Trail, for approximately 4.5 miles along Loveland Reservoir and Japatul Road before entering the CNF southeast of the intersection of Japatul Road and Abrams Ridge Road. The line then continues approximately 0.3 mile southeast before crossing Japatul Road, after which it continues 0.3 mile southeast before exiting the CNF. The line then travels for approximately 0.1 mile through private land, re-enters the CNF near Japatul Road for approximately 0.4 mile, then exits the CNF and travels for approximately 0.5 mile southeast through private land before reaching Barrett Tap on Japatul Road.

- The Barrett Tap to Descanso Substation segment (TL625C) travels northeast from the Barrett Tap for approximately 1.3 miles through private land, enters the CNF for approximately 0.1 mile, then heads northeast along Japatul Valley Road for approximately 5.1 miles through private land, and re-enters the CNF near Interstate (I-) 8. From I-8, the line continues for approximately 0.5 mile through the CNF, exits the CNF for approximately 0.3 mile, and re-enters the CNF near Wildwood Glen Lane. From Wildwood Glen Lane, the line traverses the CNF for approximately 1 mile, exits for approximately 0.1 mile, and re-enters the CNF for approximately 0.1 mile near Viejas Grade Road, then travels approximately 0.5 mile north through private land before reaching the Descanso Substation located south of Oak Grove Drive at Boulder Creek Road.

- The Barrett Tap to Barrett Substation segment (TL625D) travels south from Barrett Tap for approximately 0.1 mile and enters the CNF. The line then travels approximately 0.2 mile south through the CNF, crosses Carveacre Road, and continues south for approximately 0.1 mile before exiting the CNF. The line leaves the CNF for approximately 0.3 mile and then re-enters the CNF between Carveacre Road and Spirit Trail. After re-entering the CNF, the line travels for approximately 0.3 mile, exits the CNF for approximately 0.1 mile, then re-enters the CNF northeast of the intersection of Carveacre Road and Fog Ridge and continues southeast through the CNF for approximately 0.2 mile. The line then exits the CNF and travels approximately 0.7 mile southwest through private land before re-entering the CNF near Forest Route 16S03. The line then continues approximately 1.3 miles southwest from Forest Route 16S03, exits the CNF near Lyons Valley Road, continues for approximately 1.1 miles through private land, and re-enters the CNF near Lyons Valley Road for approximately 0.3 mile. The line then leaves the CNF for approximately 0.8 mile, re-enters the CNF west of the intersection of Skye Valley Road and Barrett Lake Road, and travels through the CNF for approximately 0.9 mile west of Barrett Lake. After crossing Forest Route 17S10 east of Barber Mountain, the line continues south for approximately 0.2 mile. The line then exits the CNF for approximately 0.5 mile, re-enters the CNF for approximately 0.5 mile near

Turmeric Way, and then leaves the CNF and travels for approximately 0.1 mile to reach Barrett Substation, located north of Manzanita Way and east of Deerhorn Valley Road.

Approximately 6.5 miles of TL625 are included in the Proposed Action. Outside of the CNF, TL625 crosses approximately 16 miles of private land, state lands, and Bureau of Land Management (BLM)-administered land. Land uses along the TL625 route include agriculture, recreation, residences, the Loveland Reservoir, and the Descanso Detention Facility.

3.0.1 TL626

TL626 is located between the communities of Santa Ysabel and Descanso in central San Diego County. TL626 runs from Santa Ysabel Substation to Descanso Substation, as shown in Attachment B: Detailed Route Maps. For the Proposed Action, TL626 has been subdivided into two segments: TL626A and TL626B.

- From Santa Ysabel Substation—located less than approximately 0.1 mile north of State Route (SR-) 78 and approximately 0.2 mile east of SR-79—TL626B travels south for approximately 0.9 mile before entering the CNF west of Inaja Memorial Park. The line then travels for approximately 0.4 mile southeast through the CNF, leaves the CNF for approximately 4.1 miles, and re-enters the CNF for approximately 0.5 mile near Eagle Peak Road. The line continues south from Eagle Peak Road for approximately 1.0 mile before tapping into Boulder Creek Substation, where section TL626B terminates.

- TL626A then begins, heading south from Boulder Creek Substation for approximately 0.1 mile before entering the CNF. TL626A then continues through the CNF for approximately 2.6 miles and crosses Cedar Creek, Kelly Creek, and Boulder Creek Road. The line then leaves the CNF for approximately 0.3 mile near McCoy Ranch Road, re-enters the CNF for approximately 0.2 mile, crosses McCoy Ranch Road, leaves the CNF for approximately 0.3 mile, and re-enters the CNF near King Creek. The line then continues approximately 1.1 miles southeast through the CNF, exits the CNF for approximately 0.6 mile near the intersection of Tule Springs Road and Boulder Creek Road, and re-enters the CNF west of Boulder Creek Road. From Boulder Creek Road, the line travels for approximately 0.5 mile, leaves the CNF for approximately 0.6 mile, and re-enters and travels through the CNF for approximately 1.2 miles. The line then leaves the CNF near Forest Route 14S09, travels for approximately 0.6 mile, and re-enters the CNF near the intersection of Boulder Creek Road and Sherilton Valley Road for approximately 0.5 mile. The line then leaves the CNF and travels for approximately 0.5 mile before re-entering near the intersection of Boulder Creek Road and Echo Hills Road. From Echo Hills Road, the line travels through the CNF for approximately 1.2 miles before exiting the CNF and traveling for approximately 1.6 mile south to Descanso Substation.

Approximately 8.2 miles of TL626 are included in the Proposed Action. Outside of the CNF, TL626 crosses approximately 10.6 miles of private land. Land uses along the TL626 route include agriculture, commercial, recreation, and residences.

3.0.2 TL629

TL629 is located near the communities of Descanso, Guatay, and Pine Valley in central San Diego County. As shown in Attachment B: Detailed Route Maps, TL629 consists of the following four sections:

- The Descanso Substation to Glencliff Substation segment (TL629A) travels east from Descanso Substation for approximately 5.6 miles through private land and Cuyamaca Rancho State Park land before it enters the CNF east of the unincorporated community of Guatay. The line travels 1.2 miles southeast through the CNF along Old Highway 80, exits the CNF for approximately 1.9 miles, then re-enters the CNF south of the unincorporated community of Pine Valley. From Pine Valley, the line travels east between Old Highway 80 and I-8 for approximately 3.4 miles before crossing I-8. From I-8, the line travels southeast for approximately 1.2 miles before reaching Glencliff Substation, located in the CNF between Old Highway 80 and I-8.

- The Glencliff Substation to Cameron Tap segment (TL629C) travels southeast through the CNF from Glencliff Substation along Old Highway 80 for approximately 1.5 miles and exits the CNF for approximately 3.1 miles. The line re-enters the CNF west of I-8 and travels an additional 1.6 miles through the CNF to Cameron Tap, located south of the intersection of Old Highway 80 and I-8 at Kitchen Creek Road.

- The Cameron Tap to Cameron Substation segment (TL629D) travels south from Cameron Tap for approximately 0.4 mile before exiting the CNF. The line leaves the CNF for approximately 0.5 mile and re-enters the CNF near Cameron Truck Trail. The line then continues approximately 0.8 mile south, crosses Cameron Truck Trail, and exits the CNF near the intersection of Cameron Truck Trail and Hyde Park Lane. From Hyde Park Lane, the line continues south for approximately 3.0 miles through private land and BLM-administered land before entering Cameron Substation, located on Buckman Springs Road.

- The Cameron Tap to Crestwood Substation segment (TL629E) travels east from Cameron Tap for approximately 1.5 miles before entering the CNF near the intersection of Cameron Truck Trail and Old Highway 80. The line travels east through the CNF along I-8 for approximately 1.7 miles, crossing La Posta Road. From La Posta Road, the line exits the CNF for approximately 4.4 miles and travels through private land, BLM-administered land, and the Campo Indian Reservation before entering Crestwood Substation, located southwest of the Golden Acorn Casino and I-8.

Approximately 9.6 miles of TL629 crosses USFS-administered land. Outside of the CNF, TL629 crosses approximately 20.2 miles of Cuyamaca Rancho State Park land, tribal land, and private land. Land uses along the TL629 route include agriculture, commercial, recreation, residences, and the Campo Indian Reservation.

3.0.3 TL682

TL682 is located near the communities of Pauma Valley and Warner Springs in central San Diego County. TL682 runs from Rincon Substation to Warners Substation, as shown in Attachment B: Detailed Route Maps. From Rincon Substation, located southwest of Valley

Center Road and south of SR-76, the line travels generally southeast along SR-76 for approximately 11 miles through private land and tribal land before entering the CNF west of Lake Henshaw. The line continues southeast along SR-76 through the CNF for approximately 0.9 mile, leaves the CNF for approximately 0.1 mile, re-enters the CNF for approximately 0.3 mile, then exits the CNF for approximately 0.4 mile. The line then crosses SR-76 and re-enters the CNF for approximately 0.1 mile, then exits the CNF for approximately 0.7 mile. The line re-enters the CNF near the intersection of East Grade Road and County Highway S7 and continues northeast along the western coast of Lake Henshaw for approximately 0.5 mile. The line then leaves the CNF for approximately 0.1 mile, re-enters the CNF and travels northeast for approximately 0.1 mile, before crossing Henshaw Truck Trail. From Henshaw Truck Trail, the line continues northeast for approximately 0.7 mile and then leaves the CNF. The line then follows the northern coast of Lake Henshaw and continues east for approximately 5.4 miles through private land before entering Warners Substation.

Approximately 2.5 miles of TL682 crosses USFS-administered land. Outside of the CNF, TL682 crosses approximately 17.7 miles of tribal land and private land. Land uses along the TL682 route include agriculture, recreation, residences, and the La Jolla Indian Reservation.

3.0.4 TL6923

TL6923 is located near the communities of Potrero and Campo in central San Diego County. TL6923 runs from Barrett Substation to Cameron Substation, as shown in Attachment B: Detailed Route Maps. From Barrett Substation, the line travels east for approximately 6.3 miles south of Barrett Lake, through private land and BLM-administered land. The line then travels approximately 1.5 miles along the boundary between the CNF and BLM-administered land, through private land for approximately 0.2 mile, then along the CNF boundary for another 0.2 mile, crossing Potrero Creek. The line then travels northeast for approximately 0.4 mile through private land, then traverses the CNF boundary for approximately 2.8 miles and crosses Hauser Creek before traveling approximately 2.1 miles to Cameron Substation.

Approximately 1.7 miles of TL6923 crosses USFS-administered land. Outside of the CNF, TL6923 crosses approximately 11.7 miles of private land. Land uses along the TL6923 route include agriculture, recreation, and residences.

3.1 12 KV DISTRIBUTION LINES

The Proposed Action involves work along the following six 12 kV distribution lines. Proposed activities on these lines outside of the CNF are analyzed as Similar Actions.

3.1.0 C78

C78 runs from approximately 400 feet east of the eastern border of the Viejas Reservation east along Viejas Grade Road to Via Arturo Road, as shown in Attachment B: Detailed Route Maps. C78 begins just east of the eastern border of the Viejas Reservation. From here, the line travels east for approximately 0.3 mile along the CNF boundary, enters the CNF and travels northeast approximately 1.5 miles along Viejas Grade Road, and then exits the CNF. The line then travels north for approximately 0.1 mile and terminates near the intersection of Via Arturo Road and Viejas Grade Road.

Approximately 1.5 miles of C78 crosses USFS-administered land. Outside of the CNF, C78 crosses approximately 0.3 mile of private land. Land uses along the C78 route include agriculture, recreation, and residences.

3.1.1 C79

C79 runs from Boulder Creek Road toward the Cuyamaca Peak Forest Station, as shown in Attachment B: Detailed Route Maps. From just southeast of Boulder Creek Road, the existing line travels for 0.1 mile, crosses Boulder Creek Road, and continues northeast for approximately 1.7 miles before exiting the CNF. After leaving the CNF, the line then continues for approximately 0.4 mile northeast through the Cuyamaca Rancho State Park to the Cuyamaca Peak Forest Station.

Approximately 1.8 miles of C79 crosses USFS-administered land. Outside of the CNF, C79 crosses approximately 0.4 mile within the Cuyamaca Rancho State Park. Land uses along the C79 route include recreation and the Cuyamaca Peak communication site.

3.1.2 C157

C157 runs from Skye Valley Road, just east of Lyons Valley Road, toward Skye Valley Ranch, as shown in Attachment B: Detailed Route Maps. The line travels northeast from Skye Valley Road for approximately 0.2 mile before entering the CNF. The line then travels for approximately 0.6 mile southeast through the CNF along Skye Valley Road. The line then exits the CNF and continues southeast for approximately 0.5 mile through private land before crossing Skye Valley Road. From Skye Valley Road, the line crosses private land for approximately 0.6 mile and enters the Pine Creek Wilderness Area just east of Barrett Lake. From Barrett Lake, the line crosses Skye Valley Road and travels for approximately 0.1 mile southeast through the Pine Creek Wilderness Area, continues approximately 0.1 mile southeast through the CNF, then enters the Hauser Wilderness Area. The line continues southeast through the Hauser Wilderness Area for approximately 0.5 mile, continues southeast approximately 0.4 mile through the CNF, then travels northeast for approximately 0.5 mile through private land to terminate at Skye Valley Ranch.

Approximately 1.8 miles of C157 crosses USFS-administered land. Outside of the CNF, C157 crosses approximately 1.7 miles of private land. Land uses along the C157 route include agriculture, recreation, and the Camp Barrett Juvenile Correctional Facility.

3.1.3 C440

C440 runs from Glencliff Substation to Mount Laguna, as shown in Attachment B: Detailed Route Maps. The line starts at Glencliff Substation within the CNF, travels for approximately 0.1 mile east across I-8, and leaves the CNF on the eastern side of I-8. The line then travels approximately 0.8 mile northeast through private land, re-enters the CNF, and travels for approximately 1.3 miles northwest until it crosses Sunrise Highway. From the Sunrise Highway crossing, the line continues north for approximately 1.3 miles, turns northeast for approximately 0.4 mile, crosses Sunrise Highway a second time, and continues east for approximately 0.2 mile before exiting the CNF. The line then turns southeast for approximately 1.4 miles through private land and branches off to the north. The northern branch continues through private land for approximately 0.4 mile, re-enters the CNF, continues approximately 0.8 mile north, and crosses

Sunrise Highway again. From the branching point, the line continues southeast for approximately 0.2 mile before re-entering the CNF. After the line re-enters the CNF, it continues for approximately 0.5 mile before crossing Kitchen Creek Road. From the Kitchen Creek Road crossing, the line continues southeast for approximately 0.2 mile, turns northeast for approximately 0.6 mile, and branches off to the south for approximately 1.4 miles, with short branches extending off this branch. The line continues northeast for approximately 0.1 mile, crosses Sunrise Highway a fourth time, then follows Sunrise Highway northeast for approximately 0.4 mile, crossing Wooded Hill Road before exiting the CNF. After exiting the CNF, the line continues to follow Sunrise Highway northeast for approximately 0.6 mile with smaller branches extending to the east and west. It then re-enters the CNF, travels north for approximately 0.5 mile, crossing Red Tail Roost Road and following the Sunrise Highway. The line then exits the CNF near Burnt Rancheria Campground. After traveling north through private land for approximately 0.3 mile with short branches extending off the line, it re-enters the CNF near Escondido Ravine Road. From Escondido Ravine Road, the line branches off to the northwest for approximately 0.2 mile, with additional branches extending off the line. From the branching point, the line crosses Sunrise Highway and continues to the northeast past Mount Laguna for approximately 0.5 mile. From Mount Laguna near the intersection of Sunrise Highway and Los Huecos Road, the line branches off to the northwest along Los Huecos Road for approximately 3.6 miles, with short branches extending farther off of this branch. The remainder of the line is located entirely within the CNF, with the exception of approximately 0.2 mile near the intersection of Boiling Spring Road and Los Huecos Road. The northwestern branch of the line passes on the eastern side of Little Laguna Lake, Big Laguna Lake, Laguna Campground, and El Prado Campground, and terminates near the intersection of Sunrise Highway and Oasis Road. From the branching point near Mount Laguna, the line continues to the northeast and follows Sunrise Highway for approximately 1.4 miles with short branches extending at intervals off the line. The line passes to the west of Pacific Crest Trail and terminates near Monument Peak Road.

Approximately 17.7 miles of C440 crosses USFS-administered land. Outside of the CNF, C440 crosses approximately 6.3 miles of private land. Land uses along the C440 route include agriculture, recreation, residences, and the Mount Laguna Observatory.

3.1.4 C442

C442 is located near the community of Pine Valley and runs from Pine Valley Road south toward Los Pinos Fire Lookout and along Pine Creek Road south toward Pine Valley, as shown in Attachment B: Detailed Route Maps. The southern segment travels southwest from Pine Valley Road, just south of I-8 and the unincorporated community of Pine Valley, for approximately 2.2 miles through the CNF, passing to the west of Long Valley Peak. The line then exits the CNF and travels southwest for approximately 2.5 miles before terminating near Los Pinos Mountain. The northern segment is located entirely within the CNF and travels south along Pine Creek Road for approximately 1.0 mile, traveling to the west of Noble Canyon National Recreation Trail and associated trailhead, with approximately 0.5 mile along three branches to the east.

Approximately 3.7 miles of C442 crosses USFS-administered land. Outside of the CNF, C442 crosses approximately 2.5 miles of private land. Land uses along the C442 route include recreation, residences, and the Los Pinos Peak Fire Lookout.

3.1.5 C449

C449 is located near the community of Cameron Corners. This portion of C449 runs from Old Highway 80 south along Buckman Springs Road to Oak Drive and southwest along Morena Stokes Valley Road to Camp Morena, as shown in Attachment B: Detailed Route Maps. The included portion of C449 begins within the CNF, approximately 0.3 mile west of Old Highway 80. From the beginning point, the line branches off to the northeast, southeast, and southwest. The northeastern branch continues for approximately 0.2 mile through the CNF and turns east for approximately 0.1 mile to cross Old Highway 80. The southeastern branch also continues through the CNF for approximately 0.4 mile. The southwestern branch travels through the CNF for approximately 0.1 mile and branches off to the northwest and southwest. The northwestern portion continues through the CNF for approximately 0.2 mile, crosses Pacific Crest Trail, and exits the CNF. After leaving the CNF, the line travels for approximately 0.3 mile and terminates at Buckman Springs Road near Tulloch Ranch.

The southwestern branch, which is the main segment of the line, continues southwest for approximately 0.7 mile. The line then branches off to the west through the CNF for approximately 0.4 mile, heading north for approximately 0.1 mile toward Cottonwood Fire Station, and heading southwest for approximately 0.3 mile and crossing Pacific Crest Trail and Buckman Springs Road. From Buckman Springs Road, the line continues southwest for approximately 0.1 mile before exiting the CNF. The line leaves the CNF for approximately 0.2 mile and travels through Lake Morena County Park, re-enters the CNF near Morena Stokes Valley Road, travels for approximately 0.1 mile southwest through the CNF, and leaves the CNF. The line continues approximately 0.4 mile southwest along Morena Stokes Valley Road through Lake Morena County Park until it re-enters the CNF. The line turns northwest for approximately 0.1 mile, then southwest for approximately 0.1 mile where it crosses Morena Stokes Valley Road, and proceeds northwest for approximately 0.3 mile before reaching the Camp Morena sub-installation of Naval Base Coronado.

The main line continues southwest through the CNF for approximately 0.4 mile, turns southeast for approximately 0.5 mile, then turns back southwest for approximately 0.1 mile before heading southwest for approximately 0.1 mile to cross Buckman Springs Road. From this crossing, the line travels south along Buckman Springs Road and to the east of Pacific Crest Trail for approximately 1.2 miles, crosses Oak Drive, and then proceeds south for approximately 0.1 mile until it terminates northeast of Morena Village and Lake Morena County Park.

Approximately 5.8 miles of C449 crosses USFS-administered land. Outside of the CNF, C449 crosses approximately 0.9 mile of San Diego County Department of Parks and Recreation land and private land. Land uses along the C449 route include recreation, residences, Boulder Oaks Elementary School, and the Camp Morena sub-installation of Naval Base Coronado.

4 – PROJECT COMPONENTS

The following subsections describe the Proposed Action activities in further detail; activities conducted for Connected Actions and Similar Actions are similar in nature and in scope to those described for the Proposed Action. Figure 3: Proposed Action Components Map, Figure 4: Connected Actions Components Map, and Figure 5: Similar Actions Components Map illustrate where these activities would occur. In addition, a description of the other facilities included under the MSUP is provided in Section 4.0 Facilities Included Under the MSUP.

4.0 FACILITIES INCLUDED UNDER THE MSUP

SDG&E has requested an MSUP, which would authorize the continued operation of 69 kV power lines and 12 kV distribution lines currently located within the CNF. These facilities include critical infrastructure necessary to maintain the safe and effective operation of SDG&E's existing electric facilities in the vicinity of the CNF. In addition to the 69 kV power lines and 12 kV distribution lines, approximately 0.03 acre of Glencliff Substation is also located within the CNF and may be included under the MSUP. The locations of these facilities are depicted in Figure 1: Facilities Included Under the MSUP.

Some of SDG&E's existing facilities were originally constructed in locations that subsequently fell within USFS administration. As a result, not all of the facilities currently located within the administrative boundary of the CNF will be included under the MSUP. SDG&E will work with the USFS to identify which specific facilities will be included under the MSUP and which will continue to be subject to SDG&E's previously existing rights.

4.1 WOOD-TO-STEEL CONVERSION

4.1.0 Pole Installation

Along each of the five 69 kV power lines and six 12 kV distribution lines, SDG&E would remove existing wood poles and replace them with reddish-brown, weathered-steel poles at an approximately one-to-one ratio. The steel poles would typically be placed in line with the existing conductors and within eight feet of the existing wood poles, except where sensitive resources were identified and avoided during preliminary design. As part of its design activities, SDG&E incorporated known data regarding cultural, biological, hydrological, and other sensitive resources in determining potential pole relocations. Where possible, SDG&E has identified replacement pole locations to avoid these areas.

SDG&E would use tangent poles when the pole alignment continues in a generally straight line, and angle poles when the run of poles changes direction.[2] As part of the Proposed Action, approximately 378 poles would be installed within the CNF—approximately 266 tangent poles and 112 angle poles—to support approximately 28.6 miles of 69 kV power lines with an average

[2] An angle pole is designed to take the additional lateral loading caused by a change in the conductors' centerline direction. Angle poles may also be used in areas of insulator uplift and near stringing sites to accommodate additional pole stress in these areas.

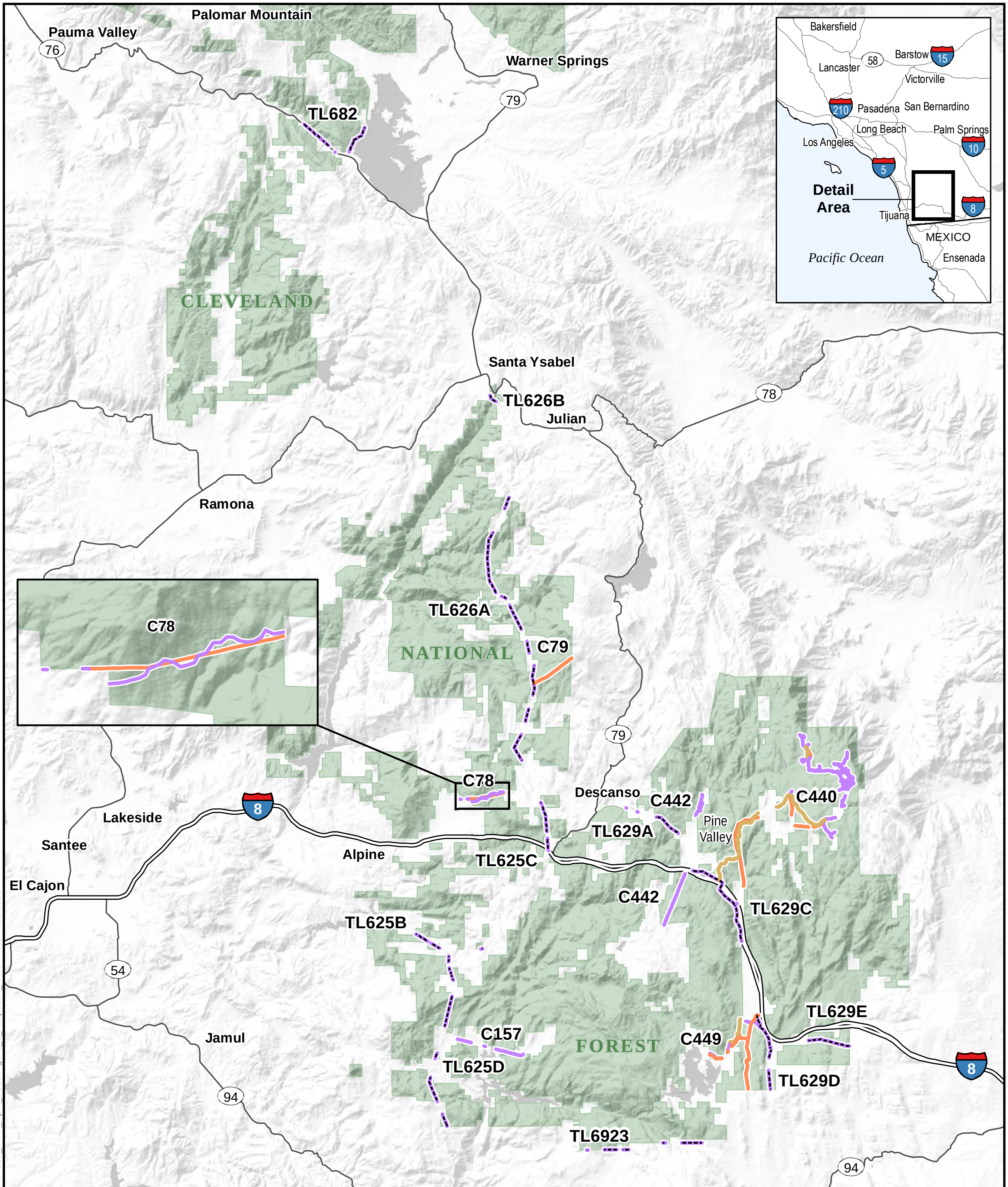

Figure 3: Proposed Action Components Map

CNF Revised Plan of Development

Removal
Undergrounding
Wood-to-Steel Replacement
69 kV Power Line Shown with Dashed Line

United States Forest Service

Interstate
State Highway
Lake/Reservoir

SDGE
A Sempra Energy utility
INSIGNIA ENVIRONMENTAL

1 inch = 6 miles
0 2 4 6 Miles

Source: SDG&E, 2012; USFS, 2012; CPAD 1.7 GreenInfo Network, 2011

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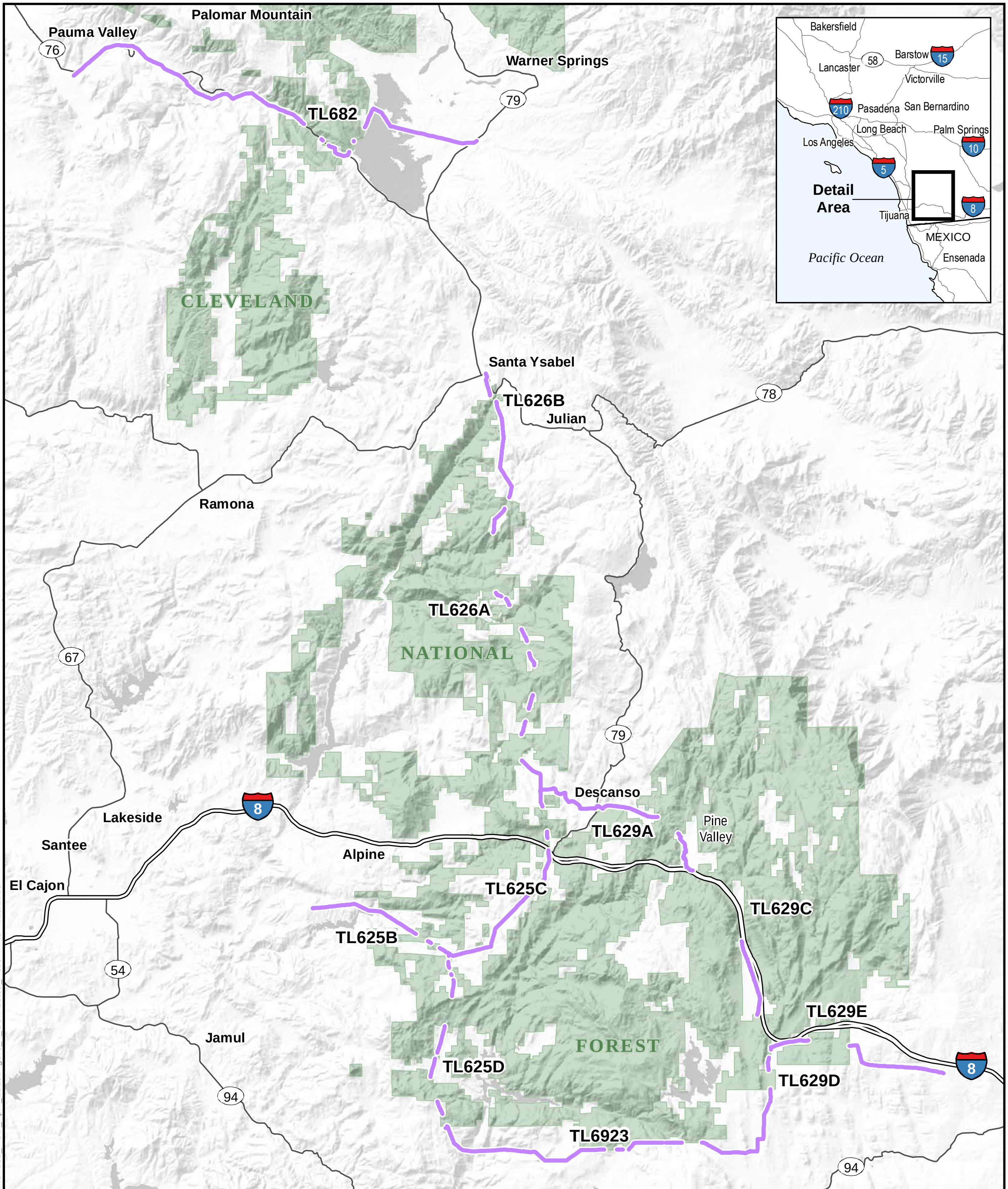

Figure 4: Connected Actions Components Map

CNF Revised Plan of Development

Wood-to-Steel Replacement
United States Forest Service
Interstate
State Highway
Lake/Reservoir

SDGE
A Sempra Energy utility
INSIGNIA ENVIRONMENTAL

1 inch = 6 miles
0 2 4 6 Miles

Source: SDG&E, 2012; USFS, 2012; CPAD 1.7 GreenInfo Network, 2011

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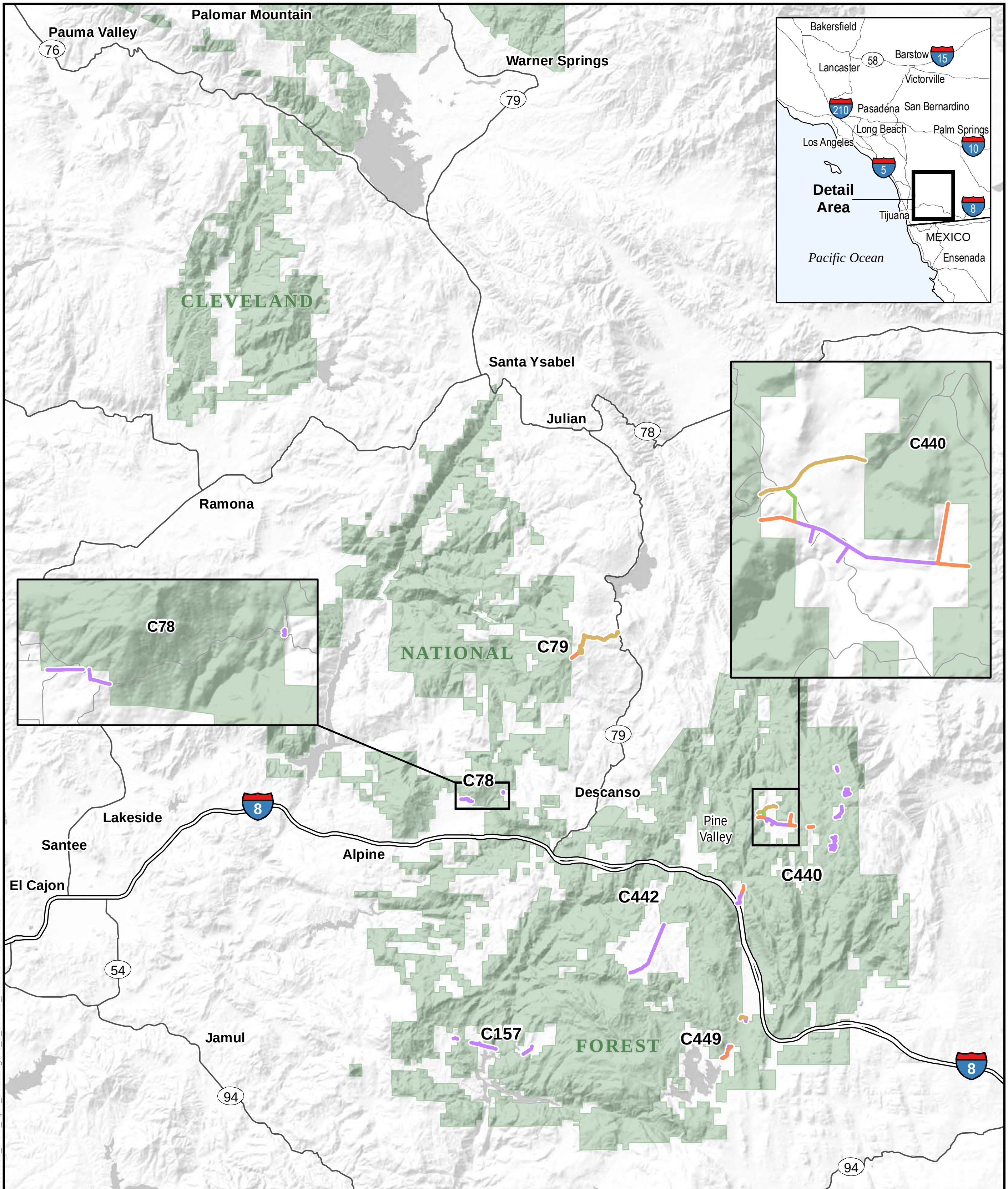

Figure 5: Similar Actions Components Map

CNF Revised Plan of Development

- New Steel
- Removal
- Undergrounding
- Wood-to-Steel Replacement
- United States Forest Service
- Interstate
- State Highway
- Lake/Reservoir

SDGE
A Sempra Energy utility
INSIGNIA ENVIRONMENTAL

1 inch = 6 miles

0 2 4 6 Miles

Source: SDG&E, 2012; USFS, 2012; CPAD 1.7 GreenInfo Network, 2011

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conductor span length of approximately 400 feet. Similarly, approximately 498 poles would be installed within the CNF—approximately 342 tangent poles, 151 angle poles, and five riser poles—to support approximately 20.6 miles of 12 kV distribution lines with an average span length of approximately 230 feet.

As part of Connected Actions, approximately 1,006 poles would be installed on lands outside the CNF—approximately 710 tangent poles and 296 angle poles—to support approximately 76 miles of 69 kV power lines, with an average conductor span length of approximately 400 feet. As part of Similar Actions, approximately 220 poles would be installed outside the CNF—approximately 146 tangent poles, 73 angle poles, and one riser pole—to support approximately 10.5 miles of 12 kV distribution lines, with an average span length of approximately 230 feet. Table 1: 69 kV Power Line Pole Summary and Table 2: 12 kV Distribution Line Pole Summary detail the quantity and approximate dimensions of replacement steel poles planned for each line. All pole locations and dimensions are based on preliminary engineering data and will not be finalized until engineering has been completed.

SDG&E would direct-bury replacement steel poles where possible or install foundation-supported steel poles on poured or micro-pile foundations, as local conditions require. Attachment E: Typical Drawings provides typical drawings of each type of pole and foundation that would be removed or installed. Tangent poles and angle poles have a maximum installed height of approximately 120 feet. SDG&E will design and install all new structures in compliance with the guidelines in the Suggested Practices for Avian Protection on Power Lines Manual developed by the Avian Power Line Interaction Committee (APLIC). A detailed discussion of pole installation methods is provided in Section 7.2 Methods.

4.1.1 Conductor Installation

Prior to stringing the new overhead 69 kV power lines and 12 kV distribution lines with replacement non-specular conductors, temporary guard structures—typically consisting of vertical wood poles with cross arms—would be installed at road crossings and crossings of energized electric and communication lines to prevent the conductors from sagging onto roadways or other lines during conductor installation.

In some cases, bucket trucks may also be used in place of these guard structures. As an alternative to using temporary guard structures, SDG&E may use flaggers to halt traffic for brief periods of time while the overhead conductor is installed at road crossings.

69 kV Power Lines

For the five 69 kV power lines, SDG&E would configure each steel pole to carry the following:

- Three 69 kV 636 kcmil (0.977-inch diameter) aluminum-clad steel-supported (ACSS) aluminum conductors.[3] For double-circuit segments, up to six 69 kV 636 kcmil ACSS conductors would be installed.

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[3] A circular mil is a unit equal to the area of a circle with a diameter of one mil (0.001 inch); this is used chiefly in specifying cross-sectional areas of round conductors. A kcmil is 1,000 circular mils.

Table 1: 69 kV Power Line Pole Summary

69 kV Power Line Pole Type	Approximate Quantity			Maximum Height (feet)	Maximum Base Diameter (feet)
	Within CNF	Outside CNF	Total		
TL625					
Tangent	49	109	158	120	3
Angle	23	86	109	120	5
Subtotal	*72*	*195*	*267*	--	--
TL626					
Tangent	98	123	221	100	3
Angle	22	36	58	100	5
Subtotal	*120*	*159*	*279*	--	--
TL629					
Tangent	86	248	334	110	3
Angle	51	57	108	110	5
Subtotal	*137*	*305*	*442*	--	--
TL682					
Tangent	24	151	175	110	3
Angle	6	78	84	110	5
Subtotal	*30*	*229*	*259*	--	--
TL6923					
Tangent	9	79	88	100	3
Angle	10	39	49	100	5
Subtotal	*19*	*118*	*137*	--	--
Total	**378**	**1,006**	**1,384**	**120**	**5**

Note: The information in this table is preliminary and subject to change based on CPUC requirements, final engineering, and other factors.

Table 2: 12 kV Distribution Line Pole Summary[4]

12 kV Distribution Pole Type	Approximate Quantity			Maximum Height (feet)	Maximum Base Diameter (feet)
	Within CNF	Outside CNF	Total		
C78					
Tangent	8	1	9	52	1.2
Angle	22	13	35	47.5	1.2
Subtotal	*30*	*14*	*44*	--	--
C79[5]					
Riser	0	0	0	--	--
Subtotal	*0*	*0*	*0*	--	--
C157					
Tangent	28	23	51	47.5	1.2
Angle	0	6	6	47.5	1.2
Subtotal	*28*	*29*	*57*	--	--
C440					
Tangent	219	72	291	61	1.6
Angle	100	45	145	62	1.6
Riser	4	0	4	50	1.1
Subtotal	*323*	*117*	*440*	--	--
C442					
Tangent	67	42	109	61	1.3
Angle	15	5	20	47.5	1.2
Subtotal	*82*	*47*	*129*	--	--
C449					
Tangent	20	8	28	52	1.2
Angle	14	4	18	38.5	1.1
Riser	1	1	2	43	1.1
Subtotal	*35*	*13*	*48*	--	--
Total	**498**	**220**	**718**	**62**	**1.6**

[4] The information in this table is preliminary and subject to change, based on CPUC requirements, final engineering, and other factors.
[5] Undergrounding on C79 would occur outside of the CNF boundary.

- Two to seven 12 kV 636 kcmil (0.997-inch diameter) aluminum-clad steel-reinforced (ACSR) aluminum conductors, 12 kV 336.4 kcmil (0.721-inch diameter) ACSR aluminum conductors, 12 kV No. 2 5/2 (0.330-inch diameter) Alumoweld aluminum conductors (AWAC), or 12 kV No. 2 3/4 (0.386-inch diameter) AWAC.

- One level of communication circuits (0.685-inch diameter).

TL629C, TL629D, and TL629E would also be designed to carry one optical ground wire (0.646-inch diameter). SDG&E would install three 69 kV conductors on one or both sides of the steel poles and would arrange the conductors in a vertical configuration with a minimum separation of 4.5 feet. Where 12 kV distribution underbuild is required, SDG&E would install two 12 kV conductors on each side of the 69 kV power line steel poles and arrange the conductors in a horizontal configuration with a minimum separation of four feet. SDG&E would install the lowest 69 kV conductor at least 30 feet above the ground (25 feet above the ground where there is pedestrian access only) and the lowest 12 kV conductor at least 25 feet above the ground (17 feet above the ground where there is pedestrian access only). For single-circuit tangent poles, the conductors would be attached using three post insulators installed on each pole. For double-circuit tangent poles, the conductors would be attached using six post insulators installed on each pole. For single-circuit angle poles, the conductors would be attached using six suspension and three post insulators installed on each pole. For double-circuit angle poles, the conductors would be attached using 12 suspension insulators installed on each pole.

The Proposed Action will not result in any increase in overall system capacity. “System capacity,” as used in this context, refers to the nominal operating voltages of the transmission facilities in question. In this case, the nominal operating voltage of the electric transmission facilities affected is 69 kV, and this will not change. What may change is the thermal load-carrying capability of affected transmission lines, as their conductors are replaced and/or reconfigured.

The Proposed Action includes the replacement of existing aluminum or copper conductors with aluminum-clad, steel-supported conductors in order to increase the safety of the lines, as well as improve efficiency and response times when repairs to the 69 kV power lines are required. The proposed conductors identified in this Revised POD were selected due to these conductors’ superior performance and strength. The larger, stronger conductor will be significantly more resistant to potential damage from extreme wind conditions, lightning strikes, and tree-line contact in comparison with the existing conductors. The proposed conductors will also reduce the potential for line breakages or other failures that could result during hazardous weather conditions. Because the proposed conductors are stronger and more resistant to damage, they are anticipated to have longer useable lifespans than the existing conductors, which would reduce maintenance requirements and further improve service reliability. In addition, the proposed conductor is one of the standard conductors in use by SDG&E. Because fewer types of conductors will be used systemwide, SDG&E will be able to stock sufficient quantities of the conductor, shortening repair times and lowering future operation and maintenance costs. Although the proposed conductors are physically capable of transmitting voltages higher than 69 kV, as discussed previously, the Proposed Action does not include or authorize any increase in voltage rating. Any such increases to system capacity would require changes to any associated substations and other infrastructure. Further, any proposed increases to system capacity would require additional CAISO and CPUC evaluation and approval beyond what has been requested in SDG&E's Permit to Construct application.

12 kV Distribution Lines

For the six 12 kV distribution lines, SDG&E would configure each steel pole to carry two to four 12 kV 636 kcmil (0.997-inch diameter) ACSR aluminum conductors, 12 kV 336.4 kcmil (0.721-inch diameter) ACSR aluminum conductors, 12 kV No. 2 5/2 (0.330-inch diameter) AWAC, or 12 kV No. 2 3/4 (0.386-inch diameter) AWAC. SDG&E would install one to two conductors on each side of the steel poles and arrange the conductors in a horizontal configuration. SDG&E would install the new conductors with a minimum horizontal separation of approximately four feet. SDG&E would install the lowest conductor at least 25 feet above the ground (17 feet above the ground where there is pedestrian access only). SDG&E would attach the conductors to the distribution poles using one polymer insulator per conductor installed on each steel pole. Attachment F: Electric and Magnetic Fields includes SDG&E's plan to address potential effects from exposure to electric and magnetic fields associated with the Proposed Action.

4.1.2 Installation of Other Facilities

In addition to the replacement steel poles and conductors, SDG&E may install all necessary and proper guys, anchorage, crossarms and braces and other fixtures for use in connection therewith, including but not limited to, ancillary facilities such as pole- or pad-mounted transformers and other equipment needed to effectively support and enable electric transmission and distribution across the system. Corollary to this equipment, SDG&E may also install appurtenant facilities as necessary or prudent to ensure the safe and reliable operation of SDG&E's system or as required by relevant statutes, orders, rules, and other technical policies and standards. For example, installation of appurtenant facilities—such as weather stations, fire safety and early fire detection equipment, smart-grid system data collection equipment, or other technologies or facilities—on the replacement steel poles within existing ROWs may be necessary or prudent to collect additional information needed to further increase fire safety and service reliability as new technologies become available.

4.2 SINGLE- TO DOUBLE-CIRCUIT CONVERSION

SDG&E proposes to convert some lines from a single- to double-circuit configuration in order to improve system reliability and reduce service interruptions in the event of accidents, natural disasters, or other events that could cause harm to or interrupt service. Doing so incorporates redundancy into the system and obviates the need for existing tap poles, which currently create added risk to the system in that if one tap pole is rendered out of service then multiple electric lines are potentially impacted. Additionally, double-circuiting portions of lines from substations enables SDG&E to divert loop flow, as needed, without creating additional risks to the system which could potentially cause conductor overload or system outages. Specifically, SDG&E would install replacement double-circuit steel poles similarly to that described in Section 4.1 Wood-to-Steel Conversion. SDG&E would string 636 kcmil ACSS aluminum conductors on post or suspension insulators; three conductors would be strung on one or both sides of the replacement poles. A summary of the 69 kV power line segments selected for single- to double-circuit conversion under the Proposed Action and as Connected Actions is included in Table 3: 69 kV Power Line Single- to Double-Circuit Conversion Summary.

Table 3: 69 kV Power Line Single- to Double-Circuit Conversion Summary

69 kV Power Line	Approximate Length (miles)		
	Within CNF	Outside CNF	Total
TL625B/TL6957	1.0	2.9	3.9
TL629E/TL6958	1.7	0.1	1.8
Total	**2.7**	**3.0**	**5.7**

No changes to the system capacity will result from the additional circuits; rather, the additional circuits will provide increased system reliability. "System capacity," as used in this context, refers to the nominal operating voltages of the transmission facilities in question. In this case, the nominal operating voltage of the electric transmission facilities affected is 69 kV, and this will not change. What may change is the thermal load-carrying capability of affected transmission lines, as their conductors are replaced and/or reconfigured.

As described in this Revised POD, the Proposed Action includes reconfiguring portions of two existing 69 kV power lines—TL625B and TL629E—from a single- to double-circuit configuration. TL625B would be reconfigured from a single three-terminal line connecting three substations (Loveland, Barrett, and Descanso substations) to two two-terminal lines connecting two substations each (Loveland and Barrett substations and Loveland and Descanso substations). This proposed reconfiguration was previously identified by SDG&E as a necessary measure to prevent potential overloading on another 69 kV power line—TL626, which connects Descanso and Santa Ysabel substations—from occurring. The proposed reconfiguration of TL625B was also evaluated and approved by the CAISO as a necessary measure to meet mandatory North American Electric Reliability Corporation reliability standards for SDG&E's electric transmission system. This change will not affect the system capacity of TL625B.

TL629E is also proposed to be reconfigured from a single three-terminal line connecting three substations (Descanso, Cameron, and Crestwood substations) to two two-terminal lines connecting two substations each (Descanso and Crestwood substations and Cameron and Crestwood substations). This proposed reconfiguration was identified by SDG&E during a review of the electric transmission system as being necessary to prevent an interruption of service to customers served from Crestwood Substation in the event TL629 is temporarily removed from service. This change will not affect the system capacity of TL629E.

These proposed reconfigurations do not in any way alter the potential system load nor allow for an increase in system capacity. From a technological perspective, the capacity of these power lines is limited to the voltage ratings of the substation facilities and other related equipment. To increase the system capacity, the installation of additional substation and associated equipment would be required. The Proposed Action does not include the installation of such equipment; therefore, the voltage rating and system capacity will remain the same. In addition, SDG&E would have to obtain CAISO approval and CPUC authority to increase the voltage ratings (i.e., the capacity of these lines). SDG&E is not requesting this authority from the CAISO or CPUC.

As noted previously, these proposed double-circuit reconfigurations are designed—and, in the case of TL625B, mandatory—to improve system reliability and maintain service to SDG&E's customers in eastern San Diego County in the event of temporary losses in service of other 69 kV power lines within SDG&E's electric transmission system. As described in this Revised POD, these single- to double-circuit configurations would eliminate existing tap poles that currently create added risk to the reliability of the system. Eliminating these poles and providing redundancy in the system will provide SDG&E with the ability to reroute electricity and maintain service, not increase system capacity.

The following subsections describe the segments of 69 kV power lines that SDG&E would convert from single- to double-circuit configuration.

4.2.0 TL625B

As part of the Proposed Action, SDG&E would reconfigure and reconductor approximately one mile of TL625B between Loveland Substation and Barrett Tap from a single-circuit line to a double-circuit line. As part of a Connected Action, SDG&E would reconfigure and reconductor approximately 5.1 miles of TL625B between Loveland Substation and Barrett Tap from a single-circuit line to a double-circuit line. The resulting 69 kV power line segments would be reclassified as TL625 (Loveland Substation to Descanso Substation) and TL6957 (Loveland Substation to Barrett Substation).

4.2.1 TL629E

As part of the Proposed Action, SDG&E would reconfigure and reconductor approximately 1.7 miles of TL629E between Cameron Tap and Crestwood Substation from a single-circuit line to a double-circuit line and remove Cameron Tap. As part of a Connected Action, SDG&E would reconfigure and reconductor an approximately 5.9-mile-long segment of TL629E between Cameron Tap and Crestwood Substation from a single-circuit line to a double-circuit line. The resulting 69 kV power lines would be reclassified as TL629C (Glencliff Substation to Crestwood Substation), and TL6958 (Cameron Substation to Crestwood Substation).

4.3 69 KV POWER LINE UNDERGROUNDING

As part of the single- to double-circuit conversion of TL629E, SDG&E would replace approximately 300 feet of existing overhead connection of TL629E to Crestwood Substation with an approximately 700-foot-long underground connection. This underground connection would begin at the replacement steel pole west of Crestwood Substation, proceed east to the western shoulder of Old Highway 80, continue north along the western shoulder of Old Highway 80, cross under Old Highway 80 to the west via jack-and-bore construction (as described further in the following paragraphs), continue east along SDG&E's access road to Crestwood Substation, and finally turn south into the substation where it would connect to the existing rack.

In order to construct this underground connection, SDG&E would use jack-and-bore construction to place the line along the approximately 700-foot-long underground route. This technique consists of a boring operation that simultaneously pushes a casing under an obstacle and removes the spoil inside the casing with a rotating auger; it is typically used to install conduit at locations where traditional open-cut trenching is not permitted or is infeasible, such as across Old Highway 80 in this case. Boring operations would begin with excavating bore pits at the sending and receiving ends of the bore. Boring and receiving pits would typically measure approximately 20 feet by 40 feet. The depth of the proposed bore pits would be between 10 and 20 feet, depending on local site conditions. It is anticipated that between approximately 590 and 1,180 cubic yards (CY) of material would be excavated to facilitate each jack-and-bore installation required to complete the substation connection. In addition, SDG&E would install one concrete splice vault along the western shoulder of Old Highway 80 to provide maintenance access to the underground conduit.

After establishing the bore pits, boring equipment would be delivered to the site and then installed into the bore pit at the sending end. The casings would be installed at least three to four feet below Old Highway 80, as practicable. Once the casing are in place, the polyvinyl chloride (PVC) cable ducts would be installed within the casing using spacers to hold them in place. The casings would be left in place to protect the conduit once it has been installed. Following the completion of all boring, installation of the casings and conduits, and completion of the concrete duct bank, the bore pits would be backfilled using native or engineered material and the duct bank would be covered with at least 36 inches of native or engineered fill, as appropriate. Soil not used for backfill would be hauled off site and disposed of at an approved facility, such as the Allied Otay Landfill. SDG&E would secure the necessary permits to conduct these specialized construction activities and would implement standard best management practices (BMPs), including silt fencing and straw wattles, in accordance with the Proposed Action's Storm Water Pollution Prevention Plan (SWPPP).

4.4 12 KV DISTRIBUTION LINE UNDERGROUNDING

SDG&E would replace some portions of existing overhead 12 kV distribution lines with underground lines installed in concrete duct banks. A summary of the 12 kV distribution line segments selected for undergrounding under the Proposed Action and Similar Actions is included in Table 4: 12 kV Distribution Line Undergrounding Summary.

Table 4: 12 kV Distribution Line Undergrounding Summary

12 kV Distribution Line	Length (miles)		
	Within CNF	Outside CNF	Total
C79	0.0	2.8	2.8
C440	7.5	0.9	8.4
C449	1.5	0.3	1.8
Total	**9.0**	**4.0**	**13.0**

One to two approximately 2.2- or 4.3-inch-diameter cables would be installed in a 1.5-foot-wide by 1.5-foot-deep duct bank containing two to three 4- to 5-inch-diameter PVC conduits encased in concrete or sand and native fill. These cables would connect to overhead 12 kV distribution facilities via six approximately 45-foot-tall new and existing riser poles. A typical drawing of the proposed duct bank has been included in Attachment E: Typical Drawings. SDG&E would also install approximately 5.5-foot-wide by eight-foot-long by seven-foot-deep splice vaults along the underground segments, approximately 500 to 800 feet apart depending on local site conditions, to provide maintenance access to the underground conductors. Approximately 61 vaults are included as part of the Proposed Action, and 25 vaults are included as part of Similar Actions.

C79

As part of Similar Actions, a new approximately 2.8-mile-long underground portion of C79 would run from the Cuyamaca Peak communication site along Lookout Road to the eastern side of SR-79, as shown in Attachment B: Detailed Route Maps. This segment would replace the existing overhead arrangement for a portion of C79, which would be removed as part of the Proposed Action and Similar Actions.

C440

As part of the Proposed Action, a new approximately 3.9-mile-long underground portion of C440 would run from near I-8 northeast along Sunrise Highway to approximately 0.2 mile southwest of Sheephead Mountain Road, as shown in Attachment B: Detailed Route Maps. A new approximately 2.9-mile-long underground portion of C440 would continue along Sunrise Highway from approximately 0.6 mile northeast of Sheephead Mountain Road to P40152, approximately 0.4 mile west of Morris Ranch Road. In addition, a new approximately 0.6-mile-long underground portion of C440 would run from P45860 to P40229 in the Laguna Campground area, which would replace a portion of the existing overhead arrangement in this area.

As part of Similar Actions, a new approximately 0.9-mile-long underground portion of C440 would run from approximately 0.2 mile southwest of Sheephead Mountain Road to approximately 0.6 mile northeast of Sheephead Mountain Road, as shown in Attachment B: Detailed Route Maps.

These underground segments would replace a portion of the existing overhead arrangement along C440, which would be removed as described in Section 4.5 Existing 12 kV Distribution Line Removal.

C449

As part of the Proposed Action, a new approximately 1.5-mile-long underground portion of C449 would run from approximately 0.1 mile south of Mountain Empire High School south along Buckman Springs Road and continue south along Morena Stokes Valley Road to New Pole 16, where it would connect to the existing overhead line that runs to Camp Morena, as shown in Attachment B: Detailed Route Maps.

As part of Similar Actions, a new approximately 0.3-mile-long underground portion of C449 would run from P45477 to approximately 0.1 mile south of Mountain Empire High School along the southern boundary of Mountain Empire High School and south along Buckman Springs Road.

These underground segments would replace a portion of the existing overhead arrangement along C449, which would be removed as described in Section 4.5 Existing 12 kV Distribution Line Removal.

4.5 EXISTING 12 KV DISTRIBUTION LINE REMOVAL

Eliminating electric lines in areas of increased fire risk or higher environmental sensitivity can be an effective fire safety and environmental improvement when electric service can be safely and adequately provided through alternative facilities. Removing existing facilities requires dismantling and disposing of existing wood distribution poles, insulators, conductors, transformers, and other associated materials. Where distribution lines are removed, the old conductor would be wound onto wooden spools, placed on flatbed trucks, and recycled at an approved facility, such as SDG&E's Mountain Empire Construction and Operations (MECO) yard in Pine Valley. The entire existing wooden pole would be removed unless protection of an environmental resource requires the pole to be cut off at the surface and the base left in place. The resulting holes would be backfilled. Imported material may be used to backfill the holes as needed; however, as much native material as possible would be used on site. These areas would then be allowed to revegetate naturally. The old wooden distribution poles would be removed from the site by a helicopter, crane, or other lift; placed on flatbed trucks; and then recycled or disposed of at an approved facility, such as at the MECO yard in Pine Valley. A summary of the distribution line segments selected for removal under the Proposed Action and Similar Actions is included in Table 5: 12 kV Distribution Line Removal Summary.

Table 5: 12 kV Distribution Line Removal Summary

12 kV Distribution Line	Approximate Length (miles)			Approximate Number of Poles Removed		
	Within CNF	Outside CNF	Total	Within CNF	Outside CNF	Total
C79	1.8	0.4	2.2	46	18	64
C440	5.8	1.4	7.2	81	18	99
C449	5.0	0.8	5.8	87	15	102
Total	**12.6**	**2.6**	**15.2**	**214**	**51**	**265**

4.5.0 C79

As part of the Proposed Action, SDG&E would remove approximately 1.8 miles of the existing C79 distribution line from its intersection with TL626 just west of Boulder Creek Road to approximately 0.4 mile southwest of its terminus at the summit of Cuyamaca Peak (Pole P377371 to Pole P377405).

As part of Similar Actions, SDG&E would remove approximately 0.4 mile of the existing C79 distribution line from Pole P676926 to Pole P377414 at the summit of Cuyamaca Peak.

Service to Cuyamaca Peak would be provided via the new underground distribution line along Lookout Road, as described in Section 4.4 12 kV Distribution Line Undergrounding.

4.5.1 C440

As part of the Proposed Action, SDG&E would remove the following five segments of C440:

- Pole P40013 to Pole P40054 (approximately 3.5 miles)
- Pole P40080 to Pole P40088 (approximately 0.8 mile)
- Pole P40102 to Pole P40111 (approximately 0.5 mile)
- Pole P40116 to Pole P40124 (approximately 0.5 mile)
- Pole P40229 to Pole P40239 (approximately 0.5 mile)

As part of Similar Actions, SDG&E would remove the following four segments of C440:

- Pole P223415 to Pole P40012 (approximately 0.3 mile)
- Pole P40055 to Pole P40057 (approximately 0.3 mile)
- Pole P40079 to Pole P45310 (approximately 0.7 mile)
- Pole P40112 to Pole P44331 (approximately 0.2 mile)

These areas would be served by the proposed underground segment along Sunrise Highway and the underground segment in the Laguna Campground area, as described in Section 4.4 12 kV Distribution Line Undergrounding, as well as wood-to-steel replacement of the remaining existing facilities for C440.

4.5.2 C449

As part of the Proposed Action, SDG&E would remove the following five segments of C449:

- Pole P40559 to Pole P40602 (approximately 0.3 mile)
- Pole P42706 to Pole P42912 (approximately 2.9 miles)
- Pole P42722 to Pole P42757 (approximately 1.1 miles)
- Pole P42761 (approximately 0.1 mile)
- Pole P42770 to Pole P42780 (approximately 0.6 mile)

As part of Similar Actions, SDG&E would remove the following four segments of C449:

- Pole P42758 to Pole P104078 (approximately 0.2 mile)
- Pole P42762 to Pole P42763 (approximately 0.1 mile)
- Pole P46465 to Pole P42769 (approximately 0.2 mile)
- Pole P45477 to Pole P163409 (approximately 0.2 mile)

These areas would be served by the proposed approximately 1.5-mile-long underground line along Buckman Springs Road and Morena Stokes Valley Road, as described in Section 4.4 12 kV Distribution Line Undergrounding, and the 12 kV distribution line underbuilt on TL629D from Cameron Substation to the tie-switch on Pole P192945. A portion of the existing load along this line would also be tied into and become part of C441 underbuilt on TL629C from the tie-switch on Pole P192945 to Glencliff Substation, which is included in part under the MSUP as part of SDG&E's overall distribution system but is outside the CNF boundary where these changes would occur. The locations of these underbuild segments are displayed in Figure 6: C449-C441 Underbuild Locations.

4.6 ACCESS ROAD MODIFICATION

Within the CNF, SDG&E has for decades regularly maintained a network of approximately 30.0 miles of existing access roads, spur roads, and turnarounds to support and provide access to its existing 69 kV power lines, as well as approximately 15.6 miles of access roads to support existing 12 kV distribution lines. SDG&E also has regularly maintained a network of approximately 0.9 mile of existing access roads, spur roads, and turnarounds to support and provide access to the existing 69 kV power lines extending outside of USFS-administered lands, as well as a network of approximately 0.7 mile of existing access roads, spur roads, and turnarounds to support and provide access to the existing 12 kV distribution lines extending outside of USFS-administered lands.

Access roads provide connectivity between established local and regional roadways and electric line ROW areas. Spur roads provide access to pole locations and other equipment where these facilities are located away from access road locations. Turnarounds are extended vehicle areas used to provide maneuverable space for work vehicles. These roads and areas may contain paved, gravel, or unpaved earth surfaces. Where replacement poles would be close to existing pole locations, existing access roads, spur roads, and turnarounds would be used as much as possible to support construction activities and would continue to be used for future line maintenance. No new access roads are currently anticipated as part of the Proposed Action based on the preliminary construction design and proposed configuration; however, changes in project design may require new access roads, depending on site-specific circumstances. Where existing access roads are damaged, repairs may be made by blading and smoothing the access road as applicable. Importing and compacting more stable materials on existing facilities in unstable areas may also be required. Generally, access roads and spur roads would be graded level and approximately 12 to 15 feet wide (approximately 20 feet wide at corners) to allow construction equipment and vehicles to access each site safely in accordance with the 2007 SDG&E Design and Procedure Manual for Transmission Line Access Roads. Turnarounds would be sized according to local site conditions and as required by construction equipment and vehicles. SDG&E would continue to utilize BMPs to minimize dust and erosion. As discussed in Section 7.3 Erosion and Sediment Control and Pollution Prevention, the Proposed Action includes erosion control measures that have been working successfully over the last few years.

Where construction design calls for removal or relocation of portions of existing 12 kV distribution lines, some or all of the existing access roads currently serving these areas would be removed and the land would be returned to pre-construction vegetative conditions to the extent feasible. Based on the most recent design, SDG&E currently anticipates removing approximately 4.2 miles of existing access roads along C79, approximately 4.0 miles along C440, approximately 0.6 mile along C442, and approximately 2.4 miles along C449. In total, approximately 11.2 miles of existing access roads would be removed, including approximately 11.1 miles within the CNF and 0.1 mile outside the CNF. In addition, SDG&E proposes to eliminate the existing access road crossing of Boulder Creek along TL626 between poles

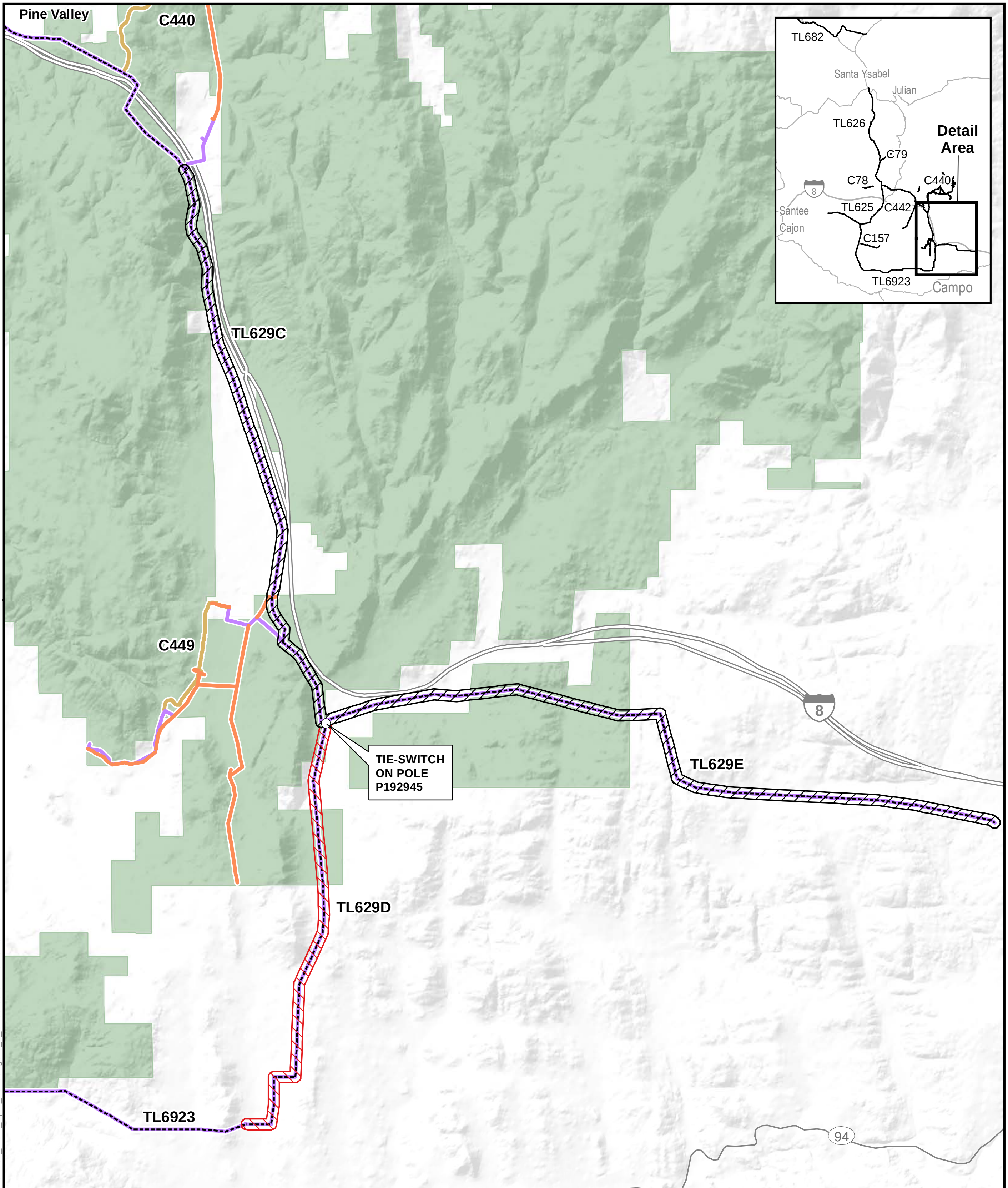

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Figure 6: C449-C441 Underbuild Locations **CNF Revised Plan of Development**

Removal
Undergrounding
Wood-to-Steel Replacement
69 kV Power Line Shown with Dashed Line
C449 Underbuild
C441 Underbuild
United States Forest Service
Interstate
State Highway
Lake/Reservoir

SDGE
A Sempra Energy utility
INSIGNIA ENVIRONMENTAL

1 inch = 1 miles
0 0.5 1 1.5 Miles

Source: SDG&E, 2013; USFS, 2012

Z372130 and Z372131; at this location, the creek crossing would be eliminated and turnarounds installed at either side to permit safe vehicle maneuvering and address erosion concerns. To address erosion concerns along the road on the north slope of Barber Mountain, SDG&E would continue to regularly maintain the road, conduct vegetation trimming or maintenance every other year, and refresh BMPs (e.g., water bars and fiber rolls) to promote continued effectiveness. Additional detail regarding SDG&E's survey and notification procedures for addressing potential erosion concerns along access roads prior to construction will be identified during the environmental review process.

In addition, the draft MSUP Operating Plan contemplates that all access roads would be surveyed and evaluated for resource issues and would include any plans necessary to correct any problems that may arise after the Proposed Action is approved.

5 – ALTERNATIVES

As noted previously, the Proposed Action originally began as a proposal to adopt an MSUP for SDG&E's existing facilities within the CNF. The Proposed Action has evolved to include fire hardening and additional undergrounding activities that were initially described in alternatives to the Proposed Project described in the 2009 EA published by the USFS. More specifically, in accordance with NEPA, the EA solicited comments on the Proposed Action and four alternatives identified in the EA; after public comments on the EA were received, the USFS determined that the MSUP and an increased fire safety component should be evaluated in an EIS. As described in the following sections, SDG&E incorporated recommendations from the EA's Increased Fire Prevention Measures Alternative, as well as various additional fire hardening activities in response to these comments. As a result, the Proposed Action itself is an alternative to the original proposal to consolidate 70 existing authorizations into one MSUP.

SDG&E has worked with the USFS to identify which lines to propose for fire hardening. During preparation of an EIS, however, the USFS may determine that any alternative described in the following sections or any combination of fire hardening activities included in the Proposed Action should be analyzed for and included in the USFS' Record of Decision for the Proposed Action. Several potential alternatives to the Proposed Action were considered and are described in the following subsections: the previous Proposed Action and alternatives analyzed in the 2009 EA, the Relocation of TL626 Alternative, and the Updated No Action Alternative. Because none of the alternatives considered would feasibly obtain the objectives of the Proposed Action, further analysis was not included in this Revised POD. Nonetheless, key elements of several alternatives were incorporated into the Proposed Action during the project design process and consultation with the USFS since 2009.

5.0 ALTERNATIVES ORIGINALLY ANALYZED IN THE EA

Four alternatives were initially analyzed in the March 2009 MSUP EA. These four alternatives were the No Action Alternative, the original Proposed Action for an MSUP, the Increased Fire Prevention Measures Alternative, and the Underground Condition Alternative. The current Proposed Action incorporates portions of all of the alternatives analyzed in the EA (except the No Action Alternative).

5.0.0 Environmental Assessment No Action Alternative

Under the EA No Action Alternative, no MSUP would be issued for the existing electric lines, the expired permits would terminate according to their terms, the existing lines would be removed, and restoration of the site would occur.

5.0.1 Environmental Assessment Proposed Action Alternative

Under the Proposed Action Alternative, the approximately 70 expired permits would be administratively combined into one MSUP to authorize the continued operation and maintenance of the existing system. However, construction of replacement facilities to increase fire safety and service reliability and other system improvements would not be included in the MSUP. Through the issuance of an MSUP under this alternative, a set of resource protection measures would be established to which all operation and maintenance activities would need to comply, and fire hardening activities could be reviewed as individual construction projects after the MSUP is approved. The MSUP would be issued for a period of 20 years.

5.0.2 Environmental Assessment Increased Fire Prevention Measures Alternative

The Increased Fire Prevention Measures Alternative, as described in the EA, would include the EA Proposed Action Alternative, as well as specific requirements for fire-prevention measures, including the preparation and approval of a Fire Control Plan. This alternative would require SDG&E to incorporate the following measures into all future operation and maintenance activities to reduce the risk of wildfire caused by vegetation-to-line contacts, power line arcing, or pole failure:

- Fuel treatment/vegetation management
- Prevention directives, including both physical and operational measures and to reduce the risk of fire from power lines
- Emergency response preparedness related to equipment and personnel availability
- Establishment of reporting procedures for permit-related fires
- Fire control/extinguishing procedures and equipment location
- Agreement to cooperate with USFS investigations of permit-related fires

5.0.3 Environmental Assessment Underground Condition Alternative

The EA Underground Condition Alternative includes the EA Increased Fire Prevention Measures Alternative described previously, with the additional condition that SDG&E develop and implement a plan to place up to 15 miles of the existing electric lines underground during the permit term. The plan would be submitted to the USFS for review and approval, at which point the USFS' Authorized Officer would determine which projects would be implemented and establish timelines for compliance.

5.1 ALTERNATIVES REQUESTED BY THE USFS

5.1.0 Potential Relocation of TL626

The USFS has requested that SDG&E evaluate the potential relocation of a portion of TL626. SDG&E notes that TL626 (including access roads) is outside of the areas identified by the USFS as proposed Recommended Wilderness, and that the area has not yet been formally recommended as Wilderness. SDG&E will continue to participate in the USFS's LMP amendment process to request that the Recommended Wilderness Land Use Zone exclude SDG&E facilities. SDG&E would not anticipate that an alternative that avoids Recommended Wilderness is required unless the adopted Recommended Wilderness area includes SDG&E facilities.

Nonetheless, at the USFS's request, SDG&E is working to identify a possible alternative location for the segment of this power line between poles Z372142 and Z213670, which is the segment of TL626 that crosses the Inventoried Roadless Area in the vicinity of the proposed Recommended Wilderness Land Use Zone. Using available existing topographical, road, parcel, land use, and environmental resource data, SDG&E has created an approximately 3,000-foot-wide preliminary study corridor within which a potential alternative route may be identified; this study corridor is shown in Figure 7: TL626 Potential Alternative Study Corridor. The study corridor's location takes into consideration the avoidance of the USFS's proposed Recommended Wilderness Land Use Zones and Inventoried Roadless Areas, while at the same time ensuring connectivity between Descanso and Santa Ysabel substations and continued service to customers served by distribution underbuild along this segment of the power line. As a result, the study corridor includes an area somewhat longer than requested by the USFS, extending from pole Z372113 to pole Z213678.

SDG&E will continue to refine its analysis in order to identify a potential alternative route that can be constructed within this study area. Although SDG&E anticipates that it will be technologically possible to reconstruct the line within an alternative location outside of the proposed Recommended Wilderness Land Use Zones, SDG&E notes that the USFS and CPUC will need to assess the "feasibility" of any such alternative location. SDG&E notes that "feasible" is defined under both the NEPA and CEQA to require consideration of a number of factors in addition to technological feasibility, including legal, environmental, social, and economic feasibility. Considerations that should be taken into account in determining whether an alternative within the study area is feasible include: safe and viable locations for new poles; access to these new pole locations; additional rights-of-way and access easements; construction methods, including any necessary helicopter landing zones and staging areas; and biological, cultural, hydrological, and other potential environmental resource impacts associated with construction outside of the existing alignment. These considerations must be properly and fully documented and evaluated prior to moving forward with any alternative within the study area.

5.1.1 Potential Relocation of C157

As previously noted, two short segments of C157 appear to be located within the Pine Creek Wilderness Area (two poles, approximately 430 feet) and Hauser Wilderness Area (seven poles, approximately 2,775 feet). C157 was constructed in the 1950s and predates these Wilderness designations. The failure to exclude C157 from the Wilderness designation appears to have been an oversight. Although the legislative history of the Wilderness Act reveals the intent to exclude other pre-existing electric facilities and the access road to Skye Valley Ranch, there is no such exclusion or other reference to C157, which—like the access road—serves Skye Valley Ranch. SDG&E continues to review the legislative history and official maps to determine conclusively whether the reconstruction of C157 presents a legal conflict with the Wilderness Act.

SDG&E requests that the USFS continue to work with SDG&E to reconsider whether the USFS currently has the legal authority to approve the fire hardening of C157. SDG&E continues to believe that—in light of the history of wildfires, known local conditions, and fire hardening/fire safety objectives of the Proposed Action—the statutory language providing the Secretary with the authority to take "such measures as are necessary in the control of fires" could be interpreted to allow the wood-to-steel conversion of C157.

In the event that the USFS concludes that it legally cannot approve the fire hardening of C157, SDG&E respectfully requests that the USFS seek Congressional authority to allow this fire safety project to move forward. Specifically, SDG&E requests that the EIS prepared as part of the USFS's NEPA review of the Proposed Action includes an alternative to the Proposed Action, whereby the USFS seeks authority from Congress to approve the Proposed Action.

At the request of the USFS, SDG&E completed a preliminary evaluation of a number of other potentially constructible alternatives, including the following three overhead relocation scenarios and one underground relocation scenario:

- Overhead relocation between the Pine Creek and Hauser wilderness areas, beginning at approximately pole P278726, following Skye Valley Road for approximately 2,000 feet before crossing the northern inlet of Barrett Lake, then rejoining Skye Valley Road for approximately one mile before connecting with the existing alignment at approximately Pole P278740

- Overhead relocation in a new alignment from Corte Madera Ranch, traveling west from existing 12 kV distribution line C442 along the southern boundary of the Pine Creek Wilderness Area for approximately seven miles to Skye Valley Ranch

- Overhead relocation in a new alignment from Los Pinos, traveling west from existing 12 kV distribution line C442 along Espinosa Creek for approximately three miles, then traveling south along the eastern boundary of the Pine Creek Wilderness Area for approximately four miles to Skye Valley Ranch

- Underground relocation within Skye Valley Road, and partially through the Pine Creek Wilderness Area where this road passes through that designated area, from approximately Pole P278726 for approximately three miles before rejoining the existing alignment at approximately Pole P278740

These potential relocation scenarios are depicted in Figure 8: C157 Potential Relocation Alternatives.

At this time, SDG&E is not able to support any of these potential relocation alternatives, primarily because of the increased environmental impacts, construction challenges, customer service implications, costs, and other factors associated with these alternatives. Based on a preliminary review, SDG&E believes that replacing the existing wood poles with steel poles within the current alignment would present the fewest environmental impacts and is the most cost-effective and overall the least impactive alternative. The potentially constructible

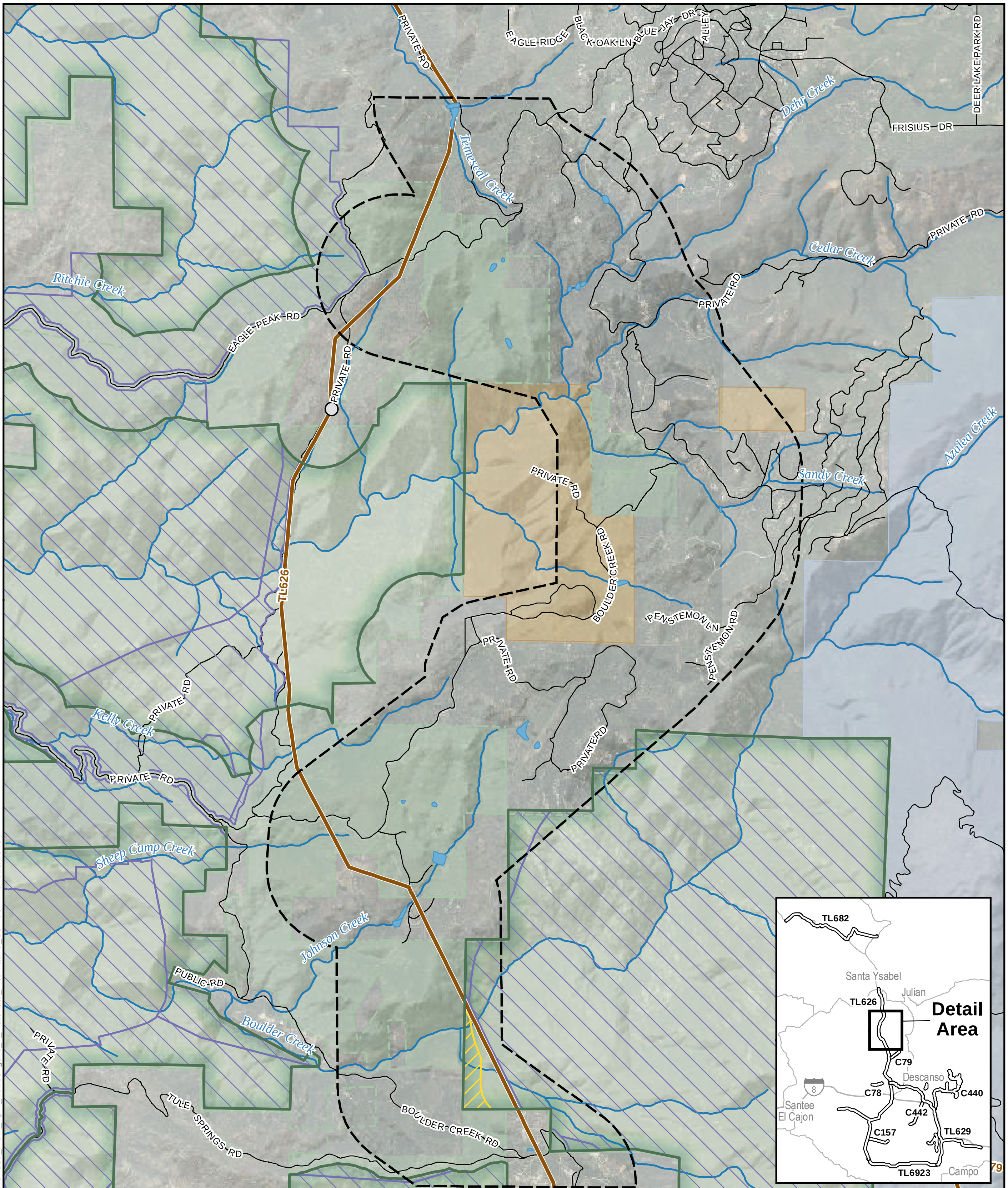

Figure 7: TL626 Potential Alternative Study Corridor

CNF Revised Plan of Development

- Potential Study Area Corridor
- Proposed Action/ Current Alignment
- Inventoried Roadless Area
- Proposed Back Country Motorized Use Restricted Area
- Proposed Recommended Wilderness
- United States Forest Service
- Bureau of Indian Affairs
- California Department of Parks and Recreation
- Road
- Lake
- Stream

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*Study corridor was identified based on preliminary review of environmental constraints and engineering considerations. Feasibility of potential realignment of TL626 is yet to be determined.

Source: SDG&E, 2013; USFS, 2012; CPAD 1.8, 2012 GreenInfo Network

1:50,000

0 0.5 1 Miles

N

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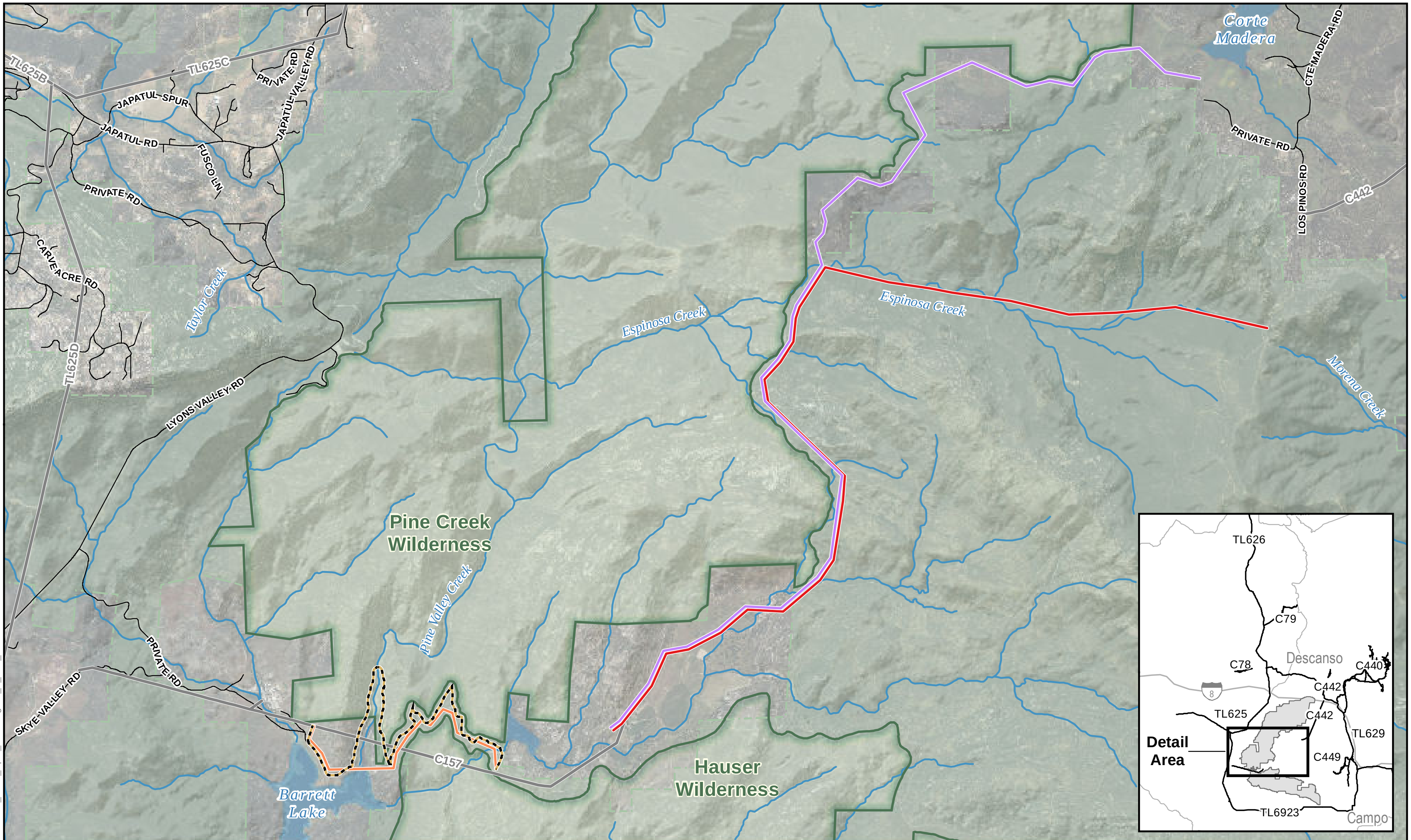

Figure 8: C157 Potential Relocation Alternatives

CNF Revised Plan of Development

Potential Relocation Alternatives*

- Overhead between Wilderness Areas
- Overhead from C442 (Corte Madera Ranch)
- Overhead from C442 (Los Pinos)
- Underground along Skye Valley Road

- Proposed Action/Current Alignment
- Wilderness Boundary**
- United States Forest Service
- Road
- Stream
- Lake

*This map illustrates potentially constructible alternatives identified by SDG&E at the request of USFS. The feasibility of these potential alternatives has not been confirmed, and SDG&E does not propose to construct any of these alternatives at this time.
**Wilderness Boundary based on GIS data downloaded from USFS at http://fsgeodata.fs.fed.us/vector/lsrs.php per USFS staff direction on January 16, 2013.
Note: SDG&E is currently reviewing other historical maps to confirm wilderness boundaries.

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1:52,000
0 0.5 1 Miles

Source: SDG&E, 2013; USFS, 2013

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alternatives, by contrast, are all located within relatively undisturbed, remote areas that are difficult to access.

C157 is currently located within designated Wilderness, and the existence of the distribution line would be included in the baseline from which environmental impacts are analyzed. Removing C157 from designated Wilderness and relocating it outside of Wilderness would present substantial additional environmental impacts.

As with the potential realignment of TL626, the USFS and the CPUC will need to thoroughly assess the feasibility of any potential relocation of C157. Considerations that would need to be taken into account in determining feasibility include the following:

- safe and viable locations for new poles;
- access to these new pole locations;
- additional ROWs and access easements;
- construction methods, including necessary helicopter landing zones and staging areas adjacent to wilderness areas; and
- biological, cultural, hydrological, and other potential environmental resource impacts associated with construction outside of the existing alignment.

In light of these considerations, SDG&E believes that seeking congressional authority to rebuild C157 in its existing alignment is the superior alternative. As noted previously, SDG&E's review of the legislative history and historical maps designating wilderness areas is ongoing, and SDG&E will continue to work with the USFS to resolve the questions raised by the existing Wilderness designations.

5.2 NO PROJECT ALTERNATIVE

Under the No Project Alternative, the existing alignments within the CNF would be maintained as they are currently, under their approximately 70 separate permits and easements. Each permit would be updated and reissued according to the specific terms negotiated between SDG&E and the USFS, and no MSUP would be issued. In addition, none of the proposed fire hardening activities would be authorized. SDG&E would continue to operate its existing facilities within the CNF and would propose the fire-hardening activities as individual projects. The USFS would be required to review and approve each of the individual fire-hardening projects, some of which may not be approved. All existing wood poles would be replaced in-kind, as needed. Further, segments TL625B and TL629E would not undergo single- to double-circuit conversion. No Fire Control Plan would be prepared for the Proposed Action area and no additional fire prevention measures would be included in future actions, beyond those which already are in place. Additionally, the fire safety measures would be processed in a less coordinated and more ad hoc fashion than that included as part of the Proposed Action.

5.3 OTHER ALTERNATIVES THAT MAY BE ANALYZED IN THE EIS

Reasonable alternatives to the Proposed Action for evaluation in the EIS that may potentially be considered include a Fire Hardening of 69 kV Power Lines Only alternative and a Fire Hardening of 12 kV Distribution Lines Only alternative. In addition, the EIS may consider alternatives for fire hardening any subset and combination of the 69 kV power lines and 12 kV distribution lines.

As previously noted, SDG&E evaluated each of these alternatives individually and determined that none could feasibly achieve the objectives of the Proposed Action. As a result, SDG&E selected the Proposed Action for further analysis in this Revised POD.

6 – RIGHT-OF-WAY

SDG&E currently has existing ROWs—or franchise rights, for those portions of the 12 kV distribution lines to be undergrounded along public roadways—along the entire lengths of the 69 kV power lines and 12 kV distribution lines included in the Proposed Action. Within the CNF, existing ROWs for overhead 69 kV power lines are 30 feet wide, and existing ROWs for overhead distribution lines are 20 feet wide. Outside the CNF, existing ROWs have varying widths based on individual property owner agreements. All existing ROWs where activities would occur as part of the Proposed Action or as Connected Actions or Similar Actions would be maintained consistent with SDG&E's existing operation and maintenance procedures or those agreed upon in the Operating Plan for the CNF MSUP, the proposed working draft of which is attached as Attachment C: MSUP Operating Plan.

7 – CONSTRUCTION ACTIVITIES

Prior to initiating construction, SDG&E would make all the appropriate and necessary notifications, including landowner notifications. In addition, SDG&E would contact the Underground Service Alert prior to the start of ground-disturbing activities in order to identify underground utilities in the immediate area. Once SDG&E completes the appropriate notifications, construction would proceed as described in the following subsections. Construction activities for Connected Actions and Similar Actions would be similar in nature and scope to those described in the follow subsections for the Proposed Action.

7.0 ACCESS

The following subsections describe existing and planned future methods of access to the Proposed Action components.

7.0.0 Access Roads

As discussed in Section 4.6 Access Road Modification, SDG&E currently maintains a network of access roads, spur roads, and turnarounds to support and provide access to its existing 69 kV power lines and 12 kV distribution lines within and around the CNF. The 69 kV power line ROWs would be accessed using existing access roads, which are approximately 12 to 15 feet wide, and up to 20 feet wide at curves. Where existing access roads are damaged, typical repairs—such as smoothing the access road, stabilizing loose areas, and improving the surface quality of the road—may be made by blading, importing and compacting more stable materials in loose areas, or applying additional surface materials to improve access conditions. Repair of these access roads would be completed according to the 2007 SDG&E Design and Procedure

Manual for Transmission Line Access Roads and according to landowner preferences, where feasible. No tree removal is planned; however, because construction would occur over an approximately five-year period, some tree removal may be required at the time of construction. In addition, some trees may be trimmed and some mature bushes and other scrub vegetation may be cleared to reduce or eliminate potential safety hazards. Where SDG&E determines existing access roads are no longer needed, these areas would be returned to pre-construction conditions consistent with the surrounding area to the extent feasible, based on NCCP restoration guidelines. Table 6: 69 kV Power Line Access Road Summary and Table 7: 12 kV Distribution Line Access Road Summary provide summaries of access road information.

In the event that an access road requires improvement outside the existing footprint of the roadway, SDG&E may evaluate the conversion to helicopter-only access for maintenance activities for the affected pole(s). SDG&E's proposed draft MSUP Operating Plan, included as Attachment C: MSUP Operating Plan, establishes a process to determine whether conversion to helicopter access would be evaluated. As discussed in Section 4.6 Access Road Modification, where construction design calls for removal or relocation of portions of existing 69 kV power lines or 12 kV distribution lines, some or all of the existing access roads currently serving these areas would be removed and the land returned to pre-construction vegetative conditions to the extent feasible. SDG&E proposes to remove a total of approximately 11.2 miles of existing access roads inside and outside of the CNF as part of the Proposed Action or Similar Actions.

7.0.1 Helicopter Access

SDG&E would conduct some portions of the Proposed Action by helicopter where overland access could create additional environmental impacts, poses safety risks, or is otherwise not feasible. Where necessary, SDG&E plans to utilize helicopters to deliver and remove construction material and personnel from areas with rugged terrain and where ground access would not safely accommodate the required construction equipment and vehicles. As part of the Proposed Action, SDG&E anticipates that approximately 333 of the approximately 876 poles would be set by helicopter. As part of Connected Actions, approximately 115 of the approximately 1,006 poles would be set by helicopter. As part of Similar Actions, approximately 66 of the approximately 220 poles would be set by helicopter.

Approximately three temporary helicopter fly yards within the CNF would be used for the Proposed Action, and nine temporary helicopter fly yards outside the CNF would be used for Connected and Similar Actions, as depicted in Attachment B: Detailed Route Maps and described in Section 7.1 Workspace. No helicopters would be stored at temporary fly yards overnight. Helicopters may be refueled at fly yards outside the CNF, if necessary. Approximately one of the three temporary helicopter fly yards would be used for both helicopter landing and for equipment and material storage for the Proposed Action. Approximately five of the nine temporary helicopter fly yards would be used for both helicopter landing and for equipment and material storage for Connected Actions. Poles and steel cages for poured foundations would be assembled on site if there is adequate space at the work site or at the staging areas, then trucked to the job site or flown in and installed via helicopter. These fly yards would be accessed using existing access roads. Because these fly yards would be located in previously disturbed areas, no additional grading would be required. However, some vegetation clearing may be conducted with gas-powered weed abatement tools to provide a safe operating

Table 6: 69 kV Power Line Access Road Summary

69 kV Power Line	Approximate Length (miles)			Approximate Width (feet)	Approximate Area (acres)		
	Within CNF	Outside CNF	Total		Within CNF	Outside CNF	Total
TL625	11.0	0.3	11.3	12-20	26.7	0.7	27.4
TL626	9.9	0.2	10.1		24.0	0.5	24.5
TL629	6.9	0.1	7.0		16.8	0.4	17.2
TL682	1.1	--	1.1		2.7	--	2.7
TL6923	1.1	0.3	1.4		2.6	0.9	3.5
Total	**30.0**	**0.9**	**30.9**		**72.8**	**2.5**	**75.3**

Note: A 20-foot-wide buffer was used for spatial analysis to capture the maximum width of access road area.

Table 7: 12 kV Distribution Line Access Road Summary

12 kV Distribution Line	Approximate Length (miles)			Approximate Width (feet)	Approximate Area (acres)		
	Within CNF	Outside CNF	Total		Within CNF	Outside CNF	Total
C78	<0.1	<0.1	0.1	12-20	0.1	0.1	0.2
C79	4.1	0.1	4.2		9.4	0.2	9.6
C157	0.3	0.1	0.4		0.9	0.2	1.1
C440	4.7	<0.1	4.7		11.3	0.0	11.4
C442	3.6	0.4	4.0		8.8	1.1	9.8
C449	2.8	--	2.8		6.7	--	6.7
Total	**15.6**	**0.8**	**16.4**		**37.1**	**1.5**	**38.6**

Note: A 20-foot-wide buffer was used for spatial analysis to capture the maximum width of access road area.

environment. No tree removal is planned; however, because construction would occur over an approximately five-year period, some tree removal may be required at the time of construction. In addition, some trees may be trimmed and some mature bushes and other scrub vegetation may be cleared. Measures to reduce impacts to sensitive noise or air receptors that may result from the operation and use of helicopters are presented in Section 10.5 Noise. Helicopter models that may be used include, but are not limited to, the Erickson Air Crane, Hughes 500D, Kaman K-MAX, and Bell 206L Long Ranger.

Helicopters would typically be used between 7:00 a.m. and 4:00 p.m.—in accordance with SDG&E's general operation and maintenance guidelines, or as allowed according to biological resource or noise constraints—to deliver poles, construction material, and personnel to the ROW. In order to begin construction at 7:00 a.m., however, in some instances SDG&E may need to fly helicopters from their respective home airfields to the Proposed Action staging areas or landing zones prior to 7:00 a.m. to pick up workers or construction materials. Where appropriate, SDG&E will coordinate with the County noise control officer regarding helicopter flights to avoid any conflicts with the County noise ordinance. Helicopters would also be used to remove materials from the ROW. The helicopters' flight paths would follow the ROW to the extent practicable and would be coordinated with the Federal Aviation Administration (FAA) where required.

Depending on final design and configuration, helicopter landing areas or pads may need to be cleared or constructed, depending on topography and the location of the pole and work areas relative to existing access roads and pads, as well as the ability to reach these areas safely by work crews on foot (generally within 300 feet).

7.1 WORKSPACE

Temporary workspaces would be required for each Proposed Action component in order to facilitate construction. These anticipated workspace requirements are described in detail in the following subsections, and are summarized in Table 8: 69 kV Power Line Temporary Work Area Summary and Table 9: 12 kV Distribution Line Temporary Work Area Summary.

7.1.0 Staging Areas

SDG&E would utilize approximately 13 staging areas within the CNF for the Proposed Action, 24 staging areas for 69 kV power line activities outside of the CNF (analyzed as Connected Actions), and seven staging areas for 12 kV distribution line activities outside of the CNF (analyzed as Similar Actions), as shown in Attachment B: Detailed Route Maps. Staging areas would be used for storage and preparation of construction materials, including replacement poles and conductors, as well as construction equipment before delivery to the individual pole work areas. The poles would be assembled at the staging areas, fly yards, and/or in pole work areas. Equipment, materials, and vehicle parking would be accommodated at these locations for the duration of construction associated with each staging area. Staging areas would be accessed using public roadways and existing access roads.

Where possible, the staging areas would be located in previously disturbed areas, requiring minimal grading or other preparation. However, some vegetation clearing may be conducted

Table 8: 69 kV Power Line Temporary Work Area Summary

69 kV Power Line	Work Area Type	Approximate Quantity			Required Improvements	Approximate Dimensions (feet)	Total Approximate Area (acres)		
		Within CNF	Outside CNF	Total			Within CNF	Outside CNF	Total
TL625	Direct-Bury Steel Pole Work Area	48	124	172	Vegetation removal and minor grading may be required.	40-foot diameter	1.4	3.5	4.9
	Foundation-Supported Steel Pole Work Area	24	71	95	Vegetation removal and minor grading may be required.	40-foot diameter	0.7	1.9	2.6
	Wood Pole Removal Area	6	7	13	Vegetation removal and minor grading may be required.	40-foot diameter	0.2	0.2	0.4
	Staging Area	0	14	14	Vegetation removal, minor grading, and gravel laydown may be required.	Varies	0.0	14.9	14.9
	Stringing Site	12	34	46	Vegetation clearing may be required.	Varies	6.1	14.7	20.8
	Fly Yard[6]	2	4[7]	6	Vegetation clearing may be required.	Varies	0.4	6.5	6.9
	Guard Structure	8	30	38	Vegetation clearing may be required.	3-foot diameter	<0.1	<0.1	<0.1
TL626	Direct-Bury Steel Pole Work Area	93	114	207	Vegetation removal and minor grading may be required.	40-foot diameter	2.7	3.3	6.0

[6] Fly yards may be used for multiple power lines or distribution lines and are included here with each power line to which the fly yard is associated; therefore, the total number of fly yards noted in Tables 8 and 9 may not necessarily equal the total number of fly yards identified for the Proposed Action, Connected Actions, and Similar Actions.

[7] These fly yards also serve as staging areas.

69 kV Power Line	Work Area Type	Approximate Quantity			Required Improvements	Approximate Dimensions (feet)	Total Approximate Area (acres)		
		Within CNF	Outside CNF	Total			Within CNF	Outside CNF	Total
TL626 (cont.)	Foundation-Supported Steel Pole Work Area	27	45	72	Vegetation removal and minor grading may be required.	40-foot diameter	0.8	1.3	2.1
	Wood Pole Removal Area	0	1	1	Vegetation removal and minor grading may be required.	40-foot diameter	0.0	<0.1	<0.1
	Staging Area	0	2	2	Vegetation removal, minor grading, and gravel laydown may be required.	Varies	0.0	0.9	0.9
	Stringing Site	8	20	28	Vegetation clearing may be required.	Varies	3.0	9.1	12.1
TL629	Direct-Bury Pole Work Area	88	187	275	Vegetation removal and minor grading may be required.	40-foot diameter	2.5	5.4	7.9
	Foundation-Supported Pole Work Area	49	118	167	Vegetation removal and minor grading may be required.	40-foot diameter	1.4	3.3	4.7
	Wood Pole Removal Area	0	2	2	Vegetation removal and minor grading may be required.	40-foot diameter	0.0	0.1	0.1
	Staging Area	0	5	5	Vegetation removal, minor grading, and gravel laydown may be required.	Varies	0.0	9.7	9.7

69 kV Power Line	Work Area Type	Approximate Quantity			Required Improvements	Approximate Dimensions (feet)	Total Approximate Area (acres)		
		Within CNF	Outside CNF	Total			Within CNF	Outside CNF	Total
TL629 (cont.)	Stringing Site	6	48	54	Vegetation clearing may be required.	Varies	3.1	23.8	26.9
	Fly Yard	0	3	3	Vegetation clearing may be required.	Varies	0.0	1.3	1.3
	Guard Structure	4	4	8	Vegetation clearing may be required.	3-foot diameter	<0.1	<0.1	<0.1
TL682	Direct-Bury Steel Pole Work Area	23	169	192	Vegetation removal and minor grading may be required.	40-foot diameter	0.7	4.9	5.6
	Foundation-Supported Steel Pole Work Area	7	60	67	Vegetation removal and minor grading may be required.	40-foot diameter	0.2	1.7	1.9
	Staging Area	0	3	3	Vegetation removal, minor grading, and gravel laydown may be required.	Varies	0.0	4.1	4.1
	Stringing Site	4	31	35	Vegetation clearing may be required.	Varies	2.1	12.2	14.3
	Fly Yard	0	2[8]	2	Vegetation clearing may be required.	Varies	0.0	5.2	5.2
	Guard Structure	2	27	29	Vegetation clearing may be required.	3-foot diameter	<0.1	<0.1	<0.1

[8] One of these fly yards also serves as a staging area.

69 kV Power Line	Work Area Type	Approximate Quantity			Required Improvements	Approximate Dimensions (feet)	Total Approximate Area (acres)		
		Within CNF	Outside CNF	Total			Within CNF	Outside CNF	Total
TL6923	Direct-Bury Steel Pole Work Area	18	63	81	Vegetation removal and minor grading may be required.	40-foot diameter	0.4	1.7	2.1
	Foundation-Supported Steel Pole Work Area	1	55	56	Vegetation removal and minor grading may be required.	40-foot diameter	<0.1	1.4	1.5
	Stringing Site	4	29	33	Vegetation clearing may be required.	Varies	0.5	5.2	5.7
	Guard Structure	0	1	1	Vegetation clearing may be required.	3-foot diameter	0.0	<0.1	<0.1

Table 9: 12 kV Distribution Line Temporary Work Area Summary

12 kV Distribution Line	Work Area Type	Approximate Quantity			Required Improvements	Approximate Dimensions (feet)	Total Approximate Area (acres)		
		Within CNF	Outside CNF	Total			Within CNF	Outside CNF	Total
C78	Direct-Bury Steel Pole Work Area	30	14	44	Vegetation removal and minor grading may be required.	20-foot diameter	0.2	0.1	0.3
	Wood Pole Removal Area	21	0	21	Vegetation removal and minor grading may be required.	20-foot diameter	0.2	0.0	0.2
	Stringing Site	0	4	4	Vegetation clearing may be required.	Varies	0.0	0.1	0.1
C79	Wood Pole Removal Area	46	18	64	Vegetation removal and minor grading may be required.	20-foot diameter	0.3	0.1	0.4
	Staging Area	1	4	5	Vegetation removal, minor grading, and gravel laydown may be required.	Varies	0.3	0.2	0.5
	Fly Yard	1[9]	0	1	Vegetation clearing may be required.	Varies	<0.1	0.0	<0.1
	Stringing Site	2	23	25	Vegetation clearing may be required.	Varies	<0.1	0.2	0.3
	Underground Duct Bank	0	1	1	Vegetation removal and minor grading may be required.	<12-foot width	0	4.1	4.1

[9] This fly yard also serves as a staging area.

12 kV Distribution Line	Work Area Type	Approximate Quantity			Required Improvements	Approximate Dimensions (feet)	Total Approximate Area (acres)		
		Within CNF	Outside CNF	Total			Within CNF	Outside CNF	Total
C157	Direct-Bury Steel Pole Work Area	28	29	57	Vegetation removal and minor grading may be required.	20-foot diameter	0.2	0.2	0.4
	Staging Area	1	1	2	Vegetation removal, minor grading, and gravel laydown may be required.	Varies	0.1	0.2	0.3
	Stringing Site	1	2	3	Vegetation clearing may be required.	Varies	<0.1	0.1	0.2
C440	Direct-Bury Steel Pole Work Area	323	117	440	Vegetation removal and minor grading may be required.	20-foot diameter	2.3	0.8	3.1
	Wood Pole Removal Area	81	18	99	Vegetation removal and minor grading may be required.	20-foot diameter	0.6	0.1	0.7
	Staging Area	10	0	10	Vegetation removal, minor grading, and gravel laydown may be required.	Varies	0.8	0.0	0.8
	Stringing Site	107	13	120	Vegetation clearing may be required.	Varies	1.7	0.3	2.0
	Underground Duct Bank	3	1	4	Vegetation removal and minor grading may be required.	<12-foot width	10.9	1.3	12.2

12 kV Distribution Line	Work Area Type	Approximate Quantity			Required Improvements	Approximate Dimensions (feet)	Total Approximate Area (acres)		
		Within CNF	Outside CNF	Total			Within CNF	Outside CNF	Total
C442	Direct-Bury Steel Pole Work Area	82	47	129	Vegetation removal and minor grading may be required.	20-foot diameter	0.6	0.3	0.9
	Staging Area	1	1	2	Vegetation removal, minor grading, and gravel laydown may be required.	Varies	<0.1	0.3	0.4
	Stringing Site	6	4	10	Vegetation clearing may be required.	Varies	0.1	0.1	0.2
C449	Direct-Bury Steel Pole Work Area	35	13	48	Vegetation removal and minor grading may be required.	20-foot diameter	0.2	0.1	0.3
	Wood Pole Removal Area	87	15	102	Vegetation removal and minor grading may be required.	20-foot diameter	0.6	0.1	0.7
	Staging Area	0	1	1	Vegetation removal, minor grading, and gravel laydown may be required.	Varies	0.0	0.2	0.2
	Stringing Site	22	8	30	Vegetation clearing may be required.	Varies	0.3	0.1	0.4
	Underground Duct Bank	1	1	2	Vegetation removal and minor grading may be required.	<12-foot width	2.2	0.4	2.6

with gas-powered weed abatement tools or other hand tools to provide a safe operating environment. No tree removal is planned; however, because construction would occur over an approximately five-year period, some tree removal may be required at the time of construction.

In addition, some trees may be trimmed and some mature bushes and other scrub vegetation may be cleared. Depending on substrate conditions, SDG&E may spread a layer of gravel over the staging areas to control mud or other track-out. Following construction, staging areas would be returned to pre-construction vegetative conditions consistent with the surrounding area to the extent feasible. SDG&E would install an approximately six- to eight-foot-tall temporary chain-link fence around the perimeter of the staging areas with a locked gate.

Table 8: 69 kV Power Line Temporary Work Area Summary and Table 9: 12 kV Distribution Line Temporary Work Area Summary provide the required improvements, approximate dimensions, and approximate acreage required for each staging area.

SDG&E may mobilize construction trailers to staging areas during construction, which would generally be used for construction management activities. If temporary power is required, a temporary tap from an existing 12 kV distribution line would be installed to provide electric service, or a small generator would be used. The temporary power would be used for the operation of the construction trailer, construction lighting, and small hand tools.

7.1.1 Work Areas

In addition to the staging areas discussed in the previous section, work areas would be required at each pole location and at intervals along the 69 kV power lines and 12 kV distribution lines to pull and tension the replacement conductors. SDG&E would access work areas by motor vehicle if access roads are available, or by helicopter if surface access is unavailable or infeasible due to site conditions. The following subsections describe these areas in more detail. Where possible, vehicles may remain on the ROW during the work period rather than return to the staging area each night in order to reduce potential impacts to environmental resources.

Pole Work Areas

In order to accommodate construction equipment and activities during pole replacement and reconductoring of the 69 kV power lines, additional temporary construction areas may be cleared at each pole location. Some vegetation clearing may be conducted with small graders or small front-end loaders to provide a safe operating environment. No tree removal is anticipated; however, some trees may be trimmed and some mature bushes and other desert scrub may be cleared. Each of the following would require an approximately less than 0.1-acre work area, measuring approximately 20 to 40 feet in diameter:

- approximately 768 direct-bury steel poles and 108 foundation-supported steel poles included as part of the Proposed Action (within USFS-administered lands),
- approximately 657 direct-bury steel poles and 349 foundation-supported steel poles included as part of Connected Actions, (69 kV power line activities extending outside of the CNF), and

- approximately 220 direct-bury steel poles included as part of Similar Actions (12 kV distribution line activities extending outside of the CNF).

A total of approximately 14.6 acres of temporary disturbance for the Proposed Action, 28.5 acres of temporary disturbance for Connected Actions, and 1.6 acres of temporary disturbance for Similar Actions would be required to facilitate pole installation. SDG&E would access pole work areas by motor vehicle if access roads are available, or by helicopter if surface access is unavailable or infeasible due to site conditions. After construction has been completed, pole work areas would be returned to pre-construction vegetative conditions consistent with the surrounding area to the extent feasible.

Stringing Sites

Approximately 172 stringing sites included as part of the Proposed Action, 162 stringing sites included as part of Connected Actions, and 54 stringing sites included as part of Similar Actions would be required for installing new conductors, tensioning the conductor to a pre-calculated level, and loading tractor-trailers with reels of conductor and trucks with tensioning equipment. Attachment B: Detailed Route Maps depicts the locations of these stringing sites. Each stringing site would vary in size depending on site conditions, but would result in an average temporary disturbance of approximately 0.2 acre per site. SDG&E does not anticipate grading would be required for most stringing sites. Some vegetation clearing may be conducted with gas-powered weed abatement tools, sickles, rakes, or other hand tools to provide a safe operating environment. No tree removal is planned; however, because construction would occur over an approximately five-year period, some tree removal may be required at the time of construction. In addition, some trees may be trimmed and some mature bushes and other scrub vegetation may be cleared. Stringing sites would be spaced approximately 7,000 feet apart for 69 kV power lines, and approximately 1,500 feet apart for 12 kV distribution lines. SDG&E would access stringing sites by motor vehicle if access roads are available, or by helicopter if surface access is unavailable or infeasible due to site conditions. Once construction has been completed, stringing sites would be returned to pre-construction vegetative conditions consistent with the surrounding area to the extent feasible.

Fly Yards

A total of three fly yards within the CNF, included as part of the Proposed Action, and nine fly yards outside the CNF included as part of Connected and Similar Actions would be utilized for helicopter take-off and landing, pole and equipment temporary storage, and pole assembly. Fueling would typically be conducted at airports or at off-site fueling locations, but may occur at fly yards outside the CNF, if necessary. Helicopters would also utilize existing access roads and staging areas for landings. Fly yards would vary in size depending on site conditions, but would result in an average temporary disturbance of approximately 1.1 acres per fly yard—approximately 0.5 acre of total temporary disturbance within USFS-administered lands and 13.0 acres of total temporary disturbance outside of USFS-administered lands. SDG&E does not expect grading of the fly yards to be necessary; however, mowing and clearing of vegetation to ground level with gas-powered weed abatement tools, sickles, rakes, or other hand tools would be required for safe use of the areas. No tree removal is planned; however, because construction would occur over an approximately five-year period, some tree removal may be required at the time of construction. In addition, some trees may be trimmed and some mature bushes and other scrub vegetation may be cleared. Fly yards would be accessed using public roadways and existing access roads. After construction has been completed, fly yards would be returned to pre-construction vegetative conditions consistent with the surrounding area to the extent feasible.

Trench Work Areas

To accommodate the installation of the underground duct banks and vaults, temporary workspaces centered on the duct bank alignments would be established. These areas would be cleared and graded as needed to provide a safe working space for the operation of construction equipment. The duct banks would require an approximately 10- to 12-foot-wide workspace. Within USFS-administered lands, a total of approximately nine miles of workspace, requiring approximately 10.9 to 13.1 acres, would be established prior to construction. Outside of the CNF, a total of approximately four miles of workspace, requiring approximately 4.9 to 5.8 acres, would be established prior to construction. Some vegetation clearing may be conducted with gas-powered weed abatement tools, sickles, rakes, or other hand tools along the trench alignment. No tree removal is planned; however, because construction would occur over an approximately five-year period, some tree removal may be required at the time of construction. In addition, some trees may be trimmed and some mature bushes and other scrub vegetation may be cleared. Trench work areas would be accessed using public roadways and existing access roads. Following construction, trench work areas would be returned to a natural state consistent with the surrounding area to the extent feasible.

Guard Structures

Approximately 14 locations within the CNF and a total of approximately 62 locations outside of the CNF would require guard structures for safe road crossings during conductor stringing. Where possible, SDG&E would utilize bucket trucks as temporary guard structures to minimize temporary impacts. Where guard structures must be installed, they would consist of two approximately 1.5-foot-wide wood poles supporting a cross arm or wood pole section secured horizontally in between the wood poles. Assuming a worst-case scenario where no bucket trucks are used as guard structures, these guard structures would result in a total temporary disturbance of approximately 99 square feet (less than 0.1 acre) for 69 kV power lines within the CNF, and a total temporary disturbance of approximately 424.1 square feet (less than 0.1 acre) for 69 kV power lines outside of the CNF. SDG&E does not expect grading of the guard structure work areas to be necessary; however, mowing and clearing of vegetation to ground level with gas-powered weed abatement tools, sickles, rakes, or other hand tools may be required for safe use of the areas. No tree removal is planned; however, because construction would occur over an approximately five-year period, some tree removal may be required at the time of construction. In addition, some trees may be trimmed and some mature bushes and other scrub vegetation may be cleared. Guard structures would be accessed using public roadways and existing access roads. These areas would be returned to pre-construction vegetative conditions consistent with the surrounding area to the extent feasible following the completion of construction.

7.2 METHODS

The following subsections describe the proposed methods for each construction activity.

7.2.0 Access Road Repairs and Improvements

SDG&E maintains existing access roads to allow operation and maintenance of the existing electric facilities. Whenever possible, construction would utilize existing access roads. The first step in modifying the electric lines would be to evaluate existing access roads, then repair those roads where necessary. Table 10: Access Road Construction Equipment lists equipment typically utilized in the repair of access roads. To allow construction equipment and vehicles to access each site safely, these roads would generally be 12 to 15 feet wide for straight sections and up to 20 feet wide at curves. Where existing access roads need repair, a grader would be used to blade and smooth the road in accordance with the engineered specifications. Importing and compacting more stable materials on existing facilities in unstable areas may also be required. Any road reconstruction would follow the specifications outlined in the 2007 SDG&E Design and Procedure Manual for Transmission Line Access Roads.

Table 10: Access Road Construction Equipment

Equipment Type	Activity	Approximate Quantity
Bulldozer	Scraping	1
Road Grader	Grading	1
Loader	Load haul trucks, transport materials	1
Haul Truck	Haul materials to/from construction site	1
Water Truck	Suppress dust	2
Mower	Trim vegetation	1
Pick-up Truck	Transport personnel	1

7.2.1 Clearing and Grading

Clearing and grading requirements are described for each type of work area in Section 7.1 Workspace. Section 10.1 Biological Resources provides detailed information regarding the effects of clearing on vegetation and habitat communities.

7.2.2 Existing Pole Removal

Once the replacement poles have been constructed, new conductor has been installed, and any third-party lines have been relocated to the replacement poles, SDG&E would remove the existing wood poles. Wood pole removal would typically require a 20- to 40-foot-diameter area around the pole. Pole-removal activities would utilize bucket trucks to remove cross arms and the conductor, or in locations where there is no truck access, helicopters would be utilized to remove poles. Poles would be completely removed where possible. The holes would be backfilled with native soil or materials similar to the surrounding area, and the site would be restored. If complete removal is not practical (e.g., if the pole cannot be pulled from the ground), the pole would be sectioned and cut at the base, or six to 12 inches below the surface, and covered with native material. If necessary to avoid impacts to sensitive resources or private property, poles may be cut off above ground level. In addition, all anchors and stub poles for 69 kV power lines would also be removed. Old poles, associated hardware, and any other debris generated from construction activities would be removed from the site and placed on flatbed trucks for recycling or disposal at an approved facility, such as the MECO yard in Pine Valley.

7.2.3 Steel Pole Installation

SDG&E would notify the Underground Service Alert a minimum of 48 hours in advance of excavating or conducting other ground-disturbing activities in order to identify buried utilities. Exploratory excavations (potholing) would also be conducted to verify the locations of existing facilities in the field, if necessary.

Direct-Bury Steel Poles

Installation of direct-bury steel poles would begin with the excavation of holes approximately 20 to 48 inches in diameter and approximately seven to 12 feet deep, depending on the height of the pole. Pole holes would be excavated using a small, truck-mounted or track-mounted drill rig if the site is land-accessible, or by platform-mounted drilling equipment if accessible only by helicopter. Rock splitting/blasting may be required if crews encounter rock while digging. Pole hole drilling would excavate between approximately 0.7 and 2.2 CY of soil per pole. New poles would be delivered to the site by a flatbed truck or by helicopter and placed in holes dug using a machine digger and/or hand digger. The annular space between 69 kV power line poles and hole walls would then be backfilled with concrete, with an additional foot of crushed rock placed beneath the bearing plate if needed due to drainage and soil conditions. Should access or site conditions prohibit the use of a concrete backfill, 69 kV power line pole holes may be backfilled and compacted with the previously excavated soil. Any remaining excavated material would be placed around the holes or spread onto access roads and adjacent areas.

The permanent footprint for each direct-bury steel pole would range from 1.1 to 2.8 feet in diameter with an average of approximately 24 inches in diameter. As part of the Proposed Action, the installation of 768 direct-bury steel poles would result in a total temporary footprint of approximately 11.2 acres and a total permanent footprint of approximately 0.1 acre. As part of Connected Actions, the installation of 657 direct-bury steel poles would result in a total temporary footprint of approximately 18.8 acres and a total permanent footprint of approximately 0.1 acre. As part of Similar Actions, the installation of 221 direct-bury steel poles would result in a total temporary footprint of approximately 1.6 acres and a total permanent footprint of less than approximately 0.1 acre.

Foundation-Supported Steel Poles

Poles required to resist terminal loads would be installed on micro-pile foundations where local subsurface conditions warrant the use of this foundation type.[10] Micro-pile foundation installation would begin with the excavation of holes approximately eight inches in diameter by approximately 10 to 40 feet deep (requiring the removal of approximately 0.1 to 0.5 CY of soil), depending on the properties of the soil or rock underlying the surface. A steel rod would be

[10] As an alternative to micro-pile foundation poles, poured foundation poles may be installed where local subsurface conditions warrant the use of this foundation type. The maximum permanent footprint and total footprint associated with poured foundation poles would be the same as for micro-pile foundation poles.

inserted into the hole, centered, and the remaining space filled with a mixture of water, cement, and sand. The steel rod would protrude above grade and would connect to the structure or a small concrete cap supporting the structure above grade. Holes for micro-pile foundations would be drilled using a small drill rig operated from the top of an elevated platform, measuring approximately eight feet by eight feet on four to six legs, and approximately six feet above grade. Depending on requirements for foundation strength, four to 12 micro-piles would be arranged in a circular pattern to take the place of a poured concrete foundation. New poles would be delivered to the site by a flatbed truck and assembled on site using a truck-mounted crane, or sections would be flown in by helicopter. If there is no truck access to the job site, poles would be partially assembled at a staging area and flown to the work area in sections by helicopter. Any remaining excavated material would be placed around the holes or spread onto access roads and adjacent areas.

The maximum permanent footprint for each foundation-supported steel pole would be approximately 84 inches in diameter. As part of the Proposed Action, the installation of 108 foundation-supported steel poles would result in a total temporary footprint of approximately 3.2 acres, and a total permanent footprint of approximately 0.1 acre. As part of Connected Actions, the installation of 349 foundation-supported steel poles would result in a total footprint of approximately 0.3 acre. No foundation-supported poles are anticipated to be required for Similar Actions.

7.2.4 Conductor Installation

SDG&E would coordinate with the CAISO to obtain all the necessary line clearances prior to beginning new conductor installation. This would ensure that SDG&E can take the electric lines out of service and redistribute power to service centers and customers.

Prior to stringing the new conductor, temporary guard structures—typically consisting of vertical wood poles with cross arms—would be installed at road crossings and crossings of energized electric and communication lines, preventing the conductors from sagging onto roadways or other lines during conductor installation. In some cases, bucket trucks may also be used as guard structures. As an alternative to using temporary guard structures, SDG&E may use flaggers to halt traffic for brief periods while overhead conductors are installed at road crossings.

Conductor stringing would begin with the installation of insulators and stringing sheaves during steel pole installation. Sheaves are rollers that temporarily attach to the lower end of the insulators to allow the conductor to be pulled along the line. A rope would be pulled through the rollers from structure to structure. The rope may be pulled through the rollers using a helicopter in instances where terrain is difficult; during this operation, the rope may drag between structures in some spans. Once the rope is in place, it would be attached to a steel or synthetic cable and pulled back through the sheaves, and into place using conventional tractor-trailer pulling equipment located within one of the designated stringing sites. The conductor would be pulled through each structure under a controlled tension to keep the conductor elevated and away from obstacles, thereby minimizing damage to the line and protecting the public.

In some cases, sleeves or splices may be installed on the 69 kV power lines. This might occur when stringing operations slightly damage the conductor, or if the conductor is not long enough and needs to be joined to another segment. If the conductor is damaged, a section of the conductor may be replaced or a repair sleeve may be wrapped around the outside of the conductor and pressed into place to protect the conductor. SDG&E would utilize full-tension splices, or compression splices, when the conductor is damaged too severely for a repair sleeve; when the conductor is not long enough to span between structures; or if stringing sites are spread too far apart. During full-tension splices, the two ends of the conductor are connected with the use of heavy-duty vices.

After the conductor is pulled into place, the sag between the structures would be adjusted to a pre-calculated level. The conductor would then be attached to the end of each insulator, the sheaves would be removed, and the vibration dampers and other hardware accessories would be installed. The lowest 69 kV conductor would be installed with a minimum ground clearance of approximately 30 feet, and 25 feet where there is pedestrian access only. The lowest 12 kV conductor would be installed with a minimum ground clearance of 25 feet, and 17 feet where there is pedestrian access only. SDG&E would accomplish the removal of existing conductors in a method similar to the reverse of the conductor installation process. The old conductors would be wound onto wooden spools, placed on flatbed trucks, and recycled at an approved facility, such as the MECO yard in Pine Valley.

7.2.5 Underground Duct Package and Installation

Prior to trenching for underground distribution lines, SDG&E would notify other utility companies (via Underground Service Alert) to locate and mark existing underground utilities along the proposed underground alignments. Exploratory excavations (potholing) would also be conducted to verify the locations of existing facilities in the field, if necessary.

Trenches would be excavated using a backhoe, saw cutter, and other trenching equipment as warranted by site conditions. The depth of the trench would be determined by localized topography and potential conflicts, but is anticipated to be approximately five feet deep, with a width of approximately 2.5 feet. Dewatering of the trenches is not anticipated, but may be required based on weather conditions during construction. If trench water is encountered, trenches would be dewatered using a portable pump and disposed of in accordance with applicable regulations and permits. Once installed, the depth from grade to the top of the concrete duct package would be approximately 2.5 feet, and the depth from grade to the top of the conduit in the duct package would be approximately three feet. The trench alignment would proceed to the riser pole and support the transition from the underground to overhead conductors. Five new riser poles included as part of the Proposed Action and one new riser pole included as part of Similar Actions would be installed with the same equipment previously described for installation of the steel poles. Table 11: 12 kV Distribution Line Underground Trenching Summary provides the approximate dimensions, footprint, and number of vaults to be used for each underground segment of the Proposed Action and Similar Actions.

The underground distribution lines would be installed in a duct bank containing two to three 4- to 5-inch-diameter PVC conduits encased in concrete or placed in sand or native fill. A typical drawing of the proposed duct bank has been included in Attachment E: Typical Drawings. In order to facilitate the pulling and splicing of the cables, underground concrete splice vaults measuring approximately eight feet long, 5.5 feet wide, and seven feet deep would be installed in

Table 11: 12 kV Distribution Line Underground Trenching Summary

Distribution Line	Approximate Length (miles)			Approximate Width (feet)	Approximate Footprint (acres)			Approximate Number of Vaults		
	Within CNF	Outside CNF	Total		Within CNF	Outside CNF	Total	Within CNF	Outside CNF	Total
C79	0.0	2.8	2.8	2.5	0.0	0.9	0.9	0	19	19
C440	7.5	0.8	8.4	2.5	2.3	0.3	2.5	51	4	55
C449	1.5	0.3	1.8	2.5	0.4	0.1	0.5	10	2	12
Total	**9.0**	**4.0**	**13.0**	**- -**	**2.7**	**1.2**	**3.9**	**61**	**25**	**86**

line with the underground duct banks every approximately 500 to 800 feet. These vaults would also provide access to the underground cables for maintenance, inspection, and repair during operation.

During trenching activities, the trench would be widened at the underground vault locations to allow for approximately two feet of additional clearance. The pre-formed, steel-reinforced, precast concrete splice vaults would be transported to the associated work areas on flatbed trucks and lowered into place using small, truck-mounted cranes. The splice vaults would then be connected to the underground duct banks before being covered with at least three feet of compacted fill. The trench alignment would proceed to the riser pole and support the transition between the underground and the overhead conductors.

After installation of the concrete duct bank, approximately 18,040.0 CY of excavated trench material would be used to backfill the trench as part of the Proposed Action, and approximately 8,017.8 CY of excavated trench material would be used to backfill the trench as part of Similar Actions. SDG&E does not anticipate that engineered backfill would be required. The remainder of the excavated material would be spread across the ROW or access roads, if possible, or disposed of at an approved facility, such as the MECO yard in Pine Valley. SDG&E does not anticipate encountering contaminated soils based on the results of the Phase I Environmental Site Assessment conducted for the Proposed Action.

After trenching activities for the underground duct banks have been completed, the PVC cable conduits would be installed (and separated by spacers), and concrete would be poured around the conduits to form the duct banks. As part of the Proposed Action, approximately nine miles of undergrounding for lines C440 and C449 would result in the temporary excavation of approximately 22,000 CY of soil and other native materials. As part of Similar Actions, approximately four miles of undergrounding for lines C79, C440, and C449 would result in the temporary excavation of approximately 9,777.8 CY of soil and other native materials. Upon completion of the duct bank, the trenches would be backfilled with these materials and the cables would be installed in the duct banks. Each cable segment would be pulled into the duct bank and terminated at the riser pole where the line converts to an overhead configuration. To pull the cable through the ducts, a cable reel would be placed at one end of the section and a pulling rig at the other end. A larger rope would then be pulled into the duct using a fish line and attached to the cable puller, which pulls the cable through the duct. Lubricant would be applied to the cable as it enters the duct to decrease friction during pulling. After installation of the conductor, the ground surface would be restored to near pre-construction conditions and repaved or reseeded as appropriate.

7.2.6 Cleanup and Post-Construction Restoration

All areas that are temporarily disturbed around each structure, areas used for conductor pulling, and all staging areas would be restored to pre-construction conditions, to the extent practicable, following installation of the replacement poles and reconductoring of the lines. This would include the removal of all construction materials and debris, returning areas to their original contours, and reseeding, as needed.

7.3 EROSION AND SEDIMENT CONTROL AND POLLUTION PREVENTION

Approximately 159.1 acres of grading would occur within USFS-administered lands as part of the Proposed Action, including minor grading and vegetation clearing associated with the use of temporary construction work areas and access roads. Approximately 139.2 acres of grading would occur in connection with 69 kV power line facilities outside of the CNF as Connected Actions, including minor grading and vegetation clearing associated with the use of temporary construction work areas and access roads. Approximately 11.6 acres of grading would occur in connection with distribution line facilities outside of the CNF as Similar Actions, including minor grading and vegetation clearing associated with the use of temporary construction work areas and access roads.

Because ground disturbance would be greater than one acre, SDG&E would obtain coverage under the California State Water Resources Control Board (SWRCB) General Permit for Storm Water Discharges Associated with Construction Activity Order No. 2009-009-DWQ (General Permit). In order to obtain coverage under the permit, SDG&E would develop and submit Permit Registration Documents, including a Notice of Intent, SWPPP, risk assessment, site map, certification, and annual fee to the SWRCB prior to initiating construction activities.

The SWPPP would be prepared by a qualified SWPPP developer and would identify BMPs for each activity that has the potential to degrade surrounding water quality through erosion, sediment run-off, and other pollutants. The SWPPP would also include the USFS requirements of an erosion control plan. The BMPs would be selected based on SDG&E's Water Quality BMPs Manual and would likely include, but are not limited to, preservation of existing vegetation, tracking controls, storm drain/drainage inlet protection, stockpile management, temporary soil stabilization, dust control, spill control, and solid waste management. These BMPs would then be implemented and monitored by a qualified SWPPP practitioner. Construction waste would be disposed of promptly at the MECO yard in Pine Valley or at another approved location to prevent these materials from polluting waterways.

The Proposed Action includes actions that have been working successfully over the past few years to address erosion concerns. These actions include the following:

- Using existing access roads only
- Recording and examining videos of existing public and private access road segments to document their condition prior to construction
- Maintaining access roads during their use for construction activities to ensure that they are left in equal or better condition than prior to construction use
- Smoothing existing dirt roads by removing ridges, especially following storm events
- Installing rolling water bars
- Utilizing turn-around locations rather than crossing through creeks, where applicable

More specifically, the Proposed Action includes specific actions that have been implemented successfully on the north slope of Barber Mountain and along Boulder Creek. At Barber Mountain, the Proposed Action includes regular maintenance of the road, vegetation trimming or maintenance every other year, and refreshing the BMPs (e.g., water bars and fiber rolls) to promote continued effectiveness.

The Proposed Action also includes actions that have been successful along Boulder Creek, including prohibiting vehicle use within Boulder Creek. The Proposed Action further includes permanent reconfiguration of the existing access road to prohibit travel through Boulder Creek for access to poles Z372130 and Z372131. The Proposed Action instead includes turn-around locations on either side of Boulder Creek, which would eliminate the creek crossing while maintaining necessary access to these poles.

Construction activities that involve placement of native, clean soil would be managed by employing BMPs that minimize soil erosion and impacts on surrounding vegetation per SDG&E's Water Quality BMPs Manual. BMPs such as silt fencing or fiber rolls would be installed where necessary (e.g., high velocity flow areas and steep slopes), and soil would be placed and compacted in a manner that sufficiently controls erosion and sediment discharge from the site.

7.4 FIRE PREPAREDNESS

During construction activities for the Proposed Action, SDG&E would comply with all applicable state and federal regulations, requirements, and procedures consistent with SDG&E Electric Standard Practice (ESP) No. 113-1 Wildland Fire Prevention & Fire Safety (July 2012) and SDG&E Electric Distribution Operation (EDO) Procedure 3017 EDO's Requirements During SDG&E Fire Conditions (September 2009). These two existing guidance documents provide background, procedure, and guidance information concerning electric line-related activities in areas where fire hazards exist, as described in the following sections. SDG&E would continue to implement these practices and procedures across all construction activities for the Proposed Action to minimize the potential for fire to occur as a result of construction of the Proposed Action. Additional existing procedures that would be implemented during operation and maintenance of the Proposed Action are described in Section 10.3 Fire Hazards of this Revised POD.

7.4.0 ESP No. 113-1 Wildland Fire Prevention & Fire Safety (July 2012)

This ESP is applied to all low complexity construction projects, as well as operation and maintenance activities, to set standards and requirements regarding how activities and fire conditions are evaluated, what restrictions must be put into place depending on anticipated fire conditions, and what tools, equipment, and other measures must be on site or in place according to these anticipated fire conditions. The ESP determines potential fire conditions based on National Weather Service (NWS) criteria, including Red Flag Warning (RFW) conditions, as well as SDG&E meteorological evaluation and assessment. Additionally, the ESP includes consideration of the USFS's Project Activity Level (PAL) designations, which were designed to help fire and timber resource managers establish the level of industrial precaution for the following day. Although intended for the timber industry, SDG&E includes these anticipated fire hazard conditions and corresponding activity restrictions, and would continue to comply with the PAL designations as a part of standard operating procedures.

In addition to keeping at each work area, or with each vehicle, the standard fire prevention and response equipment identified in Section 4.3 Tools and Equipment of the ESP, SDG&E would implement for the Proposed Action the standard fire prevention and fire safety measures included in the ESP. These measures include:

- Prohibiting vehicle idling or parking in areas of brush, grass, or vegetation litter
- Utilizing a fire patrol on high fire danger days to verify compliance with the Proposed Action's fire plan, observing activities for consistence with the fire prevention and safety measures, and checking each work area following the day's activities
- Conducting standard wind monitoring as reporting this information according to standard procedures
- Providing appropriate vegetation clearance or reduction around particularly hazardous work activities or work areas
- Ensuring exhaust systems are clear of vegetation and other combustible debris before operating portable equipment
- Wetting down adjacent vegetation when performing work that could create fires.

The ESP also includes measures concerning fire safety, such as the use of personal protective equipment and the evaluation of safety zones and escape routes when working in wildland areas during high fire danger days. During a declared RFW, SDG&E would implement further restrictions from the ESP, including:

- All electric lines within the SDG&E wildland fire area will not be tested without patrol for the duration of the RFW
- All non-critical line clearance tree pruning and removal activities will cease (hand pruning activities are permissible)
- All blasting will be discontinued
- No smoking will be permitted
- Vehicular travel will be restricted to cleared roads except in case of an emergency; no vehicles with hot exhaust systems will be driven over or parked in grassy areas

7.4.1 EDO Procedure 3017 EDO's Requirements During SDG&E Fire Conditions (September 2009)

EDO 3017 defines restrictions that apply to SDG&E's activities in high fire risk areas and the SDG&E Wildland Fire Area and is updated annually to include any changes to the mapped extents of these areas or adjustments to standard procedures that may have occurred. This document also defines standard, summer, and elevated operating conditions and the corresponding procedures for reclosing relay functions and fault testing circuits during these various operating conditions. According to EDO 3017, when an RFW has been declared, all reclosing relays must be turned off on all circuit breakers and service restorers according to which NWS Fire Weather Zone is included in the RFW.

7.5 EQUIPMENT

Table 10: Access Road Construction Equipment summarizes equipment used to maintain existing access roads and construct new roads, if needed, based on final design and project approval. Attachment G: Construction Equipment Summary provides the equipment that would be used to construct or maintain each Proposed Action component, Connected Actions, and Similar Actions, along with its approximate duration of use. In addition to this equipment, SDG&E expects pick-up trucks and worker vehicles to travel daily to and from the work site of each Proposed Action, Connected Actions, and Similar Actions component. Delivery trucks would likely travel to and from the staging areas 12 times per week, or up to 24 times per week during peak activities. Approximately one water truck, completing an average of two trips per day, may be required to deliver water to each active construction site for dust control, compaction, and fire protection. All vehicles and equipment would be used in accordance with SDG&E's Wildland Fire Prevention and Fire Safety Standard Practice.

7.6 SCHEDULE

SDG&E anticipates that construction of the entire Proposed Action as well as all Connected Actions and Similar Actions would take approximately five years from initial site development through final energization, including phasing as appropriate to avoid potential impacts to biological resources. Table 12: Proposed 69 kV Power Line Construction Schedule and Table 13: Proposed 12 kV Distribution Line Construction Schedule summarize the length of time and activities anticipated to construct each electric line.

Upon USFS approval of the Proposed Action, SDG&E would commence with construction of the distribution line fire hardening projects located within the CNF. SDG&E would proceed with construction of the 69 kV power line fire hardening projects as soon as CPUC approval of those projects is received. Construction activities would generally be limited to no more than 12 hours per 24-hour period, six days per week, as needed. On occasion, construction activities may be required at night or on weekends to minimize impacts to schedules and to facilitate cutover work, and as required by other property owners or agencies, such as the CAISO, which may require outages of certain portions of the electric system. If construction occurs outside of the hours allowed by San Diego County, SDG&E would follow its established protocols and would provide advance notice by mail to all property owners within 300 feet of planned construction activities. The announcement would state the construction start date, anticipated completion date, and hours of construction.

7.7 PERSONNEL

Table 14: Peak 69 kV Power Line Construction Personnel and Table 15: Peak 12 kV Distribution Line Construction Personnel provide the positions and number of personnel anticipated to be on site for each electric line during peak construction. Construction of each power line would be phased according to the schedule shown in Table 12: Proposed 69 kV Power Line Construction Schedule and Table 13: Proposed 12 kV Distribution Line Construction Schedule. Removal of existing poles would occur immediately following new conductor installation unless third-party facilities are present, which may temporarily delay existing pole removal by approximately 30 to 60 days until the third party relocates its facilities.

Table 12: Proposed 69 kV Power Line Construction Schedule

69 kV Power Line	Approximate Duration of Construction (Number of crew days[11])	Anticipated Construction Period (Months)
TL625B	270	7
TL625C	430	9
TL625D	210	5
TL626A	340	8
TL626B	290	7
TL629A	400	8
TL629C	210	5
TL629D	170	4
TL629E Overhead	280	11
TL629E Underground	48	1
TL682	580	9
TL6923	330	8

Table 13: Proposed 12 kV Distribution Line Construction Schedule

12 kV Distribution Line	Approximate Duration of Construction (Number of crew days[11])	Anticipated Construction Period (Months)
C78	50	4
C79 Overhead	35	4
C79 Underground	125	6
C157	85	4
C440 Overhead and Underground	685	18
C442	165	6
C449	225	6

[11] Crew days are equivalent to one crew operating for 10 hours within one calendar day. Because multiple crews may be operating during a single calendar day, there are typically multiple crew days per calendar day.

Table 14: Peak 69 kV Power Line Construction Personnel

69 kV Power Line	Approximate Number			
	Foreman	Operator	Lineman	Underground Crew
TL625B	3	10	20	0
TL625C	3	10	20	0
TL625D	3	10	20	0
TL626A	3	10	20	0
TL626B	3	10	20	0
TL629A	3	10	20	0
TL629C	3	10	20	0
TL629D	3	10	20	0
TL629E	3	10	20	8
TL682	3	10	20	0
TL6923	3	10	20	0

Table 15: Peak 12 kV Distribution Line Construction Personnel

12 kV Distribution Line	Approximate Number			
	Foreman	Operator	Lineman	Underground Crew
C78	1	6	2	0
C79	1	2	2	5
C157	1	3	2	0
C440	1	2	2	6
C442	1	5	2	0
C449	1	2	2	7

After the completion of construction, the electric lines would be operated and maintained by SDG&E at existing staffing levels. No additional staff would be necessary to maintain the electric lines.

8 – OPERATION AND MAINTENANCE ACTIVITIES

This section describes the standard operation and maintenance activities and procedures that SDG&E currently conducts and would continue to conduct, both pending agency review of the Proposed Action and after the Proposed Action and all Connected Actions and Similar Actions are constructed and in service. For decades, SDG&E has continuously operated the facilities that would be modified by the Proposed Action, Connected Actions, and Similar Actions described in this Revised POD. During the MSUP review and approval process, SDG&E must continue to operate and maintain its existing facilities to ensure continued electric service and reliability. Operation and maintenance activities that would continue to occur during the pendency of the MSUP review and approval process may range from routine inspections and preventive maintenance to potential emergency repair or replacement work. Work conducted by SDG&E during the pendency of the MSUP review would comply with SDG&E’s standard operation and maintenance practices and protocols, and would be subject to any required approvals or authorizations. Consistent with SDG&E’s existing practice, SDG&E would continue to coordinate with and notify the USFS of work activities within the CNF. Following the completion of all construction activities, SDG&E would continue to conduct these operation and maintenance activities consistent with SDG&E’s existing protocols and procedures, including SDG&E’s Subregional NCCP and Quino Checkerspot Butterfly (*Euphydryas editha quino*) (QCB) Low-Effect Habitat Conservation Plan (HCP) (QCB HCP), which is described in greater detail in Section 10.1 Biological Resources.

SDG&E would continue to regularly inspect, maintain, and repair the electric lines pending agency review and following completion of Proposed Action construction activities. These activities range from routine preventive maintenance to emergency repairs and replacements required to maintain service continuity and reliability. SDG&E performs aerial and ground inspections of electric line facilities and patrols aboveground components on a regular basis in compliance with CPUC General Order 165. Inspection for corrosion, equipment misalignment, loose fittings, and other common mechanical problems is performed every three years (per CPUC General Order 165) for overhead 69 kV power lines. SDG&E inspects underground electric lines every three years from inside the concrete splice vaults.

SDG&E maintains a working space of a minimum of 10 feet in diameter around all steel poles. SDG&E keeps these areas clear of shrubs and other obstructions for inspection and maintenance purposes, consistent with Public Resources Code (PRC) Section 4293 and CPUC General Order 95 requirements. In addition, vegetation that has a mature height of 15 feet or taller is not allowed to grow within 10 horizontal feet of any conductor within the ROW for safety and reliability reasons per CPUC General Order 95.

The following discussion provides an overview of the types of activities that currently take place for existing poles and would continue to occur after construction of the Proposed Action. Unless otherwise noted, all vehicles would have rubber tires. These activities are considered part of the environmental baseline and environmental setting for the Proposed Action.

8.0 RIGHT-OF-WAY REPAIR

ROW repair methods include grading previously built (e.g., road re-establishment) and existing access roads and spot-repair of erosion sites where access roads may be subject to scouring. SDG&E performs ROW repairs as necessary, usually following seasonal rains, and requires the use of a four-wheel-drive pick-up truck, a motor grader, a backhoe, and/or a skid steer loader. The skid steer loader has steel tracks, while the remaining equipment has rubber tires.

8.1 POLE BRUSHING

In accordance with fire break clearance requirements stipulated in PRC 4292 and California Code of Regulations, Title 14, Section 1254, SDG&E would trim or remove vegetation in the area surrounding 69 kV power line and 12 kV distribution line poles to reduce potential fire and other safety hazards. Dead, diseased, or dying limbs and foliage from living, sound trees are removed from approximately eight feet above ground to the horizontal plane of the highest point of conductor attachment; dead, diseased, or dying trees are also removed. From ground level to approximately eight feet above ground level, SDG&E removes flammable trash, debris, or other materials; grass; herbaceous and brush vegetation; and limbs and foliage of living trees. For all steel poles, SDG&E clears to bare ground an approximately 10-foot-radius around the pole, and trims all encroaching trees or other vegetation within approximately 10 feet of the pole. Three-person crews typically conduct this work using mechanical equipment consisting of chain saws, weed trimmers, rakes, shovels, and brush hooks. SDG&E typically inspects poles on an annual basis to determine if brushing is required.

8.2 APPLICATION OF PESTICIDES

SDG&E does not currently use pesticides within the CNF. Pest control is typically only necessary at substations and storage facilities; therefore, insecticide and rodenticide use is not anticipated for the facilities included in the Proposed Action. However, if pesticide use is determined to be prudent to safely maintain the 69 kV power lines and 12 kV distribution lines within the CNF, a pesticide use request that provides a schedule for a 12-month period would be submitted annually to the USFS for approval. The draft MSUP Operating Plan includes provisions for pesticide use. Consistent with SDG&E Safety Standard G8367 Pesticide Management and as described in the draft MSUP Operating Plan, SDG&E may use one of more of the following insecticides:

- Hit Squad Industrial Insecticide
- Blast ‘Em (Wasp & Hornet Killer)

Similarly, SDG&E may use one or more of the following herbicides during pole brushing, cut-stump treatments associated with tree removals, or other operation and maintenance activities where vegetation removal is necessary for fire safety reasons:

- Rodeo
- Roundup
- Roundup Pro
- Accord Concentrate
- Gallery 75DF
- Garlon 4 Ultra
- Landmark XP
- Milestone
- Pathfinder
- Payload
- Stalker
- Spra-Kil SK-26
- Dimension Ultra 40

If the use of herbicides is determined to be necessary within the CNF in the future, SDG&E would work with the USFS to obtain authorization for the specific uses for which herbicides are required. Prior to any herbicide use within the CNF, SDG&E would submit an anticipated schedule to the USFS for any proposed herbicide use on an annual basis, or more frequently as needed, and would work with the USFS to determine the appropriate herbicide per location. Herbicide application would occur under the direction of a professional pesticide applicator with either a Qualified Applicator License or an Agricultural Pest Control Adviser License in the State of California.

8.3 EQUIPMENT REPAIR AND REPLACEMENT

Poles or structures may support a variety of equipment, such as conductors, insulators, switches, transformers, lightning arrest devices, line junctions, and other electrical or safety equipment. SDG&E may need to add, repair, or replace this type of equipment in order to maintain uniform, adequate, safe, and reliable service. SDG&E may remove and replace an existing structure with a larger and stronger structure at the same location or a nearby location due to damage or changes in conductor size, including under emergency conditions. Equipment repair or replacement generally requires a crew to gain access to the location of the equipment to be repaired or replaced. If no vehicle access exists, the crew and all necessary materials are flown in by helicopter.

8.4 INSULATOR WASHING

In some areas prone to atmospheric moisture, condensation combined with dust on porcelain insulators can create an electrical discharge. This discharge, known as “arcing,” may cause outages. SDG&E can prevent the outages caused by this condition by washing the insulators routinely. The process of washing insulators involves driving a washer truck to within six feet of the facility and using a high-pressure hose to spray deionized water at the insulators. A two-person crew driving a washer truck would be required for this operation. The space needed at each location is approximately 30 feet by 40 feet. Typically, approximately 30 minutes is required to wash and set up each insulator pole set. SDG&E typically inspects insulators on an annual basis to determine if washing is required.

8.5 TREE TRIMMING

Tree trimming plays a critical role in maintaining a safe and reliable electrical system. Tree limb contact with electric lines may cause power outages. Fast-growing or diseased, dying, or dead trees may require removal during operation and maintenance of the electric lines to prevent circuit interruptions or reduce potential fire hazards. Regular inspection, regardless of habitat type, is necessary to maintain proper tree-to-conductor clearances consistent with PRC Section 4293 and CPUC General Order 95. SDG&E typically conducts tree-trimming activities with a two- to three-person crew, a one-person aerial lift truck, and a chipper trailer. Although the time required to complete tree trimming varies according to location, SDG&E can complete typical tree-trimming activities in one day. SDG&E annually inspects trees in the SDG&E service area for trimming needs.

8.6 USE OF HELICOPTERS

SDG&E uses helicopters in the visual inspection of overhead facilities. SDG&E patrols each electric line several times a year via helicopter. SDG&E may also use helicopters to deliver personnel and equipment, position poles and structures, string lines, and position aerial markers, as required by FAA regulations. SDG&E’s Transmission and Distribution Engineering departments use helicopters for patrolling electric lines during trouble jobs (e.g., outages or service curtailments) in areas that have no vehicle access or rough terrain. For patrolling during such jobs, the helicopter picks up the patrolman at the district yard and lands within a reasonable, safe walking distance of the structures targeted for service. For new construction or maintenance, the helicopter needs a flat staging area for fueling and picking up material, equipment, and personnel. The area required for small helicopter staging is generally 100 feet by 100 feet. The size of the crew needed varies from four to 10 crew members, two helicopter staff, and a water truck driver to apply water for dust control at the staging area. Most helicopter operations take only one day.

8.7 FIRE PROTECTION

SDG&E would continue to implement ESP No. 113-1 and EDO 3017, as described in Section 7.4 Fire Preparedness, during operation and maintenance. Additionally, SDG&E would comply with all applicable state and federal regulations, requirements, and procedures when conducting operation and maintenance activities within the CNF. All operation and maintenance activities performed within the CNF would be subject to a fire plan specific to the MSUP. This plan would be consistent with existing SDG&E fire plans for the CNF and would follow any applicable PAL designations, requiring monitoring and communication regarding predicted PAL indices the day prior to any activities in areas within or adjacent to wildland fuels and vegetation in the SDG&E High-Risk Fire Area, as discussed in Section 10.3 Fire Hazards.

9 – REQUIRED PERMITS AND AUTHORIZATIONS

Environmental review under NEPA is required for the Proposed Action because the USFS' approval of the Proposed Action constitutes a major federal action. An EA for the issuance of an MSUP was completed in 2009, after which the initial Proposed Action was expanded as described in this Revised POD and the accompanying SF-299 Application. The USFS has previously concluded that an EIS is required to evaluate the proposed fire hardening activities that are now included in the Proposed Action. The EIS would inform the decision-makers and the public of the potential environmental impacts that may result from the Proposed Action. The USFS would also conduct Section 106 consultation under the National Historic Preservation Act (NHPA) of 1966 for the protection of historic properties that are included in the National Register of Historic Places (NRHP) or that meet the criteria for the NRHP.

In addition to USFS approval and NEPA review, the proposed fire hardening of five 69 kV power lines is subject to CPUC review. To streamline CPUC and public review of these proposed activities, SDG&E anticipates filing a request for authorization to construct the five 69 kV power lines (each of which is considered a separate project) on one application for a Permit to Construct. CPUC approval is not required for any of the proposed 12 kV distribution line work, either within or outside of the CNF.

SDG&E would obtain all required approvals for all construction activities from federal, state, and local agencies, as applicable. Table 16: Anticipated Permits and Approvals lists the potential permits and approvals that may be required for these construction activities.

10 – PRELIMINARY ENVIRONMENTAL RESOURCE EVALUATION

In order to further supplement the SF 299, the following subsections describe the potential for, and proposed corresponding mitigation to address, potential impacts relating to air quality, biological resources, cultural resources, fire hazards, hydrology, noise, transportation and traffic, wilderness and recreation, and visual resources. Construction of the Proposed Action may temporarily impact each of these environmental resources, but these impacts would be fully mitigated by incorporating existing SDG&E practices and protocols (such as the NCCP) and the applicant-proposed measures (APMs) provided in the following sections.[12] To the extent operation and maintenance of the Proposed Action would occur in the same location as existing facilities and would have the same or substantially the same potential impacts, frequency, and

[12] SDG&E has extensive experience constructing, operating, and maintaining 69 kV and 12 kV electrical facilities. Over time, SDG&E has developed standard practices and protocols that are ordinarily incorporated into construction, and operation, and maintenance activities. These ordinary operating restrictions include, among other things, restrictions developed to comply with other applicable regulations, accepted as BMPs within the industry to minimize potential environmental impacts, and/or designed to meet internal SDG&E goals and standards. These ordinary operating restrictions are also sometimes referred to as design features or Applicant Proposed Measures.

The ordinary operating restrictions incorporated into the design of the Proposed Action will avoid or minimize potential environmental resource impacts and are considered part of the baseline for the Proposed Action.

Table 16: Anticipated Permits and Approvals

Agency	Permit/Consultation/Approval	Jurisdiction/Purpose
Federal Agencies		
USFS	NEPA compliance	Issuance of a federal permit
	MSUP	Consolidate prior use authorizations and easements for electric facilities on federal lands
	SF 299	Amend prior authorizations on federal lands
	National Historic Preservation Act Section 106 Review	Activities on federal land that may affect cultural or historic resources
U.S. Army Corps of Engineers (USACE)	Clean Water Act Section 404 Nationwide or Individual Permit	Fill of waters of the U.S.
FAA	Permission to Fly Helicopters	Activities that may affect air traffic
State Agencies		
CPUC	Permit to Construct	Construction of facilities between 50 and 200 kV
SWRCB	National Pollutant Discharge Elimination System – Construction Storm Water Permit	Storm water discharges associated with construction activities disturbing more than one acre of land
California Department of Fish and Wildlife (CDFW) (formerly known as the California Department of Fish and Game)	California Fish and Game Code Section 1600 Streambed Alteration Agreement	Activities that would disturb the bed or bank of a jurisdictional water body
Regional Water Quality Control Board (RWQCB)	Clean Water Act Section 401 Water Quality Certification	Activities authorized by federal agencies that may affect state water quality
California Department of Transportation (Caltrans)	Encroachment Permit	Construction of facilities within, under, or over state highway ROW
Local Agencies		
San Diego County	Encroachment Permit	Construction of facilities within, under, or over county road ROW

duration as operation and maintenance activities of the existing facilities, such activities are incorporated into the existing environmental setting and baseline for assessing potential impacts.

Because the Proposed Action would replace existing electric lines, and SDG&E would operate and maintain these electric lines in a manner similar to that which is currently prescribed, no impacts to environmental resources are anticipated from operation and maintenance of the electric lines. Similarly, because the electric lines, access roads, and other appurtenant facilities included in the Proposed Action are existing facilities, and because the Proposed Action would not increase system capacity or open new areas to development, there would be no growth-inducing impacts to the surrounding area as a result of the Proposed Action.

The Applicant Proposed Measures that have been incorporated into the design of the Proposed Action are described in the resource sections below and listed in Attachment H: Applicant-Proposed Measures.

10.0 AIR QUALITY

The San Diego County Air Pollution Control District (SDAPCD) is responsible for establishing and enforcing local air quality rules and regulations that address the requirements of federal and state air quality laws. Air quality is determined by measuring ambient concentrations of criteria pollutants, which are air pollutants for which acceptable levels of exposure can be determined and for which standards have been set. The degree of air quality degradation is then compared to the current National Ambient Air Quality Standards (NAAQS) and California Ambient Air Quality Standards (CAAQS). Because of unique meteorological conditions in California, and because of differences of opinion by medical panels established by the California Air Resources Board (CARB) and the U.S. Environmental Protection Agency (EPA), there is diversity between State and federal standards currently in effect in California. In general, the CAAQS are more stringent than the corresponding NAAQS.

Each geographic area is designated by either the U.S. EPA or the CARB as a nonattainment area if violations of the ambient air quality standards are persistent. San Diego County is classified as a nonattainment area for the State ozone standard, and like nearly every other area in the State of California, it is a nonattainment area with respect to particulate matter (PM) less than 10 microns in diameter (PM_{10}). San Diego County was successfully designated as an attainment area for the federal 1-hour ozone standard in 2003, but since the U.S. EPA established designations for the 8-hour ozone standard, the County has since been designated as a nonattainment area for this newer federal standard. The Proposed Action would have significant impacts on air quality if activities associated with the Proposed Action would:

- Cause or contribute to any new violation of NAAQS or CAAQS in the project area
- Interfere with the maintenance or attainment of NAAQS or CAAQS
- Increase the frequency or severity of any existing violations of NAAQS or CAAQS
- Delay the timely attainment of any standard, interim emission reduction, or other air quality milestone promulgated by the U.S. EPA, the CARB, or a local air quality agency.

In federal nonattainment areas, the federal General Conformity rule (42 U.S. Code Section 7606(c), Code of Federal Regulations, Title 40, Section 51, Subpart W) would provide additional significance criteria. In San Diego County, there are no applicable General Conformity thresholds for pollutants other than ozone precursors, such as volatile organic compounds (VOCs), because these areas attain the federal ambient air quality standards for all other pollutants. The General Conformity applicability *de minimis* threshold for VOCs in the Proposed Action area is 100 tons/year. The General Conformity applicability *de minimis* threshold for carbon monoxide (CO)—100 tons per year—is also taken into consideration as the area is designated as a maintenance area.

These thresholds apply to emissions in a federal nonattainment or maintenance area caused by a federal action. Per Section 176(c) of the Clean Air Act Amendments of 1990, the USFS must make a determination of whether the Proposed Action (i.e., federal action) “conforms” to the applicable State Implementation Plan (SIP) (i.e., the SDAPCD ozone SIP). However, if the total direct and indirect emissions caused by a Proposed Action are less than the General Conformity rule *de minimis* emission thresholds, the Proposed Action would be exempt from performing a comprehensive Air Quality Conformity Analysis, because it would be presumed to conform to the SIP within the nonattainment areas. The final General Conformity determination would be made by the USFS prior or to or in conjunction with approval of the Proposed Action. The estimated nonattainment area pollutant emissions, the preliminary findings with regards to the General Conformity *de minimis* levels, and the applicability of a full conformity determination are described in the following sections.

For purposes of the California Environmental Quality Act (CEQA), the SDAPCD has also established thresholds of significance for air quality impacts to be used when assessing potential pollutant emissions. Based on criteria applied in or adapted from the SDAPCD regulations for stationary sources (pursuant to Rule 20.1, *et seq*.), SDG&E assumes the Proposed Action’s impacts on criteria air pollution would be significant if it does the following during construction:

- result in direct emissions of more than 55 pounds per day (lbs/day) of PM less than 2.5 microns in diameter ($PM_{2.5}$);
- result in direct emissions of more than 100 lbs/day of PM_{10};
- result in direct emissions of more than 250 lbs/day of nitrogen oxides (NO_x);
- result in direct emissions of more than 250 lbs/day of sulfur oxides;
- result in direct emissions of more than 550 lbs/day of CO; or
- result in direct emissions of more than 75 lbs/day of VOCs.[13]

10.0.0 Proposed Action

The primary source of criteria air pollutant emissions during construction activities for the Proposed Action would stem from the use of heavy equipment, including crew trucks, compressors, drilling rigs, and helicopters. A list of equipment anticipated to be used during construction is provided in Attachment G: Construction Equipment Summary. Each phase of construction would require different equipment, and often multiple pieces of equipment would be required to operate simultaneously. In addition, many pieces of equipment require engine-

[13] In the absence of lbs/day VOC significance thresholds in the SDAPCD’s rules, VOC thresholds were derived from the County of San Diego Land Use and Environment Group’s Draft Guidelines for Determining Significance and Report Format and Content Report Format and Content Guidance Requirements, Air Quality.

idling to provide energy for equipment operation, such as for truck-mounted drills or compressors. Helicopters would be used to deliver personnel and equipment and position poles and structures where truck access is not available, and would also be used to string lines and position aerial markers where necessary.

Due to the large number of poles to be removed and replaced and the significant amount of construction required to underground approximately nine miles of distribution line, a large number of crews would be required to work on multiple electric lines throughout the approximate five-year construction schedule. Because of the overlapping construction schedules for these lines and the amount of equipment required to operate during construction activities, pollutant emissions are anticipated to occur but would be dispersed throughout the air basin according to the specific locations of construction.

Based on the currently anticipated schedule and construction equipment required for the Proposed Action, the Proposed Action would emit a maximum of approximately 4.2 tons/year of VOCs, well below the General Conformity applicability *de minimis* threshold for VOCs. In addition, the Proposed Action would emit a maximum of approximately 17.5 tons per year of CO, which also falls below the General Conformity applicability *de minimis* threshold for CO. The Proposed Action's largest emission would be of NO_x; the maximum annual emission of this pollutant would be approximately 33.0 tons/year, which is also well below the federal threshold of 100 tons/year that would be applied were San Diego County a nonattainment area for this pollutant.

Pollutant emissions resulting from heavy equipment used during construction are anticipated to exceed levels established by the SDAPCD for VOCs, NO_x, CO, and $PM_{2.5}$. Table 17: SDAPCD Criteria Air Pollutant Exceedances During Construction – Proposed Action lists the threshold and maximum emissions rate (lbs/day) during the approximately five-year construction schedule for all criteria air pollutants, as well as the approximate number of days during which exceedances would occur.

Table 17: SDAPCD Criteria Air Pollutant Exceedances During Construction – Proposed Action

Pollutant	Threshold (lbs/day)	Maximum (lbs/day)	Approximate Number of Weeks Exceeded
VOCs	75	136.56	19
NO_x	250	1,082.4	55
CO	550	571.08	1
Sulfur Dioxide (SO_2)	250	1.52	0
PM_{10}	100	71.18	0
$PM_{2.5}$	55	63.18	2

In addition to emissions from heavy equipment use, wood-to-steel pole replacement would involve a relatively small amount of daily ground disturbance, which would contribute to an increase of fugitive dust in the vicinity of the Proposed Action. The majority of ground disturbance and the potential for fugitive dust would result from undergrounding portions of C440 and C449 where, due to local geologic conditions, crews would likely be required to excavate through bedrock located beneath the surface of the roads where the undergrounding is proposed to occur. According to the design of the Proposed Action, however, a total of only approximately 159.1 acres of temporary ground disturbance would occur from all Proposed Action construction activities over approximately five years. Because ground disturbance would be relatively small in size at each construction location and fugitive dust emissions would be limited to the areas surrounding the Proposed Action work areas, impacts from $PM_{2.5}$ resulting from fugitive dust emissions are anticipated to be minor.

There is also the potential for air quality impacts from airborne dust to occur as a result of the use of access roads. However, airborne dust generated during access road use would be limited to the immediate vicinity of the access road, and would occur only instantaneously as vehicles traverse the access roads. In order to reduce potential impacts to air quality from the Proposed Action, SDG&E would implement the following APMs during construction:

- APM-AIR-01: To the extent feasible, unnecessary construction vehicle and idling time would be minimized. The ability to limit construction vehicle idling time is dependent upon the sequence of construction activities and when and where vehicles are needed or staged. Certain vehicles, such as large diesel-powered vehicles, have extended warm-up times following start-up that limit their availability for use following start-up. Where such diesel-powered vehicles are required for repetitive construction tasks, these vehicles may require more idling time. The project would apply a "common sense" approach to vehicle use; if a vehicle is not required for use immediately or continuously for construction activities, its engine would be shut off.

- APM-AIR-02: To control fugitive dust, SDG&E would apply water or non-toxic soil stabilizers on all unpaved access roads, staging areas, and other work areas if construction activity causes persistent visible emissions of fugitive dust beyond the work area; cover loads in haul trucks or maintain at least six inches of free-board when traveling on public roads; and apply non-toxic soil stabilizers or water to form and maintain a crust on inactive construction areas (disturbed work areas that are unused for four consecutive days).

- APM-AIR-03: Traffic speeds on unpaved roads would be limited to 15 miles per hour (mph).

- APM-AIR-04: SDG&E would maintain construction equipment per manufacturing specifications and use low-emission equipment as follows: all off-road and portable construction diesel engines not registered under the CARB Statewide Portable Equipment Registration Program, which have a rating of 50 horsepower (hp) or more, shall meet, at a minimum, the Tier 2 California Emission Standards for Off-Road Compression-Ignition Engines as specified in California Code of Regulations, Title 13, Section 2423(b)(1), unless such an engine is not available for a particular item of equipment. In the event that a Tier 2 engine is not available for any off-road engine larger than 100 hp, that engine shall be equipped with a catalyzed diesel particulate filter (soot filter), unless the engine manufacturer indicates that the use of such devices is not practical for that particular engine type.

- APM-AIR-05: SDG&E would continue to utilize BMPs to minimize dust and erosion.

Following construction, operation of the electric lines would not directly emit any criteria air pollutants. The only operational emissions associated with the Proposed Action would be from crew trucks, helicopters, and other equipment accessing the electric lines to perform periodic inspections and maintenance activities. These inspection and maintenance activities currently occur annually and are not anticipated to increase in frequency following the completion of the Proposed Action. As a result, the Proposed Action is not expected to exceed the SDAPCD's operational emission thresholds, and no operational impact to air quality is anticipated.

10.0.1 Connected Actions

Construction activities for 69 kV power lines located outside of the CNF would be the same as those described for the Proposed Action. Similarly, because of the overlapping construction schedules for these lines and the amount of equipment required to operate during construction activities, pollutant emissions resulting from heavy equipment used during construction are anticipated to exceed levels established by the SDAPCD for VOCs, NO_x, CO, and $PM_{2.5}$. SDG&E would implement APM-AIR-01 through APM-AIR-05 to reduce excess engine idling and fugitive dust, and minimize potential emissions for these sources. Table 18: Criteria Air Pollutant Exceedances During Construction – Connected Actions lists the threshold and maximum emissions rate (lbs/day) for all criteria pollutants during the construction of Connected Actions, as well as the approximate number of days during which exceedances would occur.

Table 18: Criteria Air Pollutant Exceedances During Construction – Connected Actions

Pollutant	Threshold (lbs/day)	Maximum (lbs/day)	Approximate Number of Weeks Exceeded
VOCs	75	136.56	32
NO_x	250	1,082.4	90
CO	550	571.08	1
SO_2	250	1.52	0
PM_{10}	100	71.18	0
$PM_{2.5}$	55	63.18	4

In addition to emissions from heavy equipment use, construction would involve a total of approximately 139.2 acres of ground disturbance over approximately five years of pole-replacement activities, which would contribute to an increase of fugitive dust from these Connected Actions. Because the ground disturbance would be relatively small in size and fugitive dust emissions would be limited to the areas surrounding the work areas, impacts from $PM_{2.5}$ resulting from fugitive dust emissions are anticipated to be minor.

There is also the potential for air quality impacts from airborne dust to occur as a result of the use of access roads. However, airborne dust generated during access road use would be limited to the immediate vicinity of the access road, and would occur instantaneously as vehicles traverse the access roads. In order to minimize potential impacts to air quality, SDG&E would implement the APMs described in Section 10.0.0 Proposed Action during construction of Connected Actions.

As previously discussed, the only operational emissions associated with Connected Actions would be from crew trucks, helicopters, and other equipment accessing the electric lines to perform periodic inspections and maintenance of the lines. There would be no increase in frequency of inspection and maintenance activities following construction of Connected Actions. As a result, these actions are not expected to exceed the SDAPCD's operational emission thresholds and no impact to air quality is anticipated.

10.0.2 Similar Actions

Construction activities required for wood-to-steel pole replacement, pole removal, and undergrounding of distribution lines outside the CNF would be similar to those described for the Proposed Action. Due to the large number of poles to be removed and replaced, and the significant amount of construction required to underground approximately four miles of distribution lines outside of the CNF—consisting of portions of C79, C440, and C449—a large number of crews would be required to work on multiple electric lines throughout the approximate five-year construction schedule. In addition, because of the overlapping construction schedules for these lines and the amount of equipment required to operate during construction activities, pollutant emissions resulting from heavy equipment used during construction are anticipated to exceed levels established by the SDAPCD for VOCs, NO_x, CO, and $PM_{2.5}$. SDG&E would implement APM-AIR-01 to reduce excess engine idling and minimize potential emissions for these sources. Table 19: Criteria Air Pollutant Exceedances During Construction – Similar Actions lists the threshold and maximum emissions rate (lbs/day) for criteria air pollutants during construction of Similar Actions, as well as the approximate number of days during which exceedances would occur.

Table 19: Criteria Air Pollutant Exceedances During Construction – Similar Actions

Pollutant	Threshold (lbs/day)	Maximum (lbs/day)	Approximate Number of Weeks Exceeded
VOCs	75	136.56	14
NO_x	250	1,082.4	40
CO	550	571.08	<1
SO_2	250	1.52	0
PM_{10}	100	71.18	0
$PM_{2.5}$	55	63.18	2

In addition to emissions from heavy equipment use, construction would involve a total of approximately 11.6 acres of ground disturbance over approximately five years of pole-replacement activities, which would contribute to an increase of fugitive dust in the area. Because the ground disturbance would be relatively small in size and fugitive dust emissions would be limited to the areas surrounding the electric lines, impacts from $PM_{2.5}$ resulting from fugitive dust emissions are anticipated to be minor. There is also the potential for air quality impacts from airborne dust to occur as a result of the use of access roads. In order to reduce potential impacts to air quality from these Similar Actions, SDG&E would implement dust control measures and limit traffic speeds during construction, as described in APM-AIR-02 and APM-AIR-03.

As previously discussed, operation and maintenance activities would not increase in frequency or change substantially following construction. As a result, operation and maintenance of those portions of the electric lines included as Similar Actions are not expected to exceed the SDAPCD's operational emission thresholds and no impact to air quality is anticipated.

10.1 BIOLOGICAL RESOURCES

The following section describes potential impacts to biological resources resulting from the Proposed Action, Connected Actions, and Similar Actions. Potential sensitive biological resources that could be impacted by the Proposed Action were identified through consultation with the USFS between 2009 and 2012. Additionally, SDG&E included for consideration those species identified in the February 2006 Biological Evaluation/Assessment, as prepared by the USFS, as well as species covered by SDG&E's Subregional NCCP and Low-Effect HCP. In December 1995, the U.S. Fish and Wildlife Service (USFWS) and the CDFW approved the SDG&E Subregional NCCP, developed in coordination with such agencies that addresses potential impacts to species and habitat associated with SDG&E's ongoing installation, use, maintenance, and repair of its gas and electric systems, and typical expansion to those systems throughout much of SDG&E's existing service territory.

SDG&E also prepared a Low-Effect HCP to minimize and mitigate the effects of operation and maintenance activities on the federally endangered Quino checkerspot butterfly (*Euphydryas editha quino*) (QCB) and to obtain incidental take authorization for QCB from the USFWS in 2007. The QCB HCP was prepared in consultation with the USFWS to fulfill the requirements of the Section 10(a)(1)(B) permit application and addresses the potential impact to the QCB from the use, maintenance, and repair of existing gas and electric facilities, and allows for typical expansions to those systems, including the replacement of poles and conductors.

As a part of the NCCP and QCB HCP, SDG&E has been issued incidental take authorizations (Permit PRT-809637) by the USFWS and the CDFW for 110 Covered Species. These documents were developed by following the multiple species and habitat conservation planning approach. Even with the NCCP and QCB HCP, SDG&E's goal is to avoid take of Covered Species whenever possible and to implement measures to minimize and mitigate any take to the maximum extent possible. The NCCP and QCB HCP each include mitigation measures and operational protocols that apply to construction and operations and maintenance activities. In approving the NCCP and QCB HCP, the USFWS and CDFW determined that the mitigation measures and operational protocols avoid potential impacts and provide appropriate mitigation where such impacts are not avoided, and ensure the protection and conservation of federal and state-listed species and other Covered Species. The Proposed Action falls within the area in which SDG&E's utility operations are governed by the NCCP and, as such, the NCCP would be applied to the Proposed Action. As a result, the NCCP fully addresses all of the potential construction and operations and maintenance impacts of the Proposed Action on federal and state listed species and Covered Species. The NCCP and QCB HCP mitigation measures and operational protocols have been incorporated as part of the Proposed Action description.

In preparation for the Proposed Action, SDG&E conducted biological surveys and vegetation mapping from 2010 to 2012. Additionally, focused surveys for targeted rare plant and wildlife species were conducted in accordance with survey protocols set forth by the CDFW, the California Native Plant Society (CNPS), and USFWS guidelines. Lists of plant and wildlife species targeted during these focused surveys were developed through consultation with the USFS and centered on USFS-listed species. Surveys were conducted in areas where potential habitat or suitable modeled habitat existed based on USFS species data, as well as data recorded within the California Natural Diversity Database and CNPS datasets. Surveys were not conducted in areas determined by the USFS to be occupied habitat. General field reconnaissance data on other plants and wildlife were also collected during the focused surveys.

10.1.0 Proposed Action

The Proposed Action area is situated from approximately 1,500 feet to over 5,500 feet above mean sea level. Fifteen vegetation communities—mixed oak woodland, southern riparian forest, oak savanna, southern mixed chaparral, chamise chaparral, diegan coastal sage scrub, semi-desert chaparral, montane forest, montane wet meadow, freshwater seep/open water, native grassland, non-native grassland, pastureland/cultivated agriculture, urban and developed/ornamental landscaping, and disturbed (ruderal/barren)—occur within the Proposed Action area. The Proposed Action area is located within USFWS-designated critical habitat for arroyo toad (*Anaxyrus californiucs*), southwestern willow flycatcher (*Empidonax traillii extimus*), Laguna Mountains Skipper (*Pyrgus ruralis lagunae*), San Bernardino blue grass (*Poa atropurpurea*), and San Diego thornmint (*Acanthomintha ilicifolia*). All of these species, with the exception of Laguna Mountains Skipper and San Bernardino blue grass, are covered by SDG&E's NCCP.

Based on consultation with the USFS on the USFS Regional Foresters List of Sensitive Species, the February 2006 Biological Evaluation/Assessment, the NCCP, and the results of focused surveys conducted for the Proposed Action, 31 special-status plant species and 31 special-status wildlife species were determined to be present within the ROW or have a moderate to high potential to occur based on the specific habitat types and elevations found within the ROW. These species and their respective listing statuses are shown in Table 20: Special-Status Plant Species Occurrence and Table 21: Special-Status Wildlife Species Occurrence. Due to the linear structure of utility systems, the potentials for species to occur were determined and categorized for the entire ROW of each 69 kV power line and 12 kV distribution line. Therefore, the potentials for species to occur for the Proposed Action, Connected Actions, and Similar Actions are the same. The following criteria were used to determine the potential for special-status species to occur within the Proposed Action area:

Table 20: Special-Status Plant Species Occurrence

Species Name	Listing Status[14]	Covered by NCCP/ QCB HCP	69 kV Power Line / 12 kV Distribution Line[15]										
			TL625	TL626	TL629	TL682	TL6923	C78	C79	C157	C440	C442	C449
San Diego thornmint[16] *Acanthomintha ilicifolia*	FT, CE, USFS S 1B.1 BLM S	✓	◔	◔	◔	◔	◔	●	○	○	○	○	○

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[14] Explanation of state and federal listing codes

Federal listing codes:

FE: Federally listed as Endangered
FT: Federally listed as Threatened
USFS S: USFS Sensitive
BLM S: BLM Sensitive Species
BGEPA: Bald and Golden Eagle Protection Act

California listing codes:

CE: State-listed as Endangered
CT: State-listed as Threatened
Rare: State-listed as Rare
FPS: State-listed Fully Protected
SSC: State Species of Special Concern

CNPS lists:

1B.1: Rare, threatened, or endangered in California or elsewhere; seriously threatened in California
1B.2: Rare, threatened, or endangered in California or elsewhere; fairly threatened in California
1B.3: Rare, threatened, or endangered in California or elsewhere; not very threatened in California
2.1: Rare, threatened, or endangered in California only; seriously threatened in California
2.2: Rare, threatened, or endangered in California only; fairly threatened in California
2.3: Rare, threatened, or endangered in California only; not very threatened in California
3: Plants that are on a review list and require additional information
4.1: Uncommon in California; seriously threatened in California
4.2: Uncommon in California; fairly threatened in California
4.3: Uncommon in California; not very threatened in California

[15] Explanation of potentials symbols:
○: Species has no potential to occur or is confirmed absent along the electric line
◔: Species has a low potential to occur along the electric line
◑: Species has a moderate potential to occur along the electric line
◕: Species has a high potential to occur along the electric line
●: Species is present along the electric line

[16] Special-status species that was targeted during focused surveys

Species Name	Listing Status[14]	Covered by NCCP/ QCB HCP	69 kV Power Line / 12 kV Distribution Line[15]										
			TL625	TL626	TL629	TL682	TL6923	C78	C79	C157	C440	C442	C449
Dean's milk-vetch[16] *Astragalus deanei*	USFS S 1B.1 BLM S		○	○	○	○	●[17]	○	○	●	○	○	○
Jacumba milk-vetch[16] *Astragalus douglasii* var. *perstrictus*	USFS S 1B.2 BLM S		◔	◔	●	◔	◔	○	○	●	○	○	●
San Diego milk-vetch[16] *Astragalus oocarpus*	USFS S 1B.2 BLM S		◔	◔	◔	◔	●[17]	○	○	●	●	○	○
Orcutt's brodiaea[16] *Brodiaea orcuttii*	USFS S 1B.1 BLM S		●[17]	◔	○	◔	◔	○	○	○	○	○	○
Dunn's mariposa lily[16] *Calochortus dunnii*	USFS S 1B.2 BLM S	✓	●	◔	◔	○	◔	○	●	○	○	○	○
Payson's jewel-flower[16] *Caulanthus simulans*	USFS S 4.2	✓	●	◔	●	◔	◔	○	○	○	○	○	○

[17] Species is present within the ROW outside of the CNF boundary

Species Name	Listing Status[14]	Covered by NCCP/ QCB HCP	69 kV Power Line / 12 kV Distribution Line[15]										
			TL625	TL626	TL629	TL682	TL6923	C78	C79	C157	C440	C442	C449
Long-spined spineflower[16] *Chorizanthe polygonoides* var. *longispina*	USFS S 1B.2		●	◔	●	●[17]	◔	○	○	○	○	●	●
Delicate clarkia[16] *Clarkia delicata*	USFS S 1B.2		●	●	◔	●	●	●	●[17]	●	●	○	●
Tecate tarplant[16] *Deinandra floribunda*	USFS S 1B.2 BLM S		●	●[17]	◔	◔	●	○	○	○	○	○	○
Variegated dudleya *Dudleya variegata*	1B.2 BLM S	✓	◑	○	○	◔	○	○	○	◔	○	○	○
Vanishing wild buckwheat[16] *Eriogonum evanidum*	USFS S 1B.1		◔	◔	◔	◔	◔	○	○	○	●	●[17]	○
Mexican flannelbush *Fremontodendron mexicanum*	FE, Rare 1B.1 BLM S		○	○	○	○	●[17]	○	○	○	○	○	○
Palmer's grappling-hook *Harpagonella palmeri*	4.2	✓	◕	○	◔	◔	◔	●[17]	○	◔	○	○	◔

Species Name	Listing Status[14]	Covered by NCCP/ QCB HCP	69 kV Power Line / 12 kV Distribution Line[15]										
			TL625	**TL626**	**TL629**	**TL682**	**TL6923**	**C78**	**C79**	**C157**	**C440**	**C442**	**C449**
Tecate cypress[16] *Hesperocyparis forbesii*	USFS S 1B.1 BLM S	✓	◔	◔	◔	○	◔	○	○	○	●[17]	○	○
Cuyamaca cypress[16] *Hesperocyparis stephensonii*	USFS S 1B.1		◔	◔	◔	○	○	○	○	○	●[17]	○	○
Ramona horkelia[16] *Horkelia truncata*	USFS S 1B.3		◔	●	◔	◔	◔	○	○	○	○	○	○
Parish's meadowfoam[16] *Limnanthes gracilis* ssp. *parishii*	USFS S CE 1B.2 BLM S		○	○	○	○	○	○	○	○	●	○	○
Orcutt's linanthus[16] *Linanthus orcuttii*	USFS S 1B.3 BLM S		○	○	○	○	○	○	○	○	●	●[17]	○
Felt-leaved monardella[16] *Monardella hypoleuca* ssp. *lanata*	USFS S 1B.2	✓	●	○	○	○	○	●	○	○	○	○	○
Hall's monardella *Monardella macrantha* ssp. *hallii*	1B.3		◔	◔	◔	◑	◔	◔	◔	◔	◕	◔	◔

Species Name	Listing Status[14]	Covered by NCCP/ QCB HCP	69 kV Power Line / 12 kV Distribution Line[15]										
			TL625	TL626	TL629	TL682	TL6923	C78	C79	C157	C440	C442	C449
San Felipe monardella *Monardella nana* ssp. *leptosiphon*	1B.2 BLM S		◔	◑	◔	◕	◔	◔	◔	◔	◔	◔	◔
California orcutt grass *Orcuttica californica*	FE, CE 1B.1	✓	○	○	○	◑	◔	○	○	◔	○	○	○
Gander's ragwort[16] *Packera ganderi*	USFS S Rare 1B.2 BLM S	✓	●	○	○	○	○	○	○	○	○	○	○
Moreno currant[16] *Ribes canthariforme*	USFS S 1B.3 BLM S		○	○	○	○	○	○	○	○	○	●	○
Southern skullcap[16] *Scutellaria bolanderi* ssp. *austromontana*	USFS S 1B.2		◔	◔	●	◔	◔	○	○	○	○	●	○
Laguna Mountains jewelflower[16] *Streptanthus bernardenis*	4.3		○	○	○	○	○	○	●[17]	○	○	○	○

Species Name	Listing Status[14]	Covered by NCCP/ QCB HCP	69 kV Power Line / 12 kV Distribution Line[15]										
			TL625	TL626	TL629	TL682	TL6923	C78	C79	C157	C440	C442	C449
Southern jewelflower[16] *Streptanthus campestris*	USFS S 1B.3		○	●[17]	●	○	○	○	●[17]	○	●	○	○
San Bernardino aster[16] *Symphyotrichum defoliatum*	1B.2 BLM S		○	○	○	○	○	○	○	○	●	○	○
Velvety false-lupine[16] *Thermopsis californica var. semota*	USFS S 1B.2		○	◕	○	○	○	○	○	○	●	○	○

Table 21: Special-Status Wildlife Species Occurrence

Species Name	Listing Status[14]	Covered by NCCP/ QCB HCP	69 kV Power Line / 12 kV Distribution Line[15]										
			TL625	TL626	TL629	TL682	TL6923	C78	C79	C157	C440	C442	C449
Invertebrates													
Quino Checkerspot Butterfly[16] *Euphydryas editha quino*	FE	✓	◕	○	○	○	◕	○	○	○	○	○	○
Hermes Copper Butterfly[16] *Lycaena hermes*	*Not currently listed*		●	●	◕	○	●[17]	◔	●	◕	○	○	○
Laguna Mountains Skipper *Pyrgus ruralis lagunae*	FE		○	○	◔	○	○	○	○	○	◕	◔	○
Fish													
Arroyo Chub *Gila orcutti*	USFS S SSC		○	○	○	◑	○	○	○	○	○	○	○
Amphibians													
Arroyo Toad[16] *Anaxyrus californicus*	FE, SSC	✓	◑	◔	◕	●	◕	○	○	◕	◑	◕	●

Species Name	Listing Status[14]	Covered by NCCP/ QCB HCP	69 kV Power Line / 12 kV Distribution Line[15]										
			TL625	TL626	TL629	TL682	TL6923	C78	C79	C157	C440	C442	C449
Large-Blotched Salamander *Ensatina klauberi*	USFS S SSC		◔	◑	◔	◑	◔	○	◔	◔	○	◔	◔
Reptiles													
California Legless Lizard *Anniella pulchra*	SSC USFS S		◔	◔	◔	◔	◔	○	◔	◔	●	◔	◔
Belding's Orange-Throated Whiptail *Aspidoscelis hyperythra beldingi*	SSC	✓	◕	○	◔	◕	◔	◔	○	◔	○	○	◔
Southwestern Pond Turtle *Clemmys marmorata pallida*	SSC, USFS S	✓	◕	◕	◕	◕	◕	○	○	●	○	◕	◔
Northern Red-Diamond Rattlesnake *Crotalus ruber ruber*	SSC	✓	◕	◔	◔	◔	◔	◔	◔	◔	○	◔	◔
San Diego Mountain Kingsnake *Lampropeltis zonata pulchra*	SSC, USFS S		◔	◑	◑	◑	◔	○	◕	◔	●	◑	◔

Species Name	Listing Status[14]	Covered by NCCP/ QCB HCP	69 kV Power Line / 12 kV Distribution Line[15]										
			TL625	TL626	TL629	TL682	TL6923	C78	C79	C157	C440	C442	C449
Coastal Rosy Boa *Lichanura trivirgata roseofusca*	BLM S, USFS S	✓	◔	◔	◔	◔	◑	◔	◔	◔	◔	◕	◔
Coast (San Diego) Horned Lizard *Phrynosoma coronatum blainvillii*	SSC, USFS S	✓	◕	◑	◕	◕	◕	◑	◕	◕	●	◕	◕
Coronado Island Skink *Plestiodon (Eumeces) skiltonianus interparietalis*	SSC	✓	◕	◔	◔	◔	◕	○	◔	◔	◔	◔	◔
Coast Patch-Nosed Snake *Salvadora hexalepis virgultea*	SSC	✓	◑	◔	◔	◔	◕	◔	◔	◔	◔	◔	◕
Two-Striped Garter Snake *Thamnophis hammondii*	SSC, BLM S USFS S	✓	◕	◑	◑	◑	◕	○	◔	◔	◕	◔	◕
Birds													
Tricolored Blackbird - nesting colony *Agelaius tricolor*	SSC	✓	◔	○	◔	○	◑	○	○	◔	◔	◔	◔

Species Name	Listing Status[14]	Covered by NCCP/ QCB HCP	69 kV Power Line / 12 kV Distribution Line[15]										
			TL625	TL626	TL629	TL682	TL6923	C78	C79	C157	C440	C442	C449
Golden Eagle *Aquila chrysaetos*	FPS BGEPA	✓	○	○	◕	◕	◕	○	○	○	○	○	○
Southwestern Willow Flycatcher[16] *Empidonax traillii extimus*	FE	✓	○	○	◔	●	○	○	○	○	○	○	○
Coastal California Gnatcatcher[16] *Polioptila californica californica*	FT, SSC	✓	◕	○	○	◔	◔	◔	○	◔	○	○	○
California Spotted Owl[16] *Strix occidentalis occidentalis*	SSC, USFS S		◑	○	◔	●	○	○	○	○	◑	◑	○
Least Bell's Vireo[16] *Vireo bellii pusillus*	FE, CE	✓	●	◔	◕	◕	◕	○	○	◕	○	◑	◕
Mammals													
Pallid Bat *Antrozous pallidus*	SSC, USFS S BLM S		◕	◕	◕	◑	◑	○	◔	◔	◔	◔	◔

Species Name	Listing Status[14]	Covered by NCCP/ QCB HCP	69 kV Power Line / 12 kV Distribution Line[15]										
			TL625	TL626	TL629	TL682	TL6923	C78	C79	C157	C440	C442	C449
Dulzura (California) Pocket Mouse *Chaetodipus californicus femoralis*	SSC	✓	◕	◕	◕	◔	◕	◔	◔	◔	◕	◔	◕
Northwestern San Diego Pocket Mouse *Chaetodipus fallax fallax*	SSC	✓	◔	◔	◔	◔	◕	◔	◔	◔	◔	◔	◔
Pallid San Diego Pocket Mouse *Chaetodipus fallax pallidus*	SSC	✓	○	◔	○	◔	○	◔	◔	○	◕	◔	○
Townsend's Big-Eared Bat *Corynorhinus townsendii*	SSC, USFS S BLM S		◔	◑	◕	◔	◑	○	◔	◔	◕	◑	◕
Stephens' Kangaroo Rat[16] *Dipodomys stephensi*	FE, CT	✓	○	○	○	●[17]	○	○	○	○	○	○	○
Western Red Bat *Lasiurus blossevillii*	SSC, USFS S		◑	◑	◕	◔	◕	○	◔	◔	◕	◑	◑

Species Name	Listing Status[14]	Covered by NCCP/ QCB HCP	69 kV Power Line / 12 kV Distribution Line[15]										
			TL625	TL626	TL629	TL682	TL6923	C78	C79	C157	C440	C442	C449
California Leaf-Nosed Bat *Macrotus californicus*	SSC USFS S		○	○	○	○	◑	○	○	○	○	○	○
American Badger *Taxidea taxus*	SSC	✓	◔	◕	◔	◔	◔	◔	○	◔	◔	◔	◔

- Present: Species was detected within the Proposed Action area at the time of the survey, presence is noted in recent documentation of previous surveys within the Proposed Action area, or presence is assumed based on USFS-modeled data.

- High Potential: The Proposed Action area is located within the range of the species, suitable habitat is present within the Proposed Action area, and a recent historical record (less than 10 years old) of the species has been recorded within two miles of the Proposed Action area.

- Moderate Potential: The Proposed Action area is located within the range of the species; marginal habitat is present in the Proposed Action area; and a recent historical record (less than 10 years old) of the species has been recorded within five miles of the Proposed Action area. Alternatively, environmental conditions associated with the species occur within the Proposed Action area, but no historical records exist within five miles of the site.

- Low Potential: The Proposed Action area is located within the range of the species; poor to marginal habitat is present in the project area; and no recent historical records of the species exist in the Proposed Action area, or information in the Proposed Action area was unavailable. Alternatively, suitable habitat or marginally suitable habitat for the species exists in the Proposed Action area, but protocol-level focused surveys were conducted for the species and the species was not observed.

- No Potential: The Proposed Action area—or limited portions of the Proposed Action area—are located within the range of the species and no habitat for the species exists in the project area.

The following special-status plant species were reviewed and determined to have no or low potential to occur within the ROW:

- Chaparral sand-verbena (*Abronia villosa* var. *aurita)*
- San Diego ambrosia (*Ambrosia pumila)*
- Otay manzanita (Arctostaphylos otayensis)
- Nevin's barberry (*Berberis nevinii)*
- Thread-leaved brodiaea (*Brodiaea filfolia)*
- San Bernardino owl's clover (*Castilleja lasiorhyncha*)
- Lakeside ceanothus (*Ceanothus cyaneus)*
- Wart-stemmed ceanothus (*Ceanothus verrucosus)*
- Parry's Spineflower (Chorizanthe parryi var. parryi)
- Salt marsh bird's-beak (Cordylanthus maritimus ssp. maritimus)
- Otay tarplant (Deinandra conjugens)
- Mojave tarplant (Deinandra mohavensis)
- Cuyamaca larkspur (Delphinium hesperium ssp. cuyamacae)
- Mount laguna aster (Dieteria asteroids var. lagunensis)
- Palmer's goldenbush (Ericameria palmeri var. palmeri)
- San Diego barrel cactus (*Ferocactus viridescens)*

- Mission Canyon bluecup (Githopsis diffusa ssp. filicaulis)
- Warner Springs lessingia (Lessingia glandulifera var. tomentosa)
- Lemon lily (Lilium parryi)
- Baja navarretia (Navarretia peninsularis)
- Chaparral nolina (*Nolina cismontane)*
- Dehesa nolina (Nolina interrata)
- San Bernardino blue grass (*Poa atropurpurea)*
- San Miguel savory (*Satureja chandleri)*
- Hammitt's claycress (*Sibaropsis hammittii)*
- Parry's tetracoccus (*Tetracoccus dioicus)*

The following special-status wildlife species were reviewed and determined to have no or low potential to occur within the ROW:

- Bald Eagle (Haliaeetus leucocephalus)
- San Diego Fairy Shrimp (Branchinecta sandiegonensis)
- Mountain Yellow-Legged Frog (*Rana muscosa)*
- San Diego Ring-Necked Snake (*Diadophis punctatus similis)*
- San Diego Black-Tailed Jackrabbit (*Lepus californicus bennettii)*
- San Diego Desert Woodrat (*Neotoma lepida intermedia)*
- Southern Grasshopper Mouse (*Onychomys torridus Ramona)*

Construction of the Proposed Action would result in temporary disturbance to and permanent loss of vegetation. Temporary disturbances include short-term impacts during construction of new poles and removal of existing poles, improvements to existing access roads, and work at staging/laydown areas, stringing sites, and landing zones. Permanent impacts would result to an area roughly the diameter of the replacement poles where steel poles would be installed. The Proposed Action would result in a temporary impact of approximately 33.4 acres, and a permanent impact of approximately 0.14 acres within the CNF. These temporary and permanent impacts are summarized by habitat type in Table 22: Vegetation Community Impacts of the Proposed Action in Acres (69 kV Power Lines) and Table 23: Vegetation Community Impacts of the Proposed Action in Acres (12 kV Distribution Lines).

SDG&E would consult with the appropriate resource agencies regarding potential impacts to federally and state-listed species, as appropriate, and in accordance with the NCCP. All work areas with associated temporary or permanent impacts would be surveyed for special-status plant and wildlife species by a qualified biologist prior to the commencement of construction in accordance with SDG&E's NCCP and pre-activity survey report requirements. In addition, in order to minimize impacts to sensitive species during construction, SDG&E would implement all appropriate NCCP Operational Protocols, included in Appendix A: SDG&E NCCP Protocols, which would ensure that impacts to sensitive plant and wildlife species resulting from the Proposed Action would be minor. The following paragraphs describe general impacts to special-status plant and wildlife species that may occur as a result of construction of the Proposed Action.

Table 22: Vegetation Community Impacts of the Proposed Action in Acres (69 kV Power Lines)

Habitat Type	TL625		TL626		TL629		TL682		TL6923		Total	
	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary
Chamise Chaparral	<0.01	2.37	0	0	0.01	1.63	0	0	0	0	0.02	4.00
Diegan Coastal Sage Scrub	0.01	0.88	0	0	<0.01	0.09	0	0	<0.01	0.09	0.01	1.06
Disturbed (Ruderal/Barren)	0	0	0	0	<0.01	0.06	0	0	0	0	<0.01	0.06
Freshwater Seep/Open Water	0	0	0	0	0	0	0	0	<0.01	0.02	<0.01	0.02
Mixed Oak Woodland	<0.01	0.27	<0.01	0.45	<0.01	0.20	<0.01	0.03	<0.01	0.02	0.01	0.97
Native Grassland	0	0	0	0	0	0	0	0	<0.01	0.04	<0.01	0.04
Non-Native Grassland	0	0	<0.01	0.04	<0.01	0.48	0	0	0	0	<0.01	0.52
Oak Savanna	0	0	0	0	<0.01	1.49	0	0	<0.01	0.03	<0.01	1.52
Pastureland/Cultivated Agriculture	0	0	0	0	0	0	0	0	0	0	<0.01	<0.01
Semi-Desert Chaparral	0	0	0	0	0.01	0.49	0	0	0	0	0.01	0.49
Southern Mixed Chaparral	0.01	5.01	0.02	4.39	0.01	1.81	0.01	2.52	<0.01	0.96	0.05	14.69
Southern Riparian Forest	0	0	0.01	1.53	<0.01	0.09	0	0.35	0	0	0.01	1.97
Urban and Developed/Ornamental Landscaping	<0.01	0.29	0	0	<0.01	<0.01	0	0	0	0	<0.01	0.29
Montane Forest	0	0	0	0	0	0	0	0	0	0	0	0
Montane Wet Meadow	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0.02**	**8.82**	**0.03**	**6.40**	**0.04**	**6.34**	**0.01**	**2.90**	**<0.01**	**1.15**	**0.11**	**25.61**

Table 23: Vegetation Community Impacts of the Proposed Action in Acres (12 kV Distribution Lines)

Habitat Type	C157		C440		C442		C449		C78		C79		Total	
	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary
Chamise Chaparral	0	0	0	0.09	0	0	0	0	0	0	0	0	0	0.09
Diegan Coastal Sage Scrub	0	0	0	0	0	0	0	0	<0.01	0.12	0	0	<0.01	0.12
Disturbed (Ruderal/Barren)	0	0	<0.01	0.48	0	0	0	0.02	0	0	0	0	<0.01	0.50
Freshwater Seep/Open Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mixed Oak Woodland	0	0	0	0	<0.01	0.05	<0.01	0.23	0	0	0	0	<0.01	0.28
Native Grassland	<0.01	0.04	<0.01	0.01	0	0	0	0	0	0.01	0	0	<0.01	0.06
Non-Native Grassland	<0.01	0.19	<0.01	0.04	0	0	0	0.01	0	0	0	0	<0.01	0.24
Oak Savanna	0	0	<0.01	0.01	0	0	0	0.23	0	0	0	0	<0.01	0.24
Pastureland/ Cultivated Agriculture	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0.01
Semi-Desert Chaparral	<0.01	0.02	0	0	0	0	0	0.04	0	0	0	0	<0.01	0.06
Southern Mixed Chaparral	<0.01	0.13	<0.01	0.37	<0.01	0.36	<0.01	0.43	<0.01	0.05	<0.01	0.64	0.01	1.99
Southern Riparian Forest	0	0	0	0.01	0	0	<0.01	0.02	0	0	0	0	<0.01	0.04
Urban and Developed/ Ornamental Landscaping	0	0	<0.01	0.17	0	0	0	0.12	0	0	0	0	<0.01	0.29
Montane Forest	0	0	0.02	2.83	<0.01	0.21	0	0	0	0	0	0	0.02	3.04
Montane Wet Meadow	0	0	<0.01	0.85	0	0	0	0	0	0	0	0	<0.01	0.85
Total	**<0.01**	**0.38**	**0.02**	**4.89**	**0.01**	**0.62**	**<0.01**	**1.10**	**<0.01**	**0.18**	**<0.01**	**0.64**	**0.03**	**7.79**

Potential impacts to special-status plant species may include the temporary or permanent loss of habitat, including loss of habitat that supports the species, and loss of potential seed bank due to the excavation of pole holes, consistent with construction activities conducted for other similar wood-to-steel replacement projects. Other impacts may include potential crushing by equipment, vehicles, and personnel working within suitable or occupied habitat. Project equipment and vehicles may introduce noxious weeds that compete with special-status species, or may result in petroleum product or other chemical spills that negatively affect special-status plant species and habitat. In addition, impacts such as an increase in fugitive dust could reduce the growth and vigor of special-status plant species. In order to minimize these potential impacts, SDG&E would implement NCCP protocols 1, 7, 11, 13, 14, 15, 16, 17, 20, 24, 25, 28, 29, 30, 35, 36, 39, 41, 42, 43, 44, 48, and 57 as described in Appendix A: SDG&E NCCP Protocols to avoid impacts to special-status plant species. These protocols include, but are not limited to: reducing vehicle speed to reduce fugitive dust, restricting vehicles to existing roads when feasible, minimizing impacts by defining the disturbance areas, designing the final Proposed Action construction design to avoid or minimize new disturbance and erosion, and adjusting access roads where feasible to avoid sensitive habitats. By implementing these NCCP protocols, any potential impacts to special-status plant species would be minimized.

Construction of the Proposed Action may impact two special-status invertebrate species: QCB and Hermes copper butterfly (Lycaena hermes). Impacts to these species include potential crushing of larvae or adults by equipment, vehicles, and personnel working within suitable or occupied habitat. Other impacts may include the permanent and temporary loss of habitat, including loss of vegetation (larval host plants and adult nectaring plants) that support the species. Vehicles and equipment may introduce noxious weeds, which have the potential to out-compete host and nectar plants. In addition, an increase in fugitive dust could reduce the growth and vigor of host and nectar plant species. In order to minimize these potential impacts, SDG&E would utilize NCCP protocols 1, 2, 3, 5, 7, 8, 10, 11, 13, 14, 17, 24, 25, 29, 34, 35, 41, 44, 48, 54, 55, and 57, as described in Appendix A: SDG&E NCCP Protocols. These protocols include, but are not limited to: training, pre-activity surveys, monitoring during clearing and grading activities, and reducing speeds to 15 mph along Proposed Action access roads to minimize fugitive dust.

The Proposed Action and all associated activities are also covered by the QCB HCP; as a result, SDG&E would also mitigate any potential Proposed Action effects to QCB by implementing the QCB HCP. Specifically, SDG&E would implement the protocols identified in QCB HCP Sections 3.2 Actions to Minimize Impacts and 3.3 Actions to Mitigate Impacts, which include conducting pre-activity surveys, conducting protocol-level adult QCB flight season surveys within suitable QCB habitat within the QCB HCP's designated Mapped Area prior to construction and submitting the 45-day QCB Survey Results Report to the USFWS, and mitigating for impacted habitat. If the timing of the Proposed Action would not allow for adult flight season surveys to determine the presence or absence of QCB in the Proposed Action area, SDG&E would assume that the identified Suitable QCB Habitat is occupied. These protocols also include ratios for mitigating impacts to QCB Occupied and Suitable habitat. With implementation of the QCB HCP and SDG&E's NCCP, any potential impacts to QCB from the Proposed Action would be minimized.

As part of the Proposed Action, SDG&E would also replace several poles within USFS-modeled critical habitat and occupied habitat for the Laguna Mountains Skipper (*Pyrgus ruralis lagunae*) along C440. USFWS-designated critical habitat is also within the vicinity of C440. Figure 9: Laguna Mountains Skipper Modeled Critical and Occupied Habitat displays the locations of these areas and USFWS Critical Habitat. SDG&E has conducted extensive surveys within these areas and designed the Proposed Action to minimize the number of replacement poles to be constructed within these areas; SDG&E's survey data reveal that, in the currently planned pole construction locations, the likelihood of presence of the Laguna Mountains Skipper is low. Although this species is not covered under SDG&E's NCCP, SDG&E would utilize NCCP protocols 1, 2, 3, 5, 7, 8, 10, 11, 13, 14, 17, 24, 25, 29, 34, 35, 41, 44, 48, 54, 55, and 57, as described in Appendix A: SDG&E NCCP Protocols, in these areas to minimize any potential impacts to this species. SDG&E's protocols are expected to result in the avoidance of effects to Laguna Mountains Skipper. If pre-activity surveys determine that potential effects could occur, then SDG&E would work directly with the appropriate resource agencies to determine whether additional permitting would be required on a case-by-case basis.

Construction of the Proposed Action may impact one special-status fish species, the arroyo chub (*Gila orcutti*). This species has a moderate potential to occur within the TL682 ROW within the San Luis Rey River and potential tributaries that enter the river. All Proposed Action components and access to work areas would be placed outside the San Luis Rey River. Therefore, no temporary or permanent impacts to arroyo chub would occur as a result of construction. The TL682 power line would span the river, and there would be no impacts to the river. To prevent impacts that may result from degradation of water quality or disruption of water flow, SDG&E would implement the BMPs outlined in the Proposed Action's SWPPP to prevent construction materials from entering San Luis Rey River. With implementation of the SWPPP, no impacts to arroyo chub would occur.

Construction of the Proposed Action would likely impact habitat for two special-status amphibian species, including arroyo toad (*Anaxyrus californicus*) and large-blotched salamander (*Ensatina klauberi*). Water features within the immediate vicinity of the 69 kV power line and 12 kV distribution line ROWs may provide suitable habitat for arroyo toad. The large-blotched salamander does not inhabit streams or bodies of water, and instead prefers moist, shaded, evergreen and oak woodland forests. Construction of the Proposed Action may impact these special-status amphibian species by temporarily and permanently affecting suitable habitat. Temporary impacts to amphibians may also be caused by the disruption of hibernating, feeding, and breeding from increased human activity; an increase in vehicles and equipment noise; direct mortality by vehicles; and crushing or removal of subterranean refuge. Amphibians have the potential to fall into and become trapped within the pole excavation areas, as well as trenches and bore pits where undergrounding of electric lines would occur. Impacts to water features from the Proposed Action could result from the degradation of water quality from the introduction of sediment or hazardous materials. Permanent impacts may result from the loss of suitable upland habitat.

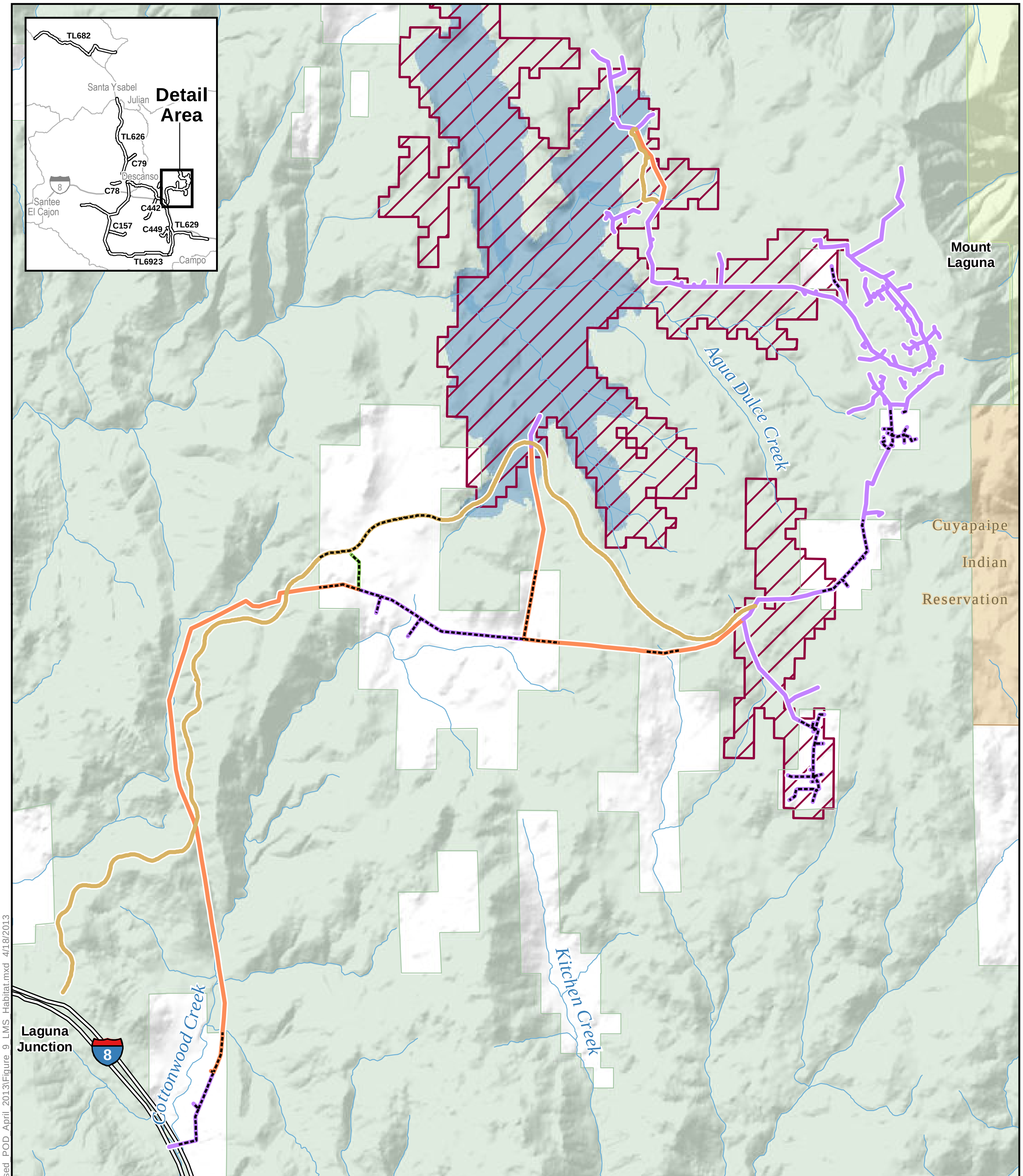

Figure 9:
Laguna Mountains Skipper Modeled Critical and Occupied Habitat

CNF Revised Plan of Development

- USFWS Critical Habitat
- USFS Occupied Habitat (Modeled)
- New Steel
- Removal
- Undergrounding
- Wood-to-Steel Replacement
- *Similar Actions Shown with Dashed Line*
- United States Forest Service
- Bureau of Land Management
- Bureau of Indian Affairs
- Interstate
- Stream
- Lake

1 inch = 1 mile
0 0.5 1 Miles

Source: SDG&E, 2012; Chambers Group Inc., 2012; USFS, 2012; USFWS, 2012; CPAD 1.7 GreenInfo Network, 2011

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Arroyo toads are known to disperse up to 1 mile from breeding habitat and large-blotched salamanders rely entirely on upland habitat. In addition, TL625, TL629, TL6923, C157, C442, and C449 cross USFWS-designated arroyo toad critical habitat. However, permanent impacts from the construction of the Proposed Action would be limited because the percentage of suitable habitat that would be removed is extremely small in comparison to the total amount of available habitat for these species in the area. SDG&E would utilize NCCP protocols 1, 2, 3, 4, 5, 7, 8, 10, 11, 13, 14, 17, 20, 24, 25, 27, 29, 34, 35, 37, 38, 41, 44, 48, 54, 55, and 57, as described in Appendix A: SDG&E NCCP Protocols. These protocols include, but are not limited to: training, pre-activity surveys, monitoring during clearing and grading activities, avoidance of burrows, requiring all trenches and excavations to be inspected twice daily for wildlife entrapment, and requiring excavations to be sloped on one end to provide an escape route. With implementation of the NCCP protocols, any potential effects on amphibians would be minor. Additionally, the Proposed Action was designed to remove a number of existing wood poles within arroyo toad habitat along C449; removing these poles would further reduce potential future impacts in these areas as operation and maintenance activities would no longer be required once the poles are removed and the electric line is relocated.

Construction of the Proposed Action may impact several special-status reptiles, including the following:

- southwestern pond turtle (*Clemmys marmorata pallida*)
- California legless lizard (*Anniella pulchra*)
- coast horned lizard(*Phrynosoma coronatum blainvillii*)
- Belding’s orange throated whiptail (*Aspidoscelis hyperythra beldingi*)
- Coronado island skink (*Plestiodon skiltonianus interparietalis*)
- northern red-diamond rattlesnake (*Crotalus ruber ruber*)
- San Diego mountain kingsnake (*Lampropeltis zonata pulchra*)
- coastal rosy boa (*Lichanura trivirgata roseofusca*)
- two-striped garter snake (*Thamnophis hammondii*)
- coast patch-nosed snake (*Salvadora hexalepis virgultea*)

Disturbance may be caused by the increase in vehicles and equipment noise; direct mortality by vehicles; disruption of hibernating, feeding, and breeding from increased human activity; and removal of burrows these species often utilize. In addition, removal of vegetation may reduce the amount of cover that special-status reptile species have to avoid predators. Other permanent impacts from the construction of the Proposed Action would be limited because the percentage of suitable habitat that would be removed is extremely small in comparison to the total amount of available habitat for these species in the area. In addition, SDG&E would utilize NCCP protocols 1, 2, 3, 4, 5, 7, 8, 10, 11, 13, 14, 17, 20, 24, 25, 27, 29, 34, 35, 37, 38, 41, 44, 48, 54, 55, and 57, as described in Appendix A: SDG&E NCCP Protocols. These protocols include, but are not limited to: training, pre-activity surveys, monitoring during clearing and grading activities, avoidance of burrows, requiring all trenches and excavations to be inspected twice daily for wildlife entrapment, and requiring excavations to be sloped on one end to provide an escape route. With implementation of SDG&E’s NCCP, any potential impacts to special-status reptile species would be minor.

Construction activities could also potentially impact nesting raptors, passerines, and other special-status bird species. Several special-status avian species were observed during the field survey or have a moderate or high potential to occur within the Proposed Action area. These species include, but are not limited to, the following:

- the golden eagle (*Aquila chrysaetos*)
- California spotted owl (*Strix occidentalis occidentalis*)
- southwestern willow flycatcher (*Empidonax traillii extimus*)
- least Bell's vireo (*Vireo bellii pusillus*)
- coastal California gnatcatcher (*Polioptila californica californica*)
- tricolor blackbird (*Agelaius tricolor*)

General impacts to all special-status avian species may include the removal of potential nesting and cover habitat and the disruption of nesting behavior due to a temporary increase in noise from construction equipment and vehicles. Construction activities could also potentially impact foraging raptors, passerines, and other special-status bird species. Impacts may include minor degradation of foraging habitat, removal of some food sources, and the disruption of foraging behavior due to a temporary increase in noise from construction equipment and vehicles. Least Bell's vireo is typically associated with riparian areas; therefore, suitable nesting and foraging habitat for this species may be temporarily lost as a result of tree-trimming activities within riparian areas. However, impacts would be limited because the percentage of suitable habitat that would be removed is extremely small in comparison to the total amount of available riparian habitat for this species in the Proposed Action area. Tricolor blackbird is typically associated with freshwater wetland areas; however, no impacts to suitable wetland nesting habitat are anticipated as a result of construction activities. The golden eagle nests on cliff faces, walled canyons, or in tall trees, and suitable nesting habitat for golden eagle is present within five miles of TL6923, TL682, and TL629. In addition, the USFS has documented a golden eagle nest at the Glencliff area along TL629. If a golden eagle nest is identified in the vicinity of the proposed work area, SDG&E would consult with the appropriate resource agencies to avoid impacts to nesting eagles.

Impacts to California spotted owl could occur from, the destruction of suitable roosting or nesting habitat or the temporary or permanent loss of foraging habitat. Direct effects may also result from disturbance related to increased construction noise and human presence. Because California spotted owls typically forage at night and all project-related work would be conducted during daylight, there is low to no potential that the Proposed Action would affect foraging activities. Suitable roosting habitat may be temporarily lost as a result of tree-trimming activities; however, the impacts would be limited because the percentage of suitable habitat that would be removed is extremely small in comparison to the total amount of available habitat for this species in the area. Adverse effects resulting from increased noise or human presence have the potential to occur if active nesting sites are within the vicinity of active construction areas. If California spotted owls are identified in the vicinity of proposed work areas during the pre-activity survey process, SDG&E would consult with the appropriate resource agencies to avoid impacts to nesting California spotted owl. With implementation of SDG&E's NCCP, any potential impacts to California spotted owl would be minor.

Southwestern willow flycatchers are typically associated with riparian areas; therefore, suitable nesting and foraging habitat for this species may be temporarily lost as a result of tree-trimming activities within riparian areas. In addition, TL682 crosses USFWS-designated southwestern willow flycatcher critical habitat along a riparian corridor. If southwestern willow flycatchers are identified in the vicinity of the proposed work area during the pre-activity survey process, SDG&E would consult with the USFWS to avoid impacts to nesting southwestern willow flycatcher. With implementation of SDG&E's NCCP, any potential impacts to southwestern willow flycatcher would be minor.

Concerns regarding potential electrocution impacts from electric lines to wildlife species are primarily focused on avian species. Electrocution of avian species can occur from wing contact as avian species perch, land, or take off from a utility pole by coming into simultaneous contact with two conductors to complete the electrical circuit; simultaneous contact with energized phase conductors and other equipment; and simultaneous contact with energized wires and a grounded wire. Electrocution of avian species is more of a potential hazard to larger birds, such as raptors, because their body size and wing span are large enough to span the distance between the conductor wires and, thus, complete the electrical circuit. All structures would be constructed in compliance with the APLIC's Suggested Practices for Avian Protection on Power Lines. The Proposed Action includes only the replacement of existing electric lines and does not include the construction of any new electric lines; therefore, the electrocution risk would not increase from the risk of the existing lines but would, in fact, decrease as additional APLIC-approved measures would be implemented. In addition, as part of the Proposed Action and Similar Actions, SDG&E would replace some portions of the existing overhead distribution lines with underground lines. The installation of underground conduit would result in an overall reduction of potential electrocution impacts to avian species.

Other permanent impacts on avian species from the construction of the Proposed Action would be limited because the percentage of suitable nesting and foraging habitat that would be removed is extremely small in comparison to the total amount of available habitat for these species in the area. In addition, SDG&E would utilize NCCP protocols 2, 3, 4, 5, 7, 8, 10, 11, 13, 14, 17, 20, 24, 25, 27, 29, 34, 35, 41, 44, 48, 50, 54, 55, and 57 to avoid impacts to special-status avian species and nesting avian species. These protocols include, but are not limited to: restricting vehicles to existing roads when feasible, avoiding wildlife to the extent practicable, conducting pre-activity nest surveys, and avoiding nesting season to the extent practicable. As a result, with implementation of SDG&E's NCCP any potential impacts to nesting avian species would be minor.

Construction activities may potentially impact special-status mammal species, including Dulzura pocket mouse (*Chaetodipus californicus femoralis*), northwestern San Diego pocket mouse (*Chaetodipus fallax fallax*), pallid San Diego pocket mouse (*Chaetodipus fallax pallidus*), and American badger (*Taxidea taxus*). Potential impacts to mammal species include the temporary and permanent loss of suitable foraging and cover habitat, as well as the potential loss of burrows or dens. Rodent species and American badgers have the potential to fall into and become trapped within the pole excavation areas, as well as trenches and bore pits. In addition, potential impacts could result from temporary disturbance due to an increase in vehicle and equipment use and possible direct morality from construction vehicles and equipment. Other permanent impacts from the construction of the Proposed Action would be limited because the percentage of suitable habitat that would be removed is extremely small in comparison to the total amount of available habitat for rodent species in the area. In addition, SDG&E would utilize protocols 1, 2, 3, 4, 5, 7, 8, 10, 11, 13, 14, 17, 24, 25, 27, 29, 34, 35, 37, 38, 41, 44, 48, 54, 55, and 57, as described in Appendix A: SDG&E NCCP Protocols. These protocols include, but are not limited to: training, pre-activity surveys, monitoring during clearing and grading activities, avoidance of active burrows and dens, requiring all trenches and excavations to be inspected twice daily for wildlife entrapment, and requiring excavations to be sloped on one end to provide an escape route. With implementation of SDG&E's NCCP, therefore, any potential impacts to special-status mammal species would be minor.

Construction activities may potentially impact special-status bat species. Four special-status bat species have a moderate or high potential to occur within the Proposed Action area. These species include the California leaf-nosed bat (*Macrotus californicus*), pallid bat (*Antrozous pallidus*), Townsend's big-eared bat (*Corynorhinus townsendii*), and western red bat (*Lasiurus blossevillii*). Impacts to bats may occur if construction activities result in the disruption or abandonment of nearby active bat roosts. Because the Proposed Action includes the replacement of existing poles with replacement steel poles, any potential impacts to bat foraging or movement are anticipated to be minimal. The western red bat roosts in small colonies in the foliage of trees and shrubs and may be directly impacted from vegetation clearing. The remaining three bat species prefer to roost in caves, rock crevices, cliff faces, or man-made structures. Potential roosting habitat for these species would be not be directly impacted, but disturbance to nearby roosts is possible due to noise from construction equipment. No bat roosts have been identified in the Proposed Action area to date; however, focused bat surveys have not been conducted, and roosts may become established prior to the start of construction. If active bat roosts are identified during pre-activity surveys, SDG&E would coordinate with the USFS/CDFW as appropriate. Other permanent impacts from the construction of the Proposed Action would be limited because the percentage of suitable habitat that would be removed is extremely small in comparison to the total amount of available habitat for this species in the area. In addition, SDG&E would utilize protocols 1, 2, 3, 4, 5, 7, 8, 10, 11, 13, 14, 17, 24, 25, 27, 29, 34, 35, 37, 44, 48, 54, 55, and 57, as described in Appendix A: SDG&E NCCP Protocols. These protocols include, but are not limited to, training and pre-activity surveys. With implementation of SDG&E's NCCP, any potential impacts to special-status bat species would be minor.

In order to avoid and minimize potential impacts to biological impacts from the Proposed Action, SDG&E would implement the following APMs during construction:

- APM-BIO-01: SDG&E will consult with the appropriate resource agencies regarding potential impacts to federally and state-listed species, as appropriate.
- APM-BIO-02: All work areas will be surveyed for special-status plant and wildlife species by a qualified biologist prior to the commencement of construction in accordance with SDG&E's pre-activity survey report requirements.
- APM-BIO-03: SDG&E will implement the protocols identified in Appendix A: SDG&E NCCP Protocols.

- APM-BIO-04: SDG&E will implement the protocols identified in SDG&E QCB HCP Sections 3.2 Actions to Minimize Impacts and 3.3 Actions to Mitigate Impacts.

- APM-BIO-05: Stringing site locations are designed with a preference toward placement within roadways, where possible, to minimize additional potential impacts from grading and vegetation removal that may otherwise be required if these stringing sites were required to be located in vegetated, off-road areas.

- APM-BIO-06: Although Laguna Mountains Skipper is not covered under SDG&E's NCCP, SDG&E will utilize NCCP protocols 1, 2, 3, 5, 7, 8, 10, 11, 13, 14, 17, 24, 25, 29, 34, 35, 41, 44, 48, 54, 55, and 57 in USFS-modeled critical habitat and occupied habitat to minimize any potential impacts to this species. In addition, SDG&E will have a qualified biologist survey any Laguna Mountains Skipper habitat prior to work.

- APM-BIO-07: If California spotted owls are identified in the vicinity of proposed work areas during the pre-activity survey process, SDG&E will consult with the appropriate resource agencies to avoid impacts to nesting California spotted owl.

- APM-BIO-08: SDG&E will design and install all new poles to conform to the guidelines in the Suggested Practices for Avian Protection on Power Lines Manual developed by the APLIC.

- APM-BIO-09: If active bat roosts are identified during pre-activity surveys, SDG&E will coordinate with the USFWS/CDFW as appropriate.

- APM-BIO-10: SDG&E will eliminate existing access roads that will no longer be used due to removal or relocation of facilities, and will return the land to near pre-construction conditions.

Following completion of construction activities, operation and maintenance of the Proposed Action facilities would occur in the same manner as that which is currently conducted for the existing facilities. Additionally, the replacement steel poles would require less frequent inspection, repairs, and routine maintenance than the existing wood poles. As a result, any potential impacts to biological resources from operation and maintenance of the Proposed Action facilities would be less than currently exists.

10.1.1 Connected Actions

Potential impacts to biological resources resulting from construction, operation, and maintenance of Connected Actions are the same as those described for the Proposed Action. Differences from the Proposed Action are summarized in this section.

Special-status plants have the same potential to occur as those listed in Table 20: Special-Status Plant Species Occurrence. The majority of special-status wildlife have the same potential to occur as those listed in Table 21: Special-Status Wildlife Species Occurrence. Species that were found to be present within areas of Connected Actions (outside the CNF boundary) include the following:

- Hermes Copper Butterfly (*Lycaena hermes*) along TL6923
- Stephens' Kangaroo Rat (*Dipodomys stephensi*) along TL682

Potential impacts—and NCCP protocols to mitigate those impacts—to Hermes copper butterfly from Connected Actions would be consistent with those discussed previously in Section 10.1.0 Proposed Action. Stephens' kangaroo rat was found to be present along TL682 to the west and north of Lake Henshaw, which is outside of the CNF boundary. Habitat within the CNF along TL682 was determined to be unsuitable for Stephens' kangaroo rat during surveys conducted in 2010. Potential impacts to Stephens' kangaroo rat are the same as those described for the Proposed Action for special-status mammal species.

Construction of Connected Actions would result in a temporary impact of approximately 128.13 acres, and a permanent impact of approximately 0.33 acres. Temporary and permanent impacts of Connected Actions would be the same as those described for the Proposed Action. These temporary and permanent impacts are summarized by habitat type in Table 24: Vegetation Community Impacts of Connected Actions in Acres (69 kV Power Lines).

10.1.2 Similar Actions

Potential impacts to biological resources resulting from construction, operation, and maintenance of Similar Actions are the same as those described for the Proposed Action. Differences from the Proposed Action are summarized in this section.

Special-status plants have the same potential to occur as those listed in Table 20: Special-Status Plant Species Occurrence. Special-status wildlife have the same potential to occur as those listed for the Proposed Action in Table 21: Special-Status Wildlife Species Occurrence.

Similar Actions would result in a temporary impact of approximately 3.10 acres, and a permanent impact of approximately 0.01 acres. Temporary and permanent impacts of Similar Actions would be the same as those described for the Proposed Action. These temporary and permanent impacts are summarized by habitat type in Table 25: Vegetation Community Impacts of Similar Actions in Acres (12 kV Distribution Lines).

10.2 CULTURAL RESOURCES

A Cultural Resource Survey Report for the Proposed Action and Connected and Similar Actions was prepared by ASM Affiliates, Inc., in April 2011. As part of compliance with the NHPA, potential adverse effects to cultural resources were identified. The Area of Potential Effect (APE) included approximately 90 feet on either side of the electric lines and approximately 30 feet on either side of the electric line access road centerlines, and the actual footprint of all stringing sites, staging areas, guard structures, and fly yards.

Table 24: Vegetation Community Impacts of Connected Actions in Acres (69 kV Power Lines)

Habitat Type	TL625		TL626		TL629		TL682		TL6923		Total	
	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary
Chamise Chaparral	0.01	3.51	0	0	0.01	2.68	0	0	<0.01	0.55	0.02	6.75
Diegan Coastal Sage Scrub	0.01	1.60	0	0	<0.01	0.03	0.01	1.71	0.02	2.59	0.04	5.92
Disturbed (Ruderal/Barren)	0.00	5.54	0	0	<0.01	1.19	0	0.98	0	0	0.01	7.71
Freshwater Seep/Open Water	0	0	0	0.48	0	0	0	0	0	0.01	0	0.49
Mixed Oak Woodland	0.01	1.75	<0.01	1.80	<0.01	0.54	0.02	4.09	0	0.01	0.04	8.19
Native Grassland	<0.01	0.58	0	0	0	0.08	0	0	<0.01	1.00	0.01	1.66
Non-Native Grassland	0	<0.01	0.01	1.21	<0.01	1.51	0.02	9.05	<0.01	0.15	0.03	11.92
Oak Savanna	<0.01	0.41	0.01	1.99	0.01	2.84	<0.01	0.03	<0.01	0.02	0.02	5.29
Pastureland/Cultivated Agriculture	<0.01	9.48	0	0	0	8.16	0.01	2.90	0	0	0.01	20.53
Semi-Desert Chaparral	0	0	0	0	0.02	5.41	0	0	0	0	0.02	5.41
Southern Mixed Chaparral	0.02	9.18	0.02	5.90	0.01	5.08	0.01	1.98	0.02	3.12	0.08	25.26
Southern Riparian Forest	0	0	<0.01	0.20	0.01	0.49	<0.01	0.38	0	0	0.01	1.06
Urban and Developed/Ornamental Landscaping	0.01	5.71	0.01	1.45	0.03	11.57	<0.01	1.21	<0.01	0.95	0.05	20.88
Montane Forest	0	0	0	0	0	0	0	0	0	0	0	0
Montane Wet Meadow	0	0	0	0	0	0	0	0	0	0	0	0
Area Not Surveyed	<0.01	1.19	0	0.79	0	0	<0.01	5.09	0	0	<0.01	7
Total	**0.07**	**38.94**	**0.04**	**13.82**	**0.10**	**39.56**	**0.06**	**27.42**	**0.05**	**8.39**	**0.33**	**128.13**

Table 25: Vegetation Community Impacts of Similar Actions in Acres (12 kV Distribution Lines)

Habitat Type	C157		C440		C442		C449		C78		C79		Total	
	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary
Chamise Chaparral	0	0	<0.01	0.11	0	0	0	0	0	0	0	0	<0.01	0.11
Diegan Coastal Sage Scrub	0	0	<0.01	0.01	<0.01	0.06	0	0	<0.01	0.04	0	0	<0.01	0.11
Disturbed (Ruderal/Barren)	0	0	<0.01	0.01	0	0.27	0	0.23	0	0	0	0	<0.01	0.52
Freshwater Seep/Open Water	0	0	0	0	<0.01	0.01	0	0	0	0	0	0	<0.01	0.01
Mixed Oak Woodland	<0.01	0.02	0	0.01	<0.01	0.16	0	0	0	0	0	0	<0.01	0.19
Native Grassland	<0.01	0.13	0	0	0	0	0	0	0	0	0	0	<0.01	0.13
Non-Native Grassland	0	0	<0.01	0.04	0	0	0	0	0	0	0	0	<0.01	0.04
Oak Savanna	0	0	0	0	0	0	0	0	0	0	0	0	0	<0.01
Pastureland/Cultivated Agriculture	0	0	<0.01	0.30	0	0	0	0	0	0	0	0	<0.01	0.30
Semi-Desert Chaparral	<0.01	0.06	0	0	0	0	0	0	0	0	0	0	<0.01	0.06
Southern Mixed Chaparral	<0.01	0.26	<0.01	0.05	<0.01	0.20	<0.01	0.11	<0.01	0.02	0	0.15	<0.01	0.78
Southern Riparian Forest	<0.01	0.02	0	0	0	0	<0.01	0.04	0	0	0	0	<0.01	0.06
Urban and Developed/Ornamental Landscaping	0	0	<0.01	0.16	<0.01	0.01	0	0.01	0	<0.01	0	0	<0.01	0.18
Montane Forest	0	0	<0.01	0.50	0	0	0	0	0	0	0	0.09	<0.01	0.59
Montane Wet Meadow	0	0	<0.01	0.02	0	0	0	0	0	0	0	0	<0.01	0.02
Total	**<0.01**	**0.49**	**0.01**	**1.21**	**<0.01**	**0.71**	**<0.01**	**0.39**	**<0.01**	**0.06**	**0**	**0.24**	**0.01**	**3.10**

Due to the presence of Native American cultural resources in the area, the Native American Heritage Commission recommended that tribal groups be contacted for additional information and input. Letters of inquiry were sent to 16 tribal groups on March 20, 2009, and 21 groups on July 19, 2010. No responses have been received to date.

A Paleontological Resource Report for the Proposed Action, Connected Actions, and Similar Actions was prepared by the San Diego Natural History Museum in March 2012. No known fossils have been recorded within 0.5 mile of any construction areas.

As previously noted, SDG&E identified and included for consideration all potential cultural resources areas within the APE during construction design. During this process, SDG&E identified these areas for exclusion when considering replacement pole locations and, to the extent feasible, relocated replacement pole locations outside of cultural resource area boundaries.

10.2.0 Proposed Action

Based on a literature review, approximately 122 cultural sites are located either partially or completely within the Proposed Action portion of the APE. Approximately 15 of these sites have existing wood poles located within their survey boundaries.

The Proposed Action area passes through two historic resources. Old Highway 80 is a historic resource that is bordered by portions of TL629 from approximately Pine Valley in the west to the Campo Indian Reservation in the east. Old Highway 80 was recorded and assessed as eligible for the NRHP in 2000. Approximately seven existing TL629 wood poles are located along Old Highway 80, but are outside the historic resource itself. Lilac Village is also a historic resource that is located along Sunrise Highway, north of Mount Laguna Drive and south of Los Huecos Road. Lilac Village was recorded and assessed as eligible for the NRHP in 1980. Approximately 10 existing C440 wood poles are located in the historic resource itself.

During construction design of the Proposed Action, SDG&E identified potentially sensitive environmental resources in the vicinity of the electric lines, access roads, and appurtenant facilities and incorporated this information into the project design. During these activities, a potentially sensitive archaeological resource was identified in the vicinity of an access road along TL626, where improvement or maintenance of this access road could potentially impact the archaeological site. In order to prevent potential impacts to this site, SDG&E would flag the site for avoidance and prohibit any grading activities in the vicinity as part of construction or operation and maintenance. Additionally, the site surface would be protected by applying a geotextile fabric, then covering the fabric surface with rock to create a drivable surface that can be maintained within impacting the site below. The resource potential of the geologic formations in the Proposed Action area has been evaluated in accordance with the Potential Fossil Yield Classification (PFYC) guidelines set forth by the BLM. The majority of Proposed Action poles (approximately 772) are located on PFYC Class 1 geologic units, very low potential, with approximately 56 poles located in areas of PFYC Class 2 units, low potential, and approximately 48 located in areas classified as PFYC Class 3, moderate or unknown potential. There are no PFYC Class 4 or 5 geologic units located within the Proposed Action ROW. TL682 is the only Proposed Action power line that contains poles located within areas of high sensitivity for buried fossil deposits.

To ensure that impacts to sensitive cultural resources would be avoided during construction, SDG&E would implement the following APMs:

- APM-CUL-01: Prior to construction, all SDG&E, contractor, and subcontractor personnel will receive training regarding the appropriate work practices necessary to effectively implement the APMs and to comply with the applicable environmental laws and regulations, including the potential for exposing subsurface cultural, archaeological, and paleontological resources and how to recognize possible buried resources. This training will include a presentation of the procedures to be followed upon discovery or suspected discovery of cultural and archaeological materials, including Native American remains and their treatment, as well as of paleontological resources.

- APM-CUL-02: Intensive pedestrian surveys will be conducted prior to construction in those areas within the ROWs for which initial survey access was not granted to determine the potential for impacts to cultural resources in these areas. Where possible, engineering design will be re-evaluated to determine whether facilities can be relocated to avoid any cultural resources identified from these additional surveys. If relocation is not feasible, APM-CUL-03 will be implemented to minimize impacts to sensitive cultural resources.

- APM-CUL-03: All potentially National Register-eligible or archaeologically sensitive sites, as defined in the Cultural Resources Technical Report, that will not be directly affected by construction but are within 50 feet of replacement pole locations will be designated as Environmentally Sensitive Areas (ESAs). Potentially eligible resources include those that are recommended eligible, as well as unevaluated sites. Protective fencing or other markers will be erected and maintained to protect these ESAs from inadvertent trespass for the duration of construction in the vicinity. ESAs will not be signed or marked as cultural, historical, or archaeological resources.

- APM-CUL-04: An archaeological or cultural monitor will be present during construction activities that occur within or adjacent to identified archaeological or cultural resource site boundaries, respectively, as identified in the Cultural Resources Technical Report to ensure conformance with prescribed avoidance measures. The monitor will identify potential archaeological or cultural resources that may be unexpectedly encountered during construction and will have the authority to divert or temporarily halt construction activities in the area of discovery. In the event that archaeological or cultural resources are discovered, the monitor will stop work and notify the Principal Investigator (PI), who will inform SDG&E and the USFS Heritage Program Manager (HPM) of the stoppage. The archaeologist, in consultation with the USFS HPM and SDG&E's Cultural Resource Specialist, will determine the significance of the discovered resources. The USFS HPM and SDG&E's Cultural Resource Specialist and Environmental Project Manager must concur with the evaluation procedures to be performed before construction activities are allowed to resume. For significant cultural resources, preservation in-place will be the preferred manner of mitigating for impacts. For resources that cannot be preserved in place, a Research Design and Data Recovery Program will be prepared and carried out to mitigate impacts in consultation with the USFS HPM, the Tribes, and the State Historic Preservation Office (SHPO). No collection of archaeological or cultural resources will occur on USFS property without prior USFS HPM consent._Daily logs will be kept by all monitors, and a monitoring report (with appropriate graphics), which describes the results, analyses, and conclusions of the monitoring program, will be prepared at the conclusion of each phase of monitoring. Any new cultural sites or features encountered will be recorded with the South Coastal Information Center. Monitors will also identify and delineate an approved footpath through the archaeological and cultural resource sites for construction crews, as needed.

- APM-CUL-05: SDG&E will implement all applicable site-specific impact avoidance measures identified and described in the Cultural Resources Technical Report, such as avoiding access road improvements within culturally sensitive areas unless improvements are required for safety reasons; replacing poles within the previously disturbed area (two to four feet) represented by the existing pole locations, where necessary, to avoid sensitive resources; and cutting existing poles off at grade level, where specified and landowner approval is provided. Same-hole pole placement will also be utilized on a case-by-case basis. No new pole locations will be placed within cultural resource boundaries unless the appropriate consultation (including Section 106) has taken place. No temporary poles will be located within sites unless the appropriate consultation (including Section 106) has taken place.

- APM-CUL-06: In consultation with the USFS HPM, the Tribes, and the SHPO, SDG&E will develop a Cultural Resources Treatment Plan that includes procedures for protection and avoidance, evaluation and treatment, and the curation of any potentially register-eligible cultural materials. Specific protective measures, including a monitoring program, will be defined in the Cultural Resources Treatment Plan to reduce potential adverse impacts on unknown cultural resources to less-than-significant levels.

- APM-CUL-07: Should any previously unidentified prehistoric or historic artifacts; indicators or examples of cultural, archaeological, or paleontological resources; or potential human remains or funerary items be discovered during the course of site preparation, grading, excavation, construction, or other activities, all operations within 50 feet of an inadvertent discovery during such activities shall cease and the PI will contact the USFS HPM and SDG&E's Cultural Resource Specialist. Once a find has been identified, the USFS HPM and SDG&E's Cultural Resources Specialist will determine if additional cultural resources work, including but not limited to a formal evaluation or Proposed Action redesign, are required treatment. Ground-disturbing work in the vicinity of the discovery will not resume without authorization by the USFS HPM and after the appropriate consultation has taken place.

- APM-CUL-08: A paleontological monitor will be present for excavation activities conducted at locations with underlying PFYC Class 3 geologic deposits where new steel poles are unable to be installed in the same location as of that of the existing wood pole. In the event that fossils are unexpectedly encountered during construction, a qualified paleontologist will have the authority to divert or temporarily halt construction activities in the area of discovery to allow the recovery of fossil remains in a timely fashion. When significant fossils are discovered, the paleontologist will recover them in accordance with professional standards. Fossil remains collected during monitoring and salvage will be cleaned, repaired, sorted, cataloged, and curated in a scientific institution with permanent paleontological collections. The paleontological monitor will follow the procedures outlined in the Paleontological Monitoring and Treatment Plan, which will be prepared and will include information regarding pre-construction field surveys, construction personnel training, necessary permits, research design, monitoring methodology, fossil discovery and recovery protocols, fossil preparation and curation procedures, and the preparation of a final monitoring report.

- APM-CUL-09: SDG&E will flag potentially sensitive archaeological resources identified in the vicinity of access roads for avoidance and prohibit any grading activities in the vicinity as part of construction or operation and maintenance.

Implementation of the aforementioned APMs would ensure that impacts to sensitive cultural resources are avoided or minimized.

10.2.1 Connected Actions

Based on a literature review, approximately 89 cultural sites are located either partially or completely within Connected Actions portions of the APE. Approximately 28 of these sites have existing wood poles located within their survey boundaries.

One historic resource, Old Highway 80, passes through a Connected Actions area and is bordered by portions of TL629 from approximately Pine Valley in the west to the Campo Indian Reservation in the east. Old Highway 80 was recorded and assessed as eligible for the NRHP in 2000. Approximately 32 existing TL629 wood poles are located along Old Highway 80, but are outside the historic resource itself.

The majority of the approximately 779 Connected Actions poles are located on PFYC Class 1 geologic units, very low potential, with approximately 161 poles located in areas of PFYC Class 2 units, low potential, and approximately 66 located in areas classified as PFYC Class 3, moderate or unknown potential. There are no PFYC Class 4 or 5 geologic units located within Connected Actions ROWs. TL682 is the only 69 kV power line with Connected Actions that contains poles located within areas of high sensitivity for buried fossil deposits.

To further ensure that impacts to sensitive cultural resources would be avoided during construction, SDG&E would implement the previously described APM-CUL-01 through APM-CUL-09. Therefore, impacts to sensitive cultural resources would be avoided or minimized.

10.2.2 Similar Actions

Based on a literature review, approximately 17 cultural sites are located either partially or completely within Similar Actions portions of the APE. Approximately seven of these sites have existing wood poles located within their survey boundaries.

The majority of the approximately 191 Similar Actions poles are located on PFYC Class 1 geologic units, very low potential, with approximately 11 poles located in areas of PFYC Class 2 units, low potential, and approximately 18 located in areas classified as PFYC Class 3, moderate or unknown potential. There are no PFYC Class 4 or 5 geologic units located within Similar Actions ROW.

As previously described, SDG&E would implement APM-CUL-01 through APM-CUL-09 to ensure that impacts to sensitive cultural resources would be avoided during construction. Therefore, impacts to sensitive cultural resources would be avoided or minimized.

10.3 FIRE HAZARDS

The following describes the potential impacts from fire hazards from the Proposed Action, Connection Actions, and Similar Actions.

10.3.0 Proposed Action

The California Department of Forestry and Fire Protection's Fire and Resource Assessment Program (FRAP) classifies the Proposed Action area as having a moderate to very high fire threat. These areas are designated as such due to the wildland fire threat relative to the fuel, weather, and topography of the area with ratings of moderate, high, very high and extreme. The FRAP defines fire threat as the likelihood that an area would burn, combined with the severity of burn behavior characteristics (such as intensity, speed, and embers produced). FRAP data for the Proposed Action area are depicted in Figure 10: Fire Hazard Severity Map. According to these data, approximately 94 percent of Proposed Action components would be located in an area of very high fire threat classification.

San Diego County is an extremely fire-prone landscape; the county is dominated by a Mediterranean-type climate with mild, wet winters and hot, dry summers, which supports dense, drought-adapted shrub lands that are highly flammable. Winds originating from the Great Basin—locally known as Santa Ana winds—create extreme fire weather conditions characterized by low humidity, sustained high-speed winds, and extremely strong gusts. The Santa Ana winds create extremely dangerous fire conditions and have been the primary driver of most of California's catastrophic wildfires. High winds can cause electric lines to touch, fall, or come in contact with adjacent vegetation, causing sparks which could ignite potentially damaging wildfires. Ten wildfires have occurred over the past 10 years in the Proposed Action area. The most recent wildfires in the Proposed Action area were the Harris, McCoy, Poomacha, and Witch fires in 2007, which burned approximately 393,290 acres.

SDG&E has developed operating protocols and safety standards that minimize the risk of wildland fires during SDG&E construction activities. Specifically, wildland fire prevention during construction is governed internally to SDG&E through implementation of ESP 113-1, as described in Section 7.4 Fire Preparedness. The purpose of ESP 113-1 is to formalize procedures and routine construction practices that would improve SDG&E's ability to prevent the start of any fire; set standards for tools and equipment to assist with rapid response to small fires; incorporate federal, state, and local requirements into standard business practices; establish restrictions based on RFWs and PAL designations; set criteria for when a formal fire plan is required; and establish a template and requirements for formal fire plans.

Construction activities do have the potential to start a fire due to the increased presence of vehicles, equipment, and human activity in areas of elevated fire hazard severity. In particular, heat or sparks from construction vehicles or equipment have the potential to ignite dry vegetation. Consistent with current SDG&E standard practices, SDG&E would implement its existing ESP 113-1, which includes requirements for carrying emergency fire suppression equipment, conducting worker-awareness trainings that cover fire prevention and safety, restrictions on smoking and idling vehicles, and construction restrictions during RFWs. As part of the Proposed Action and consistent with ESP 113-1, SDG&E would also implement the SDG&E Operation and Maintenance Project Fire Plan (CNF Fire Plan) to assist in safe practices to prevent fires in the Proposed Action area. The CNF Fire Plan takes into consideration the USFS PAL designations, and includes standard measures such as equipping diesel and gasoline-operated engines with spark arrestors; carrying emergency fire suppression equipment; furnishing a water truck on or immediately adjacent to Proposed Action work areas; and requiring construction crews to cease work during an RFW. This plan takes into account local fuels, weather, and topography in its avoidance and minimization measures in order to reduce the threat of an ignition of a wildland fire. The plan also exceeds fire prevention measures as stated in California Forestry Practice Rules 2012, Title 14, California Code of Regulations Chapters 4, 4.5, and 10. No construction activities would occur during extreme weather conditions or on red flag days.

Consistent with ESP 113-1 and the CNF-specific fire plan, prior to starting construction activities, SDG&E would clear dead and decaying vegetation from Proposed Action work areas where personnel are active or where equipment is in use or being stored within ROWs, staging areas, stringing sites, and access roads. Cleared dead and decaying vegetation would either be removed or chipped and spread on site. In addition, prescribed fire tools and backpack pumps with water would be kept within 50 feet of work activities, in accordance with ESP 113-1, to ensure the capability for rapid extinguishment in the event of a fire. Weather and fire danger would be monitored daily by SDG&E meteorologists and wildland fire specialists in order to provide timely and immediate communication of significant changes which could impact the Proposed Action. As noted previously, no construction work would occur in areas designated with RFWs or PAL E, and if conditions change after construction has commenced, work would cease in periods of extreme fire danger, such as during RFWs or other severe fire weather conditions as identified by SDG&E.

Operation and maintenance of the electric lines included in the Proposed Action would not differ substantially from that of the existing facilities. Potential fire hazards would be reduced following construction of the Proposed Action due to the fact that many of the 69 kV power line poles that are being replaced are made of wood, and the new poles would be made of steel and have greater clearance above the ground and existing vegetation. SDG&E would continue to implement EDO 3017, as described in Section 7.4 Fire Preparedness, to ensure that the proper steps are taken to maintain fire safety while meeting all operational and service requirements.

The Proposed Action is being undertaken in part to minimize the risk of wildfires that exists when certain atmospheric conditions occur within geographic areas designated as having high- to extreme-risk fire threats. The Proposed Action is consistent with SDG&E's long-term plan to improve service reliability in fire-prone areas through system hardening or other enhancements. The Proposed Action would replace existing wood pole structures with new steel pole structures designed to withstand higher wind speeds; increase conductor spacing to maximize line clearances; install new conductors and remove weak spliced locations; and install longer polymer

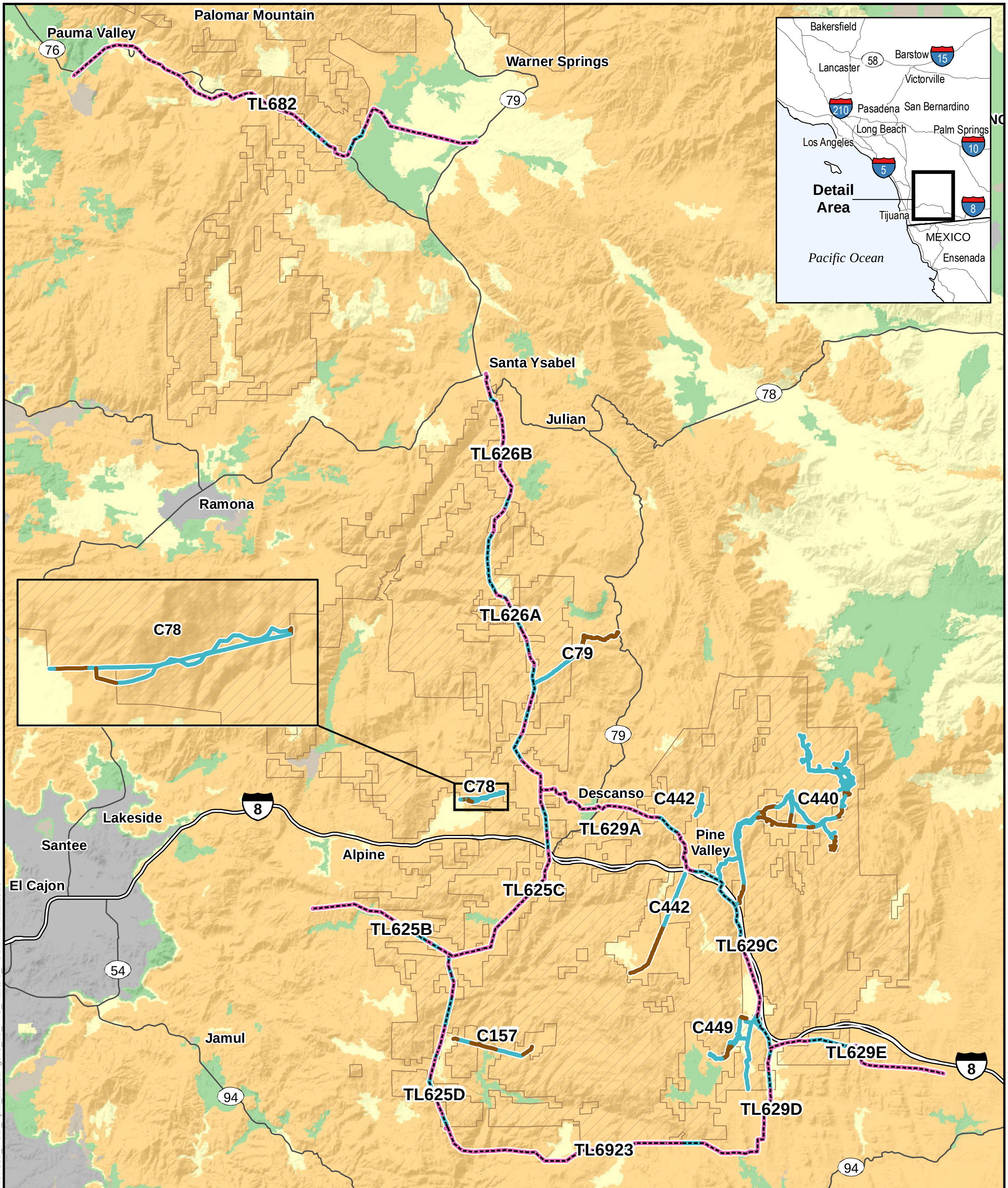

Figure 10: Fire Hazard Severity Map

CNF Revised Plan of Development

Fire Severity*

- Very High
- High
- Moderate
- Non-Wildland/Non-Urban
- Urban Unzoned

- Proposed Action
- Connected Actions
- Similar Actions
- *69 kV Power Line Shown with Dashed Line*

- United States Forest Service
- Interstate
- State Highway

SDGE
A Sempra Energy utility

INSIGNIA ENVIRONMENTAL

Source: SDG&E, 2012; CAL FIRE, 2011
* FRAP data displayed is a composite of the most recent recommended and approved hazard classifications, composed of 2007 and 2008 datasets.

1 inch = 6 miles
0 2 4 6 Miles

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insulators to minimize contamination which would improve system reliability during extreme weather conditions. With these Proposed Action design features, exposure of people or structures to loss, injury, or death involving wildland fires would not pose a significant risk, but would, in fact, be significantly reduced by comparison with the existing conditions.

In order to reduce potential impacts from fire hazards, SDG&E would implement the following APMs during construction:

- APM-HAZ-01: SDG&E will implement its existing ESP 113-1, which includes requirements for carrying emergency fire suppression equipment, conducting worker-awareness trainings that cover fire prevention and safety, restrictions on smoking and idling vehicles, and construction restrictions during RFWs.

- APM-HAZ-02: SDG&E will implement EDO 3017 to ensure that the proper steps are taken to maintain fire safety while meeting all operational and service requirements.

- APM-HAZ-03: Prior to starting construction activities, SDG&E will clear dead and decaying vegetation from Proposed Action work areas where personnel are active or where equipment is in use or being stored within ROWs, staging areas, stringing sites, and access roads.

- APM-HAZ-04: Prescribed fire tools and backpack pumps with water will be kept within 50 feet of work activities to ensure the capability for rapid extinguishment in the event of a fire.

- APM-HAZ-05: Weather and fire danger will be monitored daily by SDG&E meteorologists and wildland fire specialists in order to provide timely and immediate communication of significant changes which could impact the Proposed Action.

- APM-HAZ-06: No construction work will occur for areas affected by a Red Flag Warning or PAL E designation.

10.3.1 Connected Actions

Impacts from fire hazards due to Connected Actions would be similar to those described for the Proposed Action; however, approximately 80 percent of Connected Actions components would be located in an area of very high fire threat classification. FRAP data for Connected Actions areas are also depicted in Figure 10: Fire Hazard Severity Map.

10.3.2 Similar Actions

Impacts from fire hazards due to Similar Actions would be similar to those described for the Proposed Action; however, approximately 97 percent of Similar Actions components would be located in an area of very high fire threat classification. FRAP data for Similar Actions areas are also depicted in Figure 10: Fire Hazard Severity Map.

10.4 HYDROLOGY

The following section describes water resources and potential impacts to hydrology and water quality resulting from the Proposed Action, Connected Actions, and Similar Actions.

10.4.0 Proposed Action

Water resources and potential impacts to hydrology and water quality resulting from construction, operation, and maintenance of the Proposed Action were evaluated through reconnaissance-level surveys of the Proposed Action area, as well as a review of watershed and groundwater basin maps, Basin Plans and Urban Runoff Management Program documents for the Proposed Action area, inventories of impaired waterbodies, documents from the California Department of Water Resources (DWR) and the SWRCB, and other sources listed in Section 11 – References. Local plans were reviewed for relevant policies regarding water quality and protection. U.S. Geological Survey (USGS) 7.5-minute series quadrangle maps and aerial photography of the Proposed Action area were also examined to identify major water features and drainage patterns. Hydrologic features were then confirmed on the ground and additional features were noted during field surveys conducted between February and April 2012. Field surveys were limited to all locations identified for new and replacement steel poles; all Proposed Action staging areas, stringing sites, and other work areas; and a 50-foot buffer around each pole location and work area. These areas were assessed for potentially jurisdictional wetlands or waters of the U.S., based on the presence of hydrophytic vegetation, ordinary high water mark (OHWM), connectivity to blue-line drainages, and hydrology. Erosional features (gullies and rills) present within the 50-foot buffer were also documented at each site. However, a wetland delineation (in accordance with the 1987 USACE Wetland Delineation Manual) was not performed.

USFS-identified riparian conservation areas (RCAs) were also identified and included for consideration during project design to avoid the construction of replacement steel poles within these areas, where possible. These ecosystems contain aquatic and terrestrial features and lands adjacent to perennial, intermittent, and ephemeral streams, as well as in and around meadows, lakes, reservoirs, ponds, wetlands, vernal pools, seeps, springs, and other bodies of water. The USFS has identified these RCAs to protect riparian and aquatic ecosystems and the dependent natural resources associated with them during site-specific project planning and implementation. In accordance with the USFS' CNF Land Management Plan Goal 5.2, SDG&E included these areas for consideration during project design and avoided, where possible, the placement of steel poles and temporary work areas within RCAs to the extent feasible. As a result, the Proposed Action will temporarily impact approximately 8.76 acres of RCAs during construction, and will permanently impacts approximately 0.05 acres of these areas from the construction of the replacement steel poles. There are approximately 62,725 acres of identified RCAs within the Proposed Action area; as a result, these temporary and permanent impacts will be minor. Table 26: Temporary and Permanent Impacts to RCAs describes these potential impacts in greater detail.

Table 26: Temporary and Permanent Impacts to RCAs

Line	Approximate Number of Direct-Bury Poles	Approximate Number of Foundation-Supported Steel Poles	Approximate Number of Work Areas	Temporary Impact (acres)	Permanent Impact (acres)
TL625	1	3	1	0.5	0
TL626	10	3	2	0.7	0
TL629	36	22	4	3.7	<0.1
TL682	11	5	1	0.5	<0.1
TL6923	10	0	0	0.2	0
C78	0	0	0	<0.1	0
C79	0	0	0	0	0
C157	11	0	0	<0.1	0
C440	99	0	34	1.8	<0.1
C442	47	0	6	0.4	0
C449	18	0	20	0.9	0
Total	**243**	**33**	**68**	**8.8**	**<0.1**

Approximately 89 existing poles have been identified for removal from RCAs as part of the Proposed Action. At the request of the USFS, SDG&E is also evaluating all additional proposed replacement pole locations within the vicinity of RCAs to identify those poles and associated access roads that can be reasonably relocated outside these areas. This additional information will be developed during the environmental review process and reflected in the Final POD.

The Proposed Action components cross over or come within close proximity to various named rivers, creeks and other waterbodies, including the following:

- Sweetwater River,
- Taylor Creek,
- Wilson Creek,
- San Diego River,
- Sentenac Creek,
- Temescal Canyon Creek,
- Kelly Creek,
- Boulder Creek,
- Samagatuma Creek,
- Pine Valley Creek,
- Kitchen Creek,
- La Posta Creek,

- San Luis Rey River,
- Prisoner Creek,
- Wigham Creek,
- Cottonwood Creek,
- Potrero Creek,
- Hauser Creek,
- Viejas Creek, and
- Oak Valley Creek.

In addition, many unnamed, intermittent creeks and drainages are present throughout the Proposed Action area. All hydrological features identified within the Proposed Action area are shown in Attachment B: Detailed Route Maps. Hydrologic features located within pole work areas (measuring approximately 40 feet in diameter for 69 kV power line poles and 20 feet in diameter for 12 kV distribution line poles), stringing sites, and fly yards are described in Table 27: Potentially Jurisdictional Waters within Proposed Action Work Areas. Impacts to these hydrologic features have the potential to result from sediment runoff or erosion resulting from clearing and grading activities associated with the creation of work areas, stringing sites, staging areas, and fly yards; pole installation and removal; vegetation clearing; and changing run-off patterns during rain and snowmelt if temporarily disturbed areas are not stabilized.

The Proposed Action would require implementation of a SWPPP and would comply with USFS requirements pertaining to hydrology and water quality, as detailed in the USFS's Water Quality Management for National Forest System Lands in California, Best Management Practices. The SWPPP would identify BMPs for each activity that has the potential to degrade surrounding water quality through erosion, sediment run-off, and other pollutants. These BMPs would then be implemented and monitored throughout the Proposed Action by a Qualified SWPPP Practitioner. In addition, SDG&E would implement its Water Quality Construction Best Management Practices Manual (BMP Manual). During any construction activities, SDG&E would flag all hydrological resources occurring within work areas for avoidance, and all construction activities would occur outside of these resources. Where resource flagging and avoidance would not completely eliminate the potential for impacts to these resources, or where construction activities would be required to some extent within the mapped boundaries of a hydrological resource, SDG&E would implement the following APMs:

- APM-HYD-01: All concrete washouts will be conducted either into excavations where the concrete was poured within designated concrete washout stations, or will be captured using a washout recycling system. Crews will not be allowed to dispose of concrete directly onto the ground.

- APM-HYD-02: When construction activities are required adjacent to flowing aquatic resources, sediment barriers will be placed between the work area and flowing water.

Table 27: Potentially Jurisdictional Waters within Proposed Action Work Areas

Identification Number	Electric Line	Pole Reference or Work Area Number	Name of Waterbody	Feature Type	Flow Characteristic
D-00	TL625	Wildwood Glen Fly Yard B	Unnamed	Drainage	Ephemeral
D-01	TL625	Z272918	Unnamed	Drainage	Ephemeral
D-03	TL625	Z273014	Unnamed	Drainage	Ephemeral
D-05	TL625	Z273016	Unnamed	Drainage	Ephemeral
D-13	TL625	SS 18B	Unnamed	Drainage	Ephemeral
D-19	TL625	135624	Unnamed	Drainage	Ephemeral
D-00	TL626	SS 14	Unnamed	Drainage	Ephemeral
D-01	TL626	SS 14	Unnamed	Drainage	Ephemeral
D-04	TL626	Z372154	Unnamed	Drainage	Ephemeral
D-06	TL626	Z372163	Unnamed	Drainage	Ephemeral
D-16	TL626	SS 2	Unnamed	Drainage	Ephemeral
D-16	TL626	Z213741	Unnamed	Drainage	Ephemeral
F-02	TL626	Z213644	Unnamed	Swale	Not Applicable (NA)
F-02	TL626	Z213644	Unnamed	Swale	NA
W-03	TL626	Z213671	Unnamed	Meadow	NA
D-02	TL629	Z44163	Unnamed	Drainage	Ephemeral
D-03	TL629	Z44173	Unnamed	Drainage	Ephemeral
D-10	TL629	Z276633	Unnamed	Drainage	Intermittent
D-13	TL629	SS 30	Unnamed	Drainage	Ephemeral
D-13	TL629	Z40252	Unnamed	Drainage	Ephemeral
D-15	TL629	Z40503	Unnamed	Drainage	Lower Perennial
D-15	TL629	Z40505	Unnamed	Drainage	Lower Perennial
D-16	TL629	Z40507	Unnamed	Drainage	Ephemeral
D-24	TL682	SS 7	Unnamed	Drainage	Intermittent
D-03	C78	P-18	Unnamed	Drainage	Ephemeral
D-04	C78	P166377	Unnamed	Drainage	Ephemeral
D-07	C440	P40126	Unnamed	Drainage	Ephemeral
D-08	C440	P40127	Unnamed	Drainage	Ephemeral
D-09	C440	P40127	Unnamed	Drainage	Ephemeral

Identification Number	Electric Line	Pole Reference or Work Area Number	Name of Waterbody	Feature Type	Flow Characteristic
D-10	C440	P40452	Unnamed	Drainage	Ephemeral
D-11	C440	P40128	Unnamed	Drainage	Ephemeral
D-29	C440	P40050	Unnamed	Drainage	Intermittent
W-00	C440	P40087	Unnamed	Wetland	NA
W-01	C440	P40080	Unnamed	Wetland	NA
W-02	C440	P40129	Unnamed	Wetland	NA
W-06	C440	P40177	Unnamed	Wetland	NA
W-15	C440	SS 4604	Unnamed	Wetland	NA
D-02	C442	P178049	Unnamed	Drainage	Perennial
D-03	C442	P178049	Unnamed	Drainage	Perennial
D-04	C442	P178044	Unnamed	Drainage	Ephemeral
D-05	C442	P178042	Unnamed	Drainage	Perennial
D-06	C442	P178039	Unnamed	Drainage	Ephemeral
D-10	C442	P178030	Unnamed	Drainage	Ephemeral
D-10	C442	SS346A	Unnamed	Drainage	Ephemeral
D-05	C449	P42798	Unnamed	Drainage	Ephemeral

- APM-HYD-03: In areas where topsoil has not been salvaged, construction activities will be limited when the environmental monitor determines that the soil is too wet to adequately support vehicles and equipment. Where soil conditions are deemed too wet to work, one of the following measures will apply:
  - Access will be limited to the minimum area feasible for construction. Where possible, vehicles and equipment will be routed around wet areas so long as the re-route does not cross into sensitive resource areas.
  - If wet areas cannot be avoided and soil moisture is too high to strip topsoil, BMPs—including the use of wide-track or low ground pressure equipment or installation of prefabricated equipment pads or timber mats—will be implemented for use in these areas to minimize rutting and off-site sedimentation.
- APM-HYD-04: Any areas not surveyed for potentially jurisdictional wetlands or waters due to limited access will be surveyed prior to the start of construction activities and potential impacts will be assessed and the appropriate jurisdictional permits will be obtained as needed.
- APM-HYD-05: SDG&E will prepare and implement a SWPPP. The SWPPP will identify BMPs based on its Water Quality BMPs Manual for each activity that has the potential to degrade surrounding water quality through erosion, sediment run-off, and other pollutants. These BMPs will then be implemented and monitored by a Qualified SWPPP Practitioner.
- APM-HYD-06: During any construction activities, SDG&E will flag all hydrological resources occurring within work areas for avoidance, and all construction activities will occur outside of these resources.
- APM-HYD-07: SDG&E will comply with USFS requirements pertaining to hydrology and water quality, as detailed in the USFS's Water Quality Management for National Forest System Lands in California, BMPs.
- APM-HYD-08: If dewatering is required, dewatering systems—as outlined in SDG&E's Water Quality BMPs Manual—will be used to dispose of groundwater. Typically, groundwater will be pumped into truck-mounted storage tanks and either discharged to land in accordance with RWQCB regulations or transported to an authorized discharge location.
- APM-HYD-09: SDG&E will implement site-specific erosion and sediment control devices and the proper handling of potentially hazardous materials.
- APM-HYD-10: Following construction, the ROW, work areas, stringing sites, staging areas, and fly yards will be returned to near pre-construction conditions, which include re-establishing drainage patterns and vegetation, where feasible.

- APM-HYD-11: Existing access roads will be utilized to access the replacement structures where helicopter-only access is not required.

There are two locations where existing poles are, or where replacement poles would be located, below the OHWM of hydrological features, including pole Z44173 along TL629, and pole P40452 along C440. Removal or replacement of these poles has the potential to contribute sediment to nearby resources as a result of ground disturbance and excavation at the work sites. SDG&E has included APM-HYD-02 to minimize work within existing hydrological features. The minimal increase in impermeable surface would not substantially increase the existing velocity or volume of storm water flows either on site or in off-site areas. As such, flow rates and volumes would not be substantially altered. Therefore, existing drainage patterns on site would not change significantly from pre-construction conditions. A total of approximately 3.9 square feet (less than 0.001 acre) of potentially jurisdictional waters would be permanently impacted during construction of the Proposed Action. Estimates regarding the permanent impact resulting from the installation of poles placed below the OHWM in potentially USACE-jurisdictional waters are provided in Table 28: Estimated Permanent Impact to Waters of the U.S. – Proposed Action.

Table 28: Estimated Permanent Impact to Waters of the U.S. – Proposed Action

Line	Estimated Number of Direct-Bury Poles	Estimated Number of Foundation-Supported Steel Poles	Permanent Impact (square feet)
TL629	0	1	1.9
C440	1	0	2.0
Total	**1**	**1**	**3.9**

The installation of direct-bury steel poles would require the excavation of holes approximately 20 to 48 inches in diameter and approximately seven to 12 feet deep. Foundation-supported steel poles would be installed on poured or micro-pile foundations. Micro-pile foundation installation would require the excavation of holes approximately eight inches in diameter by approximately 10 to 40 feet deep; poured foundations would require the excavation of holes approximately six to seven feet in diameter by approximately 16 to 30 feet deep. Poles that encounter groundwater may require dewatering, which can increase the potential for sedimentation if not performed properly. However, dewatering would not likely be necessary due to the small diameter of the excavation holes. The area with the highest possibility of needing dewatering is in Cottonwood Valley, along the TL629 and C449 lines. The depth to groundwater varies widely depending on location and ranges from five feet to approximately 100 feet.

Surface waters are present in this area, including La Posta Valley Creek and Kitchen Creek. If dewatering is required, dewatering systems—as outlined in SDG&E's Water Quality BMPs Manual—would be used to dispose of groundwater. Typically, groundwater would be pumped into a tank and either discharged to land in accordance with RWQCB regulations or transported to an authorized discharge location. Excavated holes would need to be backfilled with concrete.

For direct-bury steel poles, the annular space between replacement steel poles and hole walls would be backfilled with concrete. For foundation-supported steel poles, a steel rod would be inserted into the hole and centered, and the remaining space filled with a mixture of water, cement, and sand. Use of concrete near aquatic resources, combined with storm water run-off, has the potential to affect water quality by increasing pH. Where concrete use is required near waterways, APM-HYD-01 and APM-HYD-02 would be implemented to minimize impacts.

A portion of the Proposed Action is within a watershed that drains to a 303(d)-listed waterbody. Cottonwood Creek, which is within the Tijuana Rivershed along TL629, is located approximately 40 feet from a work area. Specific requirements would be incorporated into the SWPPP, including appropriate BMPs and a sampling and monitoring plan. Implementation of site-specific erosion and sediment control devices and the proper handling of potentially hazardous materials would ensure that the Proposed Action does not contribute to the pollutant load for Cottonwood Creek.

The operation and maintenance activities required for the Proposed Action would be similar to those currently conducted for the existing lines. In addition, less frequent maintenance of the electric lines would be required in comparison to what is currently needed for the existing wood poles. Following construction, the ROW, work areas, stringing sites, staging areas, and fly yards would be returned to pre-construction conditions, which include re-establishing drainage patterns and vegetation, where feasible. Existing access roads would be utilized to access the replacement structures where helicopter-only access is not required. Because no new roads would be constructed, there would be no new impacts associated with operation and maintenance of the Proposed Action.

By following the USFS's Water Quality Management for National Forest System Lands in California, Best Management Practices, and with implementation of SDG&E's Water Quality BMPs Manual, the SWPPP, and the APMs identified in this section, any potential impacts to hydrological resources from the Proposed Action would be minor.

10.4.1 Connected Actions

Water resources and potential impacts to hydrology and water quality resulting from construction, operation, and maintenance of Connected Actions are the same as those described for the Proposed Action. Differences from the Proposed Action are summarized in this section.

Several of the proposed poles and work areas outside of the CNF were not accessible due to landowner restrictions or other access issues. These areas are listed in Table 29: Connected Actions Areas Not Surveyed. A total of 43 poles and two stringing sites were not surveyed for potentially jurisdictional wetlands or waters of the U.S. for Connected Actions.

Table 29: Connected Actions Areas Not Surveyed

Line	Number of Poles	Number of Work Areas
TL629	40	0
TL6923	3	2
Total	**43**	**2**

Connected Actions components cross over or come within close proximity to rivers, creeks and other waterbodies. Additional waters not mentioned in the Proposed Action include Loveland Reservoir, Lake Henshaw, Potrero Creek, Buena Vista Creek, Barrett Lake, San Diego City Conduit, Cedar Creek, Orinoco Creek, and King Creek. Hydrologic features located within pole work areas (measuring approximately 40 feet in diameter for 69 kV power line poles and approximately 20 feet in diameter for 12 kV distribution poles), stringing sites, and fly yards are described in Table 30: Potentially Jurisdictional Waters within Connected Actions Work Areas. Impacts to these hydrologic features are the same as those described for the Proposed Action.

There are five locations where existing poles are, or where replacement poles would be located, below the OHWM of hydrological features, including pole P273066 along TL625, pole Z371562 along TL626, pole Z41023 along TL629, and poles Z571488 and Z571489 along TL6293. Less than 0.001 acre of potentially jurisdictional waters would be permanently impacted during construction of Connected Actions. Estimates regarding the permanent impact resulting from the installation of poles placed below the OHWM in potentially USACE-jurisdictional waters are provided in Table 31: Estimated Permanent Impact to Waters of the U.S. – Connected Actions. The necessary information was not available to calculate impacts for the drainage located at pole P273066 along TL625. Impacts to water resources resulting from the removal or replacement of poles located below the OHWM of hydrological features are the same as those described for the Proposed Action.

The impacts associated with the installation and removal of poles are similar to those described in the Proposed Action. Although dewatering would not likely be necessary for Connected Actions, there are several areas where components cross over groundwater basins, including Campo Valley, San Luis Rey Valley, and Warner Valley along the TL629 and TL682 lines. The depth to groundwater varies widely depending on location, and ranges from zero feet to approximately 100 feet. Surface waters and waterbodies are present in these areas, including Potrero Creek in San Luis Rey Valley and Buena Vista Creek in Warner Valley. If dewatering is required, dewatering systems would be used to dispose of groundwater into truck-mounted storage tanks for off-site disposal.

Portions of Connected Actions work areas are within watersheds that drain to 303(d)-listed waterbodies. These waterbodies include the San Luis Rey River along TL682, Morena Reservoir along TL6923, and Loveland Reservoir along TL625. Distances from these work areas to impaired waterbodies range from 110 to 8,000 feet. As described in Section 10.4.0 Proposed Action, specific requirements would be incorporated into the SWPPP that would ensure Connected Actions do not contribute to the pollutant load for the 303(d)-listed water resource located within the vicinity of the work areas.

Table 30: Potentially Jurisdictional Waters within Connected Actions Work Areas

Identification Number	Electric Line	Pole Reference or Work Area Number	Name of Waterbody	Feature Type	Flow Characteristic
D-00	TL625	Z272948	Unnamed	Drainage	Ephemeral
D-00	TL625	Z272920	Unnamed	Drainage	Ephemeral
D-01	TL625	SS A	Unnamed	Drainage	Ephemeral
D-01	TL625	Z272930	Unnamed	Drainage	Ephemeral
D-01	TL625	Z272959	Unnamed	Drainage	Ephemeral
D-01	TL625	Z272989	Unnamed	Drainage	Ephemeral
D-02	TL625	SS B	Unnamed	Drainage	Ephemeral
D-03	TL625	SS 10B	Unnamed	Drainage	Ephemeral
D-03	TL625	SS 12B	Unnamed	Drainage	Ephemeral
D-04	TL625	Z272929	Unnamed	Drainage	Ephemeral
D-04	TL625	Z273015	Unnamed	Drainage	Ephemeral
D-05	TL625	Z272929	Unnamed	Drainage	Ephemeral
D-06	TL625	SS 11B	Unnamed	Drainage	Ephemeral
D-07	TL625	P273066	Unnamed	Drainage	Ephemeral
D-08	TL625	P273066	Unnamed	Drainage	Ephemeral
D-08	TL625	SS 11B	Unnamed	Drainage	Ephemeral
D-09	TL625	P273066	Unnamed	Drainage	Ephemeral
D-09	TL625	Z272928	Unnamed	Drainage	Ephemeral
D-10	TL625	P273066	Unnamed	Drainage	Ephemeral
D-10	TL625	Z272927	Unnamed	Drainage	Ephemeral
D-11	TL625	Martin Staging Yard and Fly Yard	Unnamed	Drainage	Ephemeral
D-11	TL625	SS 16B	Unnamed	Drainage	Ephemeral
D-13	TL625	SS 4B	Unnamed	Drainage	Ephemeral
D-14	TL625	SS 1C	Unnamed	Drainage	Ephemeral
W-00	TL625	Z272947, Z272948	Unnamed	Meadow	NA

Identification Number	Electric Line	Pole Reference or Work Area Number	Name of Waterbody	Feature Type	Flow Characteristic
W-01	TL625	Martin Staging Yard and Fly Yard	Unnamed	Meadow	NA
A-01	TL626	SS 8	Unnamed	Artificial Pond	NA
A-02	TL626	SS 9	Unnamed	Artificial Pond	NA
A-02	TL626	Z213682	Unnamed	Artificial Pond	NA
A-03	TL626	Z213682	Unnamed	Artificial Pond	NA
A-04	TL626	Z213683	Unnamed	Artificial Pond	NA
A-05	TL626	Z213684	Unnamed	Artificial Pond	NA
A-06	TL626	Z213684	Unnamed	Artificial Pond	NA
D-09	TL626	Z371562	Unnamed	Drainage	Ephemeral
D-10	TL626	SS 13	Unnamed	Drainage	Ephemeral
D-14	TL626	Z213743	Unnamed	Drainage	Ephemeral
D-17	TL626	Z213711	Unnamed	Drainage	Ephemeral
W-01	TL626	Rutherford Staging Yard	Unnamed	Meadow	NA
D-00	TL629	Z172750	Unnamed	Drainage	Ephemeral
D-00	TL629	Z46628	Unnamed	Drainage	Ephemeral
D-00	TL629	Z41023	Unnamed	Drainage	Ephemeral
D-00	TL629	Z872454	Unnamed	Drainage	Intermittent
D-03	TL629	Z373147	Unnamed	Drainage	Intermittent
D-09	TL629	Z44195	Unnamed	Drainage	Ephemeral
D-22	TL629	Z40527	Unnamed	Drainage	Ephemeral
D-22	TL629	Z40528	Unnamed	Drainage	Ephemeral
D-23	TL629	SS 25	Unnamed	Drainage	Ephemeral
D-29	TL629	SS 27	Unnamed	Drainage	Ephemeral
F-00	TL629	Z173075	Samagatuma Creek	Drainage	Unknown

Identification Number	Electric Line	Pole Reference or Work Area Number	Name of Waterbody	Feature Type	Flow Characteristic
F-00	TL629	Z173076	Samagatuma Creek	Drainage	Unknown
W-00	TL629	Z44161	Unnamed	Seep	NA
D-01	TL682	SS 1	Potrero Creek	Drainage	Intermittent
D-06	TL682	SS 2	Unnamed	Drainage	Intermittent
D-07	TL682	Z118052	Unnamed	Drainage	Ephemeral
D-07	TL682	Z118053	Unnamed	Drainage	Ephemeral
D-08	TL682	Z118052	Unnamed	Drainage	Ephemeral
D-10	TL682	SS 4	Unnamed	Drainage	Ephemeral
D-11	TL682	SS 4	Unnamed	Drainage	Ephemeral
D-12	TL682	SS 4	Unnamed	Drainage	Ephemeral
D-13	TL682	SS 4	Unnamed	Drainage	Ephemeral
D-14	TL682	SS 4	Unnamed	Drainage	Ephemeral
D-15	TL682	SS 4	Unnamed	Drainage	Ephemeral
D-16	TL682	Z118063	Unnamed	Drainage	Intermittent
D-19	TL682	Z118122	Unnamed	Drainage	Ephemeral
D-26	TL682	SS 10	Unnamed	Drainage	Ephemeral
D-32	TL682	Z118234	Unnamed	Drainage	Ephemeral
D-34	TL682	Z215013	Unnamed	Drainage	Intermittent
W-01	TL682	Lake Henshaw Staging Yard	Unnamed	Meadow	NA
W-03	TL682	SS 13	Unnamed	Meadow	NA
W-04	TL682	Z118189	Unnamed	Meadow	NA
W-05	TL682	SS 15	Unnamed	Meadow	NA
W-06	TL682	SS 16	Unnamed	Meadow	NA
W-08	TL682	Z118203	Unnamed	Meadow	NA
W-09	TL682	Z118206	Unnamed	Meadow	NA
D-00	TL6923	SS 31	Unnamed	Drainage	Ephemeral
D-00	TL6923	Z46627	Unnamed	Drainage	Ephemeral
D-00	TL6923	SS 32	Unnamed	Drainage	Ephemeral
D-03	TL6923	SS 31	Unnamed	Drainage	Ephemeral
D-03	TL6923	Z571489	Unnamed	Drainage	Ephemeral

Identification Number	Electric Line	Pole Reference or Work Area Number	Name of Waterbody	Feature Type	Flow Characteristic
D-04	TL6923	Z571488	San Diego City Conduit	Drainage	Perennial
D-05	TL6923	Z46578	Unnamed	Drainage	Ephemeral
D-06	TL6923	Z571488	Unnamed	Drainage	Ephemeral
D-16	TL6923	SS 13	Unnamed	Drainage	Ephemeral

Table 31: Estimated Permanent Impact to Waters of the U.S. – Connected Actions

Line	Estimated Number of Direct-Bury Poles	Estimated Number of Foundation-Supported Steel Poles	Permanent Impact (square feet)
TL625	0	1	Not Available
TL626	1	0	1.2
TL629	0	1	2.6
TL6923	0	2	19.1
Total	**1**	**4**	**Not Available**

10.4.2 Similar Actions

Water resources and potential impacts to hydrology and water quality resulting from construction, operation, and maintenance of Similar Actions are the same as those described for the Proposed Action. Differences from the Proposed Action are summarized in this section.

Hydrologic features located within Similar Actions work areas (each measuring approximately 40 feet in diameter), stringing sites, and fly yards are described in Table 32: Potentially Jurisdictional Waters within Similar Actions Work Areas. Impacts to these hydrologic features are the same as those described for the Proposed Action.

Table 32: Potentially Jurisdictional Waters within Similar Actions Work Areas

Identification Number	Line	Pole Reference or Work Area Number	Name of Waterbody	Feature Type	Flow Characteristic
D-00	C440	P40136	Unnamed	Drainage	Ephemeral
D-03	C440	P45116	Unnamed	Drainage	Ephemeral
D-13	C440	P40199	Unnamed	Drainage	Ephemeral
W-01	C440	P40335	Unnamed	Wetland	Not Available
W-05	C440	P40171	Unnamed	Wetland	Not Available
D-00	C449	P104078	Unnamed	Drainage	Ephemeral
D-06	C449	P46464	Unnamed	Drainage	Ephemeral
D-07	C449	P-37	Unnamed	Drainage	Ephemeral

Several of the proposed poles outside of the CNF were not accessible due to landowner restrictions or other access issues. These areas are listed in Table 33: Similar Actions Areas Not Surveyed. A total of 75 poles were not surveyed for potentially jurisdictional wetlands or waters of the U.S. for Similar Actions.

Table 33: Similar Actions Areas Not Surveyed

Line	Number of Poles	Number of Work Areas
C79	2	0
C157	7	0
C440	58	0
C449	8	0
Total	**75**	**0**

There are no locations where existing poles are or where replacement poles would be located below the OHWM of hydrological features for Similar Actions.

10.5 NOISE

The following section describes noise and potential impacts to noise resulting from the Proposed Action, Connected Actions, and Similar Actions.

10.5.0 Proposed Action

The evaluation of potential noise and vibration impacts from the Proposed Action began with a review of San Diego County's noise standards. To establish the background noise levels in the Proposed Action area, 25-hour noise surveys were conducted from June 8 to 10, 2011; August 31 to September 1, 2011; and September 2 to 8, 2011. The Noise Study Report describes the methodology and equipment used for noise measurement during these surveys and the resulting modeling of potential impacts. After characterizing the existing noise environment, the survey results and estimated noise levels of the typical major construction equipment to be used during Proposed Action construction were used to calculate potential noise levels from the Proposed Action.

Construction noise would be temporary, and noise levels would vary from hour to hour and day to day, depending on the equipment in use and the task being performed. Construction activities would require the temporary use of various types of noise-generating equipment, including graders, backhoes, drilling rigs, flatbed trucks, boom trucks, air compressors, concrete trucks, and impact equipment. Conductor stringing operations would require pullers, tensioners, and cable reel trailers. Helicopters would be used to deliver and remove construction material from areas with rugged terrain and where ground access would not safely accommodate the required construction equipment and vehicles. Typical noise levels from construction equipment are provided in the Noise Study Report.

The inventory of equipment that would be utilized during Proposed Action construction was used to determine average eight-hour noise emissions—equivalent noise level (L_{eq}) (day)—based on the estimated average hours of operation per day and the typical usage at maximum noise levels. The total L_{eq}(day) was computed for each scheduled activity category for each piece of equipment. Helicopters were assumed to operate at a height of approximately 50 feet when delivering equipment and materials, and when assisting with the installation and removal of poles and conductor, except during landing and takeoff.

The San Diego County Noise Ordinance prohibits construction noise outside the hours of 7:00 a.m. to 7:00 p.m. on Monday through Saturday, as well as on Sundays and holidays. The noise ordinance also establishes a variance process for non-emergency work on public utility facilities, pursuant to which deviations from construction noise restrictions can be permitted. Under Section 36.423 of the noise ordinance, in the event that certain construction activities cannot conform to the prescribed noise limits or hours for construction activities, the county noise control officer may grant a variance allowing deviations from those requirements. Deviations from the noise ordinance requirements can be appropriate depending on the potential noise impacts to each potentially affected property, the value to the community of the work proposed to be performed, and other similar factors. In order to begin construction at 7:00 a.m., in some instances SDG&E may need to fly helicopters from their respective home airfields to the Proposed Action staging areas or landing zones prior to 7:00 a.m. to pick up workers or construction materials. Where appropriate, SDG&E would coordinate with the county noise control officer regarding these flights to avoid any conflicts with the county noise ordinance.

Construction of the Proposed Action would result in temporary increases in noise levels in the immediate vicinity as a result of the use of construction equipment. Equipment used to construct the Proposed Action may include graders, backhoes, drilling rigs, flatbed trucks, boom trucks, air compressors, concrete trucks, and impact equipment. Potential impact zones were developed by determining the distance from each construction activity where San Diego County guidelines were surpassed. These zones are summarized in Table 34: Zones of Potential Construction Noise Impacts.

Table 34: Zones of Potential Construction Noise Impacts

Activity	Distance to L_{eq} = 75 dBA[18] (feet)
Improve Access Roads	<25
Construction Pole Foundation (Helicopter Set)	590
Construct Pole Foundation (Truck Set)	180
Install Foundation-Supported Pole (Helicopter Set)	400
Install Foundation-Supported Pole (Truck Set)	80
Construct Direct-Bury Pole (Helicopter Set)	330
Construct Direct-Bury Pole (Truck Set)	190
Pole Removal (Ground Access)	<25
Pole Removal (No Ground Access)	280
String Conductor	100
Restore ROW	150

[18] dBA = an A-weighted decibel. The human ear is not uniformly sensitive to all sound frequencies; therefore, the A-weighting scale has been devised to correspond with the human ear's sensitivity. The A-weighting scale uses the specific weighting of sound pressure levels from about 10 hertz to 20 kilohertz for determining the human response to sound.

In order to reduce noise impacts, SDG&E would implement the following APMs:

- APM-NOI-01: SDG&E will provide notice of the construction schedule to all property owners within 300 feet of the Proposed Action by mail at least one week prior to the start of construction activities. The announcement will state the construction start date, anticipated completion date, and hours of operation, as well as a telephone number to call with questions or complaints during construction.

- APM-NOI-02: Operating equipment will be positioned to maximize the distance to residences and to maintain safe and effective operation.

- APM-NOI-03: All internal combustion engine-driven equipment will be equipped with exhaust mufflers that are in good condition and meet or exceed the manufacturer's specifications. All equipment will be maintained and tuned according to manufacturer recommendations.

- APM-NOI-04: When backup alarms have more than one loudness setting, they will be set to the lowest setting that meets Occupational Safety and Health Administration safety requirements.

- APM-NOI-05: When located within 80 feet of residences, a temporary noise barrier with an effective height of approximately three feet will be placed between residences and stationary noise-generating equipment during use. The effective height is that of the barrier above the line-of-sight between the noise source and the noise-sensitive receiver.

- APM-NOI-06: Helicopters will be required to maintain a height of at least 500 feet when passing over residential areas, except when at temporary construction areas or actively assisting with conductor stringing. All helicopters will be required to maintain a lateral distance of at least 500 feet from all schools. No more than 64 flights per day will be conducted.

- APM-NOI-07: Residents who experience construction noise levels that exceed the applicable noise thresholds will be temporarily relocated, on an as-needed basis, for the duration of the activities that will impact them.

- APM-NOI-08: In the event that blasting is required within 325 feet of a residential property line, SDG&E will prepare and provide a blasting plan for the Proposed Projects that is consistent with SDG&E's blasting guidelines to reduce noise and vibration impacts from blasting activities. The blasting contractor will be required to obtain a blasting permit and explosive permit per the San Diego County Regulatory Ordinances.

- APM-NOI-09: Where appropriate, SDG&E will coordinate with the San Diego County noise control officer regarding helicopter flights between 6:30 a.m. and 7:00 a.m. to avoid any conflicts with the County noise ordinance.

- APM-NOI-10: If construction occurs outside the hours allowed by San Diego County, SDG&E will follow its established protocols and will provide advance notice by mail to all property owners within 300 feet of planned construction activities. The announcement will state the construction start date, anticipated completion date, and hours of construction.

As shown in Table 34: Zones of Potential Construction Noise Impacts, any residences located within approximately 180 feet of pole foundation construction, or within approximately 190 feet of direct-bury pole construction, may be exposed to eight-hour average noise levels in excess of 75 dBA during pole installation and removal activities. In addition, any residences located within approximately 100 feet of stringing sites along the electric lines may be exposed to eight-hour average noise levels in excess of 75 dBA during pulling activities. These construction activities would be dispersed across the electric lines throughout the approximately five-year construction period. Because the project would be constructed in a linear fashion, construction crews would move along the electric lines, staying at one pole work area for as long as seven days at a time, then revisiting the same area later during the construction process. Stringing activities would be performed at each stringing site for approximately one week.

Some of the equipment may cause groundborne vibrations and groundborne noise; however, this equipment would be used intermittently throughout the duration of construction. It is unlikely that groundborne noise or vibration would be detected by the general public due to the remoteness of the Proposed Action area. Due to the relatively short-term nature of the exposure, and with the implementation of APM-NOI-01 through APM-NOI-10, impacts from noise and groundborne vibration would be minimal.

The addition of one new 69 kV circuit each for the single- to double-circuit conversion along TL625B and TL629E would cause a small increase in the audible corona noise in these areas; however, this noise would be intermittent and generally masked by other noise sources, such as local traffic and weather events. All other electric lines included in the Proposed Action would continue to operate at their current voltages and number of circuits and, therefore, the audible corona noise from these lines would not change from the existing condition. Additional noise sources associated with operation and maintenance of the electric lines would include vegetation clearance, as needed, and annual inspections and other procedures to maintain service continuity. Because operation and maintenance activities would not change from the existing practices, there would be no change in noise levels.

Due to the short-term nature of noise impacts, the length of the construction schedule, and the size of the Proposed Action area over which these impacts would be spread, in addition to the implementation of the aforementioned APMs, potential noise impacts would be minimal.

10.5.1 Connected Actions

Impacts from noise due to Connected Actions would be similar to those described for the Proposed Action. SDG&E would also implement APM-NOI-01 through APM-NOI-10 for Connected Actions, which would minimize any potential noise impacts during construction. No noise impacts beyond what currently exists along those portions of the electric lines included as Connected Actions would occur during operation and maintenance of the electric lines.

10.5.2 Similar Actions

Impacts from noise due to Similar Actions would be similar to those described for the Proposed Action. SDG&E would also implement APM-NOI-01 through APM-NOI-10 for Similar Actions. No noise impacts beyond what currently exists along those portions of the electric lines included as Similar Actions would occur during operation and maintenance of the electric lines.

10.6 TRANSPORTATION AND TRAFFIC

The following section describes transportation and traffic and potential impacts to transportation and traffic resulting from the Proposed Action, Connected Actions, and Similar Actions.

10.6.0 Proposed Action

Transportation and traffic data were obtained primarily through relevant literature and Internet research. Relevant literature reviewed included the San Diego County General Plan, the USFS National Forest Road System and Use report, and various documents regarding road guidelines, classification, and traffic volumes through the San Diego County Department of Public Works and Department of Transportation Planning website. The Caltrans District 11 website was also consulted for state highway traffic volume information. Additional information was gathered through personal communication with San Diego County transportation, traffic, and planning staff. Site visits were conducted to most public roadways that could be directly affected by the Proposed Action.

The Proposed Action is located in the central portion of San Diego County and would cross a network of state, county, and private roadways. Figure 3: Proposed Action Components Map depicts major state and county routes within the Proposed Action area. Table 35: Public Access Roadways lists the major and local roadways that would be used for access during construction. Table 36: Public Roadways Spanned by 69 kV Power Lines and Table 37: Public Roadways Spanned by 12 kV Distribution Lines list the major and local roadways that would be spanned by 69 kV power lines and 12 kV distribution lines, respectively, along with their classification, number of lanes, and Level of Service (LOS) information, where available.[19]

Table 38: Existing Travel Volumes on Interstate and State Routes specifies average daily traffic and peak hour traffic levels for I-8, SR-76, SR-78, SR-79, and SR-94. Other roadways anticipated to be affected by the Proposed Action include a network of unnamed, unpaved access roads. Although portions of the CNF are not currently served by roads, the electric lines included in the Proposed Action are typically located within close proximity to existing access roads or unimproved county roads.

[19] LOS is based on traffic congestion, measured by dividing traffic volume by roadway capacity. The resulting number, known as the volume-to-capacity (V/C) ratio, usually ranges from 0 to 1.0. The V/C ratings are divided into six LOS categories, A through F, representing conditions ranging from unrestricted traffic flow (A) to extreme traffic congestion (F).

Table 35: Public Access Roadways

Roadway	Classification	Number of Lanes	LOS
I-8	Expressway/Freeway	4 to 6	A-C
Old Highway 80	Arterial Rural	2	A-D
SR-94	Community Collector	2	A-C
SR-76	Minor Arterial	2	B
SR-78	Collector Urban	2	A-C
SR-79	Rural Minor Arterial	2	B
Barrett Lake Road	Collector Rural	2	A-C
Bell Bluff Truck Trail	Minor Rural	2	--
Big Potrero Truck Trail	Other Roadway[20]	1	--
Boulder Creek Road	Collector Rural	2	A-C
Buckman Springs Road	Collector Rural	2	A-C
Cam Tres Aves	Other Roadway	1	--
Cameron Truck Trail	Other Roadway	1	A-C
Campbell Ranch Road	Permanent Road Division (PRD)/Municipal/Private Road[21]	2	--
Carveacre Road	Minor Rural	2	--
Chris Lane	Other Roadway	1	--
Church Road	Other Roadway	1	--
Cinnamon Drive	Other Roadway	1	--
Calle El Potrero	Other Roadway	2	--
Corral Canyon Trail	Other Roadway	2	--
Corte Madera Road	Minor Rural	2	A-C
Deodar Trail	Minor Rural	2	--
Eagle Pass	Other Roadway	1	--
East Grade Road	Collector Rural	2	--
Guatay View Lane	Minor Rural	2	--
Hamilton Lane	Minor Urban	2	--
Hauser Creek Road	Other Roadway	1	--

[20] Other Roadway refers to roads that are not maintained by San Diego County, Caltrans, or private parties. As a result, no official classification or LOS information is available for these roads.
[21] PRD/Municipal/Private Roads are county, municipal, and private roads that are not maintained by San Diego County. As a result, no official classification or LOS information is available for these roads.

Roadway	Classification	Number of Lanes	LOS
Henshaw Road	Other Roadway	1	--
Hidden Glen Drive	Other Roadway	2	--
Hoskings Ranch Road	Other Roadway	1	--
Hulburd Grove Drive	Minor Rural	2	--
Illahee Drive	Other Roadway	1	--
Japatul Road	Collector Rural	2	A-C
Japatul Valley Road	Collector Rural	2	A-C
Kitchen Creek Road	Arterial Rural	2	A-C
La Jolla Truck Trail	Other Roadway	2	--
La Posta Circle	Other Roadway	1	--
La Posta Road	Collector Rural	2	A-C
La Posta Truck Trail	Other Roadway	1	--
Lake Morena Drive	Collector Rural	2	A-C
Larry Lane	Other Roadway	1	--
Lebanon Road	Minor Rural	2	--
Los Huecos Road	Minor Rural	2	--
Lyons Valley Road	Collector Rural	2	A-C
Maggio Drive	Other Roadway	1	--
Manzanita Lane	Minor Rural	2	--
Meadow Lane	Other Roadway	2	--
Merrigan Fire Road	Other Roadway	1	--
Miller Valley Road	Minor Rural	2	--
Mizpah Lane	PRD/Municipal/Private Road	1	--
Morris Ranch Road	PRD/Municipal/Private Road	1	--
Nature’s Way	Other Roadway	1	--
Oak Drive	Collector Rural	2	A-C
Oak Grove Drive	Minor Rural	2	--
Old Buckman Springs Road	Minor Rural	2	--
Pine Creek Road	Minor Rural	2	A-C
Pine Valley Road	Minor Rural	2	A-C
Poomacha Road	Other Roadway	1	--

Roadway	Classification	Number of Lanes	LOS
Red Hawk Ridge	Other Roadway	1	--
River Drive	Arterial Rural	2	--
Round Potrero Road	Collector Rural	2	--
Sengme Oaks Road	Other Roadway	1	--
Sequan Truck Trail	Collector Rural	2	--
Skye Valley Road	PRD/Municipal/Private Road	1	--
Spargur Road	Other Roadway	1	--
Spice Way	Other Roadway	1	--
Stagecoach Springs Road	Other Roadway	1	--
Sundance View Lane	Other Roadway	1	--
Sunrise Highway	Collector Rural	2	A-C
Tecate Cypress Trail	Other Roadway	1	--
Tribal Store Road	Other Roadway	1	--
Thyme Way	Other Roadway	1	--
Valley Center Road	Collector Urban	2	--
Viejas Boulevard	Other Roadway	2	--
Viejas Grade Road	Collector Rural	2	A-C
Wildwood Glen Lane	Minor Urban	2	--

Sources: San Diego County, 2006, 2008, and 2011; Caltrans, 2008 and 2009

Table 36: Public Roadways Spanned by 69 kV Power Lines

69 kV Power Line	Roadway	Number of Times Spanned			Classification	Number of Lanes	LOS
		Within CNF	Outside CNF	Total			
TL625	Bell Bluff Truck Trail	0	1	1	Minor Rural	2	--
	Campbell Ranch Road	0	1	1	PRD/Municipal/ Private Road	2	--
	Carveacre Road	0	3	3	Minor Rural	2	--
	Cinnamon Drive	1	0	1	Other Roadway	1	--
	Eagle Pass	0	1	1	Other Roadway	1	--
	Hidden Glen Drive	1	0	1	Other Roadway	2	--
	I-8	1	0	1	Expressway/Freeway	4 to 6	A-C
	Illahee Drive	0	1	1	Other Roadway	1	--
	Japatul Road	1	3	4	Collector Rural	2	A-C
	Japatul Valley Road	0	6	6	Collector Rural	2	A-C
	Larry Lane	0	1	1	Other Roadway	1	--
	Lyons Valley Road	1	0	1	Collector Rural	2	A-C
	Red Hawk Ridge	0	1	1	Other Roadway	1	--
	Sequan Truck Trail	0	2	2	Collector Rural	2	--
	Spice Way	1	0	1	Other Roadway	1	--
	Thyme Way	1	0	1	Other Roadway	1	--
	Viejas Grade Road	0	1	1	Collector Rural	2	A-C
	Wildwood Glen Lane	1	0	1	Minor Urban	2	--

69 kV Power Line	Roadway	Number of Times Spanned			Classification	Number of Lanes	LOS
		Within CNF	Outside CNF	Total			
TL626	Boulder Creek Road	9	5	14	Collector Rural	2	A-C
	Daley Flat Road	0	1	1	Other Roadway	2	--
	Eagle Peak Road	1	0	1	Collector Rural	2	--
	Hoskings Ranch Road	0	1	1	Other Roadway	1	--
	Oak Grove Drive	0	1	1	Minor Rural	2	--
	SR-78	0	1	1	Collector Urban	2	A-C
	Sundance View Lane	0	1	1	Other Roadway	1	--
TL629	Boulder Creek Road	0	1	1	Collector Rural	2	A-C
	Buckman Springs Road	0	2	2	Collector Rural	2	A-C
	Cam Tres Aves	0	1	1	Other Roadway	1	--
	Cameron Truck Trail	2	2	4	Other Roadway	1	A-C
	Chris Lane	0	1	1	Other Roadway	1	--
	Church Road	0	1	1	Other Roadway	2	--
	Corte Madera Road	0	1	1	Minor Rural	2	A-C
	Deodar Trail	0	1	1	Minor Rural	2	--
	Guatay View Lane	0	1	1	Minor Rural	2	--
	Hamilton Lane	0	1	1	Minor Urban	2	--

69 kV Power Line	Roadway	Number of Times Spanned			Classification	Number of Lanes	LOS
		Within CNF	Outside CNF	Total			
TL629 (cont.)	Hulburd Grove Drive	0	1	1	Minor Rural	2	--
	I-8	1	0	1	Expressway/Freeway	4 to 6	A-C
	La Posta Circle	0	2	2	Other Roadway	1	--
	La Posta Road	1	1	1	Collector Rural	2	A-C
	La Posta Truck Trail	0	1	1	Arterial Rural	1	--
	Lebanon Road	0	2	2	Minor Rural	2	--
	Maggio Drive	0	1	1	Other Roadway	1	--
	Manzanita Lane	0	1	1	Minor Rural	2	--
	Meadow Lane	0	1	1	Other Roadway	2	--
	Merrigan Fire Road	0	1	1	Other Roadway	1	--
	Miller Valley Road	0	1	1	Minor Rural	2	--
	Mizpah Lane	0	1	1	PRD/Municipal/ Private Road	1	--
	Nature’s Way	0	1	1	Other Roadway	1	--
	Oak Grove Drive	0	1	1	Minor Rural	2	--
	Old Buckman Springs Road	0	1	1	Minor Rural	2	--
	Old Highway 80	3	5	8	Arterial Rural	2	A-D
	Pine Creek Road	0	1	1	Minor Rural	2	A-C

69 kV Power Line	Roadway	Number of Times Spanned			Classification	Number of Lanes	LOS
		Within CNF	Outside CNF	Total			
TL629 (cont.)	Pine Valley Road	0	1	1	Minor Rural	2	A-C
	River Drive	0	6	6	Arterial Road	2	--
	Spargur Road	0	1	1	Other Roadway	1	--
	SR-79	0	1	1	Rural Minor Arterial	2	B
	Stagecoach Springs Road	0	3	3	Other Roadway	1	--
	Tecate Cypress Trail	0	1	1	Other Roadway	1	--
	Viejas Boulevard	0	2	2	Other Roadway	2	--
TL682	Calle El Potrero	0	1	1	Other Roadway	2	--
	County Highway S7/East Grade Road	2	0	2	Collector Rural	2	--
	Henshaw Road	3	1	4	Other Roadway	1	--
	La Jolla Truck Trail	0	1	1	Other Roadway	2	--
	Poomacha Road	0	1	1	Other Roadway	1	--
	Sengme Oaks Road	0	2	2	Other Roadway	1	--
	SR-76	2	13	15	Minor Arterial	2	B
	SR-79	0	1	1	Rural Minor Arterial	2	B
	Tribal Store Road	0	1	1	Other Roadway	1	--
	Valley Center Road	0	1	1	Collector Urban	2	--

69 kV Power Line	Roadway	Number of Times Spanned			Classification	Number of Lanes	LOS
		Within CNF	Outside CNF	Total			
TL6923	Barrett Lake Road	0	1	1	Collector Rural	2	A-C
	Big Protrero Truck Trail	1	1	2	Other Roadway	1	--
	Lake Morena Drive	0	1	1	Collector Rural	2	A-C
	Round Potrero Road	0	1	1	Collector Rural	2	--

Sources: San Diego County, 2008 and 2011

Table 37: Public Roadways Spanned by 12 kV Distribution Lines

12 kV Distribution Line	Roadway	Number of Times Spanned			Classification	Number of Lanes	LOS
		Within CNF	Outside CNF	Total			
C78	Red Oak Road	0	1	1	Other Roadway	2	--
	Viejas Grade Road	3	1	4	Collector Rural	2	A-C
C79	Boulder Creek Road	1	0	1	Collector Rural	2	A-C
C157	Skye Valley Road	0	3	4	PRD/Municipal/ Private Road	1	--
C440	Boiling Springs Road	4	0	4	Other Roadway	2	--
	El Centro Trail	8	0	8	Other Roadway	1	--
	El Centro Tract	1	0	1	Other Roadway	1	--
	Escondido Ravine Road	1	0	1	Other Roadway	1	--
	I-8	1	0	1	Expressway/Freeway	4 to 6	A-C
	Kitchen Creek Road	1	0	1	Arterial Rural	2	A-C
	Los Huecos Road	4	0	4	Minor Rural	2	--
	Morris Ranch Lane	0	7	7	Other Roadway	1	--
	Morris Ranch Road	1	0	1	PRD/Municipal/ Private Road	1	--
	Mount Laguna Drive	0	8	8	Minor Rural	2	--
	Piedra Tract	1	01	1	Other Roadway	1	--

12 kV Distribution Line	Roadway	Number of Times Spanned			Classification	Number of Lanes	LOS
		Within CNF	Outside CNF	Total			
C440 (cont.)	Sunrise Highway	10	1	11	Collector Rural	2	A-C
C442	Pine Creek Road	11	0	11	Minor Rural	2	A-C
C449	Buckman Springs Road	3	0	3	Collector Rural	2	A-C
	Corral Canyon Trail	1	0	1	Other Roadway	2	--
	Oak Drive	2	0	2	Collector Rural	2	A-C
	Old Highway 80	1	0	1	Arterial Rural	2	A-D

Sources: San Diego County, 2008 and 2011

Table 38: Existing Travel Volumes on Interstate and State Routes

Intersection	Average Daily Trips	Peak Hour Trips
I-8	21,181	2,183
SR-76	4,766	480
SR-78	4,663	738
SR-79	14,525	1,885
SR-94	2,025	215

Source: Caltrans, 2009

I-8 is a major east/west transportation corridor that crosses through the Proposed Action area. It is a four-lane, divided freeway with a posted speed limit of 70 mph and would serve as the main access route to the Proposed Action area from both San Diego and Imperial counties. I-8 can be accessed via a number of on- and off-ramps. The ramps in the vicinity of the Proposed Action include Tavern Road, Alpine Boulevard/Willows Road, SR-79/Japatul Valley Road, Sunrise Highway, Old Highway 80, and Buckman Springs Road.

Secondary access to the Proposed Action area is possible via SR-76, SR-79, SR-94, Sunrise Highway, and Old Highway 80, which serve to connect the rural towns on the north and south sides of I-8. SR-76, a primarily west/east route, begins near the City of Oceanside and terminates at SR-79 between the unincorporated communities of Warner Springs and Santa Ysabel.

The segment of SR-78 that is located within the vicinity of the Proposed Action runs from I-15 near the City of Escondido to SR-86, passing near the unincorporated communities of Ramona, Santa Ysabel, and Julian. SR-79, a primarily north/south route, begins at I-15 near the City of Temecula, passes through Cuyamaca Rancho State Park, and terminates at I-8 near the unincorporated community of Descanso. SR-94, a primarily west/east route, connects the City of San Diego with eastern San Diego County and terminates at I-8. Sunrise Highway begins at I-8 and moves northward into the Laguna Mountains through Laguna Recreation Area. The primarily north/south highway terminates at SR-79 just north of Cuyamaca Rancho State Park. Old Highway 80, a primarily west/east route, begins near the town of Descanso, approximately 30 miles from downtown San Diego. This highway generally parallels I-8 until terminating near the border of San Diego and Imperial counties.

The Proposed Action is more likely to affect transportation facilities or increase traffic during the construction phase than during operation and maintenance, as typically only a very limited amount of surface activity is required to maintain an electric line. Further, the lines already exist in the area and no increase in activity is expected once construction is complete. In addition, construction of the Proposed Action would not necessitate any permanent modifications to existing public roadways.

Prior to removing existing conductors or stringing new conductors, temporary crossing structures—typically consisting of either vertical wood poles with cross arms or staged construction equipment—would be installed or mobilized at crossings of energized electric lines, communication facilities, and/or major roadways to prevent the conductors from sagging onto other lines or roads during removal or installation. In some instances, construction equipment, such as bucket trucks, can also be used instead of temporary crossing structures to assist in conductor removal or installation activities. Traffic flow may be temporarily disrupted during the installation of crossing structures for approximately two to four hours at each location.

However, if the use of crossing structures is not feasible, temporary lane closures may be required to ensure public safety during conductor installation and removal. Where temporary lane closures are required, the lanes would generally be closed for 10 to 15 minutes during the stringing of each conductor, for a total of approximately three closures at each crossing, depending on the particular 69 kV power line segment. Segments TL625B and TL629E would be converted from single- to double-circuit configurations and would necessitate several closures of 10 to 15 minutes at each crossing in the event that lane closures are required. No complete road closures would be required.

To minimize traffic impacts, temporary lane closures would occur during off-peak traffic hours, to the extent practical, in order to minimize disruptions and traffic backups. Caution signs and/or flagmen would be used to regulate traffic where necessary and to maintain a safe transportation corridor during construction. In addition, emergency vehicles would be provided access even in the event of temporary road or lane closures. SDG&E would coordinate these isolated, temporary closures with local jurisdictional agencies, as required, to cross these roadways, and perform work according to agency requirements. SDG&E would also develop and implement a Traffic Control Plan during construction of the Proposed Action. The Traffic Control Plan would include a discussion of work hours, haul routes, work area definitions, traffic control and flagging methods, parking restrictions, and methods for coordinating construction activities with training service providers. As a result, traffic increases would be minimal and any impacts on transportation or traffic would be minor.

Proposed Action construction personnel would generally drive to the work site at the beginning of the day and leave at the end of the day, with few people traveling to and from the work site throughout the day. This would result in approximately two to four personal vehicle trips per day during peak construction times and would only slightly increase the existing daily traffic in the Proposed Action area. In addition to personnel travel, approximately four to eight truck trips per day would be required to construct the Proposed Action. Because the number of vehicle trips during construction would only slightly increase daily traffic, any potential impacts due to increased roadway use would be minor.

Helicopters would be used in part along each electric line included in the Proposed Action, particularly while removing or installing new structures and stringing new conductors in areas of rugged terrain, which would temporarily increase air traffic and encroach on navigable air space. Consistent with SDG&E's current operational procedures, SDG&E would coordinate flight patterns with local air traffic control and the FAA prior to construction to prevent any adverse impacts due to increased air traffic. The Proposed Action would not be considered a potential obstruction to the FAA, as Proposed Action components would not exceed 200 feet in height.

In order to reduce potential impacts to transportation and traffic from the Proposed Action, SDG&E would implement the following APMs during construction:

- APM-TRANS-01: To minimize traffic impacts, temporary lane closures will occur during off-peak traffic hours, to the extent practical, in order to minimize disruptions and traffic backups.
- APM-TRANS-02: Caution signs and/or flagmen will be used to regulate traffic where necessary and to maintain a safe transportation corridor during construction.
- APM-TRANS-03: Emergency vehicles will be provided access even in the event of temporary road or lane closures.
- APM-TRANS-04: SDG&E will coordinate isolated, temporary road closures with local jurisdictional agencies, as required, to cross these roadways, and perform work according to agency requirements.
- APM-TRANS-05: SDG&E will develop and implement a Traffic Control Plan during construction.
- APM-TRANS-06: SDG&E will coordinate flight patterns with local air traffic control and the FAA prior to construction to prevent any adverse impacts due to increased air traffic.
- APM-TRANS-07: Where replacement poles will be close to existing pole locations, existing access roads, spur roads, and turnarounds will be used to the extent possible to support construction activities and will continue to be used for future line maintenance.

10.6.1 Connected Actions

Impacts to transportation and traffic due to Connected Actions would be similar to those described for the Proposed Action.

10.6.2 Similar Actions

Impacts to transportation and traffic due to Similar Actions would be similar to those described for the Proposed Action.

10.7 VISUAL RESOURCES

The following section describes visual resources and potential impacts to visual resources resulting from the Proposed Action, Connected Actions, and Similar Actions.

10.7.0 Proposed Action

Visual or aesthetic resources are generally defined as both the natural and built features of the landscape that can be seen and that contribute to the public’s experience and appreciation of the environment. Visual resource or aesthetic impacts are generally defined in terms of a project’s physical characteristics, potential visibility, and the extent to which its presence would alter the perceived visual character and quality of the environment. As part of the Proposed Action, SDG&E would replace existing wood utility poles with steel poles, remove existing poles, and underground portions of existing distribution lines. In general, these activities would involve incremental and minor changes to a sparsely settled landscape.

For purposes of managing visual resources of lands within its jurisdiction, the USFS applies an inventory and assessment system known as the Scenery Management System (SMS). Adopted in 1995, the SMS establishes management goals to describe the level of modification associated with acceptable land use activity in a given area. These standards—or Scenic Integrity Objectives (SIOs)—range from “Very High,” which is typically applied only to highly sensitive landscapes, such as wilderness areas or special classified areas; to “Very Low,” a standard that allows land use activity that may appear dominant in relation to the natural landscape while not completely harmonizing with the natural setting. Only one SIO class applies to any given area, and an SIO does not necessarily represent current scenery conditions, but instead is a guideline for forest management objectives over time. The following four SIOs were used to evaluate the Proposed Action area:

- Very High: This SIO generally provides for ecological changes only, where the valued (desired) landscape character is intact with only minute deviations, if any. The existing landscape character and sense of place are expressed at the highest possible level. The landscape is unaltered.

- High: This SIO is used for landscapes where the valued landscape character appears intact. Deviations may be present, but they must repeat the form, line, color, texture, and pattern common to the landscape character so completely, and at such a scale, that they are not evident.

- Moderate: This SIO is used for landscapes where the valued landscape character appears slightly altered. Noticeable deviations must remain visually subordinate to the landscape character being viewed.

- Low: This SIO is used for landscapes where the valued landscape character appears moderately altered. Deviations begin to dominate the valued landscape character being viewed, but they borrow value attributes, such as size, shape, edge effect and pattern of natural openings, vegetative type changes, or architectural styles outside the landscape being viewed. They should not only appear as a valued character outside the landscape being viewed, but should be compatible or complimentary to the character within.

The USFS CNF Plan and Design Criteria for the Southern California National Forests contains policies for managing the SIOs that have been designated for areas within the CNF. At the Proposed Action level, all activities occurring within the CNF are subject to review of the SIOs. TL625, TL626, TL629, TL6923, and C440 cross land that is classified primarily as High with some Moderate. TL682, C79, C442, and C449 cross land that is classified as High. C78 crosses land that is classified as High, with some Moderate. C157 crosses land that is classified primarily as High with some Very High; however, the area does not currently achieve the Very High visual management goal. In applying these standards to determine significance, the respective SIO visual management goal was considered, along with the fact that all of these lines currently exist, as well as:

- the extent of change to the visibility of the existing 69 kV power lines;
- the degree to which the various Proposed Action elements would contrast with or be integrated into the existing landscape;
- the extent of change in the landscape's composition and character;
- the number and sensitivity of viewers; and
- the Proposed Action's consistency with public policies regarding visual quality.

For the purpose of this evaluation, a scenic vista is defined as a distant public view along or through an opening or corridor that is recognized and valued for its scenic quality. The Proposed Action would be visible from four scenic vistas—Inaja Memorial Overlook, Lake Henshaw Scenic Vista, Cuyamaca Peak, and Los Pinos Mountain. Visual simulations portraying changes to these scenic vistas and other views within the CNF are provided in Attachment I: Visual Simulations. A comparison of the existing views and visual simulations for the 69 kV power lines and 12 kV distribution lines demonstrates that the components would not result in a noticeable change in visual contrast with regard to line, form, or color. These simulations also indicate that the 69 kV power line and 12 kV distribution line components would not cause a perceptible deviation to the intactness of the existing landscape character. The Proposed Action would result in a noticeable improvement to the existing landscape character, view, and intactness of the landscape setting from the Cuyamaca Peak scenic vista because the existing overhead distribution line, C79, would be undergrounded. The Proposed Action would not substantially affect the existing visual character of the other scenic vistas because existing poles would be replaced by somewhat taller poles, which represents a minor incremental change. However, in order to reduce potential impacts to visual resources within the CNF, SDG&E would implement the following APMs:

- APM-VIS-01: When construction has been completed, all temporary work areas will be restored to near pre-construction conditions in accordance with landowner agreements, in order to reduce potential visual contrast with the surrounding landscape setting.

- APM-VIS-02: Construction activities will be kept as clean and inconspicuous as practical. Where practical, construction storage and staging will be screened from close-range residential views with opaque fencing.

- APM-VIS-03: Non-specular conductors will be installed for new and replacement conductors along the electric line alignments in order to minimize the reflectivity and general visibility of new electric line facilities.

- APM-VIS-04: New and replacement poles to be installed along the electric line alignments will be reddish-brown, weathered-steel that will appear similar in color to existing wood poles seen in the Proposed Action area and will blend in with the surrounding landscape backdrop.

- APM-VIS-05: Any required lighting will be limited to individual pole work areas and will not exceed more than two hours per evening.

Existing wood poles would be replaced with reddish-brown, weathered-steel poles that are somewhat taller. Like the existing structures, the replacement poles would appear against a landscape backdrop. Given the viewing distance and presence of existing structures, and because the color of the new poles would blend in with the landscape backdrop, the Proposed Action change would not be particularly noticeable. Portions of the Proposed Action would be visible from several eligible state scenic highways, including I-8, SR-76, SR-78, and SR-79, which are also San Diego County scenic routes. In addition, part of the Proposed Action would be visible from historic Old Highway 80; however, this roadway's historic designation does not preclude development. Views of some Proposed Action components would also be available from places along several San Diego County scenic routes, including Buckman Springs Road, Japatul Road, Lake Morena Drive, Lyons Valley Road, and Sunrise Highway. None of the Proposed Action components would be visible from a designated state scenic highway. If noticeable, the Proposed Action would generally represent a minor and incremental change that would not substantially affect motorists' views from these roadways.

To varying degrees, construction activity would be noticeable to local residents, motorists, and recreational visitors. Construction-related visual impacts would result from the presence of equipment, materials, and work crews along the 69 kV power line alignments, temporary staging areas and stringing sites. Construction activities would take place over an approximately five-year period, but this would be considerably shorter in duration at individual locations. Minor disturbances of land within and along the Proposed Action alignments would occur as a result of activity required for removing and replacing poles. In addition, minor land disturbance may occur at some of the temporary construction areas that would be established as part of Proposed Action construction; these areas would generally be located near or along existing Proposed Action alignments. A limited degree of visual contrast could occur as a result of land disturbance activity, such as creation of newly exposed soil areas along the alignment; however, implementation of APM-VIS-01—which calls for all disturbed terrain along the Proposed Action alignment and at staging areas and stringing sites to be restored through recontouring and revegetation—would help the disturbed areas blend in with the surrounding landscape setting, thus reducing visual contrast and potential visibility of these areas. SDG&E would also implement APM-VIS-02 to help ensure that construction activities are kept as inconspicuous as possible.

The majority of construction activities would take place during daylight hours; however, some construction along the Proposed Action alignment may be required or finished at night, and these activities would require lighting for safety. Any required lighting would be limited to an individual pole work area of approximately 314 square feet to approximately 1,256 square feet, and would not exceed more than two hours per evening for more than four evenings. No new permanent lighting is required for the Proposed Action. New electric line components could create glare due to their finish, however, which could introduce additional glare to the immediate surrounding environment. To minimize potential glare from the new electric line components, APM-VIS-03 and APM-VIS-04 call for the use of non-specular conductors and reddish-brown, weathered-steel poles, which have non-reflective finishes. With the implementation of the

APMs, the visual change would be consistent with the USFS aesthetic management standards for the CNF and would meet the SIOs. Therefore, a decrease of more than one SIO level is not anticipated. Because the Proposed Action includes only incremental changes to a sparsely settled landscape—which contains existing electric lines, access roads, and other ancillary or appurtenant facilities—and with the implementation of the aforementioned APMs, any potential impacts to visual resources from the Proposed Action would be minor.

10.7.1 Connected Actions

Impacts to visual resources from Connected Actions would be similar to those described for the Proposed Action.

10.7.2 Similar Actions

Impacts to visual resources from Similar Actions would be similar to those described for the Proposed Action.

10.8 WILDERNESS AND RECREATION

The following section describes wilderness and recreation and potential impacts to wilderness and recreation resulting from the Proposed Action, Connected Actions, and Similar Actions.

10.8.0 Proposed Action

The Proposed Action is located within the CNF, which consists of more than 567,000 acres and contains a variety of terrains and recreational opportunities. Recreational activities in the CNF include camping, horseback riding, mountain biking, picnicking, scenic driving, and hiking. There are four congressionally designated wilderness areas within the CNF, two of which are located within the vicinity of the Proposed Action. The two wilderness areas located within the vicinity of the Proposed Action are Pine Creek Wilderness Area and Hauser Wilderness Area, which are managed with the goal of preserving their primitive wilderness characteristics. The two wilderness areas were designated as wilderness in 1984 pursuant to the California Wilderness Act of 1984. TL625 is located approximately 1.7 miles west of Pine Creek Wilderness Area, and TL6923 is located approximately 0.1 mile south of Hauser Wilderness Area. In addition, C157, which was originally constructed between 1920 and 1960, crosses both of these wilderness areas, which were designated in 1984 after the distribution lines and ancillary facilities were already in place. All of these lines are valid existing rights and uses under USFS Manual Section 2320.5. Approximately 0.53 mile of C157 is located within Hauser Wilderness Area, which encompasses approximately 13,000 acres. Recreational activities within the wilderness area include hiking, backpacking, climbing, kayaking, canoeing, rafting, horseback riding, bird watching, and stargazing. Approximately 0.08 mile of C157 is located within the Pine Creek Wilderness Area, which encompasses approximately 7,547 acres. Recreational activities in Hauser Wilderness Area include hiking, backpacking, climbing, kayaking, canoeing, hunting, horseback riding, bird watching, and stargazing. The Proposed Action includes wood-to-steel replacement of the existing wood utility poles along C157 and is proposed as a fire safety measure, consistent with authorizing statutory authority contained in both the Wilderness Act and the California Wilderness Act of 1984. These provisions state that the Secretary concerned may take “such measures as are necessary in the control of fire, insects and diseases, subject to such conditions as he deems desirable." Any associated impacts from the Proposed Action would be expected to occur during construction activities, would be short-term and temporary in nature, and would improve the existing condition from a fire safety perspective, consistent with the CNF Plan. As described in Section 4.1.0 Pole Installation, approximately 10 existing wood poles would be replaced with steel poles within these wilderness areas, resulting in temporary impacts of approximately 0.09 acre and permanent impacts of 0.00072 acre (approximately 40 square feet). As a result, any potential impacts to wilderness areas resulting from the Proposed Action would be minor.

Pole replacement and conductor stringing activities could also result in temporary restrictions of recreational activities elsewhere within the CNF in limited areas when new or existing poles are located within or adjacent to recreational facilities, such as trails or campgrounds. Other recreational facilities within the vicinity may be utilized in the event of unlikely temporary trail or campground closures, which could potentially increase the use of such recreational facilities and result in greater physical deterioration than was previously experienced. However, as restrictions would be temporary and short term, generally lasting approximately one to two days per recreational facility, impacts would be minimal.

Operation and maintenance of the Proposed Action would not change from those activities already occurring along the existing lines. After completion of construction, the electric lines would be operated and maintained by SDG&E at existing staffing levels and no additional staff would be hired to maintain the electric lines. Operation and maintenance activities would not result in an increase in local population in the vicinity of the CNF or in the usage of the CNF; therefore, the use of existing recreational facilities would not be increased, no additional deterioration of such facilities would occur, and no additional impacts from operation and maintenance would occur.

10.8.1 Connected Actions

No Connected Actions are proposed within wilderness areas. Pole replacement and conductor stringing activities during Connected Actions could result in temporary restrictions of recreational activities outside the CNF in limited areas where new or existing poles are located within or adjacent to recreational facilities, such as San Diego County trails. Other recreational facilities within the vicinity may be utilized in the event of unlikely and temporary trail closures, which could potentially increase the use of such recreational facilities and result in greater physical deterioration than was previously experienced. However, as restrictions would be temporary and short term, generally lasting approximately one to two days per recreational facility, impacts would be minimal.

As previously discussed, operation and maintenance of those portions of the electric lines included as Connected Actions would not change from those activities already occurring along the existing lines. Therefore, no additional impacts from operation and maintenance would occur.

10.8.2 Similar Actions

No Similar Actions would be conducted within wilderness areas. Pole replacement, undergrounding, or conductor stringing activities during Similar Actions could result in temporary restrictions of recreational activities outside the CNF where new or existing poles are located within or adjacent to these recreational facilities, however. In the event of unlikely temporary closures, other recreational facilities within the vicinity may be utilized, potentially resulting in greater physical deterioration than was previously experienced. However, as restrictions would be temporary and short term, impacts would be minimal.

As previously discussed, operation and maintenance of those portions of the electric lines included as Similar Actions would not change from those activities already occurring along the existing lines. Therefore, no additional impacts from operation and maintenance would occur.

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ATTACHMENT A: FACILITIES INCLUDED UNDER THE MSUP

ATTACHMENT B: DETAILED ROUTE MAPS

ATTACHMENT C: MSUP OPERATING PLAN

ATTACHMENT D: LMP POLICY CONSISTENCY ANALYSIS

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ATTACHMENT I: VISUAL SIMULATIONS

APPENDIX A: SDG&E NCCP PROTOCOLS

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Sent:	Friday, March 07, 2014 7:45 PM
To:	lisa.orsaba@cpuc.ca.gov; wmetz@fs.fed.us; CNFMSUP
Subject:	large footnote reference #2 A.12-10-009: SDG&E's Master Special Use Permit - POC Supplemental Scoping Comments
Attachments:	Footnote_USDA_design manual transmission lines_bulletin_1724e-200.pdf

BULLETIN 1724E-200

DESIGN MANUAL FOR
HIGH VOLTAGE TRANSMISSION LINES

U.S. DEPARTMENT OF AGRICULTURE

RURAL UTILITIES SERVICE

ELECTRIC STAFF DIVISION

Revised May 2009

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UNITED STATES DEPARTMENT OF AGRICULTURE
Rural Utilities Service

BULLETIN 1724E-200

SUBJECT: **Design Manual for High Voltage Transmission Lines**

TO: All Electric Borrowers, Consulting Engineers, and Agency Electric Staff

EFFECTIVE DATE: Date of Approval

OFFICE OF PRIMARY INTEREST: Transmission Branch, Electric Staff Division

FILING INSTRUCTIONS: This bulletin replaces Bulletin 1724E-200, "Design Manual for High Voltage Transmission Lines," dated September, 2004 and revised May, 2005.

AVAILABILITY: This bulletin can be accessed via the Internet at

http://www.usda.gov/rus/electric/bulletins.htm

PURPOSE: This guide publication is a reference containing fundamental engineering guidelines and basic recommendations on structural and electrical aspects of transmission line design, as well as explanations and illustrations. The many cross-references and examples should be of great benefit to engineers performing design work for Agency borrower transmission lines. The guide should be particularly helpful to relatively inexperienced engineers beginning their careers in transmission line design.

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ABBREVIATIONS

(See Appendix L for Engineering Symbols and Abbreviations)

AAAC	All Aluminum Alloy Conductor
AAC	All Aluminum Conductor
AACSR	Aluminum Alloy Conductor Steel Reinforced
AC	Alternating Current
ACCR	Aluminum Conductor Composite Reinforced
ACAR	Aluminum Conductor Alloy Reinforced
ACCC/TW	Aluminum Conductor, Composite Core, Trapezoidal Wire
ACSR	Aluminum Conductor Steel Reinforced
ACSS	Steel Supported Aluminum Conductor
ACSR/AW	Aluminum Conductor Steel Reinforced/Aluminum Clad Steel Reinforced
ACSR/SD	Aluminum Conductor Steel Reinforced/Self Damping
ACSR/TW	Aluminum Conductor Steel Reinforced/Trapezoidal Wire
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
AWAC	Aluminum Clad Steel, Aluminum Conductor
AWG	American Wire Guage
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
CADD	Computer-Aided Design and Drafting
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
COE	Corps of Engineers
DOE	Department of Energy
EPA	Environmental Protection Agency
EHV	Extra High Voltage
EIS	Environmental Impact Statement
EI&W	Extreme Ice & Concurrent Wind
EPRI	Electric Power Research Institute

ABBREVIATIONS

(continued from previous page)
(See Appendix L for Engineering Symbols and Abbreviations)

Eq.	Equation
FAA	Federal Aviation Agency
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FHA	Federal Highway Administration
FLPMA	Federal Land Policy and Management Act
FS	Forest Service
FWS	Fish and Wildlife Service
GIS	Geographic Information System
GPS	Global Positioning System
IEEE	Institute of Electrical and Electronics Engineers, Inc.
LF	Load Factor
LWCF	Land and Water Conservation Fund Act
M&E	Mechanical and Electrical
MCOV	Maximum Continuous Over Voltage
MOR	Modulus of Rupture
MOV	Metal Oxide Varistor
NEPA	National Environmental Protection Act
NESC	National Electrical Safety Code
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resource Conservation Service
OHGW	Overhead Ground Wire
PL	Public Law
Psf	Pounds per square foot
RI	Radio Interference
RSL	Residual Static Load
REA	Rural Electrification Administration
ROW	Right-of-Way
RTK-GPS	Real Time Kinematic-Global Positioning System
RUS	Rural Utilities Service
SHPO	State Historical Preservation Officers
SML	Specified Mechanical Load
SPCC	Spill Prevention Control and Countermeasure
SYP	Southern Yellow Pine
T2	Twisted Pair Aluminum Conductor
T&D	Transmission and Distribution
TIN	Triangular Irregular Network
TVI	Television Interference
TW	Trapezoidal Wire
USC	United States Code
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
USGS	United States Geological Survey

FOREWORD

Numerous references are made to tables, figures, charts, paragraphs, sections, and chapters. Unless stated otherwise, the tables, figures, charts, etc. referred to are found in this bulletin. When the reference is not in this bulletin, the document is identified by title and source. Any reference to agency means Rural Utilities Service.

ACKNOWLEDGEMENTS

Figures 9-6 and 9-7 of this bulletin are reprinted from IEEE Std 524-1992, “IEEE Guide to the Installation of Overhead Transmission Line Conductors, Copyright 1992 by IEEE. The IEEE disclaims any responsibility or liability resulting from the placement and use in the described manner.

Figures 4-2, 4-4, 5-2, 5-5 and 11-1 and the table on reference heights (page 4-3) of this bulletin are reprinted from IEEE/ANSI C2-2007, National Electrical Safety Code, Copyright 2007 by IEEE. The IEEE disclaims any responsibility or liability resulting from the placement and use in the described manner.

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1. GENERAL

1.1 Purpose: The primary purpose of this bulletin is to furnish engineering information for use in designing transmission lines. Good line design should result in high continuity of service, long life of physical equipment, low maintenance costs, and safe operation.

1.2 Scope: The engineering information in this bulletin is for use in design of transmission lines for voltages 230 kV and below. Much of this document makes use of standard Rural Utilities Service (referred to as the agency) structures and assemblies in conjunction with data provided in this bulletin. Where nonstandard construction is used, factors not covered in this bulletin may have to be considered and modification to the design criteria given in this bulletin may be appropriate.

Since the agency program is national in scope, it is necessary that designs be adaptable to various conditions and local requirements. Engineers should investigate local weather information, soil conditions, operation of existing lines, local regulations, and environmental requirements and evaluate known pertinent factors in arriving at design recommendations.

1.3 National Electrical Safety Code (NESC): This bulletin is based on the requirements of the 2007 edition of the National Electrical Safety Code. In accordance with the Code of Federal Regulations 7 CFR Part 1724, agency financed lines are to be a minimum of Grade B construction as defined in the NESC. However, since the NESC is a safety code and not a design guide, additional information and design criteria are provided in this bulletin as guidance to the engineer.

The NESC may be purchased from the Institute of Electrical and Electronics Engineers (IEEE) Operations Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331 or at the following website:

http://standards.ieee.org/nesc

1.4 Responsibility: The borrower is to provide or obtain all engineering services necessary for sound and economical design. Due concern for the environment in all phases of construction and cleanup should be exercised.

1.5 Environmental Regulations: Agency environmental regulations are codified in 7 CFR Part 1794, "Environmental Policies and Procedures." These regulations reference additional laws, regulations and Executive Orders relative to the protection of the environment.

The Code of Federal Regulations may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Agency environmental regulations may be found on the following website:

http://www.usda.gov/rus/electric/regs/index.htm

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2. TRANSMISSION LINE DOCUMENTATION

2.1 Purpose: The purpose of this chapter is to provide information regarding design documentation for transmission lines financed by the Rural Utilities Service.

2.2 General: Policy and procedures pertaining to construction of transmission lines by agency electric borrowers are codified in 7 CFR 1724, “Electric Engineering, Architectural Services and Design Policies and Procedures” and 7 CFR 1726, "Electric System Construction Policies and Procedures" (http://www.usda.gov/rus/electric/regs/index.htm). The requirements of 7 CFR 1726 apply to the procurement of materials and equipment for use by electric borrowers and to construction of the electric system if the material, equipment, and construction are financed, in whole or in part, with loans made or guaranteed by the Rural Utilities Service.

2.3 Design Data Summary: When design data is required by the agency, a design data summary (or its equivalent) should be submitted. Engineering design information includes design data, sample calculations, and plan-profile drawings. A ‘Transmission Line Design Data Summary Form’, which is included in Appendix A of this bulletin, has been prepared to aid in the presentation of the design data summary. A suggested outline in Appendix A indicates information that should be considered when preparing a design data summary. Appendix A also highlights information which should be included in the design data submitted to the agency when computer software has been used in the design.

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3. TRANSMISSION LINE LOCATION, ENGINEERING SURVEY AND RIGHT-OF-WAY ACTIVITIES

3.1 Route Selection: Transmission line routing requires a thorough investigation and study of several different alternate routes to assure that the most practical route is selected, taking into consideration the environmental criteria, cost of construction, land use, impact to public, maintenance and engineering considerations.

To select and identify environmentally acceptable transmission line routes, it is necessary to identify all requirements imposed by State and Federal legislation. Environmental considerations are generally outlined in agency Bulletin 1794A-601, "Guide for Preparing Environmental Reports for Electric Projects That Require Environmental Assessments." State public utility commissions and departments of natural resources may also designate avoidance and exclusion areas which have to be considered in the routing process.

Maps are developed in order to identify avoidance and exclusion areas and other requirements which might impinge on the line route. Ideally, all physical and environmental considerations should be plotted on one map so this information can be used for route evaluation. However, when there are a large number of areas to be identified or many relevant environmental concerns, more than one map may have to be prepared for clarity. The number of maps engineers need to refer to in order to analyze routing alternatives should be kept to a minimum.

Typical physical, biological and human environmental routing considerations are listed in Table 3-1. The order in which considerations are listed is not intended to imply any priority. In specific situations, environmental concerns other than those listed may be relevant. Suggested sources for such information are also included in the table. Sources of information include the United States Geological Service (USGS), Federal Emergency Management Agency (FEMA), United States Department of the Interior (USDI), United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS) and numerous local and state agencies.

For large projects, photogrammetry is contributing substantially to route selection and design of lines. Preliminary corridor location is improved when high altitude aerial photographs or satellite imagery are used to rapidly and accurately inventory existing land use. Once the preferred and alternative corridors have been identified, the engineer should consult USGS maps, county soil maps, and plat and road maps in order to produce small scale maps to be used to identify additional obstructions and considerations for the preferred transmission line.

On smaller projects, the line lengths are often short and high altitude photograph and satellite imagery offer fewer benefits. For such projects, engineers should seek existing aerial photographs. Sources for such photographs include county planning agencies, pipeline companies, county highway departments, and land development corporations. A preliminary field survey should also be made to locate possible new features which do not appear on USGS maps or aerial photographs.

As computer information systems become less expensive and easier to use, electric transmission utilities are using Geographic Information Systems(GIS) to automate the route identification process. GIS technology enables users to easily consolidate maps and attribute information from various sources and to efficiently analyze what has been collected. When used by routing experts, automated computer processes help standardize the route evaluation and selection process, promote objective quantitative analysis and help users select defendable routes. GIS tools have proven very beneficial to utilities whose goals are to minimize impact on people and the natural environment while selecting a constructible, maintainable and cost effective route.

Final route selection, whether for a large or small project, is a matter of judgment and requires sound evaluation of divergent requirements, including costs of easements, cost of clearing, and ease of maintenance as well as the effect a line may have on the environment. Public relations and public input are necessary in the corridor selection and preliminary survey stages.

TABLE 3-1
LINE ROUTING CONSIDERATIONS

Physical	**Sources**
• Highways	USGS, state & county highway department maps
• Streams, rivers, lakes	USGS, Army Corps of Engineers, flood insurance maps
• Railroads	USGS, railroad
• Airstrips	USGS, Federal Aviation Administration (FAA)
• Topography (major ridge lines, floodplains, etc.)	USGS, flood insurance maps (FEMA), Army Corps of Engineers
• Transmission lines & distribution lines	USGS, local utility system maps
• Pipelines,(water, gas, sewer), underground Electric	USGS, local utility system maps
• Occupied buildings	Local tax maps, land use maps, local GIS maps
Biological	**Sources**
• Woodlands	USGS, USDA - Forest Service,
• Wetlands	USGS, Army Corps of Engineers, USDA National Conservation Resource Service, USDI Fish and Wildlife Service
• Waterfowl, wildlife refuge areas, endangered species & critical Habitat Areas	USDI - Fish and Wildlife Service, State Fish and Game Office
Human Environmental	**Sources**
• Rangeland • Cropland • Urban development • Industrial development • Mining areas • Recreation or aesthetic areas, national parks, state and local parks	USGS aerial survey, satellite mapping, county planning agencies, state planning agencies, state soil conservation service, mining bureau, U.S. Bureau of Land Management, NRCS
• Prime or unique farmland	USGS, soil surveys, USDA - NRCS, state department of agriculture, county extension agent
• Irrigation (existing & potential)	Irrigation district maps, applications for electrical service, aerial survey, state departments of agriculture and natural resources, water management districts
• Historic and archeological sites	National Register of Historic Sites (existing), state historic preservation officer , state historic and archeological societies
• Wild and scenic rivers	USGS maps, state maps, state department of natural resources, Department of Interior
Other	**Sources**
• Federal, state and county controlled lands	USGS, state maps, USDI Park Service, Bureau of Land Management, state department of natural resources, county maps, etc.

3.2 <u>Reconnaissance and Preliminary Survey</u>: Once the best route has been selected and a field examination made, aerial photos of the corridor should be reexamined to determine what corrections will be necessary for practical line location. Certain carefully located control points should then be established from an aerial reconnaissance. Once these control points have been made, a transit line using stakes with tack points should be laid in order to fix the alignment of the line. A considerable portion of this preliminary survey usually turns out to be the final location of the line.

In many instances, after route has been selected and a field examination made, digital design data on a known coordinate system like State Plane is used for centerline alignment and profile. This alignment is provided to surveyors in a universal drawing file format. The surveyors then convert it to a format used by their field recording equipment. Once the project location is known, base control monuments are established along the route at 2 to 5 mile intervals, depending on topography, with static Global Positioning System (GPS) sessions from known horizontal and vertical control monuments. GPS equipment and radio transmitter equipment occupying the base monuments broadcast a corrected signal to roving GPS unit(s). These GPS units, with the use of an on-board field computer, allow any point or any line segment along the route to be reproduced in the field. The roving unit can be used to locate and verify wire heights at crossings, unmarked property lines or any routing concerns that may come up locally. The equipment can also be used to establish centerline points in open areas so that conventional survey equipment can be used to mark the line in wooded areas for clearing purposes. Once the right-of-way (ROW) has been cleared, all structures can be staked with the Real Time Kinematic-Global Positioning System (RTK-GPS) equipment. Since this entire process uses data of a known mapping plane, any position along the route can be converted to various formats and used within databases.

3.3 <u>Right-of-Way</u>: A right-of-way agent (or borrower's representative) should precede the preliminary survey party in order to acquaint property owners with the purpose of the project, the survey, and to secure permission to run the survey line. The agent or surveyor should also be responsible for determining property boundaries crossed and for maintaining good public relations. The agent should avoid making any commitments for individual pole locations before structures are spotted on the plan and profile sheets. However, if the landowner feels particularly sensitive about placing a pole in a particular location along the alignment, then the agent should deliver that information to the engineer, and every reasonable effort should be made by the engineer to accommodate the landowner.

As the survey proceeds, a right-of-way agent should begin a check of the records (for faulty titles, transfers, joint owners, foreclosed mortgages, etc.) against the ownership information ascertained from the residents. This phase of the work requires close coordination between the engineer and the right-of-way agent. At this time, the right-of-way agent also has to consider any access easements necessary to construct or maintain the line.

Permission may also have to be obtained to cut danger trees located outside inside the right-of-way. Costly details, misuse of survey time and effort, and misunderstanding on the part of the landowners should be avoided.

3.4 <u>Line Survey</u>: Immediately after the alignment of a line has been finalized to the satisfaction of both the engineer and the borrower, a survey should be made to map the route of the line. Based on this survey, plan-profile drawings will be produced and used to spot structures.

Long corridors can usually be mapped by photogrammetry at less cost than equivalent ground surveys. The photographs will also contain information and details which could not otherwise be discovered or recorded. Aerial survey of the corridor can be accomplished rapidly, but proper conditions for photography occur only on a comparatively few days during the year. In certain areas, photogrammetry is impossible. It cannot be used where high conifers conceal the ground or in areas such as grass-covered plains that contain no discernible objects. Necessary delays and overhead costs inherent in air mapping usually prevent their use for short lines.

When using photogrammetry to develop plan-profile drawings, proper horizontal and vertical controls should first be established in accordance with accepted surveying methods. From a series of overlapping aerial photographs, a plan of the transmission line route can be made. The plan may be in the form of an orthophoto or it may be a planimetric map (see Chapter 10). The overlapping photos also enable the development of profile drawings. The tolerance of plotted ground elevations to the actual ground profile will depend on photogrammetric equipment, flying height, and accuracy of control points.

Survey data can be gathered using a helicopter-mounted laser to scan existing lines and/or topography. Three dimensional coordinates of millions of points can be gathered while also taking forward and downward looking videos. These points can be classified into ground points, structure points and wire points.

If use of photogrammetry or laser-derived survey information for topographic mapping is not applicable for a particular line, then transit and tape or various electronic instruments for measuring distance should be used to make the route survey. This survey will generally consist of placing stakes at 100 foot intervals with the station measurement suitably marked on the stakes. It will also include the placement of intermediate stakes to note the station at property lines and reference points as required. The stakes should be aligned by transit between the hub stakes set on the preliminary survey. The survey party needs to keep notes showing property lines and topographic features of obstructions that would influence structure spotting. To facilitate the location of the route by others, colored ribbon or strips of cloth should be attached at all fence crossings and to trees at regular intervals along the route (wherever possible).

As soon as the horizontal control survey is sufficiently advanced, a level party should start taking ground elevations along the center line of the survey. Levels should be taken at every 100 foot stations and at all intermediate points where breaks in the ground contour appear. Wherever the ground slopes more than 10 percent across the line of survey, side shots should be taken for a distance of at least 10 feet beyond the outside conductor's normal position. These elevations to the right and left of the center line should be plotted as broken lines. The broken lines represent side hill profiles and are needed, when spotting structures, to assure proper ground clearance under all conductors, and proper pole lengths and setting depths for multiple-pole structures.

3.5 Drawings: As soon as the route survey has been obtained, the plan and profile should be prepared. Information on the plan and profile should include alignment, stationing, calculated courses, fences, trees, roads, ditches, streams, and swamps. The vertical and plan location of telecommunications, transmission and other electric lines should be included since they affect the proposed line. The drawings should also show railroads and river crossings, property lines, with the names of the property owners, along with any other features which may be of value in the right-of-way acquisition, design, construction, and operation of the line. Chapter 10 discusses structure spotting on the plan-profile drawings.

Structure spotting should begin after all of the topographic and level notes are plotted on the plan and profile sheets. Prints of the drawings should be furnished to the right-of-way agent for checking property lines and for recording easements. One set of prints certified as to the extent of permits, easements, etc. that has been secured by the borrower should be returned to the engineer.

3.6 Rerouting: During the final survey, it may be necessary to consider routing small segments of the line due to the inability of the right-of-way agent to satisfy the demands of property owners. In such instances, the engineer should ascertain the costs and public attitudes towards all reasonable alternatives. The engineer should then decide to either satisfy the property owner's demands, relocate the line, initiate condemnation proceedings, or take other action as appropriate. Additional environmental review may also be required.

3.7 <u>Clearing Right-of-Way</u>: The first actual work to be done on a transmission line is usually clearing the right-of-way. When clearing, it is important that the environment be considered. Environmental commitments/mitigations should be included in the construction contracts. It is also important that the clearing be done in such a manner that will not interfere with the construction, operation or maintenance of the line. In terrain having heavy timber, prior partial clearing may be desirable to facilitate surveying. All right-of-way for a given line should be secured before starting construction. See Chapter 5 for a discussion of right-of-way width.

3.8 <u>Permits, Easements, Licenses, Franchises, and Authorizations</u>: The following list of permits, easements, licenses, franchises, and authorizations that commonly need to be obtained is not meant to be exhaustive.

Private property	Easement from owner and permission to cut danger trees
Railroad	Permit or agreement
Highway	Permit from state/county/city
Other public bodies	Authorization
City, county or state	Permit
Joint and common use pole	Permit or agreement
Wire crossing	Permission of utility

Table 3-2 list required federal permits or licenses required and other environmental review requirements. The following abbreviations pertain to Table 3-2:

BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
COE	Corps of Engineers
DOE	Department of Energy
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
FAA	Federal Aviation Agency
FERC	Federal Energy Regulatory Commission
FHA	Federal Highway Administration
FLPMA	Federal Land Policy and Management Act
FS	Forest Service
FWS	Fish and Wildlife Service
LWCF	Land and Water Conservation Fund Act
NEPA	National Environmental Protection Act
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
PL	Public Law
SHPO	State Historical Preservation Officer
SPCC	Spill Prevention Control and Countermeasure
USC	United States Code

TABLE 3-2
SUMMARY OF POTENTIAL MAJOR FEDERAL PERMITS OR LICENSES THAT MAY BE REQUIRED
And other environmental review requirements for transmission line construction and operation

Issue	Action Requiring Permit, Approval, or Review	Agency	Permit, License, Compliance or Review	Relevant Laws and Regulations
NEPA (National Environmental Protection Act) Compliance	Federal; Action to grant right-of-way across land under Federal jurisdiction	Lead Agency –	EIS and Record of Decision	NEPA (42 USC 4321), CEQ (40 CFR 1500-1508). DOE NEPA implementing Regulations (10 CFR to 1021)
Right-of-Way Across Land Under Federal Management	Preconstruction surveys; construction, operation, maintenance, and abandonment	Bureau of Land Management (BLM)	Right-of-way grant and special use permit	Federal Land Policy and Management Act (FLPMA) of 1976 (PL 94-579) 43 USC 1761-1771 43 CFR 2800
		Bureau of Indian Affairs (BIA), tribe	Right-of-way grant across American Indian lands	25 CFR 169
		Forest Service (FS)	Special use authorization permit or easement	36 CFR 251
		National Park Service (NPS)	Authorization to cross National Park Service lands	18 USC, 36 CFR 14
		Fish and Wildlife Service (FWS)	Special use permit for crossing a national wildlife refuge	50 CFR 25
	"Conversion of use" for a use other than recreation on lands reserved with Land and Water Conservation Fund Act (LWCF) monies	NPS	Review of transmission line corridor to identify conflicts with recreational areas	Land and Water Conservation Fund Act PL 88-578, Section 6(f)(3)
	Construction, operation, maintenance, and abandonment of transmission line across or within highway rights-of-way	Federal Highway Administration (FHA)	Permits to cross Federal Aid Highway; 4 (f) compliance	Department of Transportation Act 23 CFR 1.23 and 1.27 23 USC 116, 123, and 315 23 CFR 645 23 CFR 771
Biological Resources	Grant right-of-way by federal land-managing agency	FWS	Endangered Species Act compliance by federal land-managing agency and lead agency	Endangered Species Act of 1973 as amended (16 USC 1531 et seq)
	Protection of migratory birds	FWS	Compliance	Migratory Bird Treaty Act of 1918 16 USC 703-712 50 CFR Ch 1
	Protection of bald and golden eagles	FWS	Compliance	Bald and Golden Eagle Protection Act of 1972 (16 USC 668)
Paleontological Resources	Ground disturbance on federal land or federal aid project	BLM	Compliance with BLM mitigation and planning standards for paleontological resources of public lands	FLPMA of 1976 (43 USC 1701-1771) Antiquities Act of 1906 (16 USC 431-433)

TABLE 3-2 (Continued)
SUMMARY OF POTENTIAL MAJOR FEDERAL PERMITS OR LICENSES THAT MAY BE REQUIRED
And other environmental review requirements for transmission line construction and operation

Issue	Action Requiring Permit, Approval, or Review	Agency	Permit, License, Compliance or Review	Relevant Laws and Regulations
Ground Disturbance and Water Quality Degradation	Construction sites with greater than five acres of land disturbance	Environmental Protection Agency (EPA)	Section 402 National Pollutant Discharge Elimination System (NPDES) General Permit for Storm Water Discharges from Construction Activities	Clean Water Act (33 USC 1342)
	Construction across water resources	Army Corps of Engineers (COE)	General easement	10 USC 2668 to 2669
	Crossing 100-year floodplain, streams, and rivers	COE	Floodplain use permits	40 USC 961
	Construction in or modification of floodplain	Federal lead agency	Compliance	Executive Order 11988 Floodplains
	Construction or modification of wetlands	Federal lead agency	Compliance	Executive Order 11990 Wetlands
	Potential discharge into water of the state (including wetlands and washes)	COE (and states); EPA on tribal lands	Section 401 permit	Clean Water Act (33 USC 1344)
	Discharge of dredge or fill material to watercourse	COE; EPA on tribal lands	404 Permit (individual or nationwide)	Clean Water Act (33 USC 1344)
	Placement of structures and construction work in navigable waters of the U.S	COE	Section 10 permit	Rivers and Harbors Act of 1899 (33 USC 403)
	Protection of all rivers included in the National Wild and Scenic Rivers System	Affected land-managing agencies	Review by permitting agencies	Wild and Scenic Rivers Act (PL 90- 542) (43 CFR 83.50)
	Potential pollutant discharge during construction, operation, and maintenance	EPA	Spill Prevention Control and Countermeasure (SPCC) plan for substations	Oil Pollution Act of 1990 (40 CFR 112)
Air Traffic	Location of towers in regards to airport facilities and airspace	Federal Aviation Administration (FAA)	A “No-hazard Declaration” required if structure is more than 200 feet in height	FAA Act of 1958 (49 USC 1501) (14 CFR 77)
			Section 1101 Air Space Permit for air space construction clearance	FAA Act of 1958 (49 USC 1501) (14 CFR 77)

TABLE 3-2 (Continued)
SUMMARY OF POTENTIAL MAJOR FEDERAL PERMITS OR LICENSES THAT MAY BE REQUIRED
And other environmental review requirements for transmission line construction and operation

Issue	Action Requiring Permit, Approval, or Review	Agency	Permit, License, Compliance or Review	Relevant Laws and Regulations
Cultural Resources	Disturbance of historic properties	Federal lead agency, State Historical Preservation Officers (SHPO), Advisory Council on Historic Preservation	Section 106 consultation	National Historic Preservation Act of 1966 (16 USC 470) (36 CFR Part 800)
	Excavation of archaeological resources	Federal land-managing agency	Permits to excavate	Archaeological Resources Protection Act of 1979 (16 USC 470aa to 470ee)
	Potential conflicts with freedom to practice traditional American Indian religions	Federal lead agency, Federal land-managing agency	Consultation with affected American Indians	American Indian Religious Freedom Act (42 USC 1996)
	Disturbance of graves, associated funerary objects, sacred objects, and items of cultural patrimony	Federal land-managing agency	Consultation with affected Native American group regarding treatment of remains and objects	Native American Graves Protection and Repatriation Act of 1990 (25 USC 3001)
	Investigation of cultural and paleontological resources	Affected land-managing agencies	Permit for study of historical, archaeological, and paleontological resources	Antiquities Act of 1906 (16 USC 432-433)
	Investigation of cultural resources	Affected land-managing agencies	Permits to excavate and remove archaeological resources on Federal lands; American Indian tribes with interests in resources must be consulted prior to issuance of permits	Archaeological Resources Protection Act of 1979 (16 USC 470aa to 470ee) (43 CFR 7)
	Protection of segments, sites, and features related to national trails	Affected land-managing agencies	National Trails Systems Act compliance	National Trails System Act (PL 90-543) (16 USC 1241 to 1249)
Rate regulation	Sales for resale and transmission services	Federal Energy Regulatory Commission (FERC)	Federal Power Act compliance by power seller	Federal Power Act (16 USC 792)

In cases where structures or conductors will exceed a height of 200 feet, or are within 20,000 feet of an airport, the nearest regional or area office of the FAA must be contacted. In addition, if required, FAA Form 7460-1, "Notice of Proposed Construction or Alteration," is to be filed. Care must also be given when locating lines near hospital landing pads, crop duster operations, and military bases.

4. CLEARANCES TO GROUND, TO OBJECTS UNDER THE LINE AND AT CROSSINGS

4.1 General: Recommended design vertical clearances for agency financed transmission lines of 230 kV and below are listed in the Tables 4-1 through 4-3. These clearances exceed the minimum clearances calculated in accordance with the 2007 edition of the NESC. If the 2007 edition has not been adopted in a particular locale, clearances and the conditions found in this chapter should be reviewed to ensure that they meet the more stringent of the applicable requirements.

Clearance values provided in the following tables are recommended design values. In order to provide an additional cushion of safety, recommended design values exceed the minimum clearances in the 2007 NESC.

4.2 Assumptions

4.2.1 Fault Clearing and Switching Surges: Clearances in tables 4-1, 4-2, 4-3, and 5-1 are recommended for transmission lines capable of clearing line-to-ground faults and voltages up to 230 kV. For 230 kV, the tables apply for switching surges less than or equal to 2.0; for higher switching surges on 230 kV transmission lines see the alternate clearance recommendations in the NESC.

4.2.2 Voltage: Listed in the chart that follows are nominal transmission line voltages and the assumed maximum allowable operating voltage for these nominal voltages. If the expected operating voltage is greater than the value given below, the clearances in this bulletin may be inadequate. Refer to the 2007 edition of the NESC for guidance.

Nominal Line-to-Line Voltage (kV)	Maximum Line-to Line Operating Voltage (kV)
34.5	*
46	*
69	72.5
115	121
138	145
161	169
230	242

*Maximum operating voltage has no effect on clearance requirements for these nominal voltages.

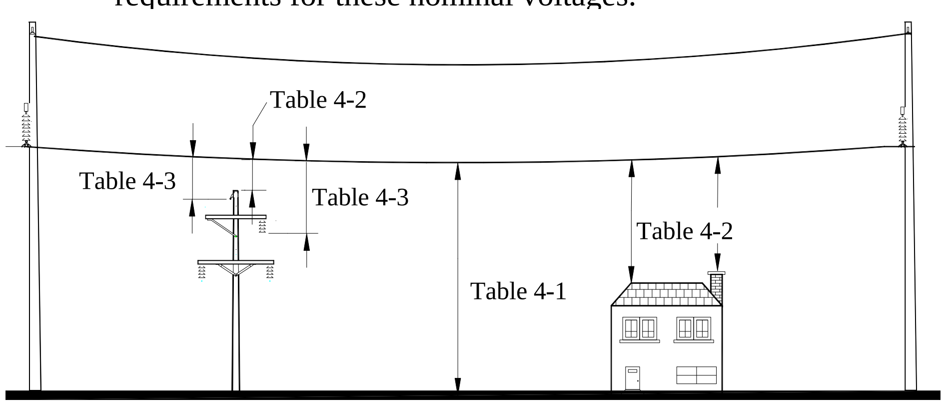

FIGURE 4-1: CLEARANCE SITUATIONS COVERED IN THIS CHAPTER

4.3 Design Vertical Clearance of Conductors: The recommended design vertical clearances under various conditions are provided in Table 4-1.

4.3.1 Conditions Under Which Clearances Apply: The clearances apply to a conductor at final sag for the conditions 'a' through 'c' listed below. The condition that produces the greatest sag for the line is the one that applies.

a. Conductor temperature of 32°F, no wind, with the radial thickness of ice for the applicable NESC loading district.

b. Conductor temperature of 167°F. A lower temperature may be considered where justified by a qualified engineering study. Under no circumstances should a design temperature be less than 120°F.

c. Maximum design conductor temperature, no wind. For high voltage bulk transmission lines of major importance to the system, consideration should be given to the use of 212°F as the maximum design conductor temperature.

According to the National Electric Reliability Council Criteria, emergency loading for lines of a system would be the line loads sustained when the worst combination of one line and one generator outage occurs. The loads used for condition "c" should be based on long range load forecasts.

Sags of overhead transmission conductors are predicted fairly accurately for normal operating temperatures. However, it has consistently been observed that sags for ACSR (Aluminum Conductor Steel Reinforced) conductors can be greater than predicted at elevated temperatures. If conductors are to be regularly operated at elevated temperatures, it is important that sag behavior be well understood. Current knowledge of the effects of high temperature operation on the long term behavior of conductors and associated hardware (splices, etc.) is probably limited; however, and a clear understanding of the issues involved is essential. The Electric Power Research Institute (EPRI) has prepared a report on the effects of high temperature conductor and associated hardware. [1]

The traditional approach in predicting ACSR conductor sag has been to assume that the aluminum and steel share only tension loads. But as conductor temperature rises, aluminum expands more rapidly than steel. Eventually the aluminum tension will reduce to zero and then go into compression. Beyond this point the steel carries the total conductor tension. These compressive stresses generally occur when conductors are operated above 176 °F to 200 °F. Greater sags than predicted at these elevated temperatures may be attributed to aluminum being in compression which is normally neglected by traditional sag and tension methods. AAC (All Aluminum Conductors) and AAAC (All Aluminum Alloy Conductor) or ACSR conductors having only one layer of aluminum or ACSR with less than 7 percent steel should not have significantly larger sags than predicted by these traditional methods at higher operating temperatures. [2]

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[1] *Conductor and Associated Hardware Impacts During High Temperature Operations – Issues and Problems, L. Shan and D. Douglass, Final Report, EPRI TR-109044, Electric Power Research Institute, Palo Alto, California, December, 1997.*

[2] *Conductor Sag and Tension Characteristics at High Temperatures, Tapani O. Seppa and Timo Seppa, The Valley Group, Inc., presented at the Southeastern Exchange Annual E/O Meeting, May 22, 1996, in Atlanta, GA.*

4.3.2 Altitude Greater than 3300 Feet: If the altitude of a transmission line (or a portion thereof) is greater than 3300 feet, an additional clearance as indicated in Table 4-1 must be added to the base clearances given.

4.3.3 Spaces and Ways Accessible to Pedestrians Only: Pedestrian-only clearances should be applied carefully. If it is possible for anything other than a person on foot to get under the line, such as a person riding a horse, the line should not be considered to be accessible to pedestrians-only and another clearance category should be used. It is expected that this type of clearance will be used rarely and only in the most unusual circumstances.

4.3.4 Clearance for Lines Along Roads in Rural Districts: If a line along a road in a rural district is adjacent to a cultivated field or other land falling into Category 3 of Table 4-1, the clearance-to-ground should be based on the clearance requirements of Category 3 unless the line is located entirely within the road right-of-way and is inaccessible to vehicular traffic, including highway right-of-way maintenance equipment. If a line meets these two requirements, its clearance may be based on the "along road in rural district" requirement. To avoid the need for future line changes, it is strongly recommended that the ground clearance for the line should be based on clearance over driveways. This should be done whenever it is considered likely a driveway will be built somewhere under the line. Heavily traveled rural roads should be considered as being in urban areas.

4.3.5 Reference Component and Tall Vehicles/Boats: There may be areas where it can be normally expected that tall vehicles/boats will pass under the line. In such areas, it is recommended that consideration be given to increasing the clearances given in Table 4-1 by the amount by which the operating height of the vehicle/boat exceeds the reference component. The reference component is that part of the clearance component which covers the activity in the area which the overhead line crosses.

For example, truck height is limited to 14 feet by state regulation, thus the reference component for roads is 14 feet. However, in northern climates sanding trucks typically operate with their box in an elevated position to distribute the sand and salt to icy roadways. The clearances in Table 4-1 are to be increased by the amount the sanding truck operating height exceeds 14 feet. In another example, the height of farm equipment may be 14 feet or more. In these cases, these clearances should be increased by the difference between the known height of the oversized vehicle and the reference height of 14 feet.

Reference heights for Table 4-1 are given below:

Item	Description	Reference height (feet)
1.0	Track rails	22.0
2.0	Roads, streets, alleys, etc	14.0
3.0	Residential driveways	14.0
4.0	Other lands traversed by vehicles	14.0
5.0	Spaces and ways--pedestrians only	8.0/10.0
6.0	Water areas--no sail boating	12.5
7.0	Water areas—sail boating	
	Less than 20 acres	16.0
	20 to 200 acres	30.0
	200 to 2000 acres	30.0
	Over 2000 acres	36.0
8.0	Areas posted for rigging or launching sailboats	See item 7.0

For reference components to Table 4-2, see Appendix A, Table A-2b of the NESC.

4.3.6 <u>Clearances Over Water</u>: Clearances over navigable waterways are governed by the U.S. Army Corps of Engineers and therefore the clearances over water provided in Table 4-1 apply only where the Corps does not have jurisdiction.

4.3.7 <u>Clearances for Sag Templates</u>: Sag templates used for spotting structures on a plan and profile sheet should be cut to allow at least one foot extra clearance than given in Table 4-1, in order to compensate for minor errors and to provide flexibility for minor shifts in structure location.

Where the terrain or survey method used in obtaining the ground profile for the plan and profile sheets is subject to greater unknowns or tolerances than the one foot allowed, appropriate additional clearance should be provided.

4.4 <u>Design Vertical Clearance of Conductors to Objects Under the Line (not including conductors of other lines)</u>: The recommended design vertical clearances to various objects under a transmission line are given in Table 4-2.

4.4.1 <u>Conditions Under Which Clearances Apply</u>: The clearances in Table 4-2 apply under the same loading and temperature conditions as outlined in section 4.3.1 of this chapter. See NESC Figures 234-1(a) and 234-1(b) and 234-1(c) for transition zones between horizontal and vertical clearance planes. See Chapter 5 for horizontal clearances.

4.4.2 <u>Lines Over Buildings</u>: Although clearances for lines passing over buildings are shown in Table 4-2, it is recommended that lines not pass directly over a building if it can be avoided.

4.4.3 <u>Clearances to Rail Cars</u>: The NESC has defined the clearance envelope around rail cars as shown in Figure 4-2 (NESC Figure 234-5):

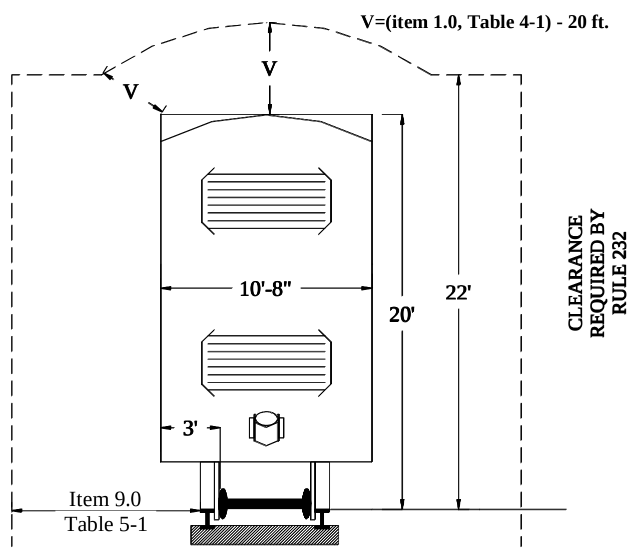

FIGURE 4-2: NESC FIGURE 234-5

To simplify the design process, Figure 4-3, which defines the recommended clearances, may be used:

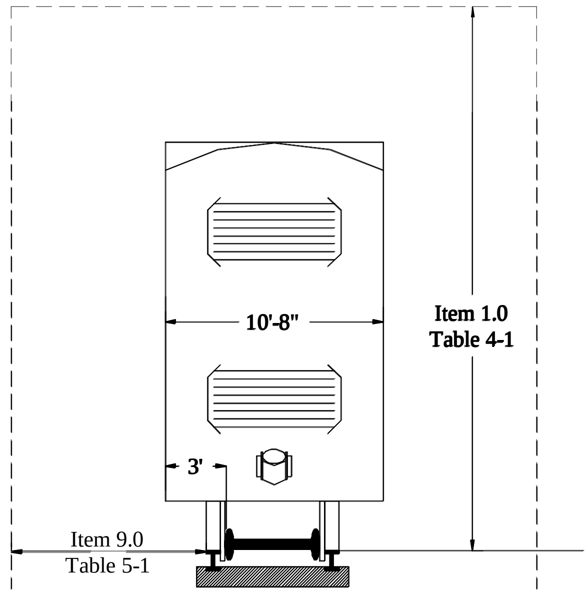

FIGURE 4-3: SIMPLIFIED CLEARANCE ENVELOPE

In cases where the base of the transmission line is below that of the railroad bed, the designer may be required to install taller poles or to offset further from the track (using the agency suggested approach) than is indicated by the NESC clearance envelope.

4.4.4 <u>Lines Over Swimming Pools</u>: Clearances over swimming pools are for reference purposes only. Lines should not pass over or within clearance 'A' of the edge of a swimming pool or the base of the diving platform. Clearance 'B' should be maintained in any direction to the diving platform or tower.

FIGURE 4-4: SWIMMING POOL CLEARANCES (See TABLE 4-2)

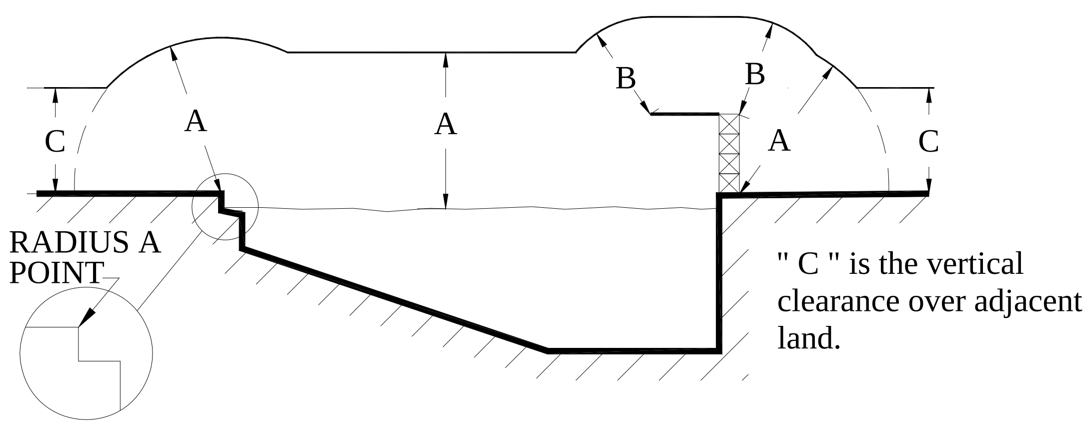

TABLE 4-1
RECOMMENDED DESIGN VERTICAL CLEARANCES OF CONDUCTORS ABOVE GROUND, ROADWAYS, RAILS, OR WATER SURFACE (in feet) (See Notes A, F & G)
(Applicable NESC Rules 232A, 232B, and Table 232-1)

Line conditions under which the NESC states vertical clearances shall be met (Calculations are based on Maximum Operating Voltage):

- 32°F, no wind, with radial thickness of ice, if any, specified in Rule 250B of the NESC for the loading district concerned.
- Maximum conductor temperature for which the line is designed to operate, with no horizontal displacement

Nominal Voltage, Phase to Phase (kV_{LL})		**34.5 & 46**	**69**	**115**	**138**	**161**	**230**
Max. Operating Voltage, Phase to Phase (kV_{LL})		----	72.5	120.8	144.9	169.1	241.5
Max. Operating Voltage, Phase to Ground (kV_{LG})		----	41.8	69.7	83.7	97.6	139.4
	NESC Basic Clear.(Note F)	Clearances in feet					
1.0 Track rails	26.5	29.2	29.7	30.6	31.1	31.5	32.9
2.0 Roads, streets, etc., subject to truck traffic	18.5	21.2	21.7	22.6	23.1	23.5	24.9
3.0 Driveways, parking lots, and alleys	18.5	21.2	21.7	22.6	23.1	23.5	24.9
4.0 Other lands cultivated etc., traversed by vehicles (Note B)	18.5	21.2	21.7	22.6	23.1	23.5	24.9
5.0 Spaces and ways accessible to pedestrians only (Note C)	14.5	17.2	17.7	18.6	19.1	19.5	20.9
6.0 Water areas – no sail boating	17.0	19.7	20.2	21.1	21.6	22.0	23.4
7.0 Water areas – sail boating suitable (Notes D & E)							
Less than 20 acres	20.5	23.2	23.7	24.6	25.1	25.5	26.9
20 to 200 acres	28.5	31.2	31.7	32.6	33.1	33.5	34.9
200 to 2000 acres	34.5	37.2	37.7	38.6	39.1	39.5	40.9
Over 2000 acres	40.5	43.2	43.7	44.6	45.1	45.5	46.9
8.0 Public or private land and water areas posted for rigging or launching sailboats (Note E)							
Less than 20 acres	25.5	28.2	28.7	29.6	30.1	30.5	31.9
20 to 200 acres	33.5	36.2	36.7	37.6	38.1	38.5	39.9
200 to 2000 acres	39.5	42.2	42.7	43.6	44.1	44.5	45.9
Over 2000 acres	45.5	48.2	48.7	49.6	50.1	50.5	51.9
ALTITUDE CORRECTION TO BE ADDED TO VALUES ABOVE:							
Additional feet of clearance per 1000 feet of altitude above 3300 feet		.00	.02	.05	.07	.08	.12

TABLE 4-1
(continued from previous page)
RECOMMENDED DESIGN VERTICAL CLEARANCE OF CONDUCTORS ABOVE GROUND, ROADWAYS, RAILS, OR WATER SURFACE (in feet) (See Notes A, F & G)
(Applicable NESC Rules 232A, 232B, and Table 232-1

Notes:

(A) For voltages exceeding 98 kV alternating current to ground, or 139 kV direct current to ground, the NESC states that either the clearance shall be increased or the electric field, or the effects thereof, shall be reduced by other means, as required, to limit the current due to electrostatic effects to 5.0 milliampere (mA), rms, if the largest anticipated truck, vehicle or equipment under the line were short circuited to ground. The size of the anticipated truck, vehicle, or equipment used to determine these clearances may be less than but need not be greater than that limited by Federal, State, or local regulations governing the area under the line. For this determination, the conductors shall be at final unloaded sag at 120° F.

Fences and large permanent metallic structures in the vicinity of the line will be grounded in accordance with the owner's grounding units for the structure concerned to meet the 5.0 milliampere requirement. There should be adequate ground clearance at crossings and along the right-of-way to meet the minimum requirement of 5 mA due to the electrostatic field effects on the anticipated vehicles under the transmission line.

Consideration should be given to using the 5.0 mA rule to the conductor under maximum sag condition of the conductor.

(B) These clearances are for land traversed by vehicles and equipment whose overall operating height is less than 14 feet.

(C) Areas accessible to pedestrians only are areas where riders on horses or other large animals, vehicles or other mobile units exceeding 8 feet in height are prohibited by regulation or permanent terrain configurations or are not normally encountered nor reasonably anticipated. Land subject to highway right-of-way maintenance equipment is not to be considered as being accessible to pedestrians only.

(D) The NESC states that "for uncontrolled water flow areas, the surface area shall be that enclosed by its annual high-water mark. Clearances shall be based on the normal flood level; if available, the 10 year flood level may be assumed as the normal flood level. The clearance over rivers, streams, and canals shall be based upon the largest surface area of any one mile-long segment which includes the crossing. The clearance over a canal, river, or stream normally used to provide access for sailboats to a larger body of water shall be the same as that required for the larger body of water."

(E) Where the U.S. Army Corps of Engineers or the state, has issued a crossing permit, the clearances of that permit shall govern.

(F) The NESC basic clearance is defined as the reference height plus the electrical component for open supply conductors up to 22 $kV_{L\text{-}G}$.

(G) An additional 2.5 feet of clearance is added to the NESC clearance to obtain the recommended design clearances. Greater values should be used where survey methods to develop the ground profile are subject to greater unknowns. See Chapter 10, paragraph 10.3 of this bulletin.

TABLE 4-2
RECOMMENDED DESIGN VERTICAL CLEARANCES FROM OTHER SUPPORTING STRUCTURES (See Note B), BUILDINGS AND OTHER INSTALLATIONS (in feet)
(Applicable NESC Rules: 234A, 234B, 234C, 234D, 234E, 234F, 234I, Tables 234-1, 234-2, 234-3)

Line conditions under which the NESC vertical clearances shall be met (Calculations are based on Maximum Operating Voltage.):

- 32°F, no wind, with radial thickness of ice, if any, specified in Rule 250B of the NESC for the loading district concerned.
- Maximum conductor temperature for which the line is designed to operate, with no horizontal displacement

Nominal Voltage, Phase to Phase (kV_{LL})		**34.5 & 46**	**69**	**115**	**138**	**161**	**230 (E)**
Max. Operating Voltage, Phase to Phase	(kV_{LL})	----	72.5	120.8	144.9	169.1	241.5
Max. Operating Voltage, Phase to Ground	(kV_{LG})	----	41.8	69.7	83.7	97.6	139.4
	NESC Basic Clear.(Note D)	Clearances in feet					
1.0 From a lighting support, traffic signal support, or supporting structure of a second line	5.5	7.5	7.5	8.2	8.6	9.1	10.8
2.0 From buildings not accessible to pedestrians	12.5	14.7	15.2	16.1	16.6	17.0	18.4
3.0 From buildings – accessible to pedestrians and vehicles but not truck traffic	13.5	15.7	16.2	17.1	17.6	18.0	19.4
4.0 From buildings – over roofs accessible to truck traffic	18.5	20.7	21.2	22.1	22.6	23.0	24.4
5.0 From signs, chimneys, billboards, radio & TV antennas, tanks & other installations **not accessible to personnel**.	8.0	10.2	10.7	11.6	12.1	12.5	13.9
6.0 From bridges – not attached (Note C)	12.5	14.7	15.2	16.1	16.6	17.0	18.4
7.0 From grain bins probe ports	18.0	20.2	20.7	21.6	22.1	22.5	23.9
8.0 Clearance in any direction from swimming pool edge and diving platform base **(Clearance A, Figure 4-4)**	25.0	27.2	27.7	28.6	29.1	29.5	30.9
Clearance in any direction from diving structures **(Clearance B, Figure 4-4)**	17.0	19.2	19.7	20.6	21.1	21.5	22.9
ALTITUDE CORRECTION TO BE ADDED TO VALUES ABOVE							
Additional feet of clearance per 1000 feet of altitude above 3300 feet		.00	.02	.05	.07	.08	.12

Notes:

(A) An additional 2.0 feet of clearance is added to NESC clearance to obtain the recommended design clearances. Greater values should be used where the survey method used to develop the ground profile is subject to greater unknowns.
(B) Other supporting structures include lighting supports, traffic signal supports, or a supporting structure of another line.
(C) If the line crosses a roadway, then Table 4-1, line 2.0 clearances are required.
(D) The NESC basic clearance is defined as the reference height plus the electrical component for open supply conductors up to 22 kV_{LG} except row '1.0' where voltage referenc is 50 kV_{LG}
(E) For 230 kV, clearances may be required to be higher if switching surges are greater than 2.0 per unit. See NESC Tables 234-4 and 234-5.

4.4.5 Examples of Clearance Calculations: The following examples demonstrate the derivation of the vertical clearances shown in Tables 4-1 and 4-2.

To determine the vertical clearance of a 161 kV line crossing a road (category 2.0 of Table 4-1), the clearance is based on NESC Table 232-1 and NESC Rule 232.

NESC Vertical Clearance = NESC Basic Clearance(Table 232-1) + .4($kV_{L\text{-}G}$ – 22)/12
= 18.5 feet + .4(97.6-22)/12 feet
= 18.5 feet + 2.52 feet
NESC Vertical Clearance = 21.02 feet

Recommended Clearance = NESC Vertical Clearance + Agency Adder
= 21.02 feet + 2.5 feet
= 23.52 feet (23.5 feet in Table 4-1)

To determine the vertical clearance of a 230 kV line over a building roof not accessible to pedestrians (category 2.0 of Table 4-2), the clearance is based on NESC Table 234-1 and NESC Rule 234.

NESC Vertical Clearance = NESC Basic Clearance(Table 234-1) + .4($kV_{L\text{-}G}$ – 22)/12
= 12.5 feet + .4(139-22)/12 feet
= 12.5 feet + 3.9 feet
NESC Vertical Clearance = 16.4 feet

Recommended Clearance = NESC Vertical Clearance + Agency Adder
= 16.4 feet + 2.0 feet
= 18.4 feet (18.4 feet in Table 4-2)

4.5 Design Vertical Clearance Between Conductors Where One Line Crosses Over or Under Another: Recommended design vertical clearances between conductors when one line crosses another are provided in Table 4-3. The clearance values in Table 4-3 are for transmission lines which are known to have ground fault relaying. The clearances should be maintained at the point where the conductors cross, regardless of where the point of crossing is located on the span.

4.5.1 Conditions Under Which Clearances Apply: The clearances apply for an upper conductor at final sag for the conditions ‘a’ through ‘c’. The condition that produces the greatest sag for the line is the one that applies.

a. A conductor temperature of 32°F, no wind, with a radial thickness of ice for the loading district concerned.

b. A conductor temperature of 167°F. A lower temperature may be considered where justified by a qualified engineering study. Under no circumstances should a design temperature be less than 120°F.

c. Maximum conductor temperature, no wind. See paragraph 4.3.1. The same maximum temperature used for vertical clearance to ground should be used.

At a minimum the NESC requires that (1) the upper and lower conductors are simultaneously subjected to the same ambient air temperature and wind loading conditions **and** (2) each is subjected individually to the full range of its icing conditions and applicable design electrical loading.

4.5.2 Altitude Greater than 3300 Feet: If the altitude of the crossing point of the two lines is greater than 3300 feet, additional clearance as indicated in Table 4-3 is added to the base clearance given.

4.5.3 Differences in Sag Conditions Between Lower and Upper Conductors: The reason for the differences in sag conditions between the upper and lower conductor at which the clearances apply is to cover situations where the lower conductor has lost its ice while the upper conductor has not, or where the upper conductor is loaded to its thermal limit while the lower conductor is only lightly loaded.

4.5.4 Examples of Clearance Calculations: The following example demonstrates the derivation of the vertical clearance of a category in Tables 4-3 of this bulletin.

To determine the vertical clearance of a 161 kV line crossing a distribution conductor (item 3 of Table 4-3), the clearance is based on NESC Table 233-1 and NESC Rule 233.

NESC Vertical Clearance= NESC Basic Clearance(Table 233-1) + .4(kV_{L-G} – 22)/12
= 2.0 feet + .4(97.6-22)/12 feet
= 2.0 feet + 2.5 feet
NESC Vertical Clearance = 4.5 feet

Recommended Clearance = NESC Vertical Clearance + Agency Adder
= 4.5 feet + 1.5 feet
= 6.0 feet (6.0 feet in Table 4-3)

4.6 Design Vertical Clearance Between Conductors of Different Lines at Noncrossing Situations: If the horizontal separation between conductors as set forth in Chapter 5 cannot be achieved, then the clearance requirements in section 4.5 should be attained.

4.7 Example of Line-to-Ground Clearance: A portion of a 161 kV line is to be built over a field of oats that is at an elevation of 7200 feet. Determine the design line-to-ground clearance.

4.7.1 Solution of the Additional Clearance for Altitude: Because the altitude of the 161 kV line is greater than 3300 feet, the basic clearance is to be increased by the amount indicated in Table 4-1. The calculation follows:

(7200-3300)(.08)/1000 = 0.32 feet

4.7.2 Total Clearance: Assuming the line meets the assumptions given in section 4.2 and Table 4-1, the recommended design clearance over cultivated fields for a 161 kV line is 23.5 feet. Therefore, the recommended clearance, taking altitude into account, is 23.8 feet.

$$0.32 \text{ feet} + 23.5 \text{ feet} = 23.8 \text{ feet}$$

An additional one foot of clearance should be added for survey, construction and design tolerance.

4.8 Example of Conductor Crossing Clearances: A 230 kV line crosses over a 115 kV line in two locations. At one location the 115 kV line has an overhead ground wire which, at the point of crossing, is 10 feet above its phase conductors. At the other location the lower voltage line does not have an overhead ground wire. Determine the required clearance between the 230 kV conductors and the 115 kV conductors at both crossing locations. Assume that the altitude of the line is below 3300 feet. Also assume that the sag of the overhead ground wire is the same as or less than the sag of the 115 kV phase conductors. The 230 kV line has ground fault relaying.

Solution: The first step in the solution is to determine if the line being crossed over has automatic ground fault relaying. We are able to determine that the lower line has automatic ground fault relaying.

From Table 4-3, (item 4), the required clearance from a 230 kV conductor to a 115 kV conductor is 9.0 feet. From Table 4-3, (item 2), the required clearance from the 230 kV conductor to the overhead ground wire is 7.4 feet; adding 10 feet for the distance between the overhead ground wire (OHGW) and the 115 kV phase conductors, the total required clearance is 17.4 feet.

When the lower circuit has an overhead ground wire, clearance requirements to the overhead ground wire govern and the required clearance between the upper and lower phase conductor is 17.4 feet.

Where there is no overhead ground wire for the 115 kV circuit, the required clearance between the phase conductors is 9.0 feet.

It is important to note that the above clearances are to be maintained where the upper conductor is at its maximum sag condition, as defined in section 4.5.1b or 4.5.1c above, and the lower conductor is at 60°F initial sag.

4.9 Vertical Clearances to Vegetation: The best practice is usually to remove all substantive vegetation (such as trees and vines) under and adjacent to the line. In certain areas, such as canyons, river crossings, or endangered species habitat, vegetation can be spanned. For vertical clearances (intended to meet NERC FAC 003), refer to radial clearances discussed in Section 5.2.2 of this bulletin.

TABLE 4-3
RECOMMENDED DESIGN VERTICAL CLEARANCES IN FEET
BETWEEN CONDUCTORS WHERE THE CONDUCTORS OF ONE LINE
CROSS OVER THE CONDUCTORS OF ANOTHER AND WHERE THE UPPER AND
LOWER CONDUCTORS HAVE GROUND FAULT RELAYING

Voltage between circuits = Voltage line to ground Top Circuit + Voltage line to ground Bottom Circuit (Calculations are based on the maximum operating voltage.)

The NESC requires that clearances not be less than that required by application of a clearance envelope developed under NESC Rules 233A1 & 233A2. Structure deflection shall also be taken into account. Agency recommended values in this table are to be adders applied for the movement of the conductor and deflection of structures, if any.

			UPPER LEVEL CONDUCTOR (Note F)					
Nominal Voltage, Phase to Phase kV $_{L-L}$			**34.5 & 46**	**69**	**115**	**138**	**161**	**230**
Max. Operating Voltage, Phase to Phase		(kV_{LL})	----	72.5	120.8	144.9	169.1	241.5
Max. Operating Voltage, Phase to Ground		(kV_{LG})	----	41.8	69.7	83.7	97.6	139.4
	NESC Basic Clear. (Note H)	(kV_{LG})	Clearances in feet					
LOWER LEVEL CONDUCTOR								
1. Communication	5.0		6.7	7.2	8.1	8.6	9.0	10.4
2. OHGW (Note G)	2.0		3.7	4.2	5.1	5.6	6.0	7.4
3. Distribution conductors	2.0		3.7	4.2	5.1	5.6	6.0	7.4
4. Transmission conductors of lines that have ground fault relaying. Nominal line – to – line voltage in kV. (Note F)								
230 kV	2.0	139.4						11.3
161 kV	2.0	97.6					8.5	9.9
138 kV	2.0	83.7				7.6	8.1	9.5
115 kV	2.0	69.7			6.7	7.1	7.6	9.0
69 kV	2.0	41.8		4.8	5.6	6.2	6.7	8.1
46 kV and below	2.0	26.4	3.8	4.3	5.2	5.7	6.2	7.6

Notes:

(A) The conductors on other supports are assumed to be from different circuits

(B) **This table applies to lines with ground fault relaying.**

(C) The NESC requires that the clearance shall be not less than that required by application of a clearance envelope developed under NESC Rule 233A2 to the positions on or within conductor movement envelopes developed under Rule 233A1 at which the two wires, conductors or cables would be closest together. For purposes of this determination, the relevant positions of the wires, conductors, or cables on or within their respective conductor movement envelopes are those which can occur when (1) both are simultaneously subjected to the same ambient air temperature and wind loading conditions and (2) each is subjected individually to the full range of its icing conditions and applicable design electrical loading.

TABLE 4-3 (continued)
RECOMMENDED DESIGN VERTICAL CLEARANCES IN FEET BETWEEN CONDUCTORS WHERE THE CONDUCTORS OF ONE LINE CROSS OVER THE CONDUCTORS OF ANOTHER AND WHERE THE UPPER AND LOWER CONDUCTORS HAVE GROUND FAULT RELAYING

(D) An additional 1.5 feet of clearance is added to NESC clearance to obtain the recommended design clearances. Greater values should be used where the survey method used to develop the ground profile is subject to greater unknowns.

(E) ***ALTITUDE CORRECTION TO BE ADDED TO VALUES ABOVE***

Total altitude correction factor	=	Correction for upper conductors	+	Correction for lower conductors

For upper conductors use correction factor from Table 4-1 of this bulletin.
For lower conductors:
Categories 1, 2, 3 above use no correction factors
Category 4 uses correction factors from Table 4-1 of this bulletin

(F) **The higher voltage line should cross over the lower voltage line**

(G) If the line on the lower level has overhead ground wire(s), this clearance will usually be the limiting factor at crossings.

(H) The NESC basic clearance is defined as the reference height plus the electrical component for open supply conductors up to 22 kV_{L-G}.

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5. HORIZONTAL CLEARANCES FROM LINE CONDUCTORS TO OBJECTS AND RIGHT-OF-WAY WIDTH

5.1 General: The preliminary comments and assumptions in Chapter 4 of this bulletin also apply to this chapter.

5.2 Minimum Horizontal Clearance of Conductor to Objects: Recommended design horizontal clearances of conductors to various objects are provided in Table 5-1 and minimum radial operating clearances of conductors to vegetation in Table 5-2. The clearances apply only for lines that are capable of automatically clearing line-to-ground faults.

Clearance values provided in Table 5-1are recommended design values. In order to provide an additional margin of safety, the recommended design values exceed the minimum clearances in the 2007 NESC. Clearance values provided in Table 5-2 are minimum operating clearances to be used by the designer to determine appropriate design clearances for vegetation maintenance management.

5.2.1 Conditions Under Which Horizontal Clearances to Other Supporting Structures, Buildings and Other Installations Apply:

Conditions at Rest (No Wind Displacement): When conductors are at rest the clearances apply for the following conditions: (a) 167°F but not less than 120°F, final sag, (b) the maximum operating temperature the line is designed to operate, final sag, (c) 32°F, final sag with radial thickness of ice for the loading district (0 in., ¼ in., or ½ in.).

Conductors Displaced by 6 psf Wind: The clearances apply when the conductor is displaced by 6 lbs. per sq. ft. at final sag at 60°F. See Figure 5-1.

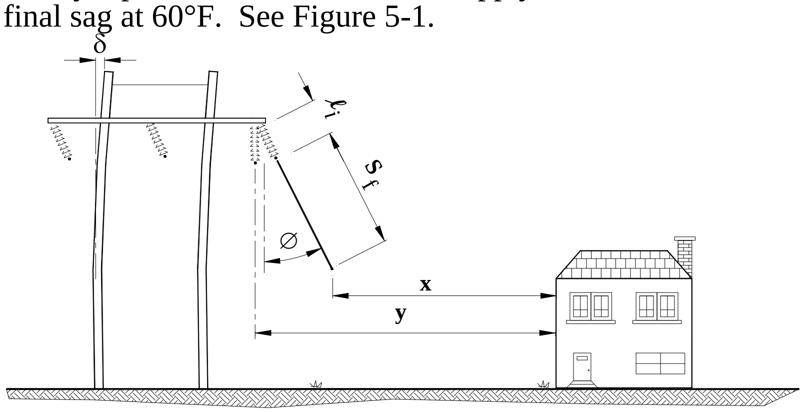


FIGURE 5-1: HORIZONTAL CLEARANCE REQUIREMENT TO BUILDINGS

where:

ϕ	=	conductor swing out angle in degrees under 6 psf. of wind
S_f	=	conductor final sag at 60°F with 6 psf. of wind
x	=	horizontal clearance required per Tables 5-1 for conductors displaced by 6 psf wind (include altitude correction if necessary)
ℓ_i	=	insulator string length (ℓ_i = 0 for post insulators or restrained suspension insulators).
y	=	total horizontal distance from insulator suspension point (conductor attachment point for post insulators) to structure with conductors at rest
δ	=	structure deflection with a 6 psf. Wind

TABLE 5-1
RECOMMENDED DESIGN HORIZONTAL CLEARANCES (in feet) FROM CONDUCTORS AT REST AND DISPLACED BY 6 PSF WIND TO OTHER SUPPORTING STRUCTURES, BUILDINGS AND OTHER INSTALLATIONS
(NESC Rules 234B, 234C, 234D, 234E, 234F, 234I, Tables 234-1, 234-2, 234-3)

Conditions under which clearances apply:

No wind: When the conductor is at rest the clearances apply at the following conditions: (a) 120°F, final sag, (b) the maximum operating temperature the line is designed to operate, final sag, (c) 32°F, final sag with radial thickness of ice for the loading district (1/4 in. for Medium or 1/2 in. Heavy).

Displaced by Wind: Horizontal clearances are to be applied with the conductor displaced from rest by a 6 psf wind at final sag at 60°F. The displacement of the conductor is to include deflection of suspension insulators and deflection of flexible structures.

The clearances shown are for the displaced conductors and do not provide for the horizontal distance required to account for blowout of the conductor and the insulator string. This distance is to be added to the required clearance. See Equation 5-1.

Clearances are based on the Maximum Operating Voltage

Nominal voltage, Phase to Phase, kV_{L-L}		**34.5 & 46**	**69**	**115**	**138**	**161**	**230**
Max. Operating Voltage, Phase to Phase, kV_{L-L}		----	72.5	120.8	144.9	169.1	241.5
Max. Operating Voltage, Phase to Ground, kV_{L-G}		----	41.8	69.7	83.7	97.6	139.4
Horizontal Clearances - (Notes 1,2,3)	NESC Basic Clear	Clearances in feet					
1.0 From a lighting support, traffic signal support or supporting structure of another line							
At rest (NESC Rule 234B1a)	5.0	6.5	6.5	7.2	7.6	8.1	9.5
Displaced by wind (NESC Rule 234B1b)	4.5	6.2	6.7	7.6	8.1	8.5	9.9
2.0 From buildings, walls, projections, guarded windows, windows not designed to open, balconies, and areas accessible to pedestrians							
At rest (NESC Rule 234C1a)	7.5	9.2	9.7	10.6	11.1	11.5	12.9
Displaced by wind (NESC Rule 234C1b)	4.5	6.2	6.7	7.6	8.1	8.5	9.9
3.0 From signs, chimneys, billboards, radio, & TV antennas, tanks & other installations not classified as buildings							
At rest (NESC Rule 234C1a)	7.5	9.2	9.7	10.6	11.1	11.5	12.9
Displaced by wind (NESC Rule 234C1b)	4.5	6.2	6.7	7.6	8.1	8.5	9.9
4.0 From portions of bridges which are readily accessible and supporting structures are not attached							
At rest (NESC Rule 234D1a)	7.5	9.2	9.7	10.6	11.1	11.5	12.9
Displaced by wind (NESC Rule 234D1b)	4.5	6.2	6.7	7.6	8.1	8.5	9.9
5.0 From portions of bridges which are ordinarily inaccessible and supporting structures are not attached							
At rest (NESC Rule 234D1a)	6.5	8.2	8.7	9.6	10.1	10.5	11.9
Displaced by wind (NESC Rule 234D1b)	4.5	6.2	6.7	7.6	8.1	8.5	9.9

TABLE 5-1 (continued)
RECOMMENDED DESIGN HORIZONTAL CLEARANCES (in feet) FROM CONDUCTORS AT REST AND DISPLACED BY 6 PSF WIND TO OTHER SUPPORTING STRUCTURES, BUILDINGS AND OTHER INSTALLATIONS
(NESC Rules 234B, 234C, 234D, 234E, 234F, 234I, Tables 234-1, 234-2, 234-3)

Conditions under which clearances apply:

No wind: When the conductor is at rest the clearances apply at the following conditions: (a) 120°F, final sag, (b) the maximum operating temperature the line is designed to operate, final sag, (c) 32°F, final sag with radial thickness of ice for the loading district (1/4 in. for Medium or 1/2 in. Heavy).

Displaced by Wind: Horizontal clearances are to be applied with the conductor displaced from rest by a 6 psf wind at final sag at 60°Funder extreme wind conditions (such as the 50 or 100-year mean wind) at final sag at 60°F. The displacement of the conductor is to include deflection of suspension insulators and deflection of flexible structures.

The clearances shown are for the displaced conductors and do not provide for the horizontal distance required to account for blowout of the conductor and the insulator string. This distance is to be added to the required clearance. See Equation 5-1.

Clearances are based on the Maximum Operating Voltage

Nominal voltage, Phase to Phase, kV_{L-L}		**34.5 & 46**	**69**	**115**	**138**	**161**	**230**
Max. Operating Voltage, Phase to Phase, kV_{L-L}		----	72.5	120.8	144.9	169.1	241.5
Max. Operating Voltage, Phase to Ground, kV_{L-G}		----	41.8	69.7	83.7	97.6	139.4
Horizontal Clearances - (Notes 1,2,3)	NESC Basic Clear	Clearances in feet					
6.0 Swimming pools – see section 4.4.3 of Chapter 4 and item 9 of Table 4–2. (NESC Rule 234E)							
Clearance in any direction from swimming pool edge (Clearance A, Figure 4-2 of this bulletin)	25.0	27.2	27.7	28.6	29.1	29.5	30.9
Clearance in any direction from diving structures (Clearance B, Figure 4-2 of this bulletin)	17.0	19.2	19.7	20.6	21.1	21.5	22.9
7.0 From grain bins loaded with permanently attached conveyor							
At rest (NESC Rule 234F1b)	15.0	17.2	17.7	18.6	19.1	19.5	20.9
Displaced by wind (NESC Rule 234C1b)	4.5	6.7	7.2	8.1	8.6	9.0	10.4
8.0 From grain bins loaded with a portable conveyor. Height 'V' of highest filling or probing port on bin must be added to clearance shown. Clearances for 'at rest' and not displaced by the wind. See NESC Figure 234-4 for other requirements.							
Horizontal clearance envelope (includes area of sloped clearance per NESC Figure 234-4b)		(24+V) + 1.5V (Note 3)					
9.0 From rail cars (Applies only to lines parallel to tracks) See Figure 234-5 and section 234I (Eye) of the NESC							
Clearance measured to the nearest rail		14.1	14.1	15.1	15.6	16.0	17.5
ALTITUDE CORRECTION TO BE ADDED TO VALUES ABOVE							
Additional feet of clearance per 1000 feet of altitude above 3300 feet		.02	.02	.05	.07	.08	.12

Notes:
1. Clearances for categories 1-5 in the table are approximately 1.5 feet greater than NESC clearances.
2. Clearances for categories 6 to 9 in the table are approximately 2.0 feet greater than NESC clearances.
3. "V" is the height of the highest filling or probing port on a grain bin. Clearance is for the highest voltage of 230 kV.

5.2.2 <u>Considerations in Establishing Radial and Horizontal Clearances to Vegetation</u>:

The designer should identify and document clearances between vegetation and any overhead, ungrounded supply conductors, taking into consideration transmission line voltage, the effects of ambient temperature on conductor sag under maximum design loading, and the effects of wind velocities on conductor sway. Specifically, the designer should establish clearances to be achieved at the time of vegetation management work and should also establish and maintain a set of clearances to prevent flashover between vegetation and overhead ungrounded supply conductors. As a mimimum, these clearances should apply to all transmission lines operated at 200 kV phase-to-phase and above and to any lower voltage lines designated as critical (refer to NERC FAC 003).

The designer should determine and document appropriate clearance distances to be achieved at the time of transmission vegetation management work based upon local conditions and the expected time frame in which the Transmission Owner plans to return for future vegetation management work. Local conditions may include, but are not limited to: operating voltage, appropriate vegetation management techniques, fire risk, reasonably anticipated tree and conductor movement, species types and growth rates, species failure characteristics, local climate and rainfall patterns, line terrain and elevation, location of the vegetation within the span, and worker approach distance requirements.

The designer should determine and document specific radial clearances to be maintained between vegetation and conductors under all rated electrical operating conditions. These minimum clearance distances are necessary to prevent flashover between vegetation and conductors and will vary due to such factors as altitude and operating voltage. These specific minimum clearance distances should be no less than those set forth in the Institute of Electrical and Electronics Engineers (IEEE) Standard 516-2003 (Guide for Maintenance Methods on Energized Power Lines) and as specified in its Section 4.2.2.3, Minimum Air Insulation Distances without Tools in the Air Gap. Where transmission system transient overvoltage factors are not known, clearances shall be derived from Table 5, IEEE 516-2003, phase-to-ground distances, with appropriate altitude correction factors applied.Where transmission system transient overvoltage factors are known, clearances shall be derived from Table 7, IEEE 516-2003, phase-to-phase voltages, with appropriate altitude correction factors applied. Table 5-2 contains radial clearances determined from Table 5, IEEE 516-2003, where transmission system transient overvoltage factors are not known.

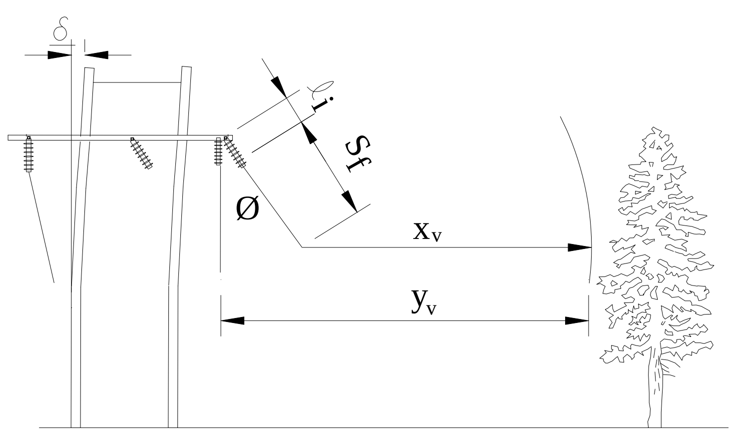


FIGURE 5-2: RADIAL CLEARANCE REQUIREMENT TO VEGETATION

where:

ϕ	=	conductor swing out angle in degrees under all rated operating conditions
S_f	=	conductor final sag at all rated operating conditions
x_v	=	radial clearance (include altitude correction if necessary)
ℓ_i	=	insulator string length (ℓ_i = 0 for post insulators or restrained suspension insulators).
y_v	=	horizontal clearance at the time of vegetation management work
δ	=	structure deflection at all rated operating conditions

TABLE 5-2
RADIAL OPERATING CLEARANCES (in feet) FROM IEEE 516 FOR USE IN DETERMINING CLEARANCES TO VEGETATION FROM CONDUCTORS
(NERC Standard FAC-003.1 Transmission Vegetation Management Program, IEEE 516, Guideline For Maintenance Methods Of Energized Power Lines)

Conditions under which clearances apply:

Displaced by Wind: Radial operating clearances are to be applied at all rated operating conditions.The designer should determine applicable conductor temperature and wind conditions for all rated operating conditions. The displacement of the conductor is to include deflection of suspension insulators and deflection of flexible structures.

The operating clearances shown are for the displaced conductors and do not provide for the horizontal distance required to account for blowout of the conductor and the insulator string. This distance is to be added to the required clearance. See Equation 5-1.

Clearances are based on the Maximum Operating Voltage.

Nominal voltage, Phase to Phase, kV_{L-L}	**34.5 & 46[1]**	**69[1]**	**115[1]**	**138[1]**	**161[1]**	**230[1,2]**
Max. Operating Voltage, Phase to Phase, kV_{L-L}	----	72.5	120.8	144.9	169.1	241.5
Max. Operating Voltage, Phase to Ground, kV_{L-G}	----	41.8	69.7	83.7	97.6	139.4
Radial Table 5 IEEE Standard 516 Operating Clearances	Clearances in feet					
Operating clearance at all rated operating conditions	1.8	1.8	1.9	2.3	2.5	2.7
Design adder for survey and installation tolerance	1.5 feet for all voltages					
Design adder for vegetation	Determined by designer (see Note 3 below)					
ALTITUDE CORRECTION TO BE ADDED TO VALUES ABOVE						
Additional feet of clearance per 1000 feet of altitude above 3300 feet	.02	.02	.05	.07	.08	.12

Notes:
1. These clearances apply to all transmission lines operated at 200 kV phase-to-phase and above and to any lower voltage lines designated as critical (refer to NERC FAC 003).
2. The 230 kV clearance is based on 3.0 Per Unit switching surge.
3. The design adder for vegetation, applied to conductors displaced by wind, should account for reasonably anticipated tree movement, species types and growth rates, species failure characteristics, and local climate and rainfall patterns. The design adder for vegetation, applied to conductors at rest, should account for worker approach distances in addition to the aforementioned factors.

5.2.3 __Clearances to Grain Bins__: The NESC has defined clearances from grain bins based on grain bins that are loaded by permanent or by portable augers, conveyers, or elevator systems.

In NESC Figure 234-4(a), the horizontal clearance envelope for permanent loading equipment is graphically displayed and shown Figure 5-2.

P = probe clearance, item 7, Table 4-2
H = horizontal clearance, item 7, Table 5-1
T = transition clearance
V_1 = vertical clearance, item 2&3, Table 4-2
V_2 = vertical clearance, Table 4-1

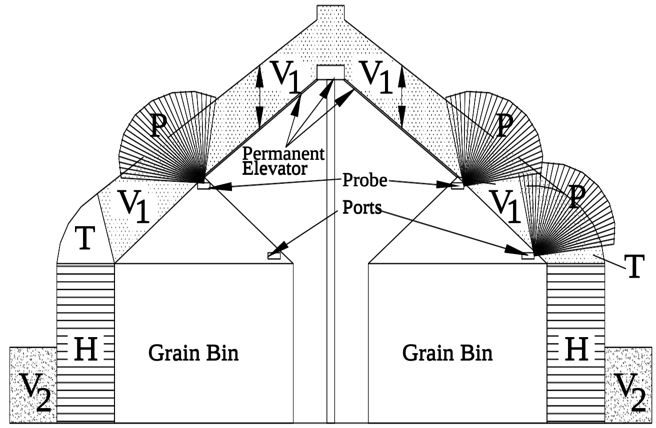


FIGURE 5-3: CLEARANCE TO GRAIN BINS
NESC FIGURE 234-4a

Because the vertical distance from the probe in Table 4-2, item 7.0, is greater than the horizontal distance, (see Table 5-1, item 7.0), the user may want to simplify design and use this distance as the horizontal clearance distance as shown below:

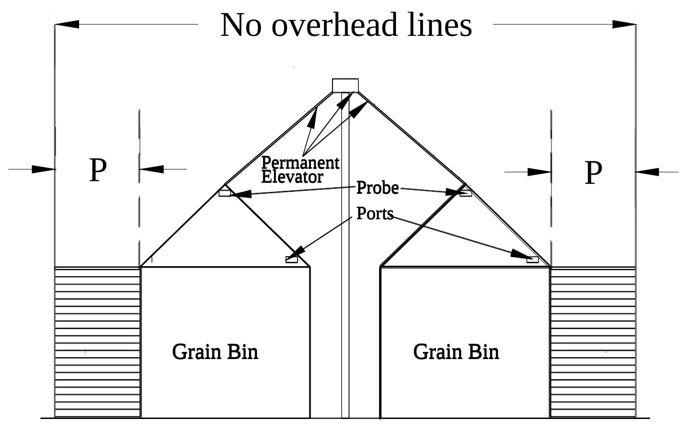


FIGURE 5-4: HORIZONTAL CLEARANCE TO GRAIN BINS, CONDUCTORS AT REST
P = clearance from item 7, Table 4-2

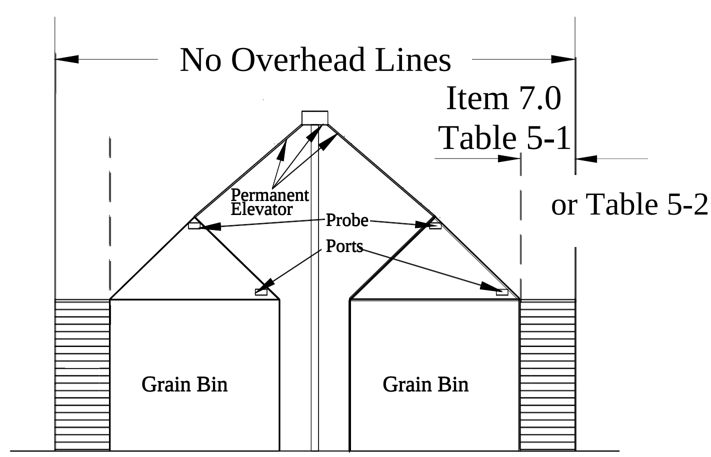


FIGURE 5-5: HORIZONTAL CLEARANCE TO GRAIN BINS, CONDUCTORS DISPLACED BY 6 PSF WIND

The clearance envelope for portable loading equipment from NESC Figure 234(b), is shown in Figure 5-6.

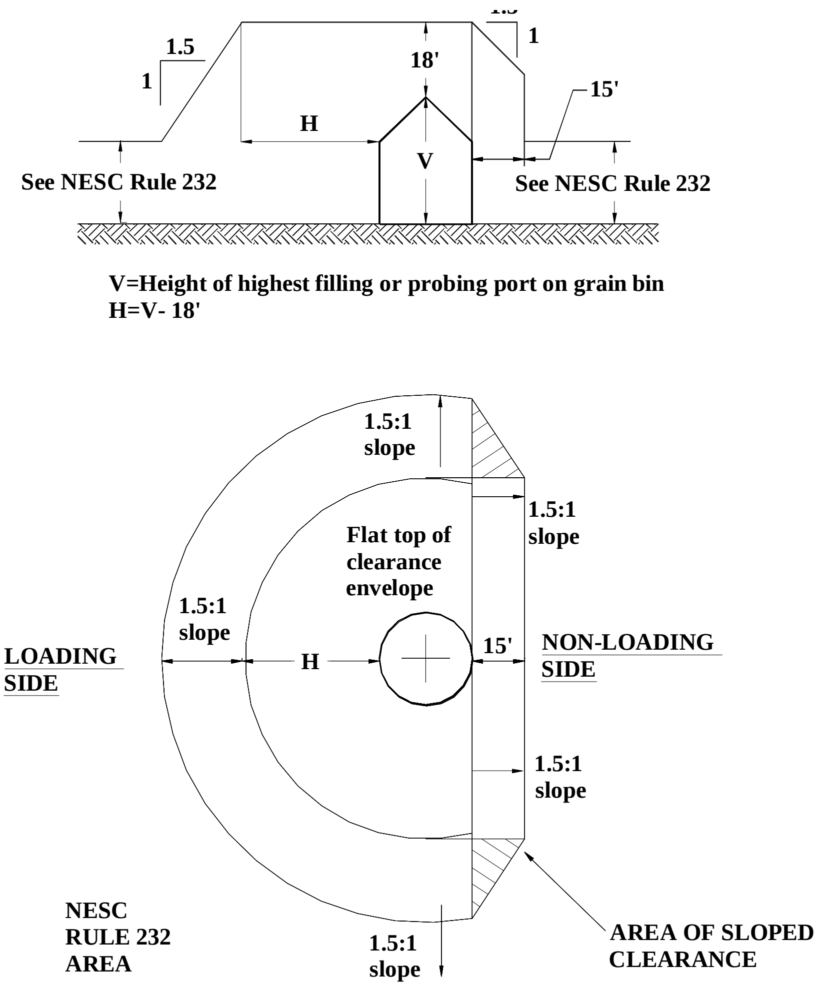


FIGURE 5-6: NESC CLEARANCE TO GRAIN BINS WITH
PORTABLE LOADING EQUIPMENT

In order to simplify the clearance envelope, the horizontal clearances in category 8 of Table 5-1 is shown as 'H' in the drawing below:

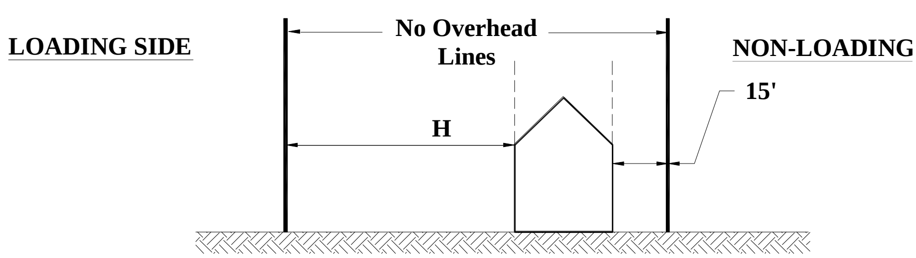


FIGURE 5-7: SIMPLIFIED RECOMMENDATIONS FOR CLEARANCES
TO GRAIN BINS WITH PORTABLE LOADING EQUIPMENT

5.2.4 <u>Altitude Greater Than 3300 Feet</u>: If the altitude of the transmission line or portion thereof is greater than 3300 feet, an additional clearance as indicated in Table 5-1 and 5-2 has to be added to the base clearance given.

5.2.5 <u>Total Horizontal Clearance to Point of Insulator Suspension to Object</u>: As can be seen from Figure 5-1, the total horizontal clearance (y) is:

$$y = \left(\ell_i + S_f\right)\sin\phi + x + \delta \qquad \text{Eq. 5-1}$$

Symbols are defined in Section 5.2.1 and figure 5-1. The factor "δ" indicates that structure deflection should be taken into account.

For the sake of simplicity when determining **horizontal** clearances, the insulator string should be assumed to have the same swing angle as the conductor. This assumption should be made only in this chapter as its use in calculations elsewhere may not be appropriate.

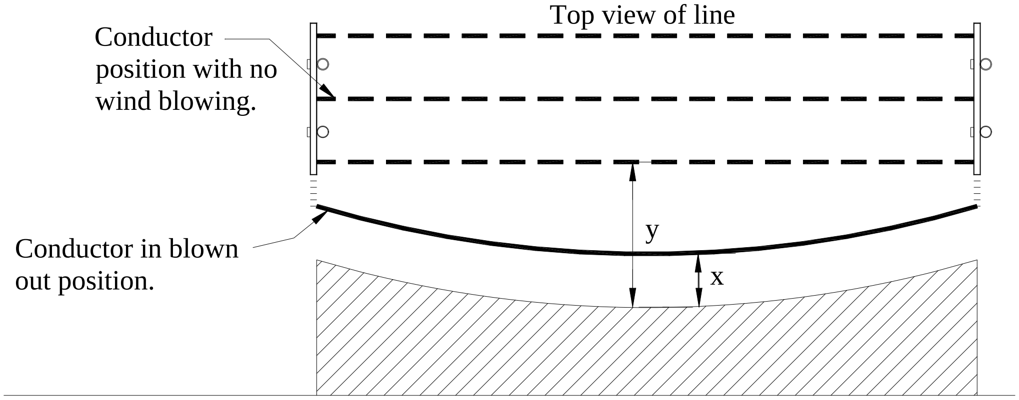
The conductor swing angle (ϕ) under wind can be determined from the formula.

$$\phi = \tan^{-1}\left(\frac{(d_c)(F)}{12\ w_c}\right) \qquad \text{Eq. 5-2}$$

where:

d_c = conductor diameter in inches
w_c = weight of conductor in lbs./ft.
F = wind force;

The total horizontal distance (y) at a particular point in the span depends upon the conductor sag at that point. The value of (y) for a structure adjacent to the maximum sag point will be greater than the value of (y) for a structure placed elsewhere along the span. See Figure 5-7.



x = clearance from wind-displaced conductor, y= total horizontal clearance from conductor at rest

FIGURE 5-8: A TOP VIEW OF A LINE SHOWING TOTAL HORIZONTAL CLEARANCE REQUIREMENTS

5.2.6 Examples of Horizontal Clearance Calculations: The following examples demonstrate the derivation of the horizontal clearance in Table 5-1 of this bulletin.

To determine the horizontal clearance of a 115 kV line to a building (category 2.0 of Table 5-1), the clearance is based on NESC Table 234-1 and NESC Rule 234.

At rest:

NESC Horizontal Clear. = NESC Basic Clearance(Table 234-1) + .4(kV_{L-G} – 22)/12
= 7.5 feet + .4(69.7-22)/12 feet
= 7.5 feet + 1.59 feet
NESC Horizontal Clear. = 9.09 feet

Recommended Clearance = NESC Horizontal Clearance + Adder
= 9.09 feet + 1.5 feet
y = 10.59 feet (10.60 feet in Table 5-1)

Conductors displaced by 6 psf wind:

NESC Horizontal Clear. = NESC Basic Clearance (Table 234-1) + .4(kV_{L-G} – 22)/12
= 4.5 feet + .4(69.7-22)/12 feet
= 4.5 feet + 1.59 feet
NESC Horizontal Clear. = 6.09 feet

Recommended Clearance = NESC Horizontal Clearance + Adder
= 6.09 feet + 1.5 feet
x = 7.59 feet (7.6 feet in Table 5-1)

5.3 Right-of-Way (ROW) Width: For transmission lines, a right-of-way provides an environment allows the line to be operated and maintained safely and reliably. Determination of the right-of-way width is a task that requires the consideration of a variety of judgmental, technical, and economic factors.

Typical right-of-way widths (predominantly H-frames) that have been used by agency borrowers in the past are shown in Table 5-2. In many cases a range of widths is provided. The actual width used will depend upon the particulars of the line design.

TABLE 5-3
TYPICAL RIGHT-OF-WAY WIDTHS

	Nominal Line-to-Line Voltage in kV				
	69	115	138	161	230
ROW Width, ft.	75-100	100	100-150	100-150	125-200

5.4 Calculation of Right-of-Way Width for a Single Line of Structures on a Right-of-Way: Right-of-way widths can be calculated using the method described below. The calculated values for right-of-way widths are directly related to the particular parameters of the line design. This method provides sufficient width to meet clearance requirements to buildings of undetermined height or vegetation located directly on the edge of the right-of-way. See Figures 5-8 and 5-9.

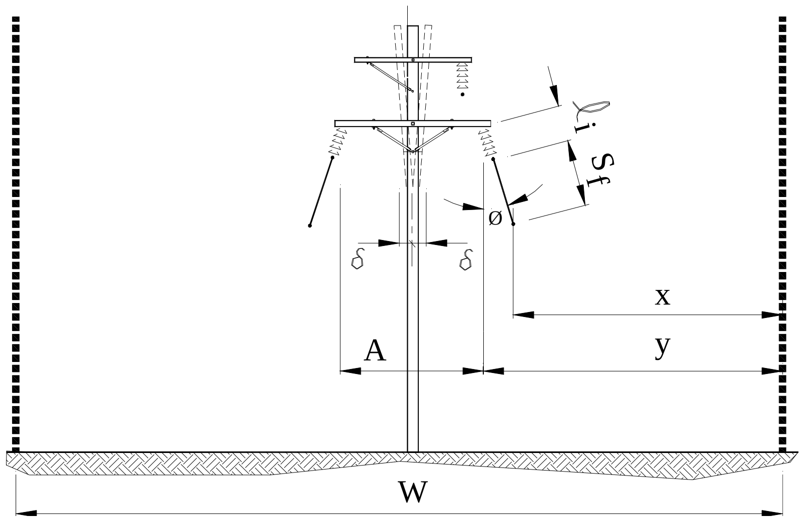


FIGURE 5-9: ROW WIDTH FOR SINGLE LINE OF STRUCTURES

$$W = A + 2(\ell_i + S_f)\sin\phi + 2\delta + 2x \qquad \text{Eq. 5-3}$$

where:

- W = total right-of-way width required
- A = separation between points of suspension of insulator strings for outer two phases
- x = clearance required per Table 5-1 and appropriate clearance derived from Table 5-2 of this bulletin (include altitude correction if necessary)
- y = clearance required per Section 5.2.1 and Table 5-1 and appropriate clearance derived from Section 5.2.2. and Table 5-2 of this bulletin (include altitude correction if necessary)

Other symbols are as previously defined. In some instances, clearance "x" may control. In other instances, clearance "y" may control.

There are two ways of choosing the length (and thus the sag) on which the right-of-way width is based. One is to use a width based on the maximum span length in the line. The other way is to base the width on a relatively long span, (the ruling span, for instance), but not the longest span. For those spans that exceed this base span, additional width is added as appropriate.

5.5 <u>Right-of-Way Width for a Line Directly Next to a Road</u>: The right-of-way width for a line next to a road can be calculated based on the two previous sections with one exception. No ROW is needed on the road side of the line as long as the appropriate clearances to existing or possible future structures on the road side of the line are met.

If a line is to be placed next to a roadway, consideration should be given to the possibility that the road may be widened. If the line is on the road right-of-way, the borrower would generally be expected to pay for moving the line. If the right-of-way is on private land, the highway department should pay. Considerations involved in placing a line on a road right-of-way should also include evaluation of local ordinances and requirements.

5.6 Right-of-Way Width for Two or More Lines of Structures on a Single Right-of-Way: To determine the right-of-way width when the right ROW contains two parallel lines, start by calculating the distance from the outside phases of the lines to the ROW edge (see Section 5.4). The distance between the two lines is governed by the two criteria provided in section 5.6.1. If one of the lines involved is an extra high voltage (EHV) line (345 kV and above), the NESC should be referred to for additional applicable clearance rules not covered in this bulletin.

5.6.1 Separation Between Lines as Dictated by Minimum Clearance Between Conductors Carried on Different Supports: The horizontal clearance between a phase conductor of one line to a phase conductor of another line shall meet the larger of C_1, or C_2 below, under the following conditions: (a) both phase conductors displaced by a 6 psf wind at 60°F, final sag; (b) if insulators are free to swing, one should be assumed to be displaced by a 6 lbs/sq. ft. wind while the other should be assumed to be unaffected by the wind (see Figure 5-10). The assumed wind direction should be that which results in the greatest separation requirement. It should be noted that in the Equations 5-5, and 5-6, the 'δ_1-δ_2' term, (the differential structure deflection between the two lines of structures involved), is to be taken into account. An additional 1.5 feet have been added to the NESC clearance to obtain design clearances 'C_1'and 'C_2'. Note Equation 5-6 has been revised from previous versions due to the voltage adder change in the 2007 NESC edition.

$$C_1 = 6.5 + (\delta_1 - \delta_2) \text{ (NESC Rule 233B1)} \qquad \text{Eq. 5-5}$$

$$C_2 = 6.5 + \frac{.4}{12}\left[(kV_{LG1} + kV_{LG2}) - 22\right] + (\delta_1 - \delta_2) \text{ (NESC Rule 233B1)} \qquad \text{Eq. 5-6}$$

where:

C_1,C_2 = clearance requirements between conductors on different lines in feet (largest value governs)
kV_{LG1} = maximum line-to-ground voltage in kV of line 1
kV_{LG2} = maximum line-to-ground voltage in kV of line 2
δ_1 = deflection of the upwind structure in feet
δ_2 = deflection of the downwind structure in feet

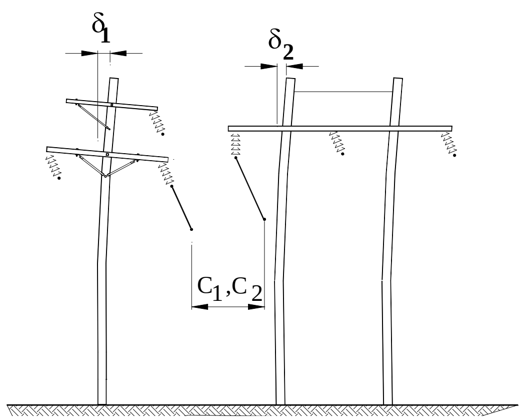


FIGURE 5-10: CLEARANCE BETWEEN CONDUCTORS OF ONE LINE TO CONDUCTOR OF ANOTHER LINE

5.6.2 <u>Separation Between Lines as Dictated by Minimum Clearance of Conductors From One Line to the Supporting Structure of Another</u>: The horizontal clearance of a phase conductor of one line to the supporting structure of another when the conductor and insulator are displaced by a 6 psf wind at 60°F final sag should meet Equation 5-7.

$$C_3 = 6' + \frac{.4}{12}\left(kV_{LG} - 22\right) + \left(\delta_1 - \delta_2\right) \quad \text{Eq. 5-7}$$

where:

kV_{LG} = the maximum line-to-ground voltage in kV
C_3 = the clearance of conductors of one line to structure of another in feet

Other symbols are defined in Figure 5-1.

Additional 1.5 feet have been added to the NESC clearance and included in equation 5-7 to obtain the design clearance 'C_3'.
.

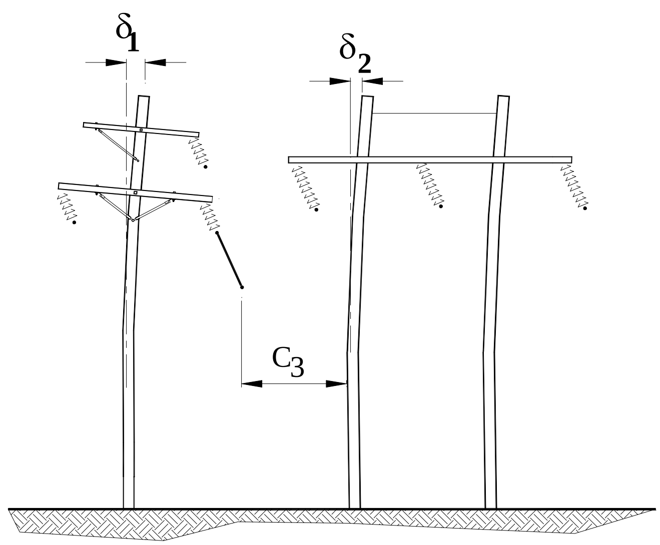


FIGURE 5-11: CLEARANCE BETWEEN CONDUCTORS OF ONE LINE AND STRUCTURE OF ANOTHER

The separation between lines will depend upon the spans and sags of the lines as well as how structures of one line match up with structures of another. In order to avoid the unreasonable task of determining separation of structures span-by-span, a standard separation value should be used, based on a worst case analysis. Thus if structures of one line do not always line up with those of the other, the separation determined in section 5.6.2 should be based on the assumption that the structure of one line is located next to the mid-span point of the line that has the most sag.

5.6.3 <u>Other Factors</u>: Galloping should be taken into account in determining line separation. In fact, it may be the determining factor in line separation. See Chapter 6 for a discussion of galloping.

Standard phase spacing should also be taken into account. For example, if two lines of the same voltage using the same type structures and phase conductors are on a single ROW, a logical separation of the two closest phases of the two lines should be at least the standard phase separation of the structure.

5.6.4 Altitude Greater than 3300 Feet: If the altitude at which the lines included in the design are installed greater than 3300 feet, NESC Section 23 rules provide additional separation requirements.

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6. CLEARANCES BETWEEN CONDUCTORS AND BETWEEN CONDUCTORS AND OVERHEAD GROUND WIRES

6.1 General: The preliminary comments and assumptions of Chapter 4, section 4.2, also apply to this chapter.

This chapter considers design limits related to conductor separation. It is assumed that only standard agency structures will be used, thus making it unnecessary to check conductor separation at structures. Therefore, the only separation values left to consider are those related to span length and conductor sags.

Maximum span lengths may be controlled by conductor separation. Other factors which may limit span length, but are not covered in this chapter, are structure strength, insulator strength, and ground clearance.

6.2 Maximum Span as Limited by Horizontal Conductor Separation: Sufficient horizontal separation between phases is necessary to prevent swinging contacts and flashovers between conductors where there is insufficient vertical separation.

6.2.1 Situations Under Which Maximum Span as Limited by Horizontal Separation are to be Met:

If the vertical separation (regardless of horizontal displacement) of phase conductors of the same or different circuit(s) at the structure is less than the appropriate values provided in Table 6-1,then the recommendations in sections 6.2.2, 6.2.3, and 6.2.4 of this section should be met.

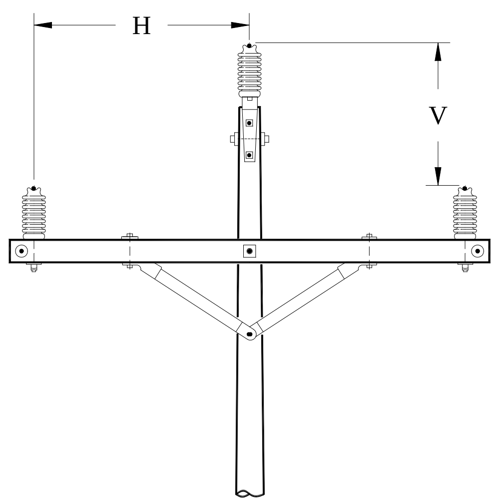


FIGURE 6-1: EXAMPLE OF VERTICAL AND HORIZONTAL SEPARATION VALUES

6.2.2 Horizontal Separation Recommendations: Equation 6-1 gives an horizontal phase spacing (relative to conductor sag, and thus indirectly to span length) that should be sufficient to prevent swinging contacts or flashovers between phases of the same or different circuits.

$$H = (0.025)kV + F_c\sqrt{S_f} + \ell_i(\sin\phi_{\max}) \qquad \text{Eq. 6-1}$$

where:

H	=	horizontal separation between the phase conductors at the structure in feet.
kV	=	(phases of the same circuit) the nominal line-to-line voltage in 1000's of volts for 34.5 and 46 kV and 1.05 times the nominal voltage in 1000's of volts for higher voltages
kV	=	(phases of different circuits) 1.05 times the magnitude of the voltage vector between the phases in 1000's of volts. kV should never be less than 1.05 times the nominal line-to-ground voltage in 1000's of volts of the higher voltage circuit involved regardless of how the voltage vectors add up. The voltage between the phases should be taken as the sum of the two line-to-ground voltages, based on 1.05 times nominal voltage.
F_C	=	experience factor
$Ø_{max}$	=	maximum 6 psf insulator swing angle for the structure in question. See Chapter 7 of this bulletin.
S_f	=	final sag of the conductor at 60°F, no load, in feet
ℓ_i	=	length of the insulator string in feet, $\ell_i = 0$ for post or restrained suspension insulators
V	=	vertical separation between phase conductors at the structure in feet

The experience factor (F_C) may vary from a minimum of 0.67 to a maximum of 1.4, depending upon how severe the wind and ice conditions are judged to be. The following are values of F_C that have proved to be satisfactory in the past.

F_C = 1.15 for the light loading zone
F_C = 1.2 for the medium loading zone
F_C = 1.25 for the heavy loading zone

Any value of F_C in the 0.67 to 1.4 range may be used if it is thought to be reasonable and prudent. There has been significant favorable experience with larger conductor sizes that have horizontal spacing based on an F_C factor of 0.67. Therefore, F_C factor values significantly less than the values listed above may be appropriate. If F_C values less than those given above are used, careful attention should be paid to galloping as a possible limiting condition on the maximum span length.

TABLE 6-1
RECOMMENDED VERTICAL SEPARATION IN FEET BETWEEN PHASES
OF THE SAME OR DIFFERENT CIRCUITS ATTACHED TO THE SAME STRUCTURE
(For separations less than those shown, Equation 6-1 applies) (See Notes E & F)

Nominal voltage, Line-to-Line Voltage in kV	**34.5 & 46**	**69**	**115**	**138**	**161**	**230**
Max. Operating Voltage, Phase to Phase, kV	----	72.5	120.8	144.9	169.1	241.5
Max. Operating Voltage, Phase to Ground, kV	----	41.8	69.7	83.7	97.6	139.4
Vertical Separation	Separation in feet					
<u>Minimum Vertical Separation at Support</u>						
1. Phases of the same circuit (Note A) (Based on NESC Table 235-5)	3.2	4.0	5.6	6.4	7.2	9.6
2. Phases of different circuits (Notes B & D) (Based on NESC Table 235-5,footnote 7 criteria for different utilities)	5.4	6.3	8.2	9.1	10.1	12.8
3. Phase conductors and overhead ground wires (Based on NESC 235C and 233C3)	2.5	2.9	3.9	4.3	4.8	6.4
<u>Minimum Vertical Separation in Span</u>						
4. Phases of the same circuit (Notes A & G) (Based on NESC Table 235-5), H ≥ 1.0 ft., Figure 6-4	2.5	3.3	4.9	5.7	6.5	9.0
5. Phases of different circuits (Notes C, D & G) (Based on NESC Table 235-5, footnote 7 **criteria for different utilities** NESC Rule 235C2b.), H ≥ 1.0 ft., Figure 6-4	4.2	5.2	7.0	7.9	8.9	11.7
6. Phase conductors and overhead ground wires (H ≥ 1.0 ft., Figure 6-4), Notes D & G	1.5	2.1	3.0	3.6	4.0	5.4
ALTITUDE CORRECTION TO BE ADDED TO VALUES IN CATEGORY '2' ABOVE (NONE REQUIRED FOR CATEGORY '1'):						
Additional feet of clearance per 1000 feet of altitude above 3300 feet	.02	.02	.05	.07	.08	.12

<u>Notes</u>:

(A) There are no NESC values specified for vertical separation of conductors of the same circuit for voltages above 50 kV line-to-line.

(B) Assumes both circuits have the same nominal voltage. If they do not, the vertical separation can be determined using Equation 6-2 below.

$$V = \frac{40}{12} + \frac{.4}{12}\left(kV_{LG1} + kV_{LG2} - 8.7\right) + \frac{6}{12}\left(NoteD\right) \qquad \text{Eq. 6-2}$$

where:

kV_{LG1} = Line to ground voltage circuit one, kilovolts.

kV_{LG2} = Line to ground voltage circuit two, kilovolts.

TABLE 6-1 (continued)
RECOMMENDED VERTICAL SEPARATION IN FEET BETWEEN PHASES
OF THE SAME OR DIFFERENT CIRCUITS ATTACHED TO THE SAME STRUCTURE
(For separations less than those shown, Equation 6-1 applies) (See Notes E & F)

(C) Assumes both circuits have the same nominal voltage. If they do not, the vertical separation can be determined using Equation 6-2a below.

$$V = .75\left[\frac{40}{12} + \frac{.4}{12}(50 - 8.7)\right] + \frac{.4}{12}\left(kV_{LG1} + kV_{LG2} - 50\right) + \frac{6}{12}\left(NoteD\right) \quad \text{Eq. 6-2a}$$

(D) An additional 0.5 feet of clearance is added to the NESC clearance to obtain the recommended design clearances.

(E) The values in this table are not recommended as minimum vertical separations at the structure for non-standard agency structures. They are intended only to be used on standard agency structures to determine whether or not horizontal separation calculations are required.

(F) The upper conductor is at final sag at the maximum operating temperature and the lower conductor is at final sag at the same ambient conditions as the upper conductor without electrical loading and without ice loading; **or**, the upper conductor is at final sag at 32º with radial ice from either the medium loading district or the heavy loading district and the lower conductor is at final sag at 32ºF.

(G) In areas subjected to icing, an additional 2.0 feet of clearance should be added to the above clearances when conductors or wires are directly over one another or have less than a one foot horizontal offset. See section 6.3 of this bulletin.

6.2.3 <u>Additional Horizontal Separation Equation</u>: Equation 6-3 below, commonly known as the Percy Thomas formula, may be used in addition to (but not instead of) equation 6-1 for determining the horizontal separation between the phases at the structure. Equation 6-3 takes into account the weight, diameter, sag, and span length of the conductor.

$$H = (.025)kV + \frac{(E_c)(d_c)(S_p)}{w_c} + \frac{\ell_i}{2} \qquad \text{Eq. 6-3}$$

where:

d_c = conductor diameter in inches
w_c = weight of conductor in lbs/ft.
E_c = an experience factor. It is generally recommended that (E_c) be larger than 1.25.
S_p = sag of conductor at 60°F, expressed as a percent of span length

All other symbols are as previously defined.

By using the Thomas formula to determine values of E_c, the spacing of conductors on lines which have operated successfully in a locality can be examined. These values of E_c may be helpful in determining other safe spacings.

6.2.4 <u>Maximum Span Based on Horizontal Separation at the Structure</u>: Equation 6-1 can be rewritten and combined with Equation 10-1 (Chapter 10) to yield the maximum allowable span, given the horizontal separation at the structure and the sag and length of the ruling span. See Chapter 9 for a discussion of ruling span.

$$L_{\max} = (RS)\left(\frac{H - (.025)kV - \ell_i \sin\phi_{\max}}{F_c\sqrt{S_{RS}}}\right) \qquad \text{Eq. 6-4}$$

where:

L_{max}	=	maximum span as limited by conductor separation in feet
RS	=	length of ruling span in feet
S_{RS}	=	sag of the ruling span at 60°F final sag in feet

Other symbols are as previously defined for Eq. 6-1.

6.2.5 <u>Maximum Span Based on Vertical Separation</u>: Since vertical separation is related to the relative sags of the phase conductors involved, and since sags are related to span length, a maximum span as limited by vertical separation can be determined. The formula for the maximum span as limited by vertical separation is:

$$L_{\max} = (RS)\sqrt{\frac{D_v - B}{S_\ell - S_u}} \qquad \text{Eq. 6-5}$$

where:

L_{max}	=	maximum allowable span in feet
D_v	=	required vertical separation at mid-span in feet
B	=	vertical separation at supports in feet
S_ℓ	=	sag of lower conductor in feet without ice
S_u	=	sag of upper conductor wire in feet with ice
RS	=	ruling span in feet

6.2.6 <u>Example of Clearance Calculations</u>: The following example demonstrates the derivation of the vertical separation at a support for phases of different circuits in Tables 6-1 of this bulletin.

To determine the vertical separation of a 115 kV line to another 115 kV circuit, the clearance is based on NESC Table 235-5 and NESC Rule 235.

At the support, phases of different circuits:

NESC Vertical Separation = 40 inches/12 in./ft + .4(kV_{L-G} + kV_{L-G} – 8.7)/12 ft.
= 3.333 ft. + .4(69.7+69.7-8.7)/12 ft.
= 3.33 ft.+ 4.36 ft.
NESC Vertical Separation = 7.69 feet

Recommended
Vertical Separation = NESC Vertical Separation + suggested Adder
= 7.69 feet + 0.5 feet
= 8.19 feet (8.2 feet in Table 6-1)

In the span, phases of different circuits:

NESC Vertical Separation $= 0.75\left[\frac{40}{12} + \frac{.4}{12}(50 - 8.7)\right] + \frac{.4}{12}\left(kV_{LG1} + kV_{LG2} - 50\right)$

= 0.75(3.33+1.37) ft + (.4/12)(69.7+69.7-50) feet
= 3.53 ft. + 2.98 feet

NESC Vertical Separation in the Span = 6.51 feet

Recommended Clearance = NESC Vertical Separation + suggested Adder
= 6.51 feet + .5 feet
= 7.01 feet (7.0 feet in Table 6-1)

6.3 Maximum Span as Limited by Conductor Separation Under Differential Ice Loading Conditions

6.3.1 General: There is a tendency among conductors covered with ice, for the conductor closest to the ground to drop its ice first. Upon unloading its ice the lower conductor may jump up toward the upper conductor, possibly resulting in a temporary short circuit. After the lower conductor recovers from its initial ice-jump it may settle into a position with less sag than before, which may persist for long periods of time. If the upper conductor has not dropped its ice, the reduced separation may result in a flashover between phases.

The clearance recommendations provided in paragraph 6.3.2 of this section are intended to insure that sufficient separation will be maintained during differential ice loading conditions with an approach towards providing clearance for the ice-jump.

6.3.2 Clearance Recommendations: The minimum vertical distance (D_v) in span between phase conductors, and between phase conductors and overhead ground wires under differential ice loading conditions, are provided in Table 6-1. These vertical separations in span are recommended in cases where the horizontal separation between conductors (H) is greater than one foot (H ≥1.0 ft). When conductors or wires are directly over one another or have less than a 1 foot horizontal offset, it is recommended that an additional 2 feet of clearance be added to the values given in Table 6-1. The purpose of this requirement is to improve the performance of the line under ice-jump conditions. It has been found that a horizontal offset of as little as 1 foot significantly lessens the ice-jump problem. Figure 6-4 indicates the horizontal and vertical components of clearance and their relationship.

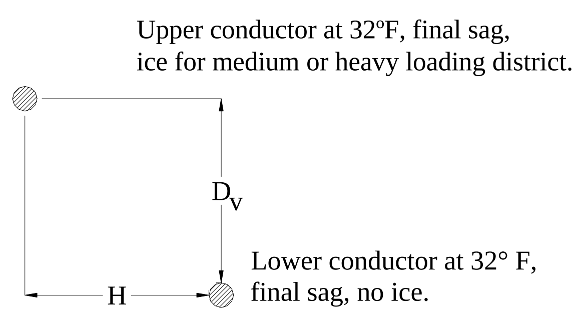


FIGURE 6-2: MINIMUM DISTANCE BETWEEN CONDUCTORS

6.3.3 Conditions Under Which Clearances Apply: Lines should be designed so that clearances are considered with the upper conductor at 32°F, final sag, and a radial thickness of ice equal to the ice thickness from either the medium loading district or the heavy loading district. The lower conductor should be at 32°F, final sag, no ice. The designer is reminded to check clearances for the upper conductor at the maximum operating temperature (no wind) and the lower conductor at ambient temperature (see Note F of Table 6-1).

6.4 Overhead Ground Wire Sags and Clearances: In addition to checking clearances between the overhead ground wire (OHGW) and phase conductors under differential ice loading conditions, it is also important that the relative sags of the phase conductors and the OHGW be coordinated so that under more commonly occurring conditions, there will be a reasonably low chance of a mid-span flashover. Adequate midspan separation is usually assured for standard agency structures by keeping the sag of the OHGW at 60°F initial sag, no load conditions to 80 percent of the phase conductors under the same conditions.

6.5 Maximum Span as Limited by Galloping

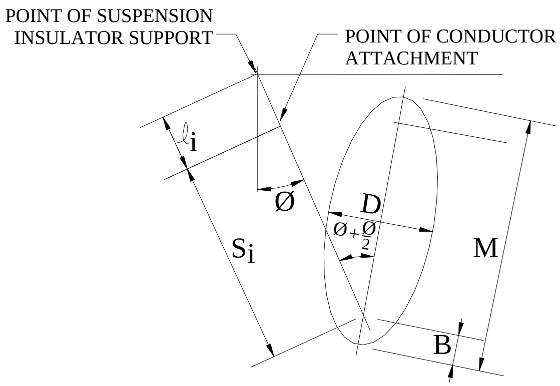
6.5.1 The Galloping Phenomenon: Galloping, sometimes called dancing, is a phenomenon where the transmission line conductors vibrate with very large amplitudes. This movement of conductors may result in: (1) contact between phase conductors or between phase conductors and overhead ground wires, resulting in electrical outages and conductor burning, (2) conductor failure at support point due to the violent stress caused by galloping, (3) possible structure damage, and (4) excessive conductor sag due to the overstressing of conductors.

Galloping usually occurs only when a steady, moderate wind blows over a conductor covered by a layer of ice deposited by freezing rain, mist or sleet. The coating may vary from a very thin glaze on one side to a solid three-inch cover and may give the conductor a slightly out-of-round, elliptical, or quasi-airfoil shape. The wind blowing over this irregular shape results in aerodynamic lift which causes the conductor to gallop. The driving wind can be anything between 5 to 45 miles per hour at an angle to the line of 10 to 90 degrees and may be unsteady in velocity or direction.

During galloping, the conductors oscillate elliptically at frequencies on the order of 1-Hz or less with vertical amplitudes of several feet. Sometimes two loops appear, superimposed on one basic loop. Single-loop galloping rarely occurs in spans over 600 to 700 feet. This is fortunate since it would be impractical to provide clearances large enough in long spans to prevent the possibility of contact between phases. In double-loop galloping, the maximum amplitude usually occurs at the quarter span points and is smaller than that resulting from single-loop galloping. There are several measures that can be incorporated at the design stage of a line to reduce potential conductor contacts caused by galloping, such as designing the line to have shorter spans, or increased phase separation. The H-frame structures provide very good phase spacing for reducing galloping contacts.

6.5.2 Galloping Considerations in the Design of Transmission Lines: In areas where galloping is either historically known to occur or is expected, designers should indicate design measures that will minimize galloping and galloping problems, especially conductor contacts. The primary tool for assuring absence of conductor contacts is to superimpose Lissajous ellipses over a scaled diagram of the structure to indicate the theoretical path of a galloping conductor. See Figures 6-3 and 6-4. To avoid contact between phase conductors or between phase conductors and overhead ground wires, none of the conductor ellipses should touch one another. However, if galloping is expected to be infrequent and of minimal severity, there may be situations where allowing ellipses to overlap may be the favored design choice when economics are considered.

FIGURE 6-3: GUIDE FOR PREPARATION OF LISSAJOUS ELLIPSES



$$\phi = \tan^{-1}\left(\frac{p_c}{w_c}\right) \quad \text{Eq. 6-6}$$

	Single Loop	Double Loop
Major Axis 'M'	$M = 1.25\ S_i + 1.0$ Eq. 6-7	$M = 1.0 + \sqrt{\dfrac{3a\left(L + \dfrac{8S_i^2}{3L} - 2a\right)}{8}}$ Eq. 6-8 where $a = \sqrt{\left(\dfrac{L}{2}\right)^2 + S_i^2}$
Distance 'B'	$B = 0.25\ S_i$ Eq. 6-9	$B = 0.2M$ Eq. 6-10
Minor Axis 'D'	$D = 0.4M$ Eq. 6-11	$D = 2\sqrt{M - 1.0}$ Eq. 6-12

Where:

p_c = wind load per unit length on iced conductor in lbs/ft. Assume a 2 psf wind.
w_c = weight per unit length of conductor plus 1/2 in. of radial ice, lbs/ft
L = span length in feet.
M = major axis of Lissajous ellipses in feet.
S_i = final sag of conductor with 1/2 in. of radial ice, no wind, at 32°F, in feet.
D = minor axis of Lissajous ellipses in feet.
B,Ø = as defined in figure above

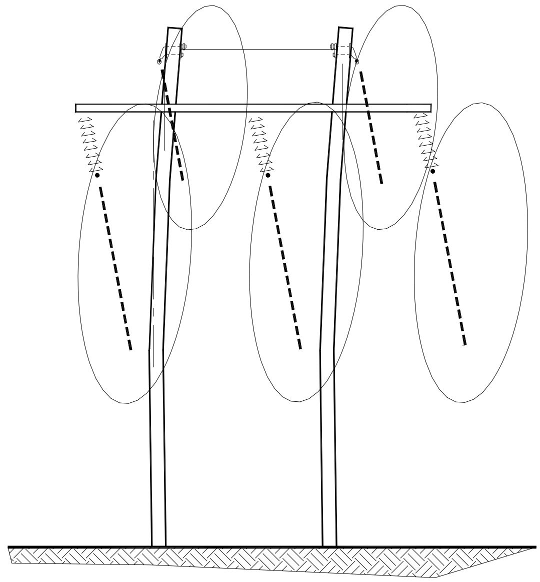


FIGURE 6-4: SINGLE LOOP GALLOPING ANALYSIS

6.6 <u>Clearance Between Conductors in a Crossarm to Vertical Construction Span</u>: Conductor contacts in spans changing from crossarm to vertical type construction may be reduced by proper phase arrangement and by limiting span lengths. Limiting span lengths well below the average span lengths is particularly important in areas where ice and sleet conditions can be expected to occur. See Figure 6-5.

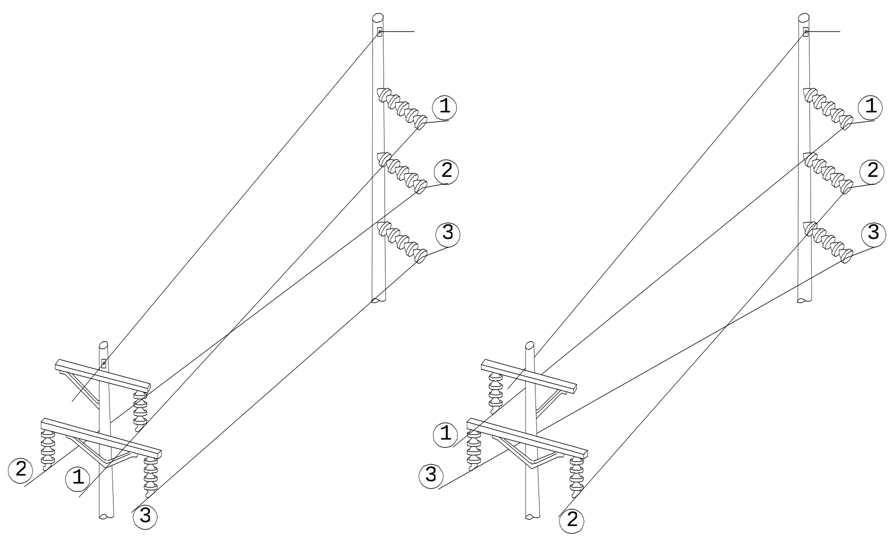


FIGURE 6-5: PROPER PHASE ARRANGEMENTS FOR CROSSARM TO VERTICAL CONSTRUCTION

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7. INSULATOR SWING AND CLEARANCES OF CONDUCTORS FROM SUPPORTING STRUCTURES

7.1 Introduction: Suspension insulator strings supporting transmission conductors, either at tangent or angle structures, are usually free to swing about their points of support. Therefore, it is necessary to ensure that when the insulators do swing, clearances are maintained to structures and guy wires. The amount of swing varies with such factors as: conductor tension, temperature, wind velocity, insulator weight, ratio of weight span to wind span, and line angle.

The force due to line angle will cause suspension strings to swing in the direction of the line angle of the structure. Wind blowing on the conductor span will exert a force in the direction of the wind. These two forces may act either in the same direction or in opposite, the algebraic sum thereby determining the net swing direction. Line angle forces and wind forces also interact with the vertical forces of the conductor weight and insulator string weight. The vector sum of these forces determines the net angle from the vertical axis to which the insulator string will swing. This net insulator swing angle should be calculated for several key weather conditions so that corresponding phase-to-ground clearances may be checked on a particular pole-top arrangement.

The purpose of this chapter is to explain how insulator swing application guides called swing charts are prepared. Chapter 10 explains how these charts are used in laying out a line.

7.2 Clearances and Their Application: Table 7-1 provides information on three sets of clearances that can ensure proper separation between conductors and structures or guys under various weather conditions. Figure 7-1 illustrates the various situations in which the clearances are to be applied.

7.2.1 No-Wind Clearance: The no wind clearance provides a balanced insulation system in which the insulating value of the air gap is approximately the same as that of the insulator string for a tangent structure. (See Table 8-1 for insulation levels. Note that tangent structures do not include the extra insulators used with angle structures).

Conditions at which no-wind clearances are to be maintained follow:

- Wind: Assume no wind.
- Temperature: Assume a temperature of 60°F. See Figure 7-1 for conductor condition. The engineer may also want to evaluate clearances at cold conditions (such as -20°F initial sag) and hot conditions (such as 167°F final sag).

7.2.2 Moderate Wind Clearance: This clearance is the minimum clearance that should be maintained under conditions that are expected to occur occasionally. A typical condition may be the wind that reoccurs no less than once every two years (probability of occurrence no more than 50 percent). Clearance values for moderate wind clearance conditions will have a lower flashover value than clearance values for the no-wind condition. These lower clearance values are acceptable because under moderate wind conditions, the specified clearance will be sufficient to withstand most of the severe voltage stress situations for wind conditions that are not expected to occur often.

There are different clearance requirements to the structure than to anchor guys. See Table 7-1, moderate wind, for differences. Also, note that Table 7-1 requires that additional clearance must be provided if the altitude is above 3300 feet.

Conditions at which moderate wind clearances are to be maintained follow:

- Wind: Assume a wind of at least 6 psf blowing in the direction shown in Figure 7-1. Higher wind pressures can be used if judgment and experience deem them to be necessary. However, the use of excessively high wind values could result in a design that is overly restrictive and costly. It is recommended that wind pressure values of no higher than 9 psf (60 mph) be used for the moderate wind clearance design unless special circumstances exist.

- Temperature: Temperature conditions under which the clearances are to be maintained depend upon the type of structure. A temperature of no more than 32°F should be used for tangent and small angle structures where the insulator string is suspended from a crossarm. A lower temperature value should be used where such a temperature can be reasonably expected to occur in conjunction with the wind value assumed. It should be borne in mind, however, the insulator swing will increase at lower temperatures because conductor tensions increase. Therefore, in choosing a temperature lower than 32°F, one should weigh the increase in conservatism of line design against the increase or decrease in line cost. NESC Rule235 requires a temperature no higher than 60°F final tension.

  A temperature of 60°F should be used for angle structures where the force due to change in direction of the conductor holds the insulator string away from the structure. Even if the maximum conductor temperature is significantly greater than 60°F, a higher temperature need not be used as an assumed wind value of 40 mph (6 psf)) has quite a cooling effect.

  Assume final sag conditions for 60°F temperature and initial sag conditions for 32°F.

7.2.3 High Wind Clearance: This is the minimum clearance that should be maintained under high wind conditions that are expected to occur very rarely. The clearances provide enough of an air gap to withstand a 60 Hz flashover but not much more. Choice of such values is based on the philosophy that under very rare high wind conditions, the line should not flashover due to the 60 Hz voltage.

Conditions under which high wind clearances are to be maintained are:

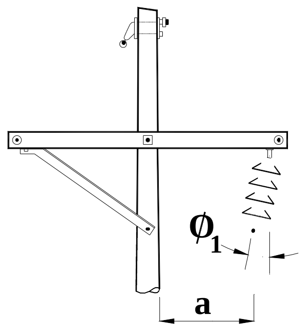
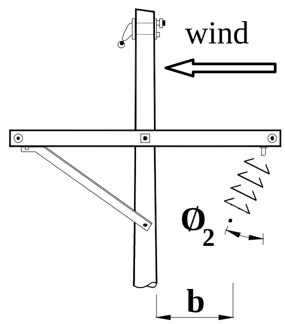
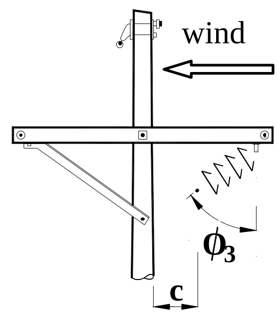
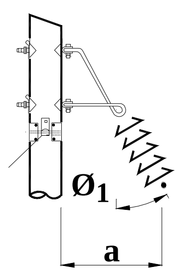
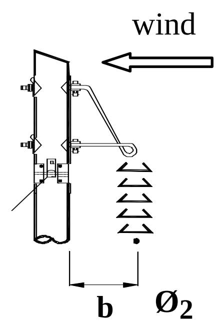
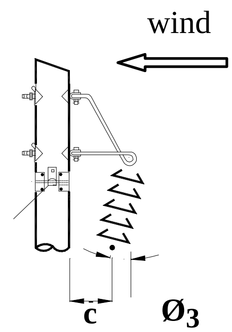
- Wind: The minimum assumed wind value should be at least the 10-year mean recurrence interval wind blowing in the direction shown in Figure 7-1. More wind may be assumed if deemed appropriate.

- Temperature: The temperature assumed should be that temperature at which the wind is expected to occur. The conductor should be assumed to be at final tension conditions.

To determine the velocity of the wind for a 10 year return period, the following factors should be applied to the 50 year peak gust wind speed (See Figures 11-2a, b, c and d in Chapter 11).

V = 85 to100 mph, Continental U.S.	Alaska	V > 100 mph (hurricane)
0.84	0.87	0.74

FIGURE 7-1: ILLUSTRATION OF STRUCTURE INSULATOR SWING ANGLE LIMITS AND CONDITIONS* UNDER WHICH THEY APPLY (EXCLUDES BACKSWING)

TANGENT AND SMALL ANGLE STRUCTURES	**No Wind Insulator Swing**	**Moderate Wind Insulator Swing**	**High Wind Insulator Swing**
Conditions* at which clearances are to be maintained			
• Line angle	Force due to line angle (if any)	Force due to line angle (if any)	Force due to line angle (if any)
• Wind force	0	6 psf minimum	10 year mean wind, recommended value
• Temperature	60ºF	32ºF or lower	Temp. at which wind value is expected
• Conductor tension	Final tension	Initial tension	Final tension
MEDIUM AND LARGE ANGLE STRUCTURES **Conditions* at which clearances are to be maintained**			
• Line angle	Force due to line angle	Force due to line angle	Force due to line angle
• Wind force	0	6 psf minimum	10 year mean wind, min.recommended value
• Temperature	60ºF	60ºF or lower	Temp. at which wind value is expected
• Conductor tension	Final tension	Final tension	Final tension

a = No wind clearance b = Moderate wind clearance c = High wind clearance
*See text for full explanation of conditions.

TABLE 7-1
RECOMMENDED MINIMUM CLEARANCES IN INCHES AT
CONDUCTOR TO SURFACE OF STRUCTURE OR GUY WIRES

Nominal voltage, Phase to Phase, kV	**34.5**	**46**	**69**	**115**	**138**	**161**	**230**
Standard Number of 5-3/4"x10" Insulators on Tangent Structures	**3**	**3**	**4**	**7**	**8**	**10**	**12**
Max. Operating Voltage, Phase to Phase, kV	34.5	46	72.5	120.8	144.9	169.1	241.5
Max. Operating Voltage, Phase to Ground, kV	19.9	26.6	41.8	69.7	83.7	97.6	139.4
	Clearance in inches						
No Wind Clearance (Not NESC)							
Min. clearance to structure or guy at no wind in inches Notes A, B	19	19	25	42	48	60	71
Moderate Wind Clearance (NESC Table 235-6)							
Min. clear. to structure at 6 psf of wind in inches. Notes C, D	9	11	16	26	30	35	50
Min. clear. to jointly used structures and a 6 psf of wind in inches. Notes C, D	11	13	18	28	32	37	52
Min. clearance to anchor guys at 6 psf in inches Notes C, D	13	16	22	34	40	46	64
High Wind Clearance (Not NESC)							
Min. clearance to structure or guy at high wind in inches	3	3	5	10	12	14	20

Notes:

(A) If insulators in excess of the standard number for tangent structures are used, the no wind clearance value shown should be increased by 6 in. for each additional bell. If the excess insulators are needed for contamination purposes, this additional clearance is not necessary.

(B) For post insulators, the no wind clearance to structure or guy is the length of the post insulator.

(C) A higher wind may be assumed if deemed necessary.

(D) The following values should be added as appropriate where the altitude exceeds 3300 feet

Additional inches of clearance per 1000 feet of altitude above 3300 feet

Voltage, kV	34.5	46	69	115	138	161	230
Clearance to structure	0	0	.14	.43	.57	.72	1.15
Clearance to anchor guy	0	0	.17	.54	.72	.90	1.44

7.2.4 <u>Example of Clearance Calculations</u>: The following examples demonstrate the derivation of the minimum clearance to anchor guys at 6 psf.

To determine the minimum clearance of a 115 kV line to an anchor guy (Table 7-1) at 6 psf, the clearance is based on NESC Table 235-6 and NESC Rule 235E.

NESC Clear. in any direction.	= NESC Basic Clearance(Table 235-6) + .25(kV_{L-L} – 50)
	= 16 inches + .25(120.8-50) inches
	= 16 inches + 17.7 inches
NESC Clear. in any direction.	= 33.7 inches (clearance in Table 7-1is 34 inches)

7.3 <u>Backswing</u>: Insulator swing considerations are illustrated in Figure 7-1. For angle structures where the insulator string is attached to the crossarm, the most severe condition is usually where the force of the wind and the force of the line angle are acting in the same direction. However, for small angle structures, it is possible that the limiting swing condition may be when the wind force is in a direction opposite of that due to the force of the line angle. This situation is called backswing, as it is a swing in a direction opposite of that in which the insulator is pulled by the line angle force. Figure 7-2 illustrates backswing.

When calculating backswing, it is necessary to assume those conditions that would tend to make the swing worse, which usually is low conductor tension or small line angles. It is recommended that the temperature conditions for large angle structures in Figure 7-1 be used, as they result in lower conductor tensions.

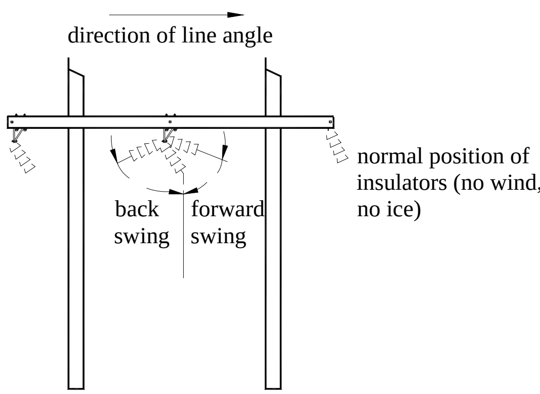


FIGURE 7-2: FORWARD AND BACKWARD SWING ANGLES

7.4 <u>Structure Insulator Swing Values</u>: Table 7-2 provides the allowable insulator swing angle values for some of the most often used standard agency tangent structures. These values represent the maximum angle from the vertical that an insulator string of the indicated number of standard bells may swing in toward the structure without violating the clearance category recommendation indicated at the top of each column. For tangent structures, the most restrictive angle for the particular clearance category for the entire structure is given. Thus, for an asymmetrical tangent structure (TS-1 for instance) where the allowable swing angle depends upon whether the insulators are assumed to be displaced to the right or left, the use of the most restrictive value means that the orientation of the structures with respect to the line angle need not be considered. For certain angle structures the insulator string has to be swung away from the structure in order to maintain the necessary clearance. These situations usually occur for large angle structures where the insulator string is attached directly to the pole or to a bracket on the pole and where the force due to the change in direction of the conductors is relied upon to hold the conductors away from the structure.

TABLE 7-2
INSULATOR SWING ANGLE VALUES IN DEGREES
(For insulator string with ball hooks)
(For insulator swing of other structures, see Appendix J)

Structure and Voltage	Number of Insulators	No Wind Swing Angle	Moderate Wind Swing Angle	High Wind Swing Angle
69 kV				
TS-1, TS-1X	4	20.0	38.5	74.0
TSZ-1, TSZ-2	4	41.7	61.2	82.6
TH-1,TH-1G	4	35.6	61.2	85.6
115 kV – TH-1A	7	28.3	58.7	80.8
161 kV – TH-10	10	16.4	53.2	77.7
230 kV – TH-230	12	16.5	47.5	74.8

7.5 <u>Line Design and Structure Clearances</u>: Insulator swing has a key effect on acceptable horizontal to vertical span ratios. Under a given set of wind and temperature conditions, an insulator string on a structure will swing at an angle toward the structure a given number of degrees. The angle of this swing is related to a ratio of horizontal to vertical forces on the insulator string. A relationship between the horizontal span, the vertical span, and if applicable, the line angle can then be developed for the structure, conductor, and weather. Horizontal and vertical spans are explained in Figure 7-4.

The acceptable limits of horizontal to vertical span ratios are plotted on a chart called an insulator swing chart. Such a chart can be easily used for checking or plotting out plan and profile sheets. Figures 7-3 and 7-5 show simplified insulator swing charts for the moderate wind condition only. There is one significant difference between the chart for tangent structures, and the chart for angle (running corner) structures. In Figure 7-3 for a typical tangent structure, the greater the vertical span for a fixed horizontal span the less swing occurs. The reverse is true for chart of Figure 7-5 for a typical angle structure. This occurs because the swing chart in Figure 7-5 is for a large angle structure where the force of the line angle is used to pull the insulator string away from the structure. As such, the less vertical force there is from the weight span, the greater the horizontal span can be.

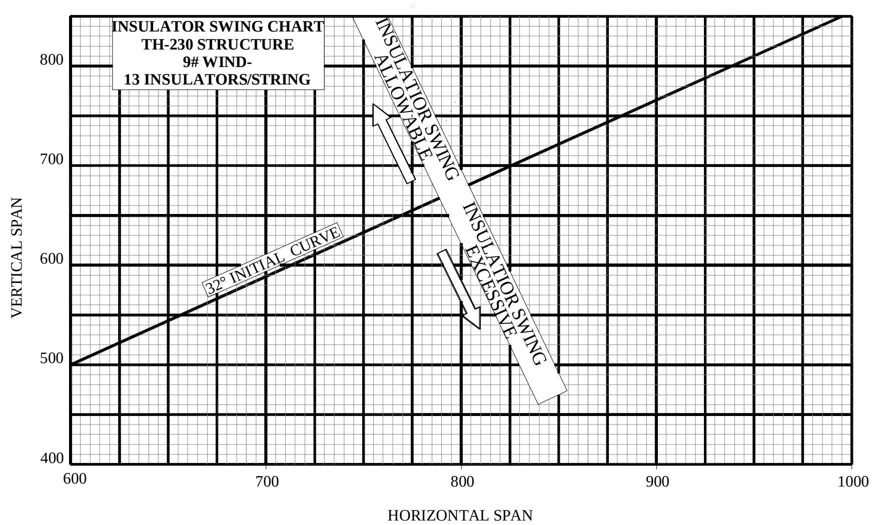
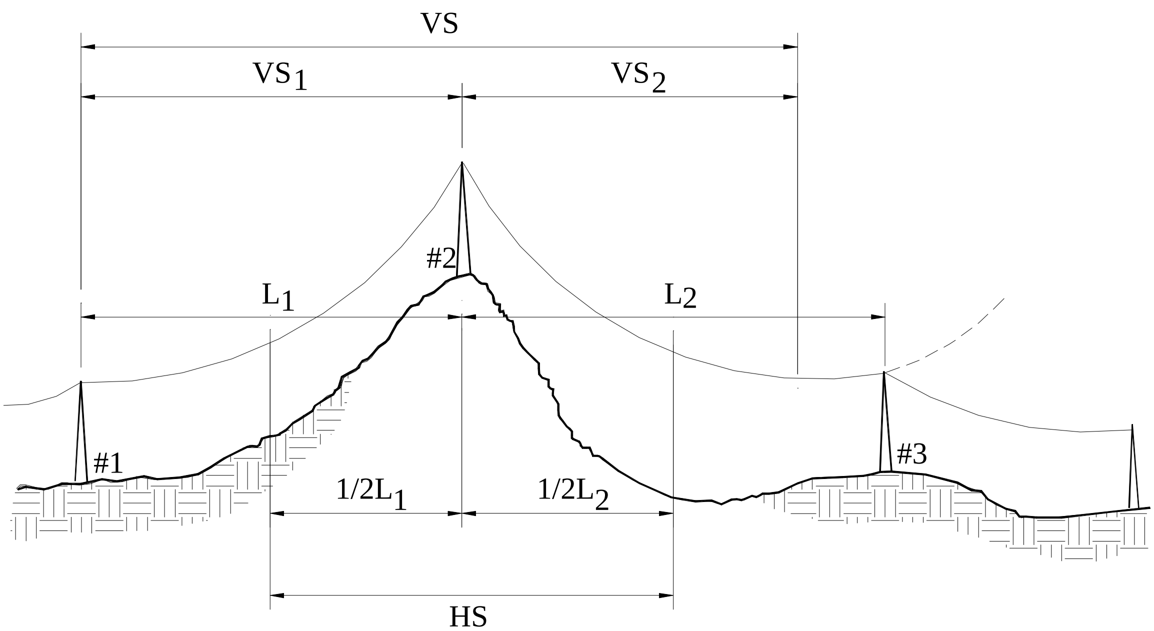


FIGURE 7-3: TYPICAL INSULATOR SWING CHART FOR A TH-230 TANGENT



L = span,

L_1 - span from structure 1 to 2
L_2 = span from structure 2 to 3

HS = horizontal span
VS = vertical span

<u>Span</u>

Span is the horizontal distance from one structure to an adjacent structure along the line.

<u>Vertical Span</u>

The vertical span (sometimes called the weight span) is the horizontal distance between the lowest points on the sag curve of two adjacent spans. The maximum sag point of a span may actually fall outside the span. The vertical span length times the weight of the loaded conductor per foot will yield the vertical force per conductor bearing down upon the structure and insulators

<u>Horizontal Span</u>

The horizontal span (sometimes called the wind span) is the horizontal distance between the mid-span points of adjacent spans. Thus, twice the horizontal span is equal to the sum of the adjacent spans. The horizontal span length times the wind force per foot on the conductor will yield the total horizontal force per conductor on the insulators and structure.

FIGURE 7-4: HORIZONTAL AND VERTICAL SPANS

The 'no wind' insulator swing criteria will not be a limiting condition on tangent structures as long as the line direction does not change and create an angle in the line. If an angle is turned, it is possible that the 'no wind' condition might control. The other two criteria may control under any circumstance. However, the high wind criteria will be significant in those areas where unusually high winds can be expected. Thus, all three conditions specified need to be checked.

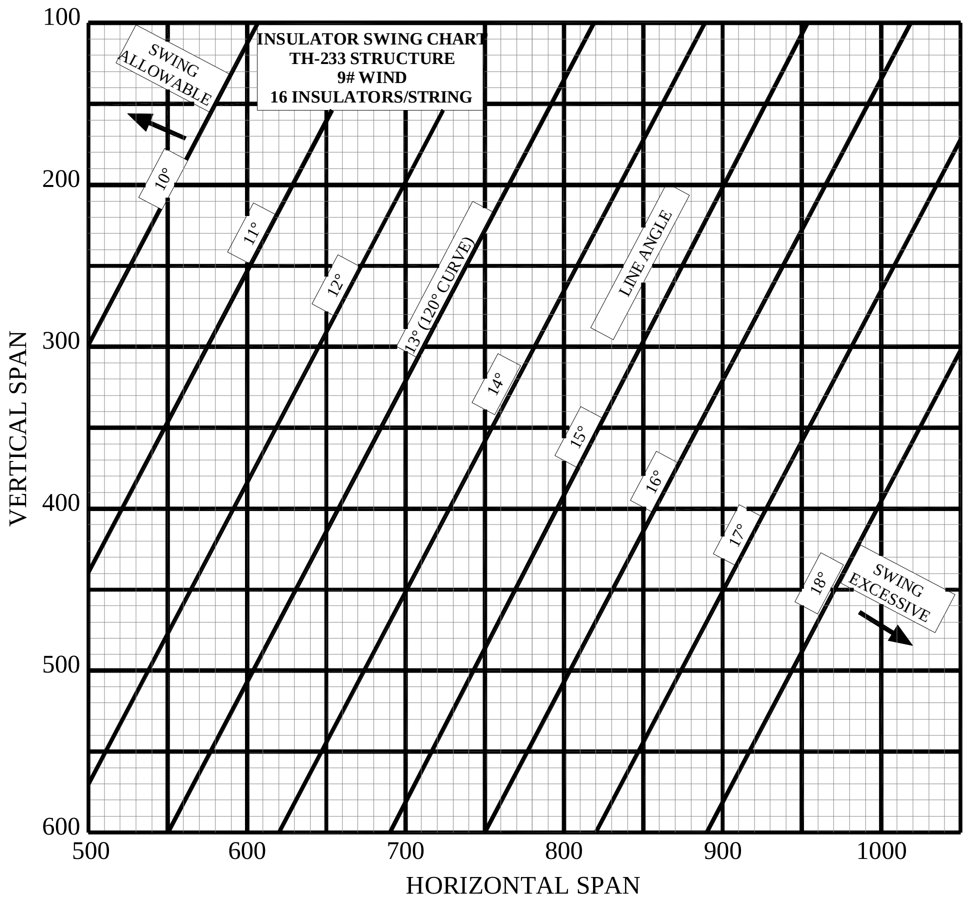


FIGURE 7-5: TYPICAL INSULATOR SWING CHART FOR A TH-233 MEDIUM ANGLE STRUCTURE (Moderate Wind Swing Condition, 9 psf assumed instead of minimum NESC 6 psf)

7.6 <u>Formulas for Insulator Swing</u>: The formulas in equations 7-1 and 7-2, can be used to determine the angle of insulator swing that will occur under a given set of conditions for either tangent or angle structures.

$$\tan\phi = \frac{(2)(T)(\sin\theta/2)+(HS)(p_c)}{(VS)(w_c)+(1/2)(W_i)} \qquad \text{Eq. 7-1}$$

$$p_c = \frac{(d_c)(F)}{12} \qquad \text{Eq. 7-2}$$

where:

$\varnothing$	=	angle with the vertical through which the insulator string swings, in degrees
θ	=	line angle, in degrees
T	=	conductor tension, pounds
HS	=	horizontal span, feet
VS	=	vertical span, feet
p_c	=	wind load per unit length of bare conductor in pounds per foot
w_c	=	weight per unit length of bare conductor in pounds per foot
W_i	=	weight of insulator string (wind pressure neglected), in pounds. (See Appendix C for insulator string weights).
d_c	=	conductor diameter in inches
F	=	wind force in lbs/ft^2

In order for equation 7-1 to be used properly, the following sign conventions are to be followed:

Condition	Sign Assumed
• Wind - Blowing insulator toward structure	+
• "(2)(T)(sin θ/2)" term (force on insulator due to line angle):	
Pulling insulator toward structure	+
Pulling insulator away from structure	-
• Insulator swing angle Angle measured from a vertical line through point of insulator support in toward structure	+
Angle measured from a vertical line through point of insulator support away from structure	-

7.7 Insulator Swing Charts: Insulator swing charts similar to those in Figures 7-4 and 7-5 can be developed by using equation 7-3 and the maximum angle of insulator swing values as limited by clearance to structure.

$$VS = \frac{(2)(T)(\sin\theta/2) + (HS)(p_c)}{(w_c)(\tan\phi)} - \frac{W_i}{(2)(w_c)} \qquad \text{Eq. 7-3}$$

The symbols and sign conditions are the same as those provided for equation 7-1. Equation 7-3 is derived from equation 7-1 and solving for VS.

7.8 Excessive Angles of Insulator Swing: If upon spotting a line, calculations shown a structure will have excessive insulator swing, one or more of the measures outlined in Section 10.4 of Chapter 10 of this bulletin may be required to alleviate the problem.

7.9 Example: For the TH-10 tangent structure, develop the insulator swing chart. Assume that it is desired to turn slight angles with the tangent structure and the insulator string assembly uses the ball hook.

7.9.1 Given:

a. Voltage: 161 kV
Structure: TH-10
Conductor: 795 kcmil 26/7 ACSR
Insulation: Standard (10 bells)

b. NESC heavy loading district
High winds: 14 psf
Ruling Span: 800 ft.

c. Conductor Tensions

6 psf wind
0°F
6,244 lbs. initial tension

No wind
60°F
4,633 lbs. final tension

12.5 psf wind
32°F
10,400 lbs. final tension

7.9.2 Solution: Using the information on conductor sizes and weights, allowable swing angles, insulator string weights from the appendices of this bulletin and using equation 7-3, the following calculation tables and the swing chart in Figure 7-6 are created.

7.10 Example: On the plan and profile drawings, the engineering is checking insulator swing for the TH-10 structure in example 7-9. For a certain TH-10 structure with no line angle, the horizontal span is 800 feet. Determine the minimum vertical span.

7.10.1 Same Information as 7.9.1

7.10.2 Solution: From Figure 7-6, for a horizontal span of 800 feet, the vertical span must be greater than 241 feet (see also tables for Figure 7-6). Many programs which are used to develop plan-profile drawings will automatically check insulator swing or will use insulator swing as a parameter in the spotting of structures.

FIGURE 7-6: INSULATOR SWING CHART FOR EXAMPLE 7-9

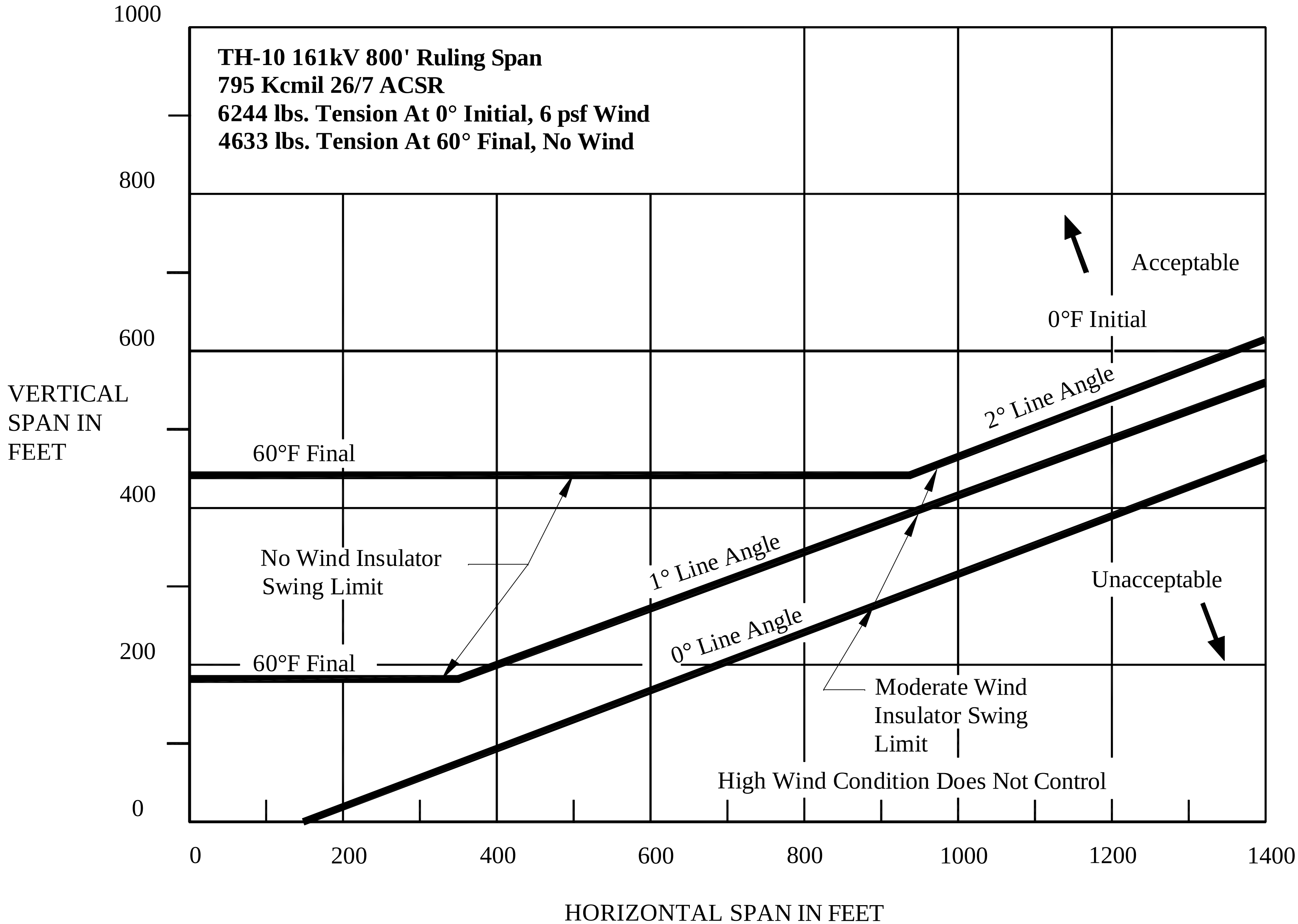


FIGURE 7-6 INSULATOR SWING CHART FOR EXAMPLE 7-9 (continued)

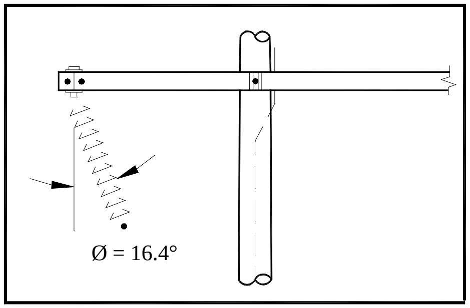
$$VS = \frac{(2)(T)(\sin \theta/2) + (HS)(p_c)}{(w_c)(\tan \phi)} - \frac{W_i}{(2)(w_c)}$$

Note: for the no wind case, vertical span is independent of horizontal span. It is only dependent upon line angle.

θ	**1°**	**2°**			
sin θ/2	.00872	.01745			
a) (2)(T)(sin θ/2)	80.26	161.71			
b) (HS)(p_c)	0	0			
a + b	80.26	161.71			
c) (w_c)(tan Ø)	.32	.32			
d) (a + b)/c	251.13	502.25			
e) W_i/(2)(w_c)	61.70	61.70			
d – e = VS	189.43	440.55			
θ					
sin θ/2					
a) (2)(T)(sin θ/2)					
b) (HS)(p_c)					
a + b					
c) (w_c)(tan Ø)					
d) (a + b)/c					
e) W_i/(2)(w_c)					
d – e = VS					
θ					
sin θ/2					
a) (2)(T)(sin θ/2)					
b) (HS)(p_c)					
a + b					
c) (w_c)(tan Ø)					
d) (a + b)/c					
e) W_i/(2)(w_c)					
d – e = VS					

Ø = angle with the vertical through which insulator string swings.

θ = line angle
T = conductor tension
HS = horizontal span
VS = vertical span
p_c = wind load on conductors
w_c = weight of conductor/ft.
W_i = weight of insulator string



Structure: TH-10
Conductor: 795 26/7 ACSR
Voltage: 161 kV
Insulator Swing Condition:

Ruling span 800 ft.
Loading district: Heavy
No of Insulators: 10
No wind
(F=0 lbs at 60°F)

Ø = 16.4°
p_c = 0 lbs./ft
w_c= 1.0940 lbs./ft
T= 4,633 lbs
W_i= 135 lbs

Conductor dia: 1.108

$$p_c = \frac{(d)(F)}{12}$$

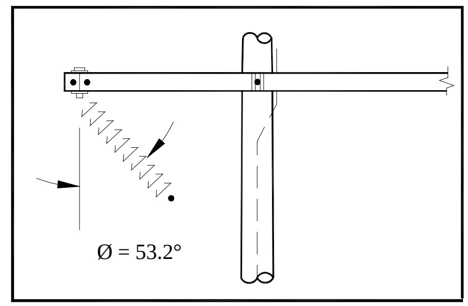
FIGURE 7-6: INSULATOR SWING CHART FOR EXAMPLE 7-9 (continued)

$$VS = \frac{(2)(T)(\sin\theta/2) + (HS)(p_c)}{(w_c)(\tan\phi)} - \frac{W_i}{(2)(w_c)}$$

θ = 0°	HS=200	HS=400	HS=800	HS=1000	
sin θ/2	0	0	0	0	
a) (2)(T)(sin θ/2)	0	0	0	0	
b) (HS)(pc)	110.80	221.60	443.20	554.00	
a + b	110.80	221.60	443.20	554.00	
c) (wc)(tan Ø)	1.460	1.460	1.460	1.460	
d) (a + b)/c	75.77	151.53	303.07	378.83	
e) Wi/(2)(wc)	61.70	61.70	61.70	61.70	
d – e = VS	14.07	89.83	241.37	317.13	
θ = 1°	HS=200	HS=400	HS=800	HS=1000	
sin θ/2	.008727	.008727	.008727	.008727	
a) (2)(T)(sin θ/2)	1.08.98	108.98	108.98	108.98	
b) (HS)(pc)	110.80	221.60	443.20	554.00	
a + b	219.78	330.58	552.18	662.98	
c) (wc)(tan Ø)	1.460	1.460	1.460	1.460	
d) (a + b)/c	150.29	226.05	377.59	453.35	
e) Wi/(2)(wc)	61.70	61.70	61.70	61.70	
d – e = VS	88.59	164.35	315.89	391.65	
θ = 2°	HS=200	HS=400	HS=800	HS=1000	
sin θ/2	.017452	.017452	.017452	.017452	
a) (2)(T)(sin θ/2)	217.95	217.95	217.95	217.95	
b) (HS)(pc)	110.80	221.60	443.20	554.00	
a + b	328.75	439.55	661.15	771.95	
c) (wc)(tan Ø)	1.460	1.460	1.460	1.460	
d) (a + b)/c	224.80	300.57	452.10	527.87	
e) Wi/(2)(wc)	61.70	61.70	61.70	61.70	
d – e = VS	163.10	238.87	390.40	466.17	

Ø = angle with the vertical through which insulator string swings.

θ = line angle
T = conductor tension
HS = horizontal span
VS = vertical span
p_c = wind load on conductors
w_c = weight of conductor/ft.
W_i = weight of insulator string



Structure: TH-10
Ruling span 800 ft.
Conductor: 795 26/7 ACSR
Loading district: Heavy
Voltage: 161 kV
No of Insulators: 10
Insulator Swing Condition: **Moderate wind (F=6 psf at 0°F)**

Ø = 53.2°
p_c = 0.554 lbs./ft
w_c= 1.0940 lbs./ft
T= 6,244 lbs
W_i= 135 lbs

Conductor dia: 1.108

$$p_c = \frac{(d)(F)}{12}$$

FIGURE 7-6: INSULATOR SWING CHART FOR EXAMPLE 7-9 (continued)

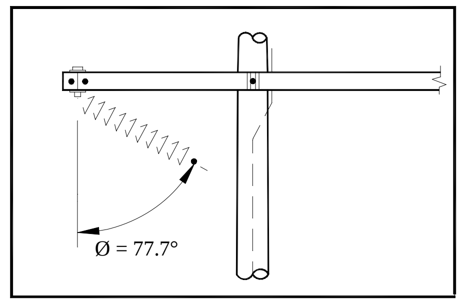
$$VS = \frac{(2)(T)(\sin\theta/2)+(HS)(p_c)}{(w_c)(\tan\phi)} - \frac{W_i}{(2)(w_c)}$$

θ = 0°	**HS=200**	**HS=400**	**HS=800**	**HS=1000**	
sin θ/2	0	0	0	0	
a) (2)(T)(sin θ/2)	0	0	0	0	
b) (HS)(p_c)	230.80	461.60	923.20	1154.00	
a + b	230.80	461.60	923.20	1154.00	
c) (w_c)(tan Ø)	5.02	5.02	5.02	5.02	
d) (a + b)/c	46.00	92.00	183.99	229.99	
e) W_i/(2)(w_c)	61.70	61.70	61.70	61.70	
d – e = VS	-15.70	30.30	122.29	168.29	

θ = 1°	**HS=200**	**HS=400**	**HS=800**	**HS=1000**	
sin θ/2	.008727	.008727	.008727	.008727	
a) (2)(T)(sin θ/2)	181.51	181.51	181.51	181.51	
b) (HS)(p_c)	230.80	461.60	923.20	1154.00	
a + b	412.31	643.11	1104.71	1335.51	
c) (w_c)(tan Ø)	5.02	5.02	5.02	5.02	
d) (a + b)/c	82.17	128.17	220.17	266.17	
e) W_i/(2)(w_c)	61.70	61.70	61.70	61.70	
d – e = VS	20.47	66.47	158.47	204.47	

θ = 2°	**HS=200**	**HS=400**	**HS=800**	**HS=1000**	
sin θ/2	.017452	.017452	.017452	.017452	
a) (2)(T)(sin θ/2)	363.01	363.01	363.01	363.01	
b) (HS)(p_c)	230.80	461.60	923.01	1154.00	
a + b	593.81	824.61	1286.21	1517.01	
c) (w_c)(tan Ø)	5.02	5.02	5.02	5.02	
d) (a + b)/c	118.35	164.35	256.34	302.34	
e) W_i/(2)(w_c)	61.70	61.70	61.70	61.70	
d – e = VS	56.65	102.65	194.64	240.64	

Ø = angle with the vertical through which insulator string swings.
θ = line angle
T = conductor tension
HS = horizontal span
VS = vertical span
p_c = wind load on conductors
w_c = weight of conductor/ft.
W_i = weight of insulator string



Structure: TH-10
Ruling span 800 ft.
Conductor: 795 26/7 ACSR
Loading district: Heavy
Voltage: 161 kV
No of Insulators: 10
Insulator Swing Condition: **High wind (F=12.5 psf at 32°F)**

Ø = 77.7°
p_c = 1.154 lbs./ft
w_c= 1.0940 lbs./ft
T= 10,400 lbs
W_i= 135 lbs

Conductor dia: 1.108
$$p_c = \frac{(d)(F)}{12}$$

8. INSULATION AND INSULATORS

8.1 <u>Insulator Types</u>: Insulation is defined as the separation between conducting surfaces by means of a non-conducting (dielectric) material that would economically offer a high resistance to current. Insulators may be fabricated from porcelain, toughened glass, fiberglass rods and sheds of polymer or silicone construction.

The main types of insulators used on transmission lines are suspension insulators using bells or polymer strings, pin insulators, and vertical and horizontal posts. Several suspension bell units are connected in a string to achieve the insulation level desired. The polymer suspension is one unit with an insulation level determined largely by its length. Horizontal post units are made of porcelain or polymer and are single units with a desired rating. See Figures 8-1 and 8-2.

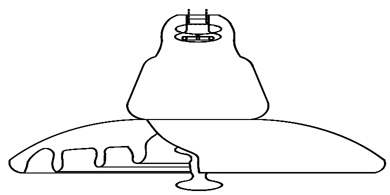


FIGURE 8-1: A STANDARD PORCELAIN SUSPENSION BELL

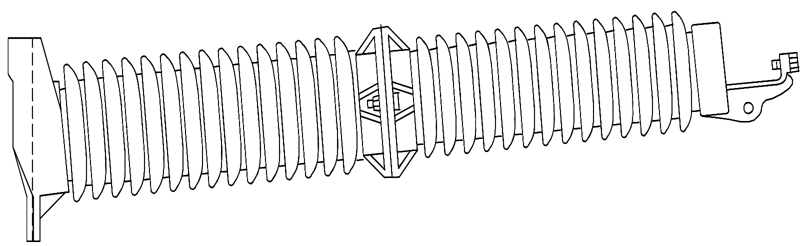


FIGURE 8-2: A TYPICAL PORCELAIN HORIZONTAL POST INSULATOR

8.2 Insulator Materials

8.2.1 <u>Porcelain insulators</u> have been the industry standard as specified by ANSI requirements for electrical and mechanical capacities. Although porcelain insulators have a history of long, useful lives, the strings are heavy and subject to breakage from gunshots. The connecting portions of porcelain insulators are metal components which are embedded in high strength cement as specified by ANSI standards. Strength ratings for porcelain insulators are verified by proof loading requirements of each manufactured unit, and stamped accordingly.

8.2.2 <u>Toughened glass insulators</u> are similar in construction to the porcelain insulator. They are heavy, and are also subject to vandalism exposure. ANSI fabrication standards are also available for toughened glass.

8.2.3 <u>Non-ceramic (polymer) insulators</u> typically consist of a fiberglass rod that is sheathed with weathershed 'bells' made of either rubber-based or silicone-based polymers. The connecting ends are typically compressed metal fittings. ANSI standards have been developed for suspension units.

Non-ceramic assemblies offer varieties of end fittings, lengths and strength capacities. They are much lighter in weight than their porcelain and glass counterparts. Polymers may be subject to damage by corona voltage, ultraviolet radiation, or physical deterioration which may not be apparent. Deterioration of a fiberglass rod may result in a reduction in strength of the unit.

8.3 <u>Insulation Levels Using Suspension Bells</u>: Table 8-1 provides suggested insulation levels. However, circumstances such as high altitude, contamination, high isokeraunic levels, or high footing resistance, may warrant additional insulation. If wood structures with steel arms, steel structures, or concrete pole structures are used in areas where there is a high isokeraunic level, consideration should be given to using one additional suspension bell beyond the standard agency recommended insulation levels.

8.3.1 <u>Tangent and Small Angles</u>: Table 8-1 indicates the recommended number of 5-3/4 x 10 in. suspension insulators to be used per phase on wood tangent and small angle structures. Also given are the electrical characteristics of the insulator strings.

8.3.2 <u>Angles</u>: For angle structures where the conductor tension is depended upon to pull the insulator string away from the structure, one more insulator bell should be added to the number of bells recommended for tangent structures. The sole exception to this is 34.5 kV where no additional bells are needed.

TABLE 8-1
RECOMMENDED ISULATION LEVELS*AT SEA LEVEL
(SUSPENSION AT TANGENT AND SMALL ANGLE STRUCTURES)
Flashover Characteristics in kV

Nominal L-L Voltage in kV	No. of 5-3/4x10" Bells	60 Hz Low Freq Dry*	60 Hz Low Freq Wet	Impulse Positive	Impulse Negative	Total Leakage Distance inches
34.5	3	215	130	355	340	34.5
46	3	215	130	355	340	34.5
69	4	270	170	440	415	46
115	7	435	295	695	670	80.5
138	8	485	335	780	760	92
161	10	590	415	945	930	115
230	12	690	490	1105	1105	138

**See NESC Rule 273, Table 273-1 for minimum insulation level requirements*

8.3.3 <u>Deadends</u>: In situations where the insulator string is in line with the conductor, the number of bells should be two more than is used for tangent structures. These situations occur at large angles, and tangent deadends where the conductor is deadended onto an insulator string. The sole exception to this is 34.5 kV where one additional bell is used.

8.4 <u>Insulation Levels Using Post Insulators</u>: Agency recommended electrical characteristics for horizontal post insulators are given in Table 8-2.

TABLE 8-2
RECOMMENDED INSULATION LEVELS AT SEA LEVEL
(POSTS AT TANGENT AND SMALL ANGLE STRUCTURES)
Flashover Characteristics in kV

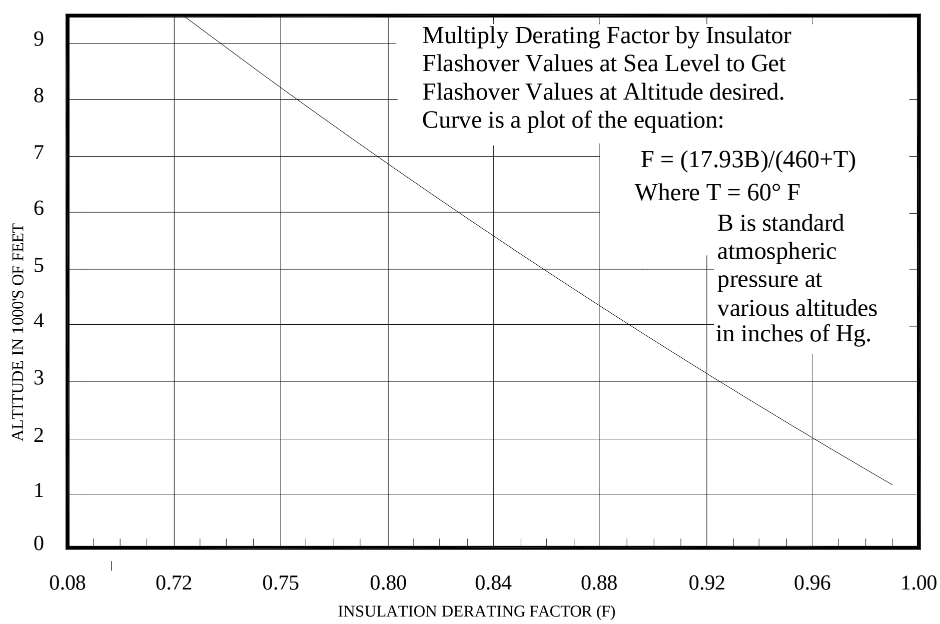
Nominal L-L Voltage in kV	60 Hz Low Freq Dry	60 Hz Low Freq Wet	Impulse Positive	Impulse Negative	Total Leakage Distance inches
34.5	125	115	210	260	29
46	150	135	255	344	40
69	200	180	330	425	53
115	380	330	610	780	100
138	430	390	690	870	110

8.5 <u>Electrical Characteristics of Insulators</u>: Because low frequency dry flashover ratings can be tested easily and accurately, these ratings are generally the most common flashover values referred to when comparing insulators. However, flashover (60 Hz) of an insulator in service almost never occurs under normal dry operating conditions, so these ratings are probably the least significant of insulator electrical characteristics. When comparing different types of insulators (e.g., post vs. suspension) characteristics such as impulse and wet flashover do not necessarily follow the same pattern as the low frequency dry flashover ratings. For these reasons, Tables 8-1 and 8-2 are developed and provide both impulse and wet flashover values. For voltages up to 230 kV the most severe stress on the insulation is usually caused by lightning, and the most important flashover characteristic is the impulse flashover values.

8.6 <u>High Altitude Considerations</u>

8.6.1 <u>General</u>: As altitude increases, the insulation value of air decreases and an insulator at a high elevation will flash over at a lower voltage than the same insulator at sea level. Figure 8-3 gives the derating factors for insulator flashover values as a function of altitude. These derating factors apply to both low frequency flashover values and impulse flashover values.

FIGURE 8-3: INSULATION DERATING FACTOR vs. ALTITUDE IN 1,000's OF FEET (230 kV and below)



In addition to increasing the number of insulators for high altitude, it is also necessary to increase the structure air gap clearances. This could result in a decreased allowable insulator swing angle or a longer crossarm (see Chapter 7 for details).

8.6.2 Example of Insulation Needed at High Altitudes: A line is located at 6000 feet elevation. The derating factor (from Figure 8-3) is .827. At 138 kV, using the sea-level requirement for low frequency dry flashover of 435 kV from Table 8-1, the line would require 526 kV (435/.827) at 6000 feet. A 10 bell string should be used instead of 7 bells. The clearance to structure and clearance to guy wire should be increased (see Table 7-1 for guidance).

8.6.3 Insulation for Lines with Relatively Small Changes in Altitude: When the insulation derating factor for the line altitude is at a value less than approximately 90 percent of the insulation value at sea level (see Figure 8-3), then additional insulation should be added to bring the insulation level up to at least 90 percent of the sea level value.

8.6.4 Insulation for Lines with Significant Elevation Changes but Less than 5000 Feet: If the elevation change in a line from its low point to its highest point is less than 5000 feet, it is recommended that insulation for the entire length of the line be based on the weighted average altitude of the line. This can be achieved by applying the procedure given in paragraph 8.6.2 to that weighted average altitude.

8.6.5 Insulation for Line with Elevation Changes Greater than 5000 Feet: Where the elevation change is greater than 5000 feet, the following two steps should be taken:

a. The entire line insulation should be upgraded for the minimum altitude of the line using the procedure in paragraph 8.6.2 above.

b. Additional insulation should be added in sections of line where it is needed. This need arises where the altitude of the line increases to the point where the insulation value is less than approximately 90 percent of the insulation value at the minimum line altitude. This means there may be different numbers of insulator bells at different points along the same line.

8.6.6 Example of Additional Insulation for High Altitudes and Line Elevation Changes Less than 5000 feet: A 161 kV line is to be built in an area where altitude ranges from 5430 ft. to 7580 ft. Determine how much additional insulation, if any, is necessary.

<u>Solution</u>: The elevation change for the line from its lowest point to its highest point is less than 5000 ft. Therefore, the insulation should be based on the weighted average altitude. Since we do not know the distribution of the line at the various altitudes, we will assume a uniform distribution. Thus:

$$\text{Average altitude} = \frac{5430 + 7580}{2} = 6505 \text{ ft.}$$

From Figure 8-3 the derating factor for an average altitude of 6505 ft is 0.81. Since paragraph 8.6.2 indicates that additional insulation is needed if the derating factor is less than 0.90, additional insulation will be needed.

According to paragraph 8.6.5, the insulation value should be brought up to approximately 90 percent of the sea level value, which for 161 kV is:

(0.9)(590) kV) = 531 kV

(590 kV is the low frequency dry flashover value of 10 bells at sea level).

The 531 kV requirement for low frequency dry flashover at sea level needs to be increased to account for the higher elevation. Applying the derating factor to the 531 kV, the low frequency dry flashover value of the string needs to be:

531/.81 = 655 kV

From Appendix C, the low frequency dry flashover of 11 bells is 640 kV. For 12 bells it is 690 kV. Therefore, the addition of one extra bell will not quite bring the insulation level up to the 90 percent of sea level. The above calculations seem to indicate the need to add two extra bells. However, some judgment should be exercised as to whether the second additional bell is used. Even though one bell extra does not quite provide enough additional insulation, it comes close. If the expected frequency and severity of lightning storms is not particularly high, one extra bell might be sufficient. Depending on experience and judgement, at least one and possibly two extra bells should be used.

8.7 Lightning Considerations

8.7.1 General: Transmission lines are subjected to three types of voltage stress that may cause flashover of the insulation: power frequency voltage, switching surges and lightning surges. Flashovers due to power frequency voltages are primarily a problem in contaminated conditions and are discussed in section 8.8. Of the remaining two causes of flashovers, lightning is the more severe for lines of 230 kV and below.

8.7.2 Lightning Flashover Mechanism: When lightning strikes a transmission line, it may hit either the overhead ground wire or a phase conductor. If a phase conductor is hit, there will almost certainly be a flashover of the insulation. To minimize this near certainty of a flashover, an overhead ground wire is used to intercept the lightning strokes. To reduce the possibility of a shielding failure, the shielding angle should be kept at 30° or less. (The shielding angle is the angle measured from the vertical between the OHGW and the phase conductors, as shown in Figure 8-4). On H-frame structures where two overhead ground wires are used, the center phase may be considered to be properly shielded even if the shielding angle to it is greater than 30°. For structures whose height is in excess of 92 feet, shielding angles of less than 30° as indicated in Table 8-3, should be used. Where there is an unusually high exposure to lightning, such as at river crossings, an even smaller shielding angle may be warranted.

TABLE 8-3
REDUCED SHIELDING ANGLE VALUES

Structure Height, feet	Recommended Shielding Angle, degrees
92	30
99	26
116	21

If lightning strikes an overhead ground wire, a traveling current wave will be set up which will induce a traveling voltage wave. This voltage wave will generally increase in magnitude as it travels down the wire, until it reaches a structure where the reflection of the traveling wave from the ground prevents the voltage from further increasing. (The overhead ground wire is grounded at every structure). If the traveling voltage wave at the structure is sufficiently high, a "back flashover" across the insulation from the structure ground wire or from the overhead ground wire to the phase conductor will occur. The factors that determine if a back flashover will occur are: the amount of insulation, the footing resistance (the higher the footing resistance, the higher the voltage rise at the structure) and the span length.

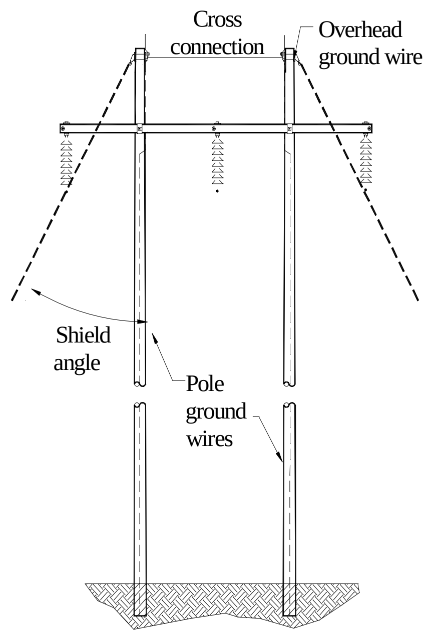


FIGURE 8-4: SHIELDING ANGLE, POLE AND OVERHEAD GROUND WIRES

8.7.3 <u>Designing for Lightning</u>: An overhead ground wire should be used in all locations where the isokeraunic level is above 20. The overhead ground wire should be grounded at every structure by way of a structure ground wire. At H-frame structures, the OHGW's should each be connected to a structure ground wire and to one another so that if one structure ground wire breaks, both overhead ground wires will still be grounded.

In areas where the isokeraunic level is 20 or less, an overhead ground wire should still be used for a distance of 1/2 mile from a substation. A map of isokeraunic levels is given in Appendix E.

8.7.4 <u>Footing Resistance</u>: For satisfactory lightning performance of a line, low footing resistance is essential. Exactly what value of footing resistance is acceptable or unacceptable is not a simple matter as it depends upon several variables. Previous successful experience with a similar line in similar circumstances can be one guide. The following references may be useful in determining what lightning outage rate a given footing resistance would yield.

(a) "Transmission Line Reference Book, 115 kV and Below," Palo Alto, Calif., Electric Power Research Institute, 1975.

(b) "Estimating Lightning Performance of Transmission Lines," J. M. Clayton and F. S. Young. <u>IEEE Transactions on Power Apparatus and Systems</u>, November 1964, pp. 1102-1110.

A grounded structure has a good chance to withstand a lightning flashover provided that conductor insulation and ground resistance have been properly analyzed and coordinated.

A lightning outage rate of 1 to 4 per 100 miles per year is acceptable with the lower number more appropriate for lines in the 161 to 230 kV range.

Generally, experience has shown that the footing resistance of individual structures of the line especially within 1/2 mile of the substation should be less than 25 ohms in high isokeraunic areas.

When a line is being built, it is recommended that the footing resistance of the ground connection be measured and recorded on a spot check basis. If footing resistance problems are expected, more frequent measurements should be made and recorded. If experience indicates that the lightning outage rate is not acceptable, these measurements readings can be useful when taking remedial measures.

Footing resistance should not be measured immediately after a rain when the soil is moist. If the footing resistance is higher than desired, additional driven rods may be used to reduce it. If the earth's resistivity is very high, counterpoise rather than driven rods may be required. Reference (b) this section gives guidance in the selection of counterpoise.

8.7.5 Lightning Arresters: In areas where structure grounding is difficult to achieve, or the lightning performance of an existing transmission line needs to be improved, Metal Oxide Varistor (MOV) line arresters can be installed. These arresters should be coordinated with the substation station class arresters for proper performance. The engineer should determine the size of the substation arresters and choose a slightly higher Maximum Continuous Over Voltage (MCOV) rating on the transmission line to prevent the line arresters from taking all of the flashover duty.

On a triangular three wire designs, adding an arrester to the top phase of every structure will typically give some shield angle protection to the other phases. For best performance, the arrester should be tied to a ground system with 10 ohms or less of resistance. If good grounding is not available, the borrower should consider adding lightning arresters to all three phases. Lightning arresters can also be installed on shielded lines to minimize back flashover where good grounding is difficult. The engineer should design for phase-to-phase clearances between the failed arrester, open position, and other phase wires since the arrester may drop near the other energized phase position.

8.8 Contamination Considerations: The problem of contamination induced flashovers should be considered if a line is to be built near a seacoast, an industrial district, or at other locales where airborne contaminants may accumulate on insulators.

8.8.1 Contamination Flashover Mechanism: When a layer of contaminants on an insulator is moistened by fog, dew, light rain or snow, it will become more conductive and the leakage current along the surface of the insulator will greatly increase. Where the current density is the greatest (for suspension insulators near the pin, and for post insulators at the points of least diameter), heat caused by the increased leakage current will evaporate the moisture causing the formation of a dry band. This band usually has an higher resistance than the adjacent moistened area which means that the band will support almost all the voltage across it. This will result in the breakdown of the air and the formation of an arc across the dry band. The arc will cause the moisture film at the dry band edges to dry out, enlarging the dry band, eventually to the point where the voltage across the band is just below the air breakdown value. If an increase in precipitation occurs causing a lowering of contaminant resistance, a second breakdown can occur. If conditions are right, a cycle of repeated and ever-increasing surges will be set up which will result in several discharges joining, elongating and bridging the entire insulator and resulting in a power arc. See Figure 8-5 for a graphic description.

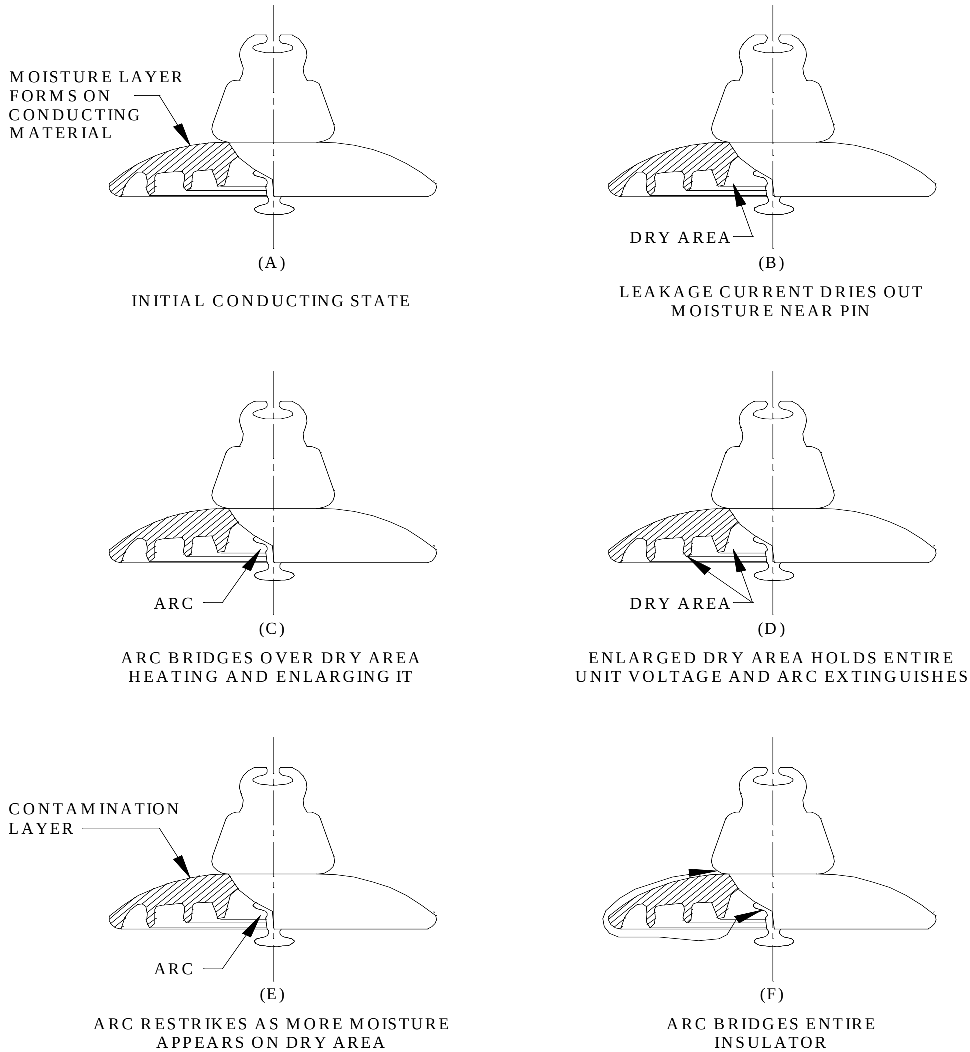


FIGURE 8-5: CONTAMINATION BREAKDOWN PROCESS
OF A SINGLE PORCELAIN INSULATOR UNIT

8.8.2 <u>Effect of Insulator Orientation</u>: The orientation of insulators has an effect on contamination performance. Vertical strings of suspension insulators or vertical post insulators do not wash well in the rain because of the sheltering effects of the insulator skirts. Contaminants will tend to remain on the underside of the insulator which is not immune from the moistening effects of fog or wind blown rain and snow. Horizontally oriented suspension insulators and post insulators have their undersides more thoroughly washed by the rain and therefore tend to fare better than vertical insulators in contaminated areas. Another advantage of insulators in nonvertical positions is that any ionized gases caused by arcing will not contribute to setting up conditions where an arc could jump from one bell to another or along the skirts of a vertical post.

8.8.3 <u>Designing for Adverse Contamination Conditions</u>: There are several means available for improving line insulation performance in a contaminated atmosphere.

One way to compensate for contaminated conditions is to increase the leakage distance of the insulation. The leakage distance is the distance along the surface of the insulators from the top of the string (or post) to the energized hardware, not including any metal such as insulator caps and pins.

Table 8-4 gives recommended leakage distances for various levels of contamination. The increased leakage distance can be obtained by adding additional standard insulator bells (using a longer post insulator) or by using fog insulators, which have more leakage distance for the same overall insulator length. The additional leakage distance on fog insulators is obtained by having more and/or deeper skirts on the underside of the insulator bell. In addition to the leakage distance, the shape of the insulator has an effect on contamination performance, especially when fog units are being used.

Research into the performance of existing lines with similar contamination should play an important part in the final determination of insulating for atmospheric contamination.

An alternative to increasing the total leakage distance of the insulator string is to use a resistance graded insulators. These insulators have a glaze that permits a small but steady leakage current to flow over their surface. This leakage current gives the insulator much better contamination performance without having to increase leakage distance. The base of a resistance graded insulator should be solidly bonded to the structure ground wire to permit the leakage current to flow easily to the ground. To aid in determining whether to use this type of insulator, its advantages and disadvantages are listed below.

Advantages and Disadvantages of Resistance Graded Insulators

<u>Advantages</u>

- No extra leakage distance required.
- Longer intervals between insulator washings.
- No radio noise (due to a more uniform voltage distribution across string).

<u>Disadvantages</u>

- Higher initial costs.
- Small but continuous power loss.
- Not entirely successful in very heavily contaminated areas.

TABLE 8-4
SUGGESTED LEAKAGE DISTANCES FOR CONTAMINATED AREAS

Contaminate Level	Environment	Equivalent Amount NaCl mg/cm^2	Suggested Leakage Distance rms L-G* in/kV
Very Light	Areas without industries and with low density of houses equipped with heating plants. Areas with some density of industries or houses but subject to frequent winds and/or rainfall. Areas not exposed to sea winds.	0-.03	NA-1.0
Light	Areas with industries not producing particularly polluting smoke and/or areas with average density of houses equipped with heating plants. Areas with high density of houses and/or rainfall. Areas exposed to winds from the sea but not less than 10 miles from the coast	.03-.06	1.0-1.25
Moderate	Areas with high density of industries and suburbs of large cities with high density of heating plants producing pollution. Areas close to the sea or in any case exposed to relatively strong winds from the sea (within 10 miles of the sea).	.06-.1	1.5-1.75
Heavy	Areas subjected to industrial smoke producing particularly thick conductive deposits. Areas with very strong and polluting winds from the sea. Desert areas, characterized by no rain for long periods, exposed to strong winds carrying sand and salt, and subjected to regular condensation	.1-.25	2.0-2.5
*rms L-G is root mean square line to ground voltage			

Washing of the insulators should not be used in place of properly designing for contamination but rather should be used in addition to the other steps where it is felt to be necessary.

Insulator performance in a contaminated environment can be improved by coating the surface with suitable silicone grease. The grease absorbs the contamination and repels water. It is necessary, however, to remove and replace the grease at intervals determined by the degree of contamination. As with washing, the use of grease should only be considered as a remedial step. Resistance graded insulators should not be greased.

8.9 Mechanical Considerations (Porcelain and Non-ceramic)

8.9.1 Suspension Insulators: Strength rating methods and nomenclature vary depending on the insulator material.

For porcelain, ANSI C29.1 specifies Mechanical and Electrical (M&E) procedures. The M&E value is determined by a combined mechanical and electrical test. The insulator has a voltage (75 percent of its rated dry flashover) impressed across it while a mechanical load is gradually applied to the insulator. For non-ceramics, most manufacturers conduct specified mechanical loading (SML) procedures to determine a polymer insulator's failure rating. These procedures are similar to the M&E for porcelain, but no electrical test is applied.

ANSI C 29.2 defines standard mechanical ratings for porcelain as: 15,000 lbs., 25,000 lbs., 36,000 lbs. and 50,000 lbs. ANSI C29.12 defines standard SML's for non-ceramic transmission insulators as: 20,000 lbs., 25,000 lbs., 36,000 lbs. and 40,000 lbs.

For recommended insulator loading limits, refer to Table 8-5. Under NESC district loading conditions, suspension insulators should not be loaded to more than 40 percent of their standard ANSI M&E rating for porcelain insulators or 40 percent of their ANSI SML for non-ceramics. If a heavier loading than the NESC district loading can be expected to occur with reasonable regularity, then the 40 percent loading limit should be maintained at the higher loading limit.

Under extreme ice or high wind (50-year mean recurrence interval wind conditions) the load on the insulator should not exceed 65 percent of the M&E strength of the insulator for porcelain and 50 percent of the M&E strength for non-ceramics.

Generally, porcelain insulators with a 15,000 pound M&E rating will be satisfactory for tangent structures. However, stronger insulators may be needed on long spans with large conductors and at deadends and angles where the insulators carry the resultant conductor tension.

TABLE 8-5
SUMMARY OF RECOMMENDED INSULATOR LOADING LIMITS

Insulator Type	NESC District Loading	Extreme Loading	
		Non-ceramic	Porcelain
Suspension	40% (% of ANSI standard SML or M&E strength)	50% (% of ANSI standard SML strength)	65% (% of ANSI standard M&E strength)
Horizontal Post Cantilever Tension, Compression	 40% 50% (% of appropriate rated ultimate strength value)	 50% 50% (% of appropriate rated ultimate strength value)	 65% 65% (% of appropriate rated ultimate strength value)
Vertical Post (Porcelain)	750 lbs.		-----
Vertical Pin Insulator (Porcelain, Mounted on the Crossarm)	500 lbs.		-----

When suspension non-ceramic insulators are used, the designer must be aware of the effects on insulator swing calculations due to increased length and reduced weight. Agency Bulletin 1724E-220, “Procurement and Application Guide for Non-Ceramic Composite Insulators,” provides additional information on non-ceramic insulators. When used as a jumper, polymer suspension insulators may be pulled towards the structure because of their lightweight.

8.9.2 Horizontal Post Insulators (Porcelain and Non-ceramic): Under NESC loading district conditions, horizontal post insulators must not be loaded to more than 40 percent of their ultimate cantilever strength. As with suspension insulators, if a loading more severe than the NESC loading can be expected to occur with reasonable regularity, then the limit recommended for the more severe loading should be used. Under extreme ice conditions, the cantilever load on horizontal post insulators should not exceed 65 percent of the ultimate strength for porcelain and 50 percent of the ultimate strength for non-ceramics.

When a line angle is turned at a horizontal post structure, some or all of the insulators will be in tension. Under standard NESC loading conditions, the tension or compression load on the insulator must not exceed 50 percent of the ultimate tension or compression strength of the insulator. Under extreme loading conditions, the tension load on the insulator must not exceed 65 percent of the ultimate tension strength for porcelain and 50 percent of the ultimate tension strength of non-ceramic insulators.

Line post insulators are actually subjected to vertical, transverse and longitudinal loads simultaneously. These loads represent the actual applied stresses to the line post insulator core that are experienced in the field. Vertical, transverse and longitudinal loads each contribute to the total bending moment, or total stress on the rod. Non-ceramic manufacturers provide combined loading application curves, which represent the mechanical strength limits of a non-ceramic line post insulator when subjected to simultaneous loads. These curves are used to determine how the insulator’s combined loading requirements compare with its cantilever (bending) strength. The combined loading application curves are used during the engineering stage to evaluate the mechanical strength of the insulator for specific line loading criteria.

There are three **special considerations** that must be mentioned in relation to horizontal post insulators:

Insulator Grounding: Where the structure ground wire passes near horizontal post insulators, it either should be stood off from the pole by means of a non-conducting strut **or** must be solidly bonded to the base of the insulator. This grounding is necessary to avoid radio noise problems.

Mechanical Impact Failures**:** Porcelain post insulators mounted on steel, concrete, or (in some cases) on wood structures using H-class poles, have experienced cascading mechanical failures due to impact loads because of the relative rigidity of the structures. To minimize the affects of impact loads, it is recommended that on rigid structures, non-ceramic insulators be used, **or** that porcelain post insulators be equipped with deformable bases, shear pin devices, or other means of relieving mechanical overloads.

Live Line Maintenance Issues: Many compact designs restrict the lineman for working on transmission lines while energized. Rule 441 of the NESC provides Table 441-1 which gives the recommended AC live work minimum approach distance for various voltages.

8.9.3 Porcelain Vertical Post and Pin Insulators Mounted on Crossarms: The maximum transverse load should be limited to 500 lbs. for standard single pin type agency standard structures and 750 lbs for standard vertical post type structures. The 500 lb. limit applies whether the load is from standard NESC loading district loadings alone or from a combination of loading district loading and the resultant of conductor tension on line angles. These limit will prevent excessive stress on the insulator, the tie wires (if used), insulator pin (if used), and the wood crossarm. The transverse load can be doubled by using double pin or post construction. See Table 8-5 for a summary of recommended insulator loading limits.

8.9.4 Coordination of Insulator Strength with Strength of Associated Hardware: Care should be taken to coordinate the strength of the hardware associated with the insulator with the strength of the insulator itself.

8.9.5 Example of Maximum Vertical Span Due to Horizontal Post Insulator Strength:
A 115 kV line is to be built using horizontal post insulators with a cantilever strength of 2,800 lbs. The conductor to be used is 477 kcmil 26/7 ACSR. Determine the maximum vertical span under:

1. Heavy loading district conditions; and
2. Under an extreme ice load, no wind, and 1.5 in. of radial ice

(See Chapter 11 for definitions of heavy loading and Chapter 9 for information on conductors).

Solution: From Appendix B, Conductors, the weights per unit length for the two conditions of the conductor are:

Heavy Loading District of 1/2 inch radial ice = 1.5014 lbs./ft.
Extreme radial ice of 1.5 inch =5.0554 lbs./ft.

Span Limits for Heavy Loading District:

$$\frac{2800 \text{ lbs.}(0.40)}{1.5014 \text{ lbs./ft.}} = 746 \text{ ft.}$$

Span Limits for Extreme Ice Condition:

$$\frac{2800 \text{ lbs.}(0.65)}{5.0554 \text{ lbs./ft.}} = 360 \text{ ft.}$$

The maximum vertical span is therefore 360 ft.

8.9.6 Example of Determining Minimum Suspension Insulator M&E Rating: A conductor has a maximum tension under heavy loading district conditions of 10,000 1bs. Under extreme radial ice of 1.5 in, it has a maximum tension of 16,000 lbs. Determine the minimum M&E rating of suspension bell insulators to be used in tension strings. (Tension strings are those insulator strings that are in line with the conductor and bear its full tension).

Solution:

Under NESC loading district conditions, the insulator can be loaded up to 40 percent of its M&E rating. Therefore:

(M&E rating)(0.4) = load
M&E rating = load/(0.4)
M&E rating = 10000 lbs./(0.4) = 25000 lbs.

Under extreme ice conditions the insulator can be loaded to 50 percent of its M&E rating. Therefore:

(M&E rating)(.65) = load
M&E rating = load/(0.65)
M&E rating = 16,000 lbs./(0.65) = 24,615 lbs.

c. Based on ANSI standard M&E ratings, the insulators to be used should have a minimum standard rating of 25,000 lbs.

9. CONDUCTORS AND OVERHEAD GROUND WIRES

9.1 Introduction: Of all the components that go into making up a transmission system, nothing is more important than the conductors. There are a surprising number of variables and factors that are to be considered when dealing with conductors. These include:

- Conductor type
- Conductor size
- Conductor ampacity
- Conductor thermal capacity
- Conductor tensions
- Corrosive atmosphere considerations
- Radio noise
- Conductor motion considerations
- Economic considerations

9.2 Types of Conductors: Of the currently available types of conductors, some are used much more extensively than others. Sections 9.2.1 through 9.2.11 provide descriptions of many of the conductor types.

9.2.1 ACSR (Aluminum Conductor Steel-Reinforced): ACSR is the most common type of conductor used today. It is composed of one or more layers of hard-drawn concentrically-stranded 1350 aluminum wire with a high-strength galvanized steel core. The core may be a single wire or stranded depending on the size. Because numerous stranding combinations of aluminum and steel wires may be used, it is possible to vary the proportions of aluminum and steel to obtain a wide range of current carrying capacities and mechanical strength characteristics.

The steel core may be furnished with three different coating weights of zinc. The "A" coating is the standard weight zinc coating. To provide better protection where corrosive conditions are present, heavier class "B" or "C" zinc coatings may be specified where "C" is the heaviest coating.

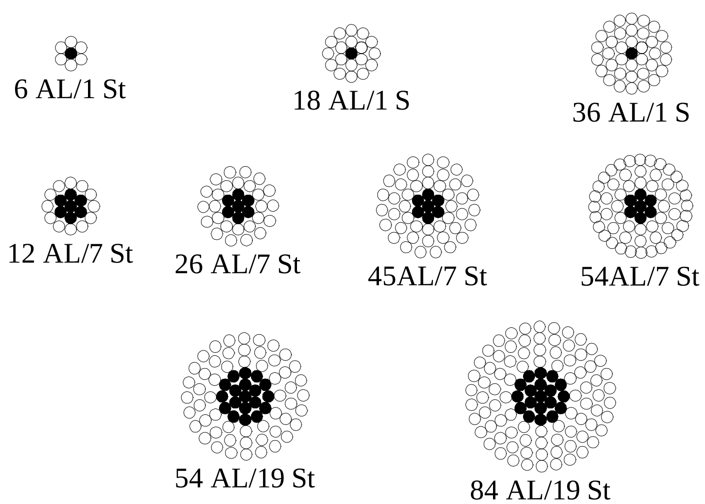


FIGURE 9-1: TYPICAL ACSR STRANDINGS

Aluminum coating is also available (not to be confused with an aluminum cladding which is thicker). There is a slight reduction in rated conductor strengths when the heavier zinc or aluminum coating is used.

9.2.2 <u>ACSR/AW (Aluminum Conductor, Aluminum-Clad Steel Reinforced)</u>: ACSR/AW conductor is similar to conventional ACSR except the core wires are high strength aluminum-clad steel instead of galvanized steel. Aluminum-clad core wire has a minimum aluminum thickness of 20 percent of its nominal wire radius. This cladding provides greater protection against corrosion than any of the other types of steel core wire, and it is applicable for use where corrosive conditions are severe. ACSR/AW also has a significantly lower resistivity than galvanized steel core wire and may provide somewhat lower losses.

9.2.3 <u>AAC (All Aluminum Conductors – 1350 H19)</u>: AAC conductor is made up entirely of hard-drawn 1350 aluminum strands. With a minimum aluminum content of 99.5%, 1350 aluminum is essentially pure aluminum. It is usually less expensive than other conductors, but is not as strong and tends to sag more. AAC conductors are most useful where electrical loads are heavy and where spans are short and mechanical loads are low.

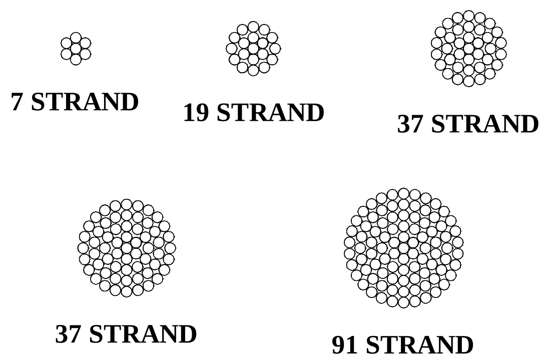


FIGURE 9-2: 1350 ALUMINUM CONDUCTOR STRANDINGS

9.2.4 <u>AAAC-6201 (All Aluminum Alloy Conductor - 6201 Alloy)</u>: AAAC conductor is composed entirely of 6201-T81 high strength aluminum alloy wires, concentrically stranded and similar in construction and appearance to 1350 aluminum conductors. Its strength is comparable with that of ACSR. It was developed to fill the need for a conductor with higher strength than that obtainable with 1350 aluminum conductors, but without a steel core.

AAAC conductors were designed to have diameters the same as those of standard sizes and strandings of ACSR. The DC resistance of 6201 conductor is approximately equivalent to that of standard ACSR conductor with the same diameter. AAAC conductor may be used where contamination and corrosion of the steel wires is a problem. It has proven to be somewhat more susceptible to vibration problems than standard ACSR conductor strung at the same tension. The use of conductor sizes smaller than 3/0 ACSR equivalent on suspension type constructions should be avoided because the light weight of the conductor may result in inadequate downward force on the suspension insulators causing radio noise and insulator swing problems.

9.2.5 <u>ACAR (Aluminum Conductor Alloy Reinforced)</u>: ACAR conductor consists of 1350 aluminum strands reinforced by a core of higher strength 6201 alloy. These 6201 reinforcement wires may be used in varying amounts allowing almost any desired property of strength/conductivity (between conductors using all 1350 wires and those using all 6201 wires) to be achieved. Strength and conductivity characteristics of ACAR are somewhere between those of a 1350 aluminum conductor and a 6201 conductor.

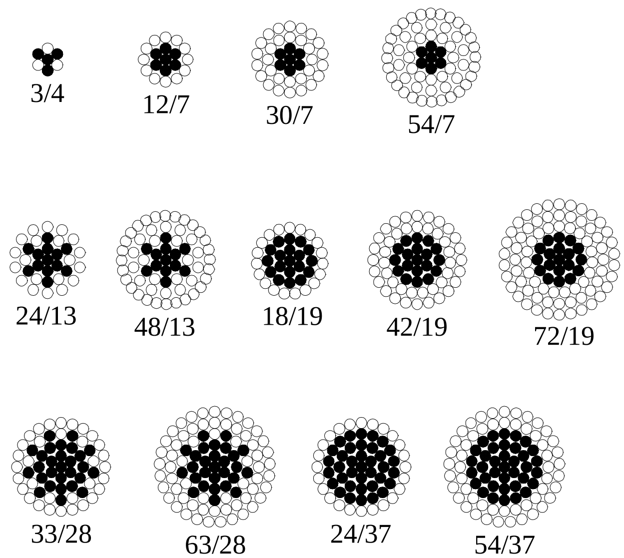


FIGURE 9-3: TYPICAL ACAR STRANDINGS

9.2.6 <u>AWAC (Aluminum-Clad Steel Conductor)</u>: AWAC conductor is made up of aluminum-clad steel and 1350 aluminum strands. The corrosion resistant aluminum clad wires of the AWAC conductor act as strength members as well as conductivity members, thereby reducing the weight of the conductor without reducing strength. For the same designated size and stranding, the AWAC conductors have a slightly smaller diameter than standard ACSR. For smaller AWAC sizes, the ratio of aluminum-clad to aluminum strands is varied to provide a wide range of rated strengths.

9.2.7 <u>ACSR/SD (Aluminum Conductor Steel Reinforced - Self Damping)</u>: ACSR/SD conductor may use either two layers of trapezoidal-shaped aluminum wires or two layers of trapezoidal-shaped aluminum wires and one layer of stranded round wires of hard-drawn 1350 aluminum. The steel core may be a single wire or stranded depending on the size of the conductor.

From a performance point of view, ACSR/SD conductor is similar to conventional ACSR except that it has self damping characteristics. That is, the conductor is designed to reduce aeolian vibration. The damping occurs because of the interaction between the two trapezoidal layers and between the trapezoidal layers and the core. Some special considerations associated with this conductor are that:

- During stringing, special precautions are taken and procedures followed to avoid difficulties.
- It may be more expensive than conventional ACSR, but its ability to be strung at higher tensions to reduce sag, which may result in economic advantages that offset its extra cost.

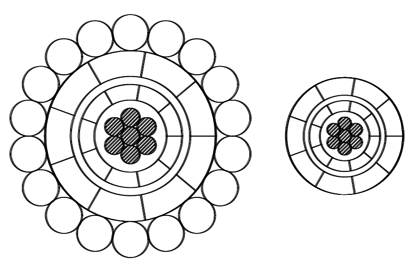


FIGURE 9-4: TYPICAL ACSR/SD STRANDINGS

9.2.8 ACSR/TW (Trapezoidal Shaped Strand Concentric - Lay Stranded Aluminum Conductors, Steel Reinforced): As with ACSR/SD, the conductor layers of ACSR/TW are trapezoidal-shaped aluminum wires. However, unlike ACSR/SD conductor, no gaps exist between layers ACSR/TW strands. The compact trapezoidal-shaped wires result in an increased capacity for an equivalent standard range of ACSR conductor diameters. Also, for a given aluminum area, a smaller conductor diameter can be designed for ACSR/TW than for equivalent round-wire ACSR which results in reduced wind-on-wire load on the structure. These are important advantages when existing transmission lines are considered for uprating or reconductoring. Other advantages and improvements of ACSR/TW include corrosion resistance and lower temperature gradient.

Use of ACSR/TW should be based on an economic evaluation to determine whether savings will be achieved in comparison with the use of conventional ACSR conductor.

9.2.9 AACSR (Aluminum Alloy Conductor, Steel Reinforced): AACSR conductor is the same as a conventional ACSR conductor except that the 1350 strands are replaced with higher strength 6201 alloy strands. The resulting greater strength of the conductor allows the sags to be decreased without exceeding the standard conductor percent tension limits. AACSR type of conductor is primarily used at river crossings where sag limitations are important. The higher tensions associated with this type of conductor require that special attention be paid to the possibility of aeolian vibration.

9.2.10 T2 (Twisted Pair Aluminum Conductor): When designing transmission lines with twisted pair (T2) type conductor, the designer should be aware of Rule 251 of NESC on conductor wind loading. The rule states for multiconductor cable an equivalent diameter of two times the single conductor diameter should be assumed for wind loading unless there is a qualified engineering study to reduce the overall cable diameter.

9.2.11 High Temperature Conductors: Three types of conductors are considered high temperature, ACCR (aluminum conductor composite reinforced), ACCC™ (aluminum conductor composite core) and ACSS (aluminum conductor steel supported). For sizes equivalent to other types of conductor (*i.e.,* ACSR), higher ampacities can be achieved at similar overall sag levels while operating the conductors a much higher temperatures. One benefit of these types of conductors can be the avoided cost of replacing existing structures. The temperature ratings for these conductors can be limited by hardware, so extreme care should be used when specifying hardware and establishing operating temperature limits. Also, the unique natures of these conductors result in the use of special precautins during stringing, such as special stringing blocks in certain locations and multiple grips when installing conductors with multi-layer annealed aluminum conductor strands.

ACCR conductors are composed of heat resistant aluminum-zirconium alloy outer strands and aluminum oxide matrix core strands. . The core of the ACCR is composed of stranded fiber reinforced metal matrix, an aluminum oxide fiber embedded in high-purity aluminum. The fiber reinforced metal matrix has strength similar to steel and weight similar to aluminum. The outer strands may be round or trapezoidal in shape and are similar to 1350 aluminum ultimate strength but may be heated to high temperatures without softening (annealing) and without losing strength. Additionally, the thermal expansion of the metal matrix core has less thermal expansion than steel and retains its strength at high temperatures. ACCR conductors use similar stranding as ACSR. Because of the lightweight core, heat resistant outer and core strands, higher electrical conductivity, and lower thermal expansion for less sag, higher operating temperatures may be used with this conductor which leads to higher ampacities. ACCR conductors and hardware are usually rated up to 210 C continuous operating temperature with 240 C for short term maximum operating temperature.

ACCC™ (Aluminum Conductor, Composite Core) are composed of trapezoidal wire of 1350 aluminum stranded around the composite core. The core of the ACCC conductor is a solid with no voids and is a carbon/glass fiber polymer matrix core. This solid polymer matrix core is composed of carbon fibers surrounded by an outer shell of boron-free E-glass fibers that insulates the carbon from the aluminum conductor. The 1350 aluminum trapezoidal wires are fully annealed which make them softer compared to the hardened aluminum wires used in some other conductors. The aluminum strands are tempered because the composite core of the ACCC is designed to carry the entire load Because the core exhibits a very low coefficient of thermal expansion, the amount of sag the ACCC will experience when operating at high temperatures is considerably less than other types of conductor (*i.e.*, ACSR). ACCC ™ conductors and hardware are usually rated up to 180 C continuous operating temperature with 200 C for short term maximum operating temperature. However, because of the softer temper of the aluminum wires, the outer wires can be more susceptible to damage from improper installation and handling.

ACSS (Aluminum Conductor, Steel Supported) can be considered as another type of high temperature conductor which can be supplied with round or trapezoidal aluminum strands. ACSS conductor is similar to ACSR; however, the aluminum strands in ACSS are fully annealed and depends on the steel for its strength and sag characteristics. ACSS conductors and hardware are usually rated up to 250 C or more continuous operating temperature, depending upon the coating on the steel core, without loss of strength. However, because of the softer temper of the aluminum wires, the outer wires can be more susceptible to damage from improper installation and handling.

9.3 Selecting a Conductor Type

9.3.1 Agency Standards: The conductor selected should generally be of a type and stranding listed as being acceptable for use borrower systems of the Rural Utilities Service. See Informational Publication 202-1, "List of Materials Acceptable for Use on Systems of USDA Rural Development Electrification Borrowers".

9.3.2 Corrosion Considerations: Conductors with galvanized steel cores should not be used in areas of severe corrosion. Rather, a conductor with other types of core wire, such as mischmetal or aluminum-clad core wire should be used. A conductor with a steel core wire coated with aluminum or with a heavier weight zinc may be considered, if such materials have been successfully (*i.e.*, reliably operated without core deterioration) used in similar locations or corrosive environments..

9.3.3 Economics: The relative cost of one conductor type versus another is very important. When comparing costs, one should take overall line costs into consideration. However, a less expensive conductor with greater sags may not be a more economical selection than a more expensive conductor with lesser sag. When overall line costs are considered, the conductor that allows longer spans and shorter structures may prove to be the better choice.

9.3.4 Strength: The strength of the conductor and its ability to sustain mechanical loads without unreasonable sags must be evaluated.

9.4 Selection of Conductor Size

9.4.1 Minimum Conductor Size: Table 9-1 provides a list of minimum allowable conductor sizes for each standard agency transmission voltage. The minimums are based on a combination of radio noise, corona, and mechanical sag and strength considerations. (See Appendix I for additional details on radio noise and corona). If a conductor type other than ACSR or 6201 AAAC is used, the conductor diameter should not be less than the diameter of the ACSR specified for the particular given voltage.

TABLE 9-1
RECOMMENDED MINIMUM CONDUCTOR SIZES

kV_{LL}	ACSR	AAAC - 6201
34.5	1/0	123.3 kcmil
46	2/0	155.4 kcmil
69	3/0	195.7 kcmil
115	266.8 kcmil	312.8 kcmil
138	336.4 kcmil	394.5 kcmil
161	397.5 kcmil	465.4 kcmil
230	795 kcmil	927.2 kcmil

9.4.2 Voltage Drop Considerations: Not only should the conductor be sufficiently large to meet the requirements of paragraph 9.4.1 of this section, but it should also meet the system voltage drop requirements. Typically, the conductor impedance would have to be sufficiently low so that, under a given set of electrical loading conditions, the voltage drop would not exceed approximately 5 percent. In general, voltage drop becomes a factor for longer lines. Voltage drop can be evaluated by either running a load flow computer program or by using the estimating tables in Bulletin 1724E-201, "Electrical Characteristics of Agency Alternating Current Transmission Line Designs."

9.4.3 Thermal Capability Considerations: When sizing a phase conductor, the thermal capability of the conductor (ampacity) should also be considered. The conductor should be able to carry the maximum expected long-term load current without overheating. Generally, a conductor is assumed to be able to heat up to 167°F without any long-term decrease in strength. Above that temperature, there may be a decrease in strength depending on how long the conductor remains at the elevated temperature. A conductor's ampacity depends not only upon its assumed maximum temperature, but also on the wind and sun conditions that are assumed. See Appendix D of this bulletin for ampacity tables.

9.4.4 Economic Considerations: Economics is an important factor in determining conductor size. The minimum conductor sizes given in Table 9-1 will rarely be the most economical in the long run. The added cost of a larger conductor may be more than offset by the present worth of the savings from the lower line losses during the entire life of the conductor. A proper economic analysis should at a minimum consider the following factors for each of the conductor sizes considered:

- The total per mile cost of building the line with the particular conductor being considered;
- The present worth of the energy losses associated with the conductor;
- The capital cost per kilowatt of loss of the generation, substation and transmission facilities necessary to supply the line losses;
- Load growth.

The results of an economic conductor analysis can often be best understood when presented in a graphical form as shown in Figure 9-5. At an initial load of approximately 200 MW, 1272 kcmil becomes more economical than 795 kcmil. 954 kcmil is not economical at any load level included on the graph.

9.4.5 <u>Standardization and Stocking Considerations</u>: In addition to the above factors, the problem of standardization and stocking should be considered. When a conductor is electrically and economically optimum, but is not a standard size already in use on the system, the additional cost and complications of having one more conductor size to stock should be weighed against the advantages of using the optimum conductor. A proliferation of conductor sizes in use on a power system is undesirable because of the expense of stocking many sizes. In addition, if a power system does not standardize on conductors then there may be a need for additional associated hardware such as end fittings and splices.

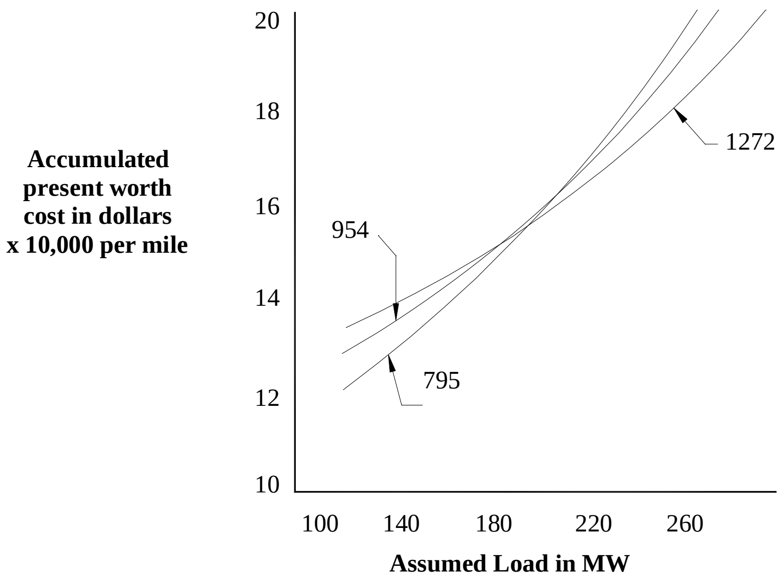


FIGURE 9-5: RESULTS OF A TYPICAL ECONOMICAL CONDUCTOR ANALYSIS – 230 kV, 795 vs. 954 vs. 1272 kcmil ACSR

9.5 <u>Overhead Ground Wires (OHGW)</u>

9.5.1 <u>High Strength or Extra High Strength Galvanized Steel Wires</u>: High strength OHGW included in Informational Publication 202-1 are 3/8" and 7/16", while extra high strength listed sizes include 5/16", 3/8", and 7/16". Siemens Martin grade wires of any size and 1/4" steel strand are not accepted by the agency for use as overhead ground wires. Overhead ground wires are required to be in full compliance with ASTM A-363, "Standard Specification for Zinc-Coated (Galvanized) Steel Overhead Ground Wire Strand," ASTM A-363 does not allow steel wires to have brazed or welded joints. Steel wires for overhead ground wires are available in three weights of zinc coating. The standard weight zinc coating is designated as 'A'. The heavier zinc coating is designated 'B' and 'C', with 'C' having the heaviest weight of zinc.

9.5.2 Aluminum-Clad Steel Strand: A thick cladding of aluminum which makes aluminum-clad steel strand more resistant to corrosion than strands with a thin coating of zinc. In addition, the aluminum clad material has greater conductivity.

The sizes of this material that may be used as overhead ground wires are 7 No. 10AWG, 7 No. 9AWG, 7 No. 8AWG, and 7 No. 7AWG. The material is in accordance with ASTM B416, "Standard Specification for Concentric-Lay-Stranded Aluminum-Clad Steel Conductors."

9.5.3 Selecting a Size and Type: Selecting an overhead ground wire size and type is dependent upon only a few factors, the most important of which is how the sag of the OHGW coordinates with that of the phase conductors. Other factors that may have to be considered are corrosion resistance and conductivity.

If a line is to be built in a seacoast region or in another location where there is a highly corrosive atmosphere, aluminum-clad steel wire should be considered. If the OHGW is to be used to carry any type of communications signal, or if large magnitudes of lightning stroke currents are expected, a higher conductivity than normal may be desirable.

9.6 Conductor and Overhead Ground Wire Design Tensions

9.6.1 General: Throughout the life of a transmission line, the conductor tensions may vary between 10 and 60 percent, or more, of rated conductor strength due to change in loading and temperature. Most of the time, however, the tension will vary within relatively narrow limits, since ice, high winds, and extreme temperatures are relatively infrequent in many areas. Such normal tensions may actually be more important in determining the life of the conductor than higher tensions which are experienced infrequently.

9.6.2 Conductor Design Tensions: In Table 9-3 provides recommended maximum conductor tension values for ACSR and 6201 AAAC conductors that should be observed for the ruling span. Note that the values given are maximum design values. If deemed prudent, tensions less than those specified or loadings greater than the standard loading condition (tension limit for condition 3 of Table 9-3) may be used. However, it is unwise to base the selection of a "maximum loading" condition on a single or very infrequent case of excessive loading. Mountainous areas above 4000 feet in which ice is expected, should be treated as being in heavy loading district even if they are not.

In open areas where steady winds are encountered, aeolian vibration can be a problem, especially if conductor tensions are high. Generally, lower tensions at conditions at which aeolian vibration is likely to occur, can reduce vibration problems (see paragraph 9.9.2 for further discussion).

Explained below are the several conditions at which maximum conductor tension limits are specified.

1. Initial Unloaded Tension: Initial unloaded tension refers to the state of the conductor when it is initially strung and is under no ice or wind load.

2. Final Unloaded Tension: After a conductor has been subjected to the assumed ice and wind loads, and/or long time creep, it receives a permanent or inelastic stretch. The tension of the conductor in this state, when it is again unloaded, is called the final unloaded tension.

3. Standard Loaded Tension: The standard loaded tension refers to the state of a conductor when it is loaded to the assumed simultaneous ice and wind loading for the NESC loading district concerned (see Table 11-1, Chapter 11 for the loads associated with each loading districts). The constants in Table 9-2 are to be added to the vector resultant of the transverse and vertical loads to get the total load on the conductor:

TABLE 9-2
CONSTANTS TO BE ADDED TO THE TOTAL
LOAD ON A WIRE FOR NESC DISTRICT LOADS

Heavy	Medium	Light
0.30 lbs/ft.	0.20 lbs/ft.	0.05 lbs/ft.

In cases where the standard loaded condition is the maximum mechanical load used in the calculations, the initial and final sags and tensions for the standard loaded condition will be the same unless creep is the governing factor. If another condition, such as extreme ice, is the maximum mechanical load, then the initial and final sags and tensions for the standard loaded condition can be significantly different from one another. In this case, it is important that the loaded tension limits be set for initial conditions.

4. Extreme Wind Tension**:** The extreme wind tension refers to the state of the conductor when a wind is blowing on it with a value not less than the 50-year mean recurrence interval (see Figure 11-3 in Chapter 11 of this bulletin). No ice should be assumed to be on the conductor.

5. Extreme Ice Tension**:** The tension in a conductor when it is loaded with an extreme amount of ice for the area concerned is called the extreme ice tension. It should be assumed that there is no wind blowing when the ice is on the conductor. Values of 1 to 2 in. of radial ice are commonly used as extreme ice loads.

6. Extreme Ice with Concurrent Wind: The tension in a conductor when it is loaded with an extreme ice with a concurrent wind (see Figure 11-3 in Chapter 11 of this bulletin).

9.6.3 Controlling Conditions: For a given ruling span, usually only one of the tension limit conditions will control the design of the line and the others will have relatively little significance as far as line tensions are concerned.

If the conductor loading under extreme ice or wind loads is greater than under the standard loaded condition, calculated sag and tension values at other conditions could be somewhat different from what they would be if the standard loaded condition were the maximum case. In these situations, stringing sags should be based upon tension limits for tension conditions 1, 2, and 3 only, as tensions at conditions 4 and 5 are satisfactory.

9.6.4 Overhead Ground Wire (OHGW): To avoid unnecessarily high mechanical stresses in the OHGW, supporting structures, and guys, the OHGW should not be strung with any more tension than is necessary to coordinate its sags at different conditions with the phase conductors. See Chapters 6 and 8.

TABLE 9-3
RECOMMENDED CONDUCTOR AND OVERHEAD
GROUND WIRE TENSION AND TEMPERATURE LIMITS (Note B)

Temperatures

- Tension limits for conditions 1, 2 and 3 below are to be met at the following temperatures:

Heavy loading district	0º F
Medium loading district	15º F
Light loading district	30º F

- Tension limits for condition 4 are to be met at the temperature at which the extreme wind is expected.
- Tension limits for condition 5 & 6 are to be met at 32º F

Tension Condition (See section 9.6.2 for explanation)	Tension Limits (percentage of rated breaking strength)		
	Conductor	OHGW High Strength Steel	OHGW Extra High Strength Steel
1. Maximum initial unloaded	33.3 (Note C)	25	20
2. Maximum final unloaded	25 (Note D)	25	20
3. Standard Loaded (usually NESC district loading)	50	50	50
4. Maximum extreme wind (Note A)	70 (Note E)	80	80
5 . Maximum extreme ice (Note A)	70 (Note E)	80	80
6. Extreme ice with concurrent wind	70 (Note E)	80	80

Notes:
(A) These limits are for tension only. When conductor stringing sags are to be determined, tension limits 1, 2 and 3 should be considered as longs as tensions at conditions 4, 5 and 6 are satisfactory.

(B) Tension limits do not apply for self-damping and other special conductors.

(C) In areas prone to aeolian vibration, a value of approximately 20 percent at the average annual minimum temperature is recommended, if vibration dampers or other means of controlling vibration are not used (see section 9.9 for further details).

(D) For 6201 AAAC, a value of 20 percent is recommended**.**

(E) For ACSR only. For 6201 Aluminum, use 60 percent**.**

9.7 Ruling Span

9.7.1 Why a Ruling Span? If all spans in a section of line between deadends are of the same length, uniform ice and wind loads will result in equal conductor tension in all spans. But span lengths usually vary in any section of line, with the result that temperature change and ice and wind loads will cause conductor tensions to become greater in the longer spans and less in the shorter spans when compared to the tensions of loaded uniform spans. Movement of insulator strings and/or flexing of the structures will tend to reduce this unequal tension. It is possible, however, for conductor tension in long spans to reach a value greater than desired unless the line is spotted and the conductor strung to limit this undesirable condition.

A ruling span is an assumed uniform design span which approximately portrays the mechanical performance of a section of line between its deadend supports. The ruling span is used in the design and construction of a line to provide a uniform span length which is representative of the various lengths of spans between deadends. This uniform span length allows sags and clearances to be readily calculated for structure spotting and conductor stringing.

Use of a ruling span in the design of a line assumes that flexing of the structure and/or insulator string deflection at the intermediate supporting structures will allow for the equalization of tension in the conductor between adjacent spans to the ruling span tension.

9.7.2 Calculations of the Ruling Span: On a line where all spans are equal, the ruling span is the same length as the line spans. Where spans vary in length, the ruling span is between the shortest and the longest span lengths on the line, but is mainly determined by the longer spans.

- Approximate Method. Some judgment should be exercised in using this method since a large difference between the average and maximum span may cause a substantial error in the ruling span value.

$$RS = L_{avg} + 2/3\left(L_{\max} - L_{avg}\right) \qquad \text{Eq. 9-1}$$

where:

RS = ruling span in feet.
L_{avg} = average span in a line segment between deadends, in feet.
L_{max} = maximum span in a line segment between deadends, in feet.

- Exact Method. The following is the exact formula for determining the ruling span in a line segment between deadend structures:

$$RS = \sqrt{\frac{L_1^{\ 3} + L_2^{\ 3} + L_3^{\ 3} + \ldots + L_n^{\ 3}}{L_1 + L_2 + L_3 + \ldots + L_n}} \qquad \text{Eq. 9-2}$$

where:

L_1, L_2, L_3, etc. = the different span length in the line segment, in feet

Other symbols are as previously defined.

9.7.3 Establishing a Ruling Span: As can be seen from Equation 9-2, the exact value of the ruling span can only be calculated after the structures have been spotted and all the span lengths determined. However, the ruling span has to be known in advance of structure spotting. Thus the ruling span needs to be **estimated** before spotting structures on the plan-profile drawings.

When following any procedure for estimating ruling span, keep in mind that estimation of a ruling span is an intuitive process based on experience, judgment, and trial and error. A good starting point for estimating ruling span is the height of the base structure. The base structure is the structure that is expected to occur most often throughout the line. After assuming a base structure height, subtract the minimum ground clearance value from the height of the lowest phase conductor above ground at the structure. The allowable sag as limited by ground clearance is the result. Using this sag value and tables of sags for various ruling span lengths, a ruling span length can be chosen whose sag is approximately equal to the allowable sag for the base structure height. In other words, a ruling span is chosen to be approximately equal to the level ground span -- the maximum span limited by line-to-ground conductor clearance for a particular height structure. This method of choosing a ruling span is useful if the terrain is flat or rolling. However, if it is rough, the ruling span should be somewhat greater than the level ground span.

The ruling span value initially chosen should be checked to see that it coordinates reasonably well with the minimum span values as limited by such factors as structure strength, conductor separation, galloping, etc. Also, Equation 9-1 should be used in conjunction with estimated maximum and average span values to further check the reasonableness of the estimated ruling span. If the initial estimate does not check out, the value should be changed and the procedure repeated.

In cases where the spans in one extended section of line are consistently and considerably longer or shorter than in another section of line, use of more than one ruling span may be unavoidable. It is a common practice to permit long spans to double the average span without deadends, provided conductor tension limits are satisfactory. In addition, short spans should not be less than approximately one-half of the ruling span. After the plan and profile sheets are plotted, the validity of the estimated ruling span value should be checked by comparing it to the actual value obtained. It is not essential that the estimated ruling span value be equal to the actual value, provided the estimated ruling span results in satisfactory ground clearance and economical structure spotting without excessive conductor tensions. However, if the difference between the estimated and actual ruling span is more than approximately 15 percent, the effects resulting from the difference should be carefully checked.

9.7.4 Effects of the "Wrong" Ruling Span: It is important that the actual ruling span be reasonably close to the ruling span value that is used to spot the line. If this is not the case, there may be significant differences between the predicted conductor tensions and clearances and the actual values. There have been instances where sags were greater than predicted, resulting in clearance problems, because the wrong ruling span was assumed. Table 9-4 will be of use in determining how conductor sags differ from the predicted value when there are differences between actual and assumed ruling span. Note that tension variation is opposite of that of the sags. Thus, increased sags mean decreased tension and vice versa.

TABLE 9-4
DIRECTION OF DEVIATION OF SAGS FROM
PREDICTED VALUES WHEN ACTUAL AND ASSUMED (DESIGN)
RULING SPAN VALUES ARE SIGNIFICANTLY DIFFERENT
(Applies to Unloaded Condition)

	Assumed RS is greater than Actual RS	**Assumed RS is less than Actual RS**
Conductor temperature is less than temperature at which the conductor was strung	Actual sag is less than predicted-- *INCREASED TENSIONS*	Actual sag is greater than predicted-- *CLEARANCE PROBLEMS*
Conductor temperature is greater than temperature at which the conductor was strung	Actual sag is greater than predicted-- *CLEARANCE PROBLEMS*	Actual sag is less than predicted-- *INCREASED TENSIONS*

CLEARANCE PROBLEMS – Conductor sags greater than indicated on the plan and profile sheets may result in clearance problems

INCREASED TENSIONS – Conductor tensions greater than anticipated will result

9.8 <u>Determining Conductor Sags and Tensions</u>: Determination of conductor sags and tensions, given a set of tension limits as outlined in section 9.6, is a complex and difficult task. This is true because only one of the tension limits may control, and it is not always predictable which limit it will be. In addition, it is necessary to work with conductor stress strain curves which for a compound conductor such as ACSR can be rather complex.

The best method of obtaining conductor sag and tension values is to use one of the numerous computer programs written for that purpose. When using a computer program, several factors should be checked:

- The program should be written so that a check is made of all the limiting conditions simultaneously and the governing condition noted.

- The program should take conductor creep into account.

- The tension values given should be average tension values and not tension at support or horizontal tension values.

- The source of the stress stain data used should be indicated.

If computerized sag tension values are not available from the software, values can be generated using the graphical method given in the publication, "Graphic Method for Sag Tension Calculations for ACSR and Other Conductors," Publication No. 8, Aluminum Company of America, 1961.

9.9 Aeolian Vibration

9.9.1 General: Overhead conductors of transmission lines are subject to aeolian and galloping, both of which are produced by wind. Galloping is discussed in section 6.3. Aeolian vibration is a high-frequency low-amplitude oscillation generated by a low velocity, comparatively steady wind blowing across the conductors. This steady wind will create air vortices or eddies on the lee side of the conductor. These vortices or eddies will detach at regular intervals from the top and bottom area of the conductor creating a force on the conductor that is alternately impressed from above and below. If the frequency of the forces approximately corresponds to a frequency of a mode of resonant vibration of the span, the conductor will tend to vibrate in many loops in a vertical plane. The frequency of vibration depends mainly on conductor size and wind velocity and is generally between 5 and 100 Hz for wind speeds within the range of 0 to 15 miles per hour. The peak-to-peak amplitudes of vibration will cause alternating bending stresses great enough to produce fatigue failure in the strands of the conductor or OHGW at the points of attachment. Highly tensioned conductors in long spans are particularly subject to vibration fatigue. This vibration is generally more severe in flat open terrain where steady winds are more often encountered.

The frequency and loop length of the vibration can be determined using equation 9-3.

Frequency of the vibration:

$$f = 3.26 \frac{V}{d_c} \qquad \text{Eq. 9-3}$$

where:

f = frequency of conductor vibration in Hertz
V = transverse wind velocity in miles per hour
d_c = conductor diameter in inches

Loop Length (for a conductor that is assumed to have negligible stiffness):

$$LL = \frac{1}{2f} \sqrt{\left(\frac{(T_{avg})(g)}{w_c} \right)} \qquad \text{Eq. 9-4}$$

where:

LL = loop length in feet
T_{avg} = average conductor tension in pounds
w_c = unit weight of conductor in pounds per foot
g = universal gravitational constant, 32.2 ft/sec^2

Other symbols are as previously defined.

9.9.2 Designing for Vibration Problems: If an area is expected to have aeolian vibration problems, measures ‘a’ through ‘d’ may be taken to mitigate possible problems with damage to conductors, shield wire, and hardware. It is also important to note that structures, not just conductors, shield wires, and hardware, may be adversely affected by vibration. The measures are not necessarily mutually exclusive; more than one measure may be used simultaneously.

a. Reduced Tension: The two line design variables that have the greatest effect upon a line's vibration characteristics are conductor tension and span length. Singly or in combination, these two variables can be reduced to the point where the level of vibration, without any vibration damping devices, will not be damaging. For similar sag characteristics, conductors of different types, with their different characteristics, may require a different degree of vibration protection.

   A rule of thumb that has proved generally successful in eliminating vibration problems is to keep the conductor tension for short and medium length spans under initial unloaded conditions at the average annual minimum temperature to approximately 20 percent or less of the conductor's rated strength. For long spans, a somewhat lower percent tension limit should be used. Due to their vibration characteristics, 6201 AAAC and 1350 aluminum conductors should be held to tensions somewhat lower than the 20 percent value, even for relatively short spans.

b. Armor Rods: In addition to reinforcing the conductor at the support points, armor rods provide a small amount of damping of aeolian vibration. In lines with lower conductor tension and shorter spans, this damping may provide adequate protection against conductor strand fatigue.

c. Cushioned Suspensions: Cushioned suspensions combine armor rods with a resilient cushioning of the conductor. These suspension clamps provide somewhat more damping than armor rods, but the degree of damping is still relatively small compared to vibration dampers.

d. Dampers: Stockbridge and other types of dampers are effective devices for controlling vibration. The selection of damper sizes and the best placement of them in the spans should be determined by the damper or conductor manufacturer on the basis of the tension, weight, and diameter of the conductor and the expected range of wind velocities. The length of the suspension clamp and the effect of the armor rods or cushioned suspensions should also be considered. With new efficient damper designs and usual conductor tensions and span lengths, one damper is installed near one span support joint. For long spans, additional dampers may be required.

9.10 Galloping: See Chapter 6 for details.

9.11 Maximum Possible Single Span: For a given span length, as the sag is increased, the tension at the support will decrease, until a point is reached where the tension will begin to increase due to the weight of the conductor. This point occurs when the sag is equal to 0.337 times the span length.

The relationship between span length and tension can be expressed as:

$$L_{max} = 1.33\frac{T}{w_c} \qquad \text{Eq. 9-5}$$

where:

w_c = unit weight of conductor in pounds per foot
T = resultant tension at support, pounds
L_{max} = maximum span, feet

The above formula can be used to determine the maximum possible span given a maximum tension at supports. This is most useful when dealing with river crossings, etc.

9.12 Sag and Tension Relationships: The relationships in paragraphs 9.12.1 through 9.12.3 are useful for understanding the sag-tension relationships for conductors:

9.12.1 Level Span Sags: Equation 9-6, the approximate "parabola method", is helpful in solving some sag and tension problems in span lengths below 1,000 feet, or where sag is less than 5 percent of the span length.

$$S = \frac{w_c L^2}{8T_h} \qquad \text{Eq. 9-6}$$

where:

S = sag at center of span in feet
L = span length in feet
T_h = horizontal tension in pounds

The exact formula for determining sags is:

$$S = \frac{T_h}{w_c}\left(\cosh \frac{w_c L}{2T_h} - 1\right) \qquad \text{Eq. 9-7}$$

9.12.2 Inclined Span Sags: See Figure 9-6 for method of determining inclined span sags.

9.12.3 Tension: The conductor tension in a level span varies from a maximum value at the point of support to a minimum value at mid-span point.

The tension at the point of support is:

$$T = T_h + w_c S = T_h \cosh \frac{w_c L}{2T_h} \qquad \text{Eq. 9-8}$$

The value that is generally referred to, when the "tension" of a conductor is indicated, is usually the average of the tension at the support and the tension at mid-span. Thus:

$$T_{avg} = \frac{T_h + T}{2} = T_h + \frac{w_c S}{2} \qquad \text{Eq. 9-9}$$

where:

T_{avg} = average tension in pounds

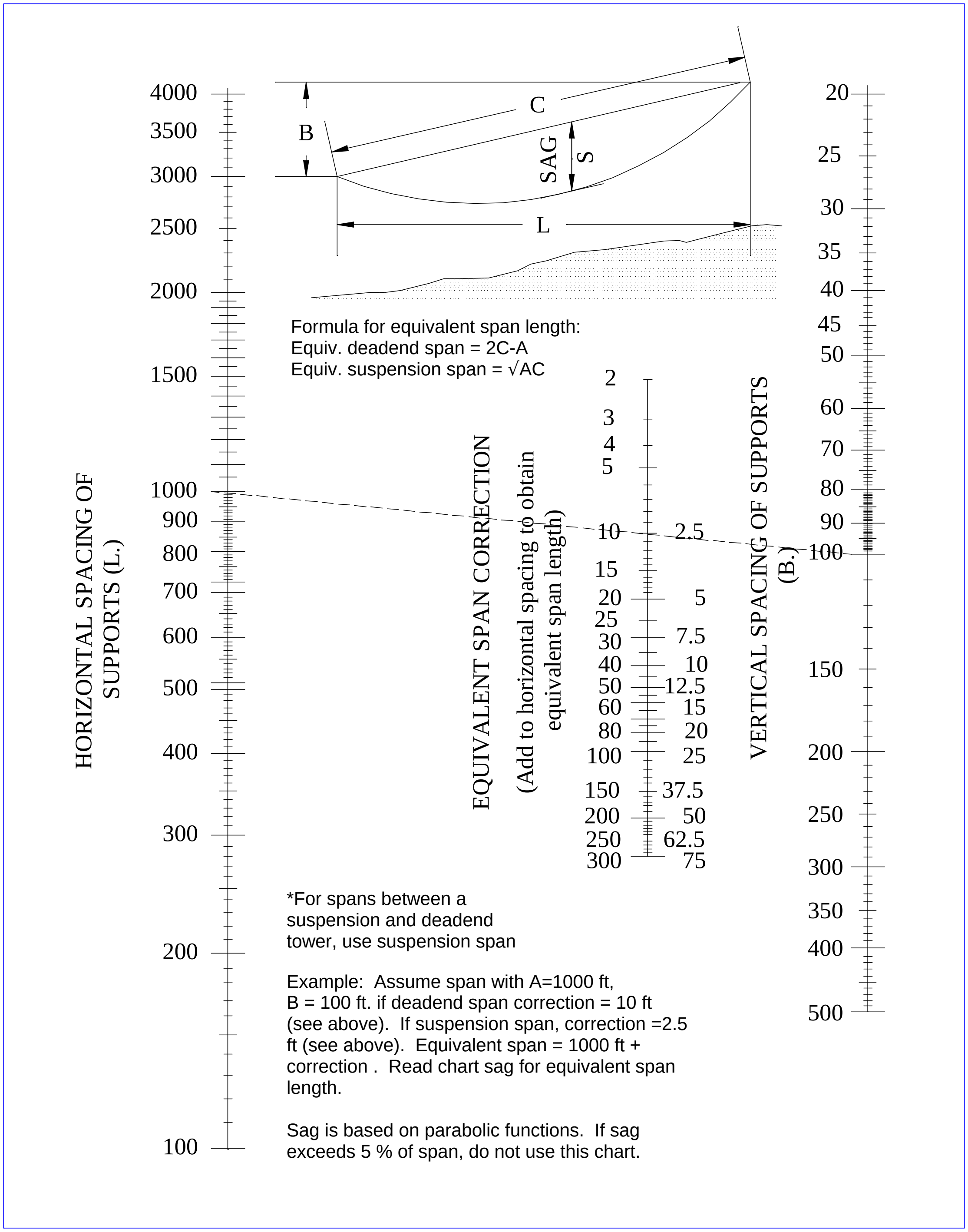


FIGURE 9-6: NOMOGRAPH FOR DETERMINING LEVEL SPAN EQUIVALENTS OF NON-LEVEL SPANS

9.13 Stringing Conductors

9.13.1 Tension Method (Preferred) for Stringing Conductors: Using this method, the conductor is kept under tension during the stringing process. Normally, the tension method is used to keep the conductor clear of the ground and of obstacles which might cause conductor surface damage and clear of energized circuits. The method requires pulling a light pilot line into the sheaves. The pilot line is then used to pull a heavier line. The heavier pulling line is used to pull conductors from reel stands using specially designed tensioners and pullers. For lighter conductors, a lightweight pulling line may be used in place of the pilot line to directly pull the conductor. A helicopter or ground vehicle can be used to pull or lay out a pilot line or pulling line. When a helicopter is used to pull a line, synthetic rope is normally used to attach the line to the helicopter and prevent the ‘pilot line’ or pulling line from flipping into the rotor blades upon release. With the tension method, the amount of right-of-way travel by heavy equipment can be minimized. Usually, this tension method provides the most economical means of stringing conductor. Use of a helicopter is particularly advantageous in rugged or poorly accessible terrain.

Major equipment required for tension stringing includes reel stands, tensioner, puller, reel winder, pilot line winder, splicing cart and helicopter or pulling vehicle.

9.13.2 Slack or Layout Method: Using this method, the conductor is dragged along the ground by means of a pulling vehicle, or the reel is carried along the line on a vehicle and the conductor is deposited on the ground. Conductor reels are positioned on reel stands or "jacks," either placed on the ground or mounted on a transport vehicle. These stands are designed to support the reel on an arbor, permitting the reel to turn as the conductor is pulled. Usually a braking device is provided to prevent overrunning and backlash. When the conductor is dragged past a supporting structure, pulling is stopped and the conductor placed in sheaves attached to the structure before proceeding to the next structure.

This method is chiefly applicable to the construction of new lines where maintenance of conductor surface condition is not critical and where terrain is easily accessible to a pulling vehicle. The method is not usually economically applicable in urban locations where hazards exist from traffic or where there is danger of contact with energized circuits, nor is it practical in mountainous regions inaccessible to pulling vehicles.

Major equipment required to perform slack stringing includes reel stands, pulling vehicle(s) and a splicing cart.

9.13.3 Stringing Conductors During Temperature Changes: An examination of conductor sag and tension tables will generally indicate the changes that take place in various span lengths with a change of conditions. For a given set of conditions, spans of various lengths may have a different rate of tension change with a change of loading or temperature. The ruling span tension of an unloaded conductor matches the tension of any other span only at one temperature. Large changes in temperature during stringing require care in matching average tensions in any section. It is desirable to complete stringing between deadends during periods of minimum temperature change and at zero wind load. Where spans are supported by suspension insulators, each span will have an influence on adjacent spans such that no span can be considered independently of the remainder of spans in the same section between anchor structures. Change in temperature has a greater effect on short spans than loading does, while long spans are affected more by loading. In short spans a slight movement of supports results in substantial changes in tension while in longer spans, relatively greater movement is required. The relation between adjacent span lengths therefore determines the movement required to equalize tension.

9.14 <u>The Sagging of Conductors</u>: It is important that the conductors be properly sagged in at the right stringing tension for the ruling span used. When installing conductors, a series of several spans is usually sagged in one operation by pulling the conductors to proper tension while they are supported on free rolling sheaves. To obtain the correct sags and to ensure that the suspension insulators will hang vertically, the horizontal components of tension must be the same in all spans for a selected condition. In a series of spans of varying length, greater sag tends to form in the long spans. On steep inclines the sheaves will deflect in the uphill direction and there will be a horizontal component of tension in the sheave itself. The horizontal component of tension in the conductor will therefore increase from one span to the next, as the elevation increases, by an amount equal to the horizontal component in the sheave. As a result, sags will proportionally decrease. In order to avoid this effect, it may be necessary to use a procedure called offset clipping. In this procedure, the point along the conductor at which it is attached to the insulator string is moved a specific distance down span from the point at which the conductor sits in the stringing block. See Figure 9-7 for further details on offset clipping.

It is important that the sags of the conductor be properly checked. It is best to do this in a series of level spans as nearly equal to the ruling span as possible.

For additional information, see:

> "A Guide to the Installation of Overhead Transmission Line Conductors," IEEE Standard 524-1992, IEEE, 1992.

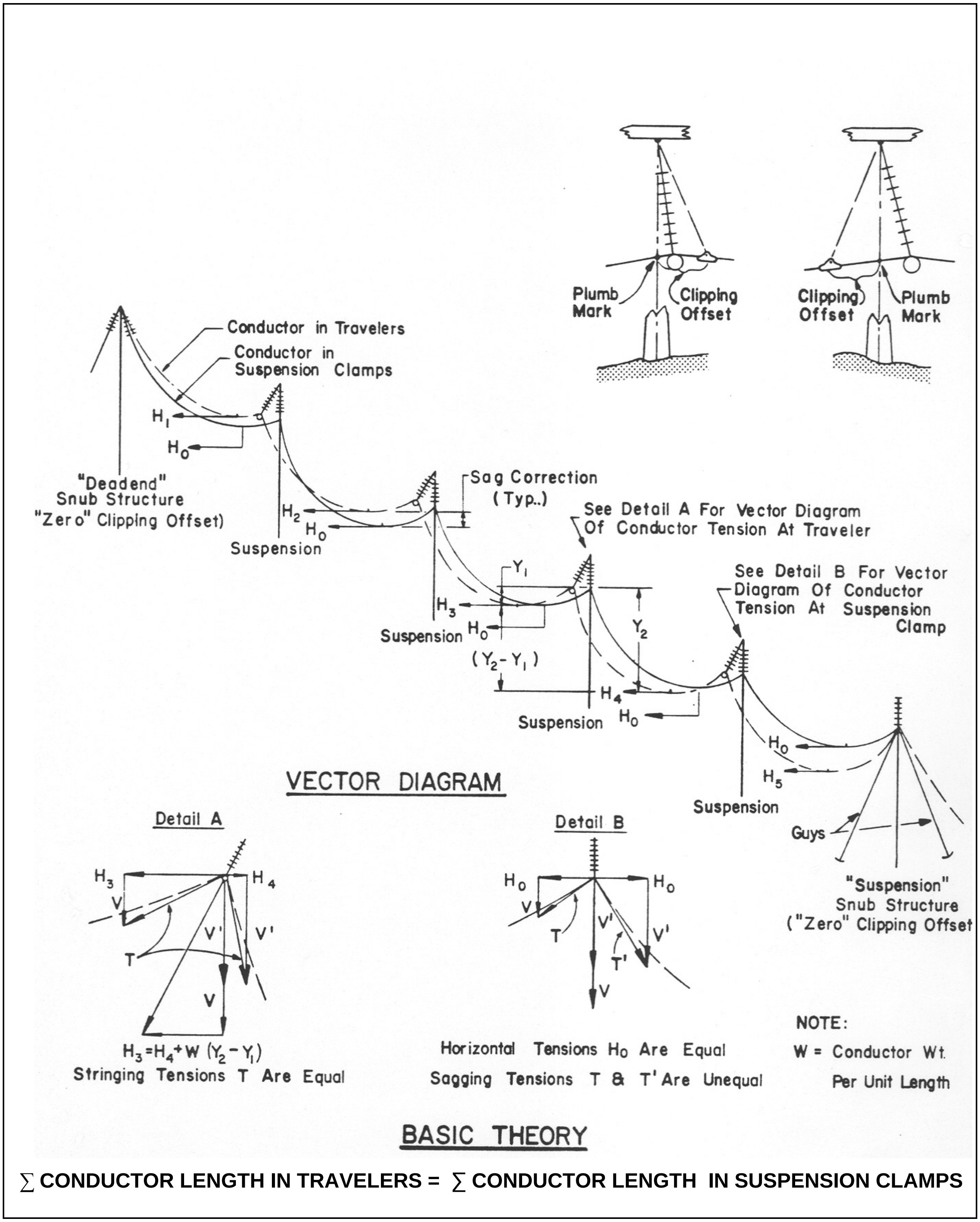


FIGURE 9-7: ANALYSIS FOR APPLICATION OF CLIPPING OFFSETS
From IEEE Standard 524-1992, "IEEE Guide to the Installation of Overhead Transmission Line Conductors,"

9.15 <u>Example 9-1</u>: Determination of Ruling Span: Determine the ruling span for the line segment given below using both the exact and approximate method.

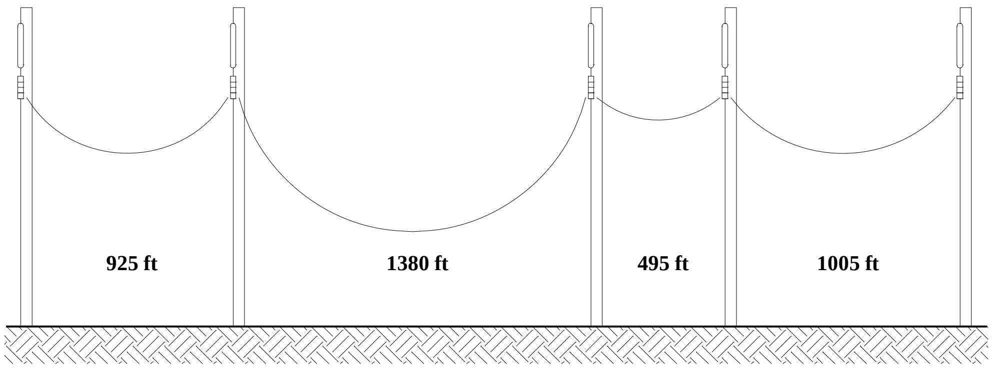


FIGURE 9-8: LINE SECTION FOR EXAMPLE 9-1

<u>Solution, Exact Method</u>:

$$RS = \sqrt{\frac{L_1^{\ 3} + L_2^{\ 3} + L_3^{\ 3} + \ldots + L_n^{\ 3}}{L_1 + L_2 + L_3 + \ldots + L_n}}$$ See Eq. 9-2

$$\text{RS} = \sqrt{\frac{925^3 + 1380^3 + 495^3 + 1005^3}{925 + 1380 + 495 + 1005}}$$

RS = 1094 ft.

<u>Solution, Approximate Method</u>**:**

$RS = L_{avg} + 2/3(L_{max} - L_{avg})$ See Eq. 9-1

L_{avg} = (925 + 1380 + 495 + 1005)/4 = 951 ft.

L_{max} = 1380

RS = 951 + 2/3(1380 - 951)

RS = 1237 ft.

As previously mentioned in the text, the error between the exact and approximate methods of determining ruling span is caused by a rather significant error between the average and maximum span values.

9.16 <u>Example 9-2, Maximum Span Determination</u>: Determine the maximum span (for river crossings, etc.) for a 795 kcmil 26/7 ACSR conductor. Assume that under heavy loading district conditions, the conductor can be loaded up to 40 percent of its rated strength.

Solution**:** From the conductor tables in Appendix B, the rated strength of the conductor is 31,500 lbs. and the weight of the conductor with 1/2 in. of radial ice is 2.0930 lbs/ft..

T = 31500(0.4) = 12600 lbs.

$$L_{max} = 1.33 \frac{T}{w_c}$$ See Eq. 9-5

$$L_{max} = 1.33 \frac{12600 \text{ lbs.}}{2.0930 \text{ lbs/ft.}} = 8007 \text{ ft.}$$

9.17 Example 9-3, Determination of Tensions at the Mid Span Point and at the Point of Support: A level 800 ft. span of 795 kcmil 26/7 ACSR conductor has a sag of 21.95 ft. The average tension value is 9,185 lbs. and there is no ice or wind on the conductor. Determine the actual tension values at the mid span point and at the point of conductor support.

Solution for the Tension at Mid Span Point:

$$T_{avg} = \frac{T_h + T}{2} = T_h + \frac{w_c S}{2}$$ See Eq. 9-9

$$T_h = T_{avg} - \frac{w_c S}{2}$$

From the conductor tables in Appendix B, the weight of the conductor without ice is 1.0940 lbs/ft.

$$T_h = 9185 - \frac{(1.094)(21.95)}{2}$$

T_h = 9173 lbs.

Solution for the Tension at Support:

$$T = T_h + w_c S = T_h \cosh \frac{w_c L}{2T_h}$$ See Eq. 9-8

$T = T_h + w_c S$

T = 9173 + (1.094)(21.95)
T = 9197 lbs.

10. PLAN-PROFILE DRAWINGS

10.1 General: Transmission line plan-profile drawings serve an important function in linking together the various stages involved in the design and construction of the line. Initially, the drawings are prepared based on a route survey. These drawings show the location and elevation of all natural and man-made features to be traversed by, or which are adjacent to, the proposed line which may affect right-of-way, line design and construction. They also indicate ownership of lands near the line. The drawings are then used to complete line design work such as structure spotting. During material procurement and construction, the drawings are used to control purchase of materials and they serve as construction specification drawings. After construction, the final plan-profile drawings become the permanent record and right-of-way data, useful in line operation and maintenance or future modifications.

Accuracy, clarity, and completeness of the drawings should be maintained, beginning with initial preparation, to ensure economical design and correct construction. All revisions made subsequent to initial preparation and transmittal of drawings should be noted in the revision block by date and brief description of revision. Originals of the plan-profile drawings, revised for as-built conditions, should be filed by the borrower for future reference.

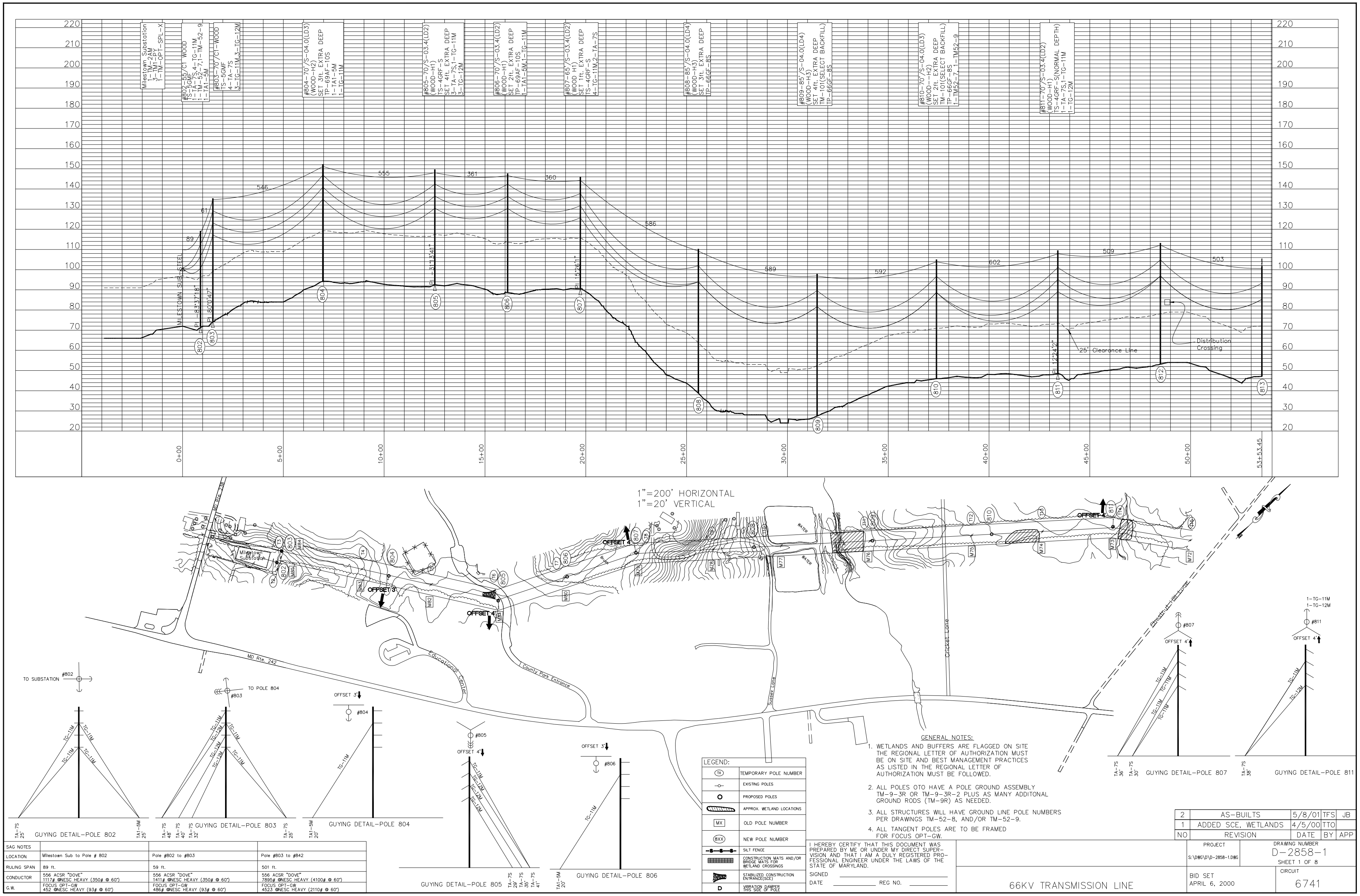
10.2 Drawing Preparation: Adequate control of field survey, including ground check of aerial survey, and proper translation of data to the plan-profile drawings are of utmost importance. Errors which occur during this initial stage will affect line design because a graphical method is used to locate the structures and conductor. Normally, plan-profile sheets are prepared using a scale of 200 feet to the inch horizontally and 20 feet to the inch vertically. On this scale, each sheet of plan-profile can conveniently accommodate about 1 mile of line with overlap to connect the end span on adjacent sheets. On lines with abrupt ground terrain changes and on lines where there is need to minimize breaks in elevation view, plan-profile sheets may use a scale of one inch equal to 400 feet horizontally and one inch equal to 40 feet vertically may be used.

A sample format for plan-profile drawing, detailing dimensions and stationings in U.S. customary (English) units, is shown in Figure 10-1. Stationing and structure numbering increases from left to right and the profile and corresponding plan view are included on the same sheet. Drawings prepared in ink on Mylar or tracing cloth will provide a better permanent record than on paper. However, structure spotting initially should be marked in pencil on plan-profile drawing paper and transferred to the base tracings in ink after the drawings are approved and the line is released for construction.

Conventional symbols used to denote features on the drawings are shown in Figure 10-2. Features of existing obstacles, structures, etc. to be crossed by the transmission line, including the height and position of power and telecommunication lines, should be shown and noted by station and description in both the plan and profile views. The magnitude and direction of all deflection angles in the line should be included and referenced by “P.I. Station No. XX” in plan and elevation views. (P.I. refers to point of intersection). In rough terrain, broken lines representing side-hill profiles should be accurately plotted to assure final designs will provide for adequate conductor-to-ground clearances and pole heights. A drawing title block should be included. The block should identify the line and include the station numbers that are covered on the drawing sheet. The block should also include space for recording the names of personnel and the dates involved in various stages of drawing preparation, line design, checking, approval, and revisions.

Line design computer software may be used to import survey data and develop the land profile for the transmission line. Developments in surveying technologies have allowed the industry to go beyond the station-elevation-offset formats that have traditionally been used for transmission profile

FIGURE 10-1: SAMPLE OF A PLAN AND PROFILE



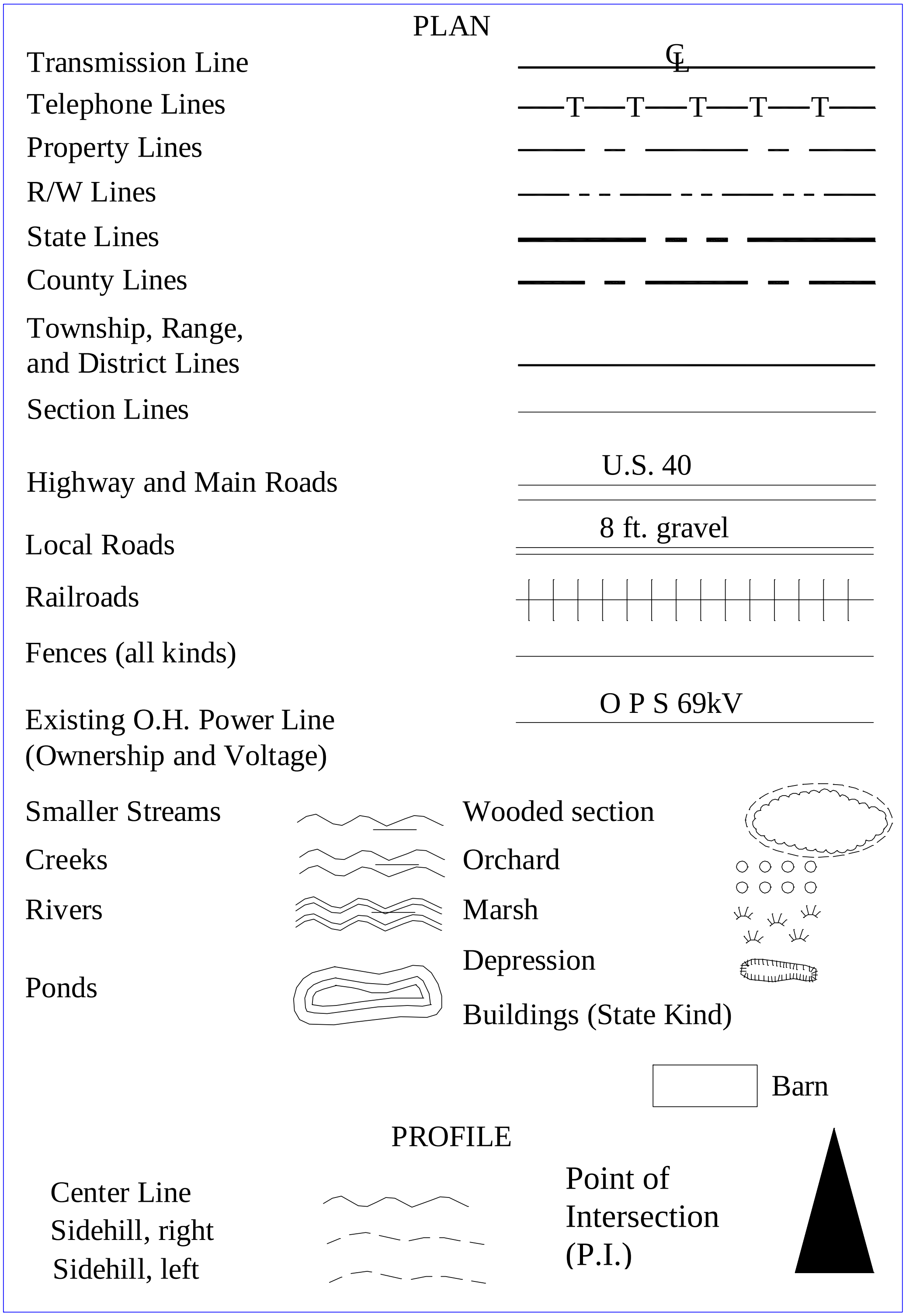


FIGURE 10-2: CONVENTIONAL SYMBOLS FOR PLAN-PROFILE

modeling. Use of three-dimensional Geographical Information System (GIS) modeling is becoming more common. Total station, geographical positioning system, photogrammetry, and electronic topographical maps (United States Geological Survey, USGS, maps) have been employed to collect data in electronic format and to develop quick and accurate terrain plan and profile for transmission lines.

Design software can use a three-dimensional survey format and develop profile drawings of the terrain along the centerline of the line. Some software can create interpolated points on profiles by creating a Triangular Irregular Network (TIN). The TIN can be used to develop a three-dimensional rendering of a transmission line.

Once the alignment and profile have been developed, computer programs are then used to spot structures along the profile. For an established family of structures, the computer can be used to automatically spot structures for the most economical line cost or the user may manually spot structures. Programs have been developed to automatically plot the sag curve of the conductor and to check insulator swing, structure strength, and clearances. A material list is often developed from computer generated plan-profile drawings.

Computer aided drafting and design software may provide all or part of the following:

- Importing survey data, to model terrain, and to create a profile;
- Modeling of structure, including strength, geometry, insulator swing and complete bill of material;
- Calculating conductor sag and tension;
- Locating structures (spotting) on the profile drawing;
- Calculating conductor stringing and sagging, at almost any temperature, to check design conditions such as uplift, ground clearance or insulator swing;
- Checking the line plan-profile against specific design criteria;
- Displaying the plan-profile or structure analysis in three dimensions; and
- Preparing reports and construction documents showing all construction material units on the plan and profile, as well as developing material reports, staking tables, offset clipping reports, etc.

Some design programs provide more custom drafting capabilities. Some are AutoCAD based; others are MICRO STATION based. Traditional methods used to spot structures can be as much as 70-80 percent more conservative than the computer aided design and drafting approach.

10.3 <u>Sag Template</u>: When computers are not used to spot structures and draw the conductor sag curve, manual techniques are used. Once the profile of the line has been drawn, the next step is to develop a sag template. The sag template is a scaling device used for structure spotting and for showing the vertical position of conductor (or ground wire) for specified design conditions . A sample conductor sag template is shown by Figure 10-3. The template is used on plan-profile drawings to graphically determine the location and height of supporting structures required to meet line design criteria for vertical clearances, insulator swing, and span limitations. The sag template permits alternate layout for portions of the line to be investigated and thereby aids in optimizing line design for economy.

Generally, the conductor sag curves control the line design. The sag template for the overhead ground wire is used to show the position of the wire in relationship to the conductors for special spans or change in conductor configuration. An uplift condition at the overhead ground wire may be checked by using the template cold curve.

10.3.1 <u>Sag Template Curves</u>: The sag template should include the following sag curves based on the design ruling span:

a. <u>Hot (Maximum Sag) Curve</u>: At maximum operating temperature, no ice, no wind, final sag curve, the hot curve is used to check for minimum vertical clearances. However, if the maximum sag occurs under an icing condition, this sag curve should be used for the sag template.

b. <u>Cold Curve</u>: At minimum temperature, no ice, no wind, initial sag curve, the cold curve is used to check for uplift and insulator swing.

c. <u>Normal Curve</u>: At 60°F, no ice, no wind, final sag curve, the normal curve is used to check normal clearances and insulator swing.

Sag curves are also used to locate the low point of sags and determine the vertical span lengths as illustrated by Figure 10-6. The curve intersection with the vertical axis line represents the low point position of sag.

Conductors of underbuild lines may be of different types or sizes than the transmission conductor. The hot curve of the lowest distribution conductor should be used for checking ground clearance. Cold curves may be required for each size of conductor to check for uplift or insulator swing.

10.3.2 <u>Sag Template Design</u>: Sag templates may be developed from information provided by the manufacturer of the conductor or from a graphical calculation method. Sag values needed to construct the template are available from the conductor manufacturer for a given conductor, ruling span, design condition and temperature. Sag values may also be determined using the graphic method referred to in Section 9.8 of Chapter 9. The template should be made to include spans three or four times as long as the normal level ground span to allow for spotting structures on steep terrain.

The form of the template is based on the fact that, at the time when the conductors are installed, horizontal tensions have to be equal in all level and inclined spans if the suspension insulators are plumb in profile. This is also approximately true at maximum temperature. To obtain values for plotting the sag curves, sag values for the ruling span are extended for spans shorter and longer than the ruling span. Generally for spans up to 1000 feet, it is sufficiently accurate to assume that the sag is proportional to the square of the spans (unless more accurate computed sag values are unavailable). The sag values used for the template may be determined as follows:

a. For the ruling span and its sag under each appropriate design condition and temperature, calculate other sags by the relationship:

$$S = \left(\frac{L}{RS}\right)^2 (S_{RS}) \qquad \text{Eq. 10-1}$$

where:

S = sag of other span in ft.
S_{RS} = sag of ruling span in ft.
L = length of other span in ft.
RS = ruling span sag in ft.

b. Apply catenary sag correction for long spans having large sags.

The template should be cut to include a minimum of one foot additional clearance than given in Table 4-1 (Chapter 4), to account for possible minor shifts in structure location and error in the plotted profile. Where the terrain or the surveying method used in obtaining ground profile is subject to greater unknowns or tolerances, the one foot additional clearance should be increased. The vertical offset between the upper two maximum temperature (hot) curves is equal to the total required clearance, including the specified additional clearance. It is shown as dimension "C" in Figures 10-3 and 10-4. The minimum temperature and the 60°F curves may be placed in any convenient location on the template.

A sag template drawing similar to Figure 10-3, made to the same scales as the plan-profile sheets, should be prepared as a guide for cutting the template. This template is made for a specified conductor, ruling span, and loading condition. A new template should be prepared for each line where there is any variation in voltage, conductor size, loading condition, design tension, or ruling span. A change in any one of these factors may affect the design characteristics of the template.

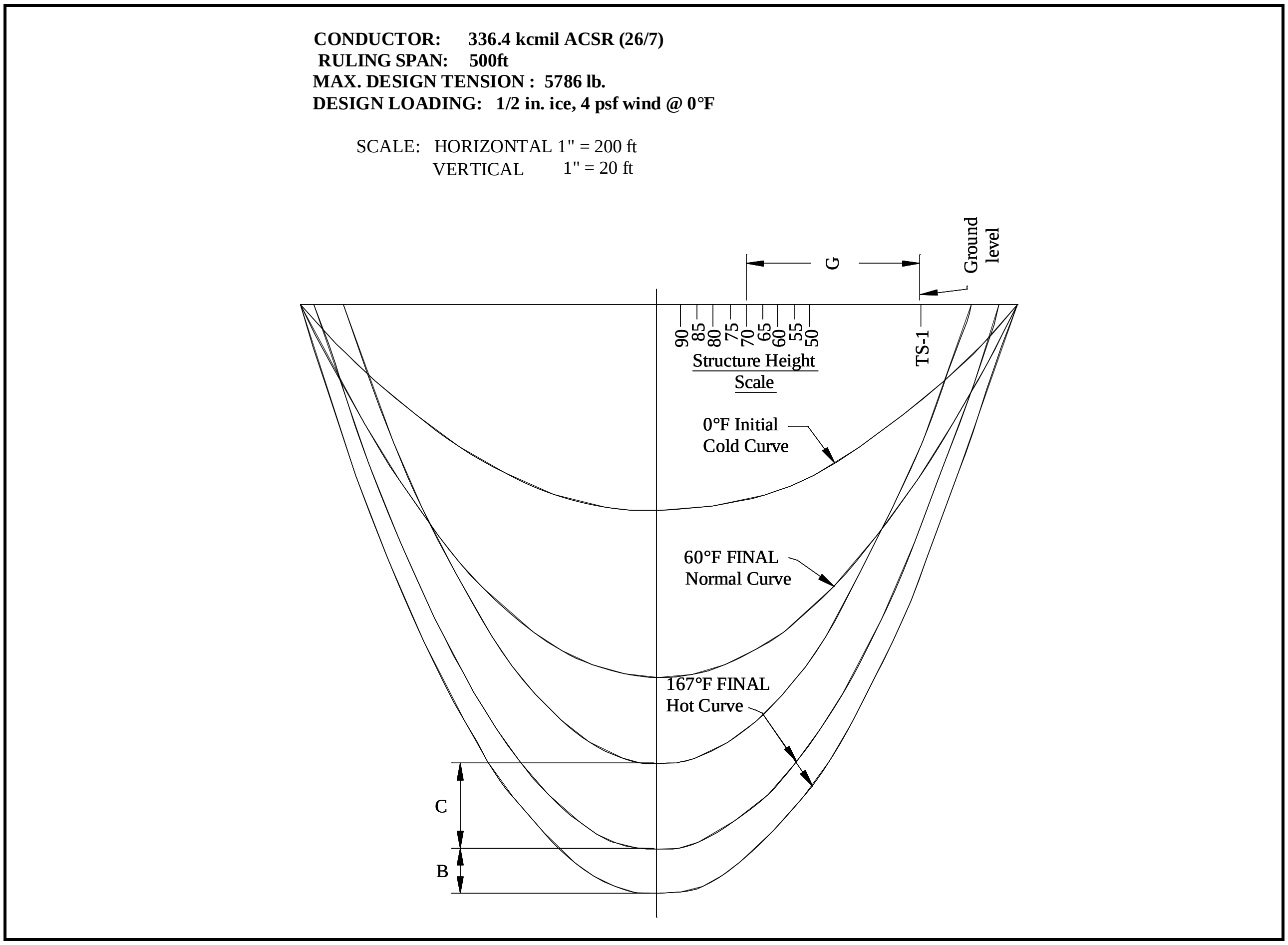


FIGURE 10-3: SPECIMEN SAG TEMPLATE FOR CONDUCTOR
(Reduced size, not to scale)
B = Sag for the level ground span, C = Total Ground Clearance,
G = Dimension from ground to point of attachment of lowest conductor

10.3.3 Sag Template Construction: The sag template should be made of dimensionally-stable transparent plastic material. A contrasting colored material (for example, red) is very helpful when the template is used to check plan-profile blueprint drawings.

Curves are first plotted on paper using the correct scales and then reproduced or copied on the plastic material. To cut a template, the transparent material is fastened securely over the curves drawn on paper and the centerline and upper curves are etched lightly by a sharp-pointed steel scriber. The outside edges of the template should be etched deeply so that the template can be easily broken out and the edges sanded smooth. Structure height scales may also be drawn or etched on the sag template, or a separate template, for determining the pole height required for each type of structure used. Etched lines should be filled with ink to make them easier to see when the template is used.

Conductor size, design tension and loading condition as well as ruling span and descriptive data for each curve should be shown on the template.

10.4 Structure Spotting

10.4.1 General: Structure spotting is the design process which determines the height, location, and type of consecutive structures on the plan-profile sheets. Actual economy and safety of the transmission line depends on how well this final step in the design is performed. Structure spotting should closely conform to the design criteria established for the line. Constraints on structure locations and other physical limitations encountered may prevent spotting of structures at optimum locations. Success of the effort to minimize or overcome these special conditions can be judged by how closely the final line layout follows the original design parameters.

Desired objectives of a well-designed and economical line layout are:

a. Spans should be approximately uniform in length, equal to or slightly less than the design ruling span. Generally, differential conductor tensions are minimized and may be ignored if adjacent span lengths are kept below a ratio of 1.5 to 1.

b. Maximum use should be made of the basic structure of equal height and type. The basic structure is the pole height and class which has been selected as the most economical structure for the given design condition.

c. The shape of the running conductor profile, also referred to as the grading of the line, should be smooth. If the conductor attachment points at the structures lie in a smooth-flowing curve, the loadings are equalized on successive structures.

For a generally level and straight line, with few constraints on structure locations, there is no conflict between these objectives. They can be readily achieved. Greater skill and effort are needed for lines with abrupt or undulating ground profile and for those where constraints on structure location exist. For example, there may be high or low points in the profile or features such as line angle points, crossings over highway, railroad, water, power and telecommunication lines, and ground with poor soil conditions. Structure locations and heights are often controlled or fixed by these special considerations. Alternative layouts between fixed locations may then be required to determine the best arrangement based on factors of cost and effective design.

10.4.2 Design Factors for Structure Spotting: The following design factors are involved in structure spotting and are covered in the identified chapters of this bulletin:

a. Vertical Clearances (Chapter 4)
- Basic, level ground
- Crossings
- Side hill
- Underbuild

b. Horizontal Clearances
- For insulator side swing condition (Chapter 7)
- To edge of right-of-way, vertical obstructions and steep side hills (Chapter 5)

c. Uplift (Chapter 12)

d. Horizontal or Vertical Span Limitations Due to:
- Vertical sag - clearance requirement (Chapters 4, 6)
- Conductor separation (Chapter 6)
- Galloping (Chapter 6)
- Structure strength (Chapters 13, 14)
- Crossarm strength (Chapter 13)

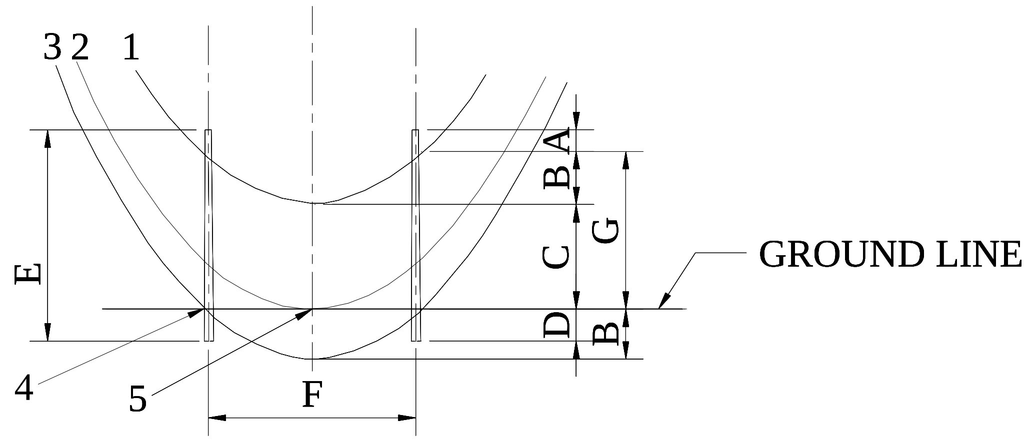
e. Angle and Deadend (Chapter 14)
- Guying arrangements
- Guy anchors

10.4.3 Preparation: The following are necessary for structure spotting:

- Plan-profile drawings of the transmission line,
- Sag template of the same scale as the plan-profile prepared for the design temperatures, loading condition, and ruling span of the specified conductor and overhead ground wire,
- Table of minimum conductor clearances over ground features and other overhead lines (Chapter 4),
- Insulator swing charts (Chapter 7),
- Horizontal and vertical span limitations due to clearance or strength requirements (Chapters 8, 9, and 13), and
- Guy arrangement and anchor requirements for angle and deadend structures (Chapter 14).

A height scale prepared for each structure type will aid in structure height determination. Supporting calculations should be summarized in chart or tabular form to facilitate application during structure spotting. This is especially advisable for the standard suspension structure which has a greater range of pole height and class, as well as bracing variations for H-frame structures. Selection of the proper pole may be affected by various criteria, such as span-controlled-by-clearance or span-limited-by-pole-strength, for a given pole height and class or bracing.

10.4.4 Process of Spotting: The process of spotting begins at a known or established conductor attachment point such as a substation take-off structure. For level terrain, the profile is essentially a straight line. When a sag template is held vertically and the ground clearance curve is held tangent to the ground profile, the edge of the template will intersect the ground line at points where structures of the basic height should be set. This relation is illustrated for a level span in Figure 10-4. Curve 1 (lowest conductor sag position) represents the actual sag of the conductor. Curve 2 (basic ground clearance curve) represents the actual position of the lowest conductor plus the required total ground clearance, "C."



Hot Curves (Maximum Sag)

Curve 1 - Lowest Conductor Sag Position
Curve 2 - Basic Ground Clearance Curve
Curve 3 - Edge of Template or Reference Line
Point 4 - Intersection Locates Pole of Basic Height
Point 5 - Tangent to Ground Profile

A = Dimension from top of pole to point of attachment of lowest conductor.-
B = Sag in level ground span.
C = Total ground clearance.
D = Setting depth of pole
E = Length of pole.

F = Level ground span.
G = Dimension from ground to point of attachment of lowest conductor

FIGURE 10-4: APPLICATION OF SAG TEMPLATE - LEVEL GROUND SPAN

The point where Curve 3 intersects the ground line determines the location of the next structure. This new location is found by drawing an arc along the edge of the template from Point 4 to the next point where Curve 3 intersects the ground line. The template should then be shifted and adjusted so that with the opposite edge of the template held on the conductor attachment point previously located with the clearance curve again barely touching the profile. The process is repeated to establish the location of each succeeding structure. After all structures are located, the structures and lowest conductor should be drawn in.

The above procedure can be followed only on lines that are approximately straight and which cross relatively flat terrain with the basic ground clearances. When line angles, broken terrain, and crossings are encountered, it may be necessary to try several different arrangements of structure locations and heights at increased clearances to determine the arrangement that is most satisfactory. Special considerations often fix or limit the structure locations. It is advisable to examine the profile for several span lengths ahead, take note of these conditions and adjust the structure spotting accordingly. Sometimes, a more balanced arrangement of span lengths is achieved by moving ahead to a fixed location and working back.

The relationship between the ground clearance and conductor curves is also used for spans other than level-ground spans. This is done by shifting the sag template until ground profile touches or is below the clearance curve with the previously established conductor attachment point is positioned on the conductor curve. The conductor curve would then indicate the required conductor height for any selected span. Structure height may be determined by scaling or by use of the proper structure height template, taking into account the change in the embedded pole length for poles other than the basic pole. Design limitations due to clearance or structure strength should be observed.

10.4.5 Crossings: For spans-crossing features such as highway and power lines, with different clearance requirements than the normal clearance, the ground clearance curve should be adjusted accordingly. In California, adequate ground clearance has to be maintained over all railroads, major highways, major telecommunication and power lines when a broken conductor condition in either of the spans adjacent to the crossing span. Other states are governed by the NESC, which does not require the broken conductor condition. The increase in sag due to a broken conductor in an adjacent span is usually significant only where suspension-type structures are used at crossings and for voltage at 230 kV or above. For tension structures, and for suspension structures at lower voltages, the sag increase normally will not seriously affect the clearance.

10.4.6 Insulator Side Swing - Vertical Span: Horizontal conductor clearances to supporting structures are reduced by insulator side swing under transverse wind pressure. This condition occurs where the conductor is supported by suspension-type insulators. Conductors supported by pin-type, post, or tension insulators are not affected and horizontal clearance of the deflected conductor position within the span becomes the controlling factor (see Chapter 5 of this bulletin). Suspension insulators also deflect laterally at line angle locations due to the transverse component of conductor tension.

Chapter 7 covers the preparation of insulator swing charts. At each structure location the charts are used to determine if insulator swing is within the allowed limit for the vertical and horizontal spans and line angle conditions. For suspension insulators supported on horizontal crossarms, a minimum vertical span has to be maintained to avoid excessive side swing. To maintain adequate clearance for insulators attached directly to the pole, and for some types of angle structures, the vertical span cannot exceed a maximum value (as indicated by the insulator swing chart). See Figure 7-5 of this bulletin for an example swing angle chart for the TH-233 large angle structure.

The vertical span is the distance between the conductor low points in spans adjacent to the structure. The horizontal span is the average value of the two adjacent spans to a structure. Where conductor attachments are at different elevations on adjacent structures, the low point is not at mid-span and will shift its position as the temperature changes. This shift can be readily seen by comparing the low point for the hot curve with its position for the cold curve. The vertical span value used to check the insulator swing should be based on the low point position which yields the most critical condition for the structure type. (See Chapter 7 for details on insulator swing)

Where minimum vertical span or uplift is the concern, the cold curve should be used. The normal temperature is more critical and should be used if the vertical span is limited by a maximum value. Figure 10-6 shows some examples of the relationship of conductor low points and vertical spans which may occur in a line profile.

If insulator swing is unacceptable, one of the following corrective steps, in order of preference, is recommended:

a. Relocate structures to adjust horizontal-vertical span ratio;
b. Increase structure height or lower adjacent structures;
c. Use a different structure, one with greater allowable swing angle or a deadend structure; or
d. Add weight at insulators to provide the needed vertical force.

10.4.7 Uplift: Uplift is defined as negative vertical span and is determined by the same procedure as vertical span. On steeply inclined spans when the cold sag curve shows the low point to be above the lower support structure, the conductors in the uphill span exert upward forces on the lower structure. The amount of this force at each attachment point is related to the weight of the loaded conductor from the lower support to the low point of sag. Uplift exists at a structure (see Structure No. 4 in Figure 10-6) when the total vertical span from the ahead and back spans is negative. Uplift has to be avoided for suspension, pin-type, and post insulator construction. For structures with suspension insulators, the check for allowable insulator swing is usually the controlling criteria on vertical span. A rapid method to check for uplift is shown by Figure 10-5. There is no danger of uplift if the cold curve passes below the point of conductor support on a given structure with the curve on the point of conductor support at the two adjacent structures.

Designing for uplift, or minimizing its effects, is similar to the corrective measures listed for excessive insulator swing, except that adding of excessive weights should be avoided. Double deadends and certain angle structures can have uplift as long as the total force of uplift does not approach the structure weight. If it does, hold-down guys are necessary.

Care should be exercised to avoid locating structures that result in poor line grading (see Paragraph 10.1.4a of this chapter).

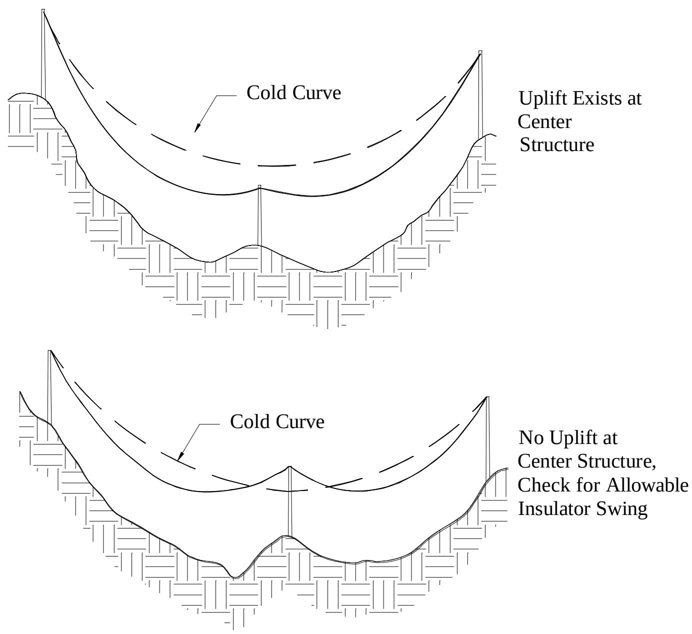


FIGURE 10-5: CHECK FOR UPLIFT

10.4.8 <u>Other Considerations</u>: If maximum conductor tension or other limits are not exceeded, it may be preferable to use one long span with adequate conductor separation over a depression in the profile rather than use two short spans with a deadend structure at the bottom of the depression. A structure at the bottom of the depression may be subjected to considerable uplift at minimum conductor temperature. Also, poorer soil foundation conditions usually exist in the depression.

Care has to be exercised at locations where the profile falls sharply away from the structure to see that the maximum allowable vertical span as limited by the strength of the crossarm or insulator is not exceeded. Structure No. 2 in Figure 10-6 illustrates this condition. For maximum accuracy in the heavy or medium loading zone, the vertical span for this purpose should be determined with a curve made for the sag under ice load, no wind, at 32°F. For most conductors, however, the maximum temperature final sag curve will closely approximate the

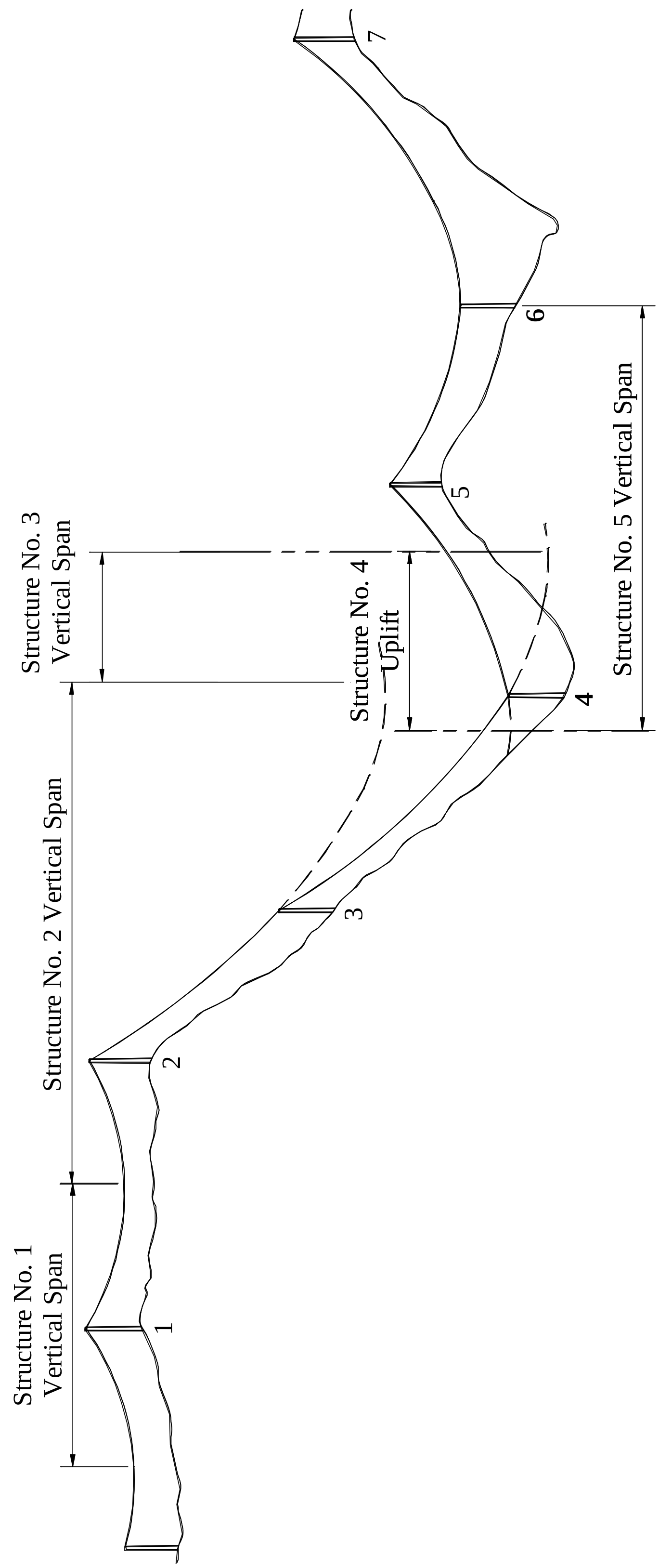


Figure 10-6 Sag Low Point, Vertical Spans and Uplift

curve for the ice-loaded conductor, and it may be used when checking for maximum vertical span. For guyed structures, the maximum vertical loads added to the vertical components from guy loads should be checked against the buckling strength of the pole

The profile in rough country where side hills are encountered should be prepared so that the actual clearances under the uphill and downhill conductor may be checked. For some long spans it may be necessary to check side hill clearance with the conductors in their maximum transverse swing position. H-frame type structures installed on side hills may require different pole heights to keep the crossarm level or one pole may be set a greater than normal setting depth.

Structures with adequate longitudinal strength (guyed deadends usually) are required at locations where longitudinal loading results from unequal line tensions in adjacent spans. For lines subject to heavy ice and high wind conditions and with long, uninterrupted section of standard suspension structures, consideration should be given to include some structures with in-line guys or other means to contain and prevent progressive, cascading-type failure. This is especially important for H-frame type structures with lower strength in the longitudinal direction when compared with its transverse strength. Measures to prevent cascading failures are also important for lines without overhead ground wire which tends to restrain the structure from collapsing longitudinally. A maximum interval of 5 to 10 miles is suggested between structures with adequate longitudinal capacity (guyed deadends usually), depending on the importance of the line and the degree of reliability sought.

10.5 Other Design Data: Conductor and ground wire sizes, design tensions, ruling span, and the design loading condition should be shown on the first sheet of the plan-profile drawings. For completeness, it is preferable that these design data be shown on all sheets. A copy of the sag template reproduced on the first sheet could serve as a record of design in case the template is misplaced or lost. Design data for underbuild and portions of the line where a change in design parameters occurs should similarly be indicated. The actual ruling spans between deadends should be calculated and noted on the sheets. This serves as a check that the actual ruling span has not deviated greatly from the design ruling span. The significance of this deviation is also covered in the ruling span section of Chapter 9. Where spans are spotted at lengths less than one-half or over twice the ruling span, deadending may be required.

As conductor sags and structures are spotted on each profile sheet, the structure locations are marked on the plan view and examined to insure that the locations are satisfactory and do not conflict with existing features or obstructions. To facilitate preparation of a structure list and the tabulation of the number of construction units, the following items, where required, should be indicated at each structure station in the profile view:

- Structure type designation,
- Pole height and class,
- Pole top, crossarm, and brace assemblies,
- Pole grounding units,
- Miscellaneous hardware units (vibration dampers at span locations), and
- Guying assemblies and anchors.

The required number of units or items required should be shown in parenthesis if greater than one. Successive plan-profile sheets should overlap. For continuity, and to avoid duplicate count, the end structure on a sheet should be shown as a broken line on the following sheet. The number and type of guying assemblies and guy anchors required at angle or deadend locations, based on guying calculations or application charts, should also be indicated. Design check, line construction, and inspection are facilitated if an enlarged guying arrangement, showing attachments and leads in plan and elevation, is added on the plan-profile sheet adjacent to each guyed structure. Any special notes or large-scale diagrams necessary to guide the construction should be inserted on the plan-profile sheet. This is important at locations where changes in line design or construction occur, such as a slack span adjacent to a substation, line transposition, or change in transmission and underbuild circuits.

10.6 Drawing Check and Review: The completed plan-profile drawings should be checked to ensure that:

- The line meets the design requirements and criteria originally specified,
- Adequate clearances and computed limitations have been maintained, and
- Required strength capacities have been satisfied.

The sheets should be checked for accuracy, completeness, and clarity. Figure 10-7 is a Sample Check List for review of plan and profile sheets.

Profile: ______________________________	***Date:*** _________________________________
Line: ________________________________	***Voltage:*** _______________
Plan and Profile Drawing Nos. ____________	***Checked by:*** ____________________________
Loadings ***NESC District*** ___________________ ***50 yr extreme wind(psf)*** ___________ ***Extreme ice load (radial inches)*** _____	***Ruling Span:*** ___________________________
Conductor: ___________________________	***Design Tension:*** _______________________
OHGW: _____________________________	***Design Tension:*** _______________________
Underbuild: __________________________	***Design Tension:*** _______________________

Sheet Number														
	PLAN													
	Property Information													
	Swamps, Rivers, Lakes, etc.													
	R/W Data, Boundaries													
	Location of Buildings, Schools, etc.													
	Other Utilities													
	Obstructions, Hazards													
	Roads													
	Angles, P.I., Bearing of Centerline													
	PROFILE													
	Horizontal Span Length													
	Vertical Span Length													
	Type Structure													
	Pole Strength													
	Pole Height													
	Pole Foundation Stability													
	Crossarm Strength													
	Conductor Clearance:													
	To Ground or Side Hill													
	To Support and Guys													
	To Buildings													
	Crossing													
	Conductor Separation													
	Conductor Tension Limitations													
	Climbing or Working Space													
	Guy Tension													
	Guy Lead and Height													
	Anchors													
	Insulator Swing or Uplift													
	Tap Off, Switches, Substations													
	Underbuild													
	Code Requirements													

FIGURE 10-7: SAMPLE CHECK LIST FOR REVIEW OF PLAN AND PROFILE

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11. LOADINGS AND LOAD FACTORS

11.1 General: The strength to be designed into a transmission line depends to a large extent on wind and ice loads that may be imposed on the conductor, overhead ground wire and supporting structure. These loadings are related generally to the geographical location of the line.

When selecting appropriate design loads, the engineer should evaluate climatic conditions, previous line operation experience and the importance of the line to the system. Conservative load assumptions should be made for a transmission line which is the only tie to important load centers.

The 2007 NESC indicates that structure and component strength should take into account temporary loads. Temporary loads imposed on a structure or component may include lifting of equipment, stringing operations, or a worker on a structure or component. This design manual does not address temporary loads.

The alternate method in the 2007 NESC has not been included in this design manual. The alternate method will not be used after July 31, 2010.

11.2 Loads

11.2.1 NESC Loading Districts: The NESC divides the country into three weather or loading districts, as shown in Figure 11-1.

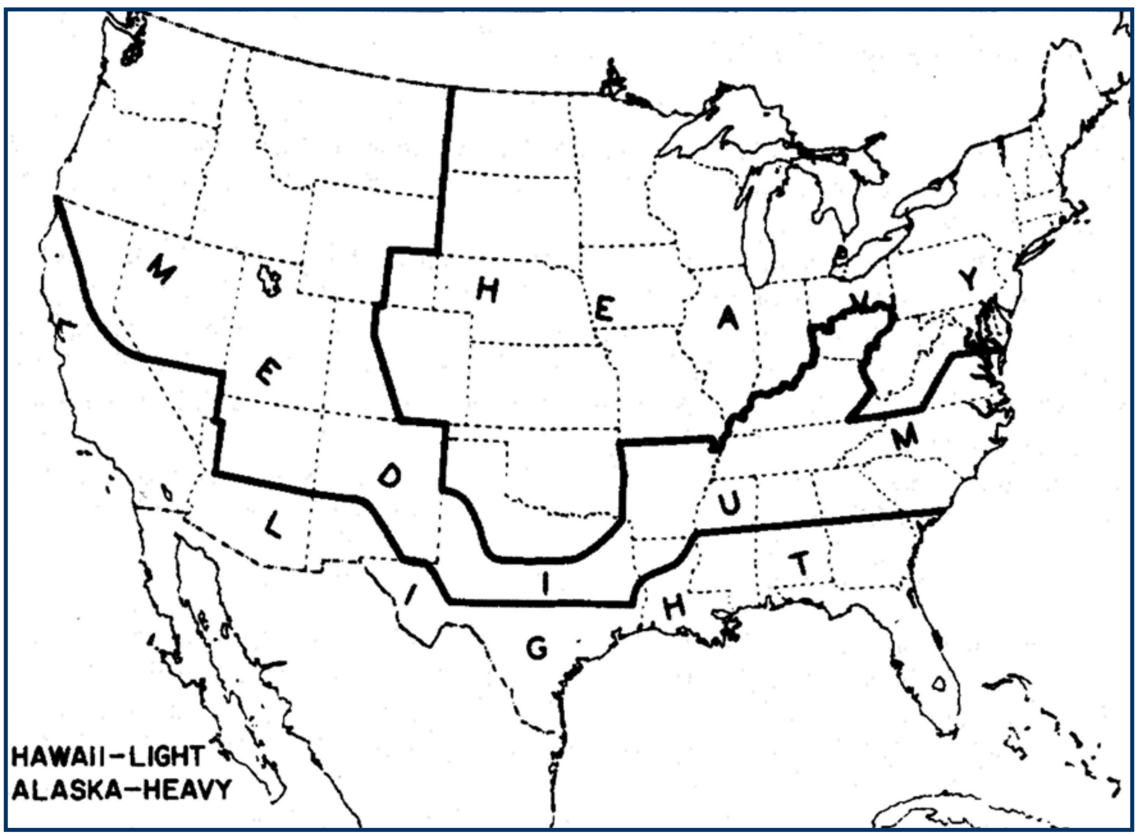


FIGURE 11-1: NESC LOADING DISTRICTS

The minimum design conditions associated with each loading district are given in Table 11-1. Constants in this table are to be added to the vector resultant for tension calculations only.

TABLE 11-1
ICE, WIND, TEMPERATURE, AND CONSTANTS

NESC Loading		Design Temp. (F°)	Radial Ice Thickness (inches)	Wind Loading	Constants (lbs/ft)
Loading District	Heavy	0°	0.50	4 psf	0.30
	Medium	15°	0.25	4 psf	0.20
	Light	30°	0	9 psf	0.05
Extreme Wind		60°	0	See Figure 11-2	NA
Extreme Ice with Concurrent Wind		15°	See Figure 11-3	See Figure 11-3	NA

Designing to these minimum requirements may not be sufficient. Extreme winds and special ice conditions should be investigated. Determination of an appropriate design load to account for extreme winds is easier than determining a heavy ice design load. Meteorological data may be available on high winds, but little data is available on extreme ice loads. Heavy ice combined with a relatively high wind should also be considered.

11.2.2 <u>Extreme Ice</u>: In certain areas of the country heavy ice may be predominant. The engineer should review the experience of utilities or cooperatives in the area of the line concerning ice conditions. The number and frequency of outages in the area due to ice storms, and the design assumptions used for existing lines in the area should be examined. From this data, the engineer can reasonably decide if a heavy ice condition greater than what is required by the NESC needs to be included in the design.

If historical data on icing conditions is lacking, the engineer should consider designing the line for extreme wind conditions without ice, and for loading zone conditions. The engineer would then calculate the maximum ice load the structure could sustain without wind and evaluate this specific ice condition.

11.2.3 <u>Extreme Winds</u>: Although the NESC requires that structures over 60 ft. sustain high winds, Rural Utilities Programs recommends that all transmission lines meet extreme wind requirements. Required values for temperature and wind are listed in Table 11-1 and Figure 11-2. The NESC allows linear interpolation when considering locations between isotachs. Local meteorological data should also be evaluated in determining a design high wind speed. For wind speeds other than a 50 year recurrence interval, refer to Appendix E.

Equations in Tables 250-2 and 250-3 of the NESC have been incorporated in computer programs as part of the structure analysis. These equations are included in the definitions for the variables in Equations 11-1 and 11-2 of this bulletin. Tables 11-2, 11-3, 11-4 and 11-5 provide calculated values for the parameters in these equations.

Equation 11-1 should be used to calculate the load in the unit wind load on a circular **wire** in pounds per linear foot.

$$p = 0.00256 * V^2 * k_z * G_{RF} * d / 12 \qquad \text{Eq. 11-1}$$

p = unit load per unit foot, lbs./ft.

V = Basic Wind Speed, 3 –second gust wind speed in miles per hour at 33 ft. above ground with an annual probability of .02 (50 year return period), Figure 11-2

k_Z = Velocity Pressure Exposure Coefficient, shown in Table 11-2 or by the equation:
$k_z = 2.01(h/900)^{(2/9.5)}$ where h = height of the wire at the structure and is between 33 feet and 900 feet

G_{RF} = Gust Response Factor, shown in Table 11-3 or by the equation: $G_{RF} = [1+(2.7E_w B_w^{0.5})]/k_v^2$ where
$E_w = 0.346 (33/h)^{1/7}$ and
$B_w = 1/(1+0.8L/220)$
$k_v = 1.43$
h = height of the wire at the structure
L = design wind span (also known as HS)

d = diameter of the conductor in inches

TABLE 11-2
WIRE VELOCITY PRESSURE EXPOSURE COEFFICIENT (k_Z)

Height of Wire(ft)	k_Z
≤ 33	1.00
34 – 50	1.10
51 – 80	1.20
81 – 115	1.30
116 – 165	1.40

TABLE 11-3
WIRE GUST RESPONSE FACTOR, G_{RF}

Height of Wire At the Structure h (ft.)	Wire, G_{RF}, for Various Span Lengths in feet			
	251 - 500	501 - 750	751 - 1000	1001 -1500
≤33	0.86	0.79	0.75	0.73
34 – 50	0.82	0.76	0.72	0.70
51 – 80	0.80	0.75	0.71	0.69
81 – 115	0.78	0.73	0.70	0.68
116 – 165	0.77	0.72	0.69	0.67

TABLE 11-4
COMBINED FACTOR k_Z*G_{RF}
FOR COMMON WIRE HEIGHTS

Height of Wire At the Structure h (ft.)	Wire, G_{RF}, for Various Span Lengths in feet)			
	251 – 500	501 - 750	751 - 1000	1001 -1500
34 - 50	0.90	0.84	0.79	0.77
51 - 80	0.96	0.90	0.85	0.83
81 - 115	1.01	0.95	0.91	0.88

For simplicity, the designer may wish to use the height of wire to be the height to the overhead groundwire at the structure.

To calculate the wind load on a **structure** in pounds, equation 11-2 should be used.

$$P = .00256 * V^2 * k_z * G_{RF} * C_f * A \quad \text{Eq. 11-2}$$

P = wind load in pounds

V = As defined for Equation 11-1

k_Z = Velocity Pressure Exposure Coefficient, shown in Table 11-5 or by the equation: $k_z = 2.01(0.67h/900)^{(2/9.5)}$ where h = height of the structure above groundline

G_{RF} = Gust Response Factor, shown in Table 11-5 or by the equation : $G_{RF} = [1+(2.7E_s B_s^{0.5})]/k_v^2$ where
$E_s = 0.346 (33/(0.67\text{-}h)^{1/7}$ and
$B_s = 1/(1+0.8L/220)$
$k_v = 1.43$
h = height of the structure above groundline
L = design wind span (also known as HS)

C_f = drag coefficient

A = projected wind area in square feet

TABLE 11-5
STRUCTURE k_Z, G_{RF} , and COMBINED k_Z G_{RF} Factor

Height of Structure, ft	k_Z	G_{RF}	Combined 'k_Z G_{RF}' factor
≤ 33	0.92	1.02	0.94
34 – 50	1.00	0.97	0.97
51 – 80	1.10	0.93	1.02
81 – 115	1.20	0.89	1.07
116 – 165	1.30	0.86	1.12

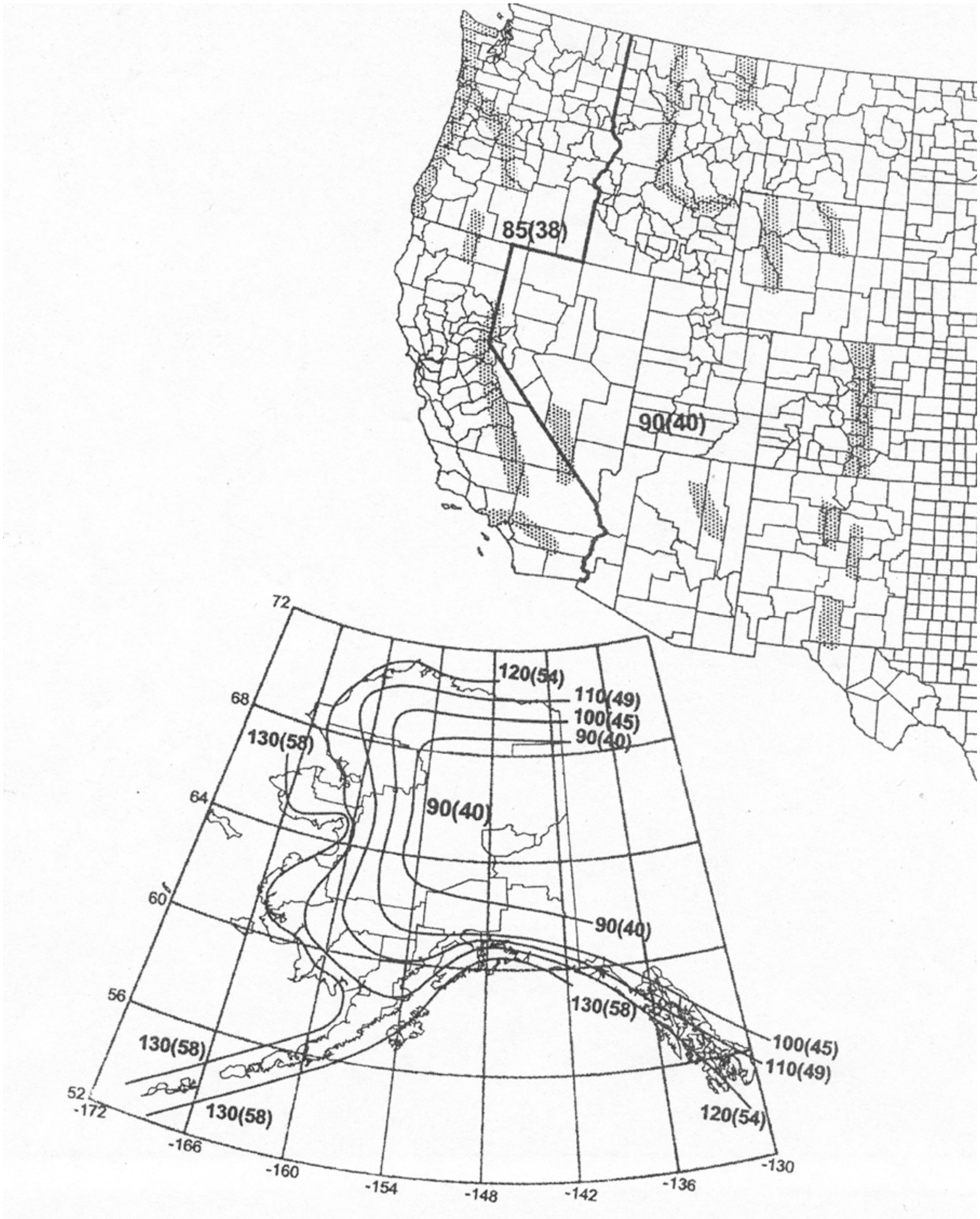
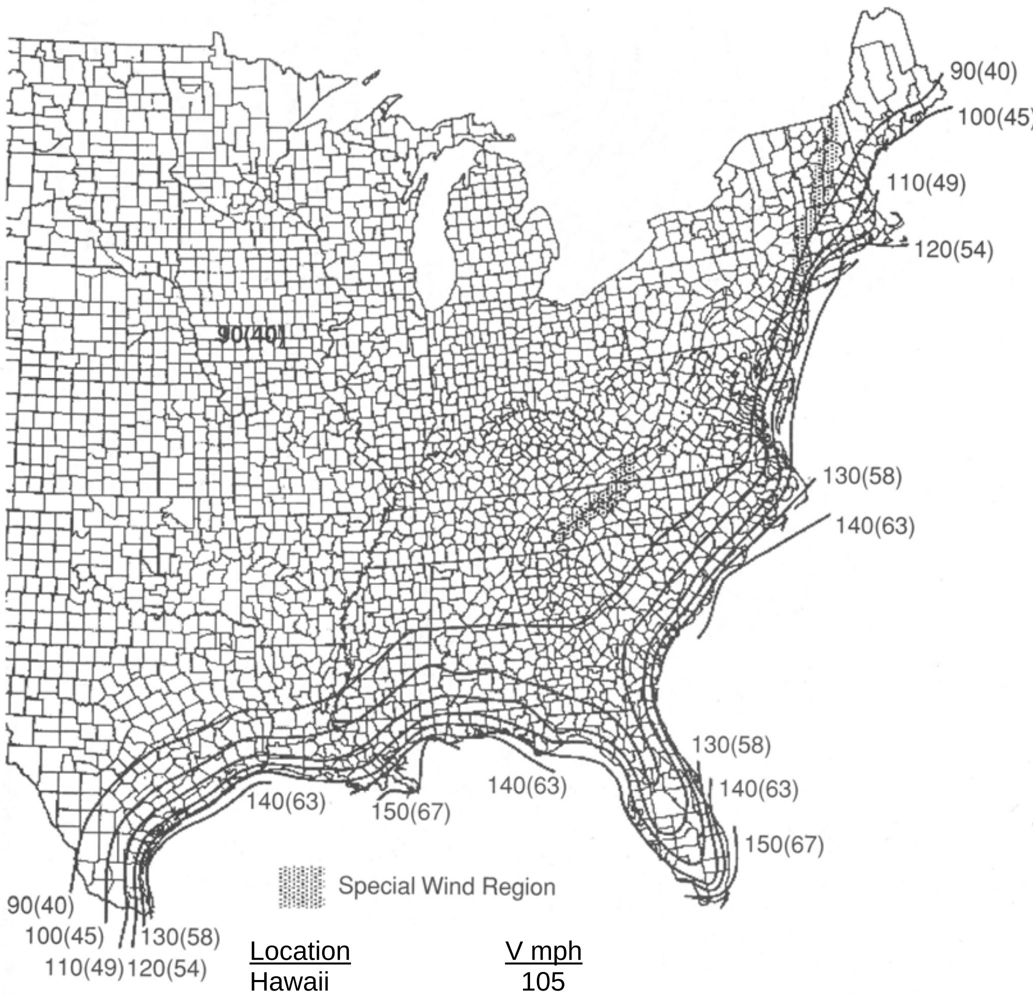


FIGURE 11-2a: EXTREME WIND SPEED IN MILES PER HOUR AT 33 FT. ABOVE GROUND (50-year mean recurrence interval)

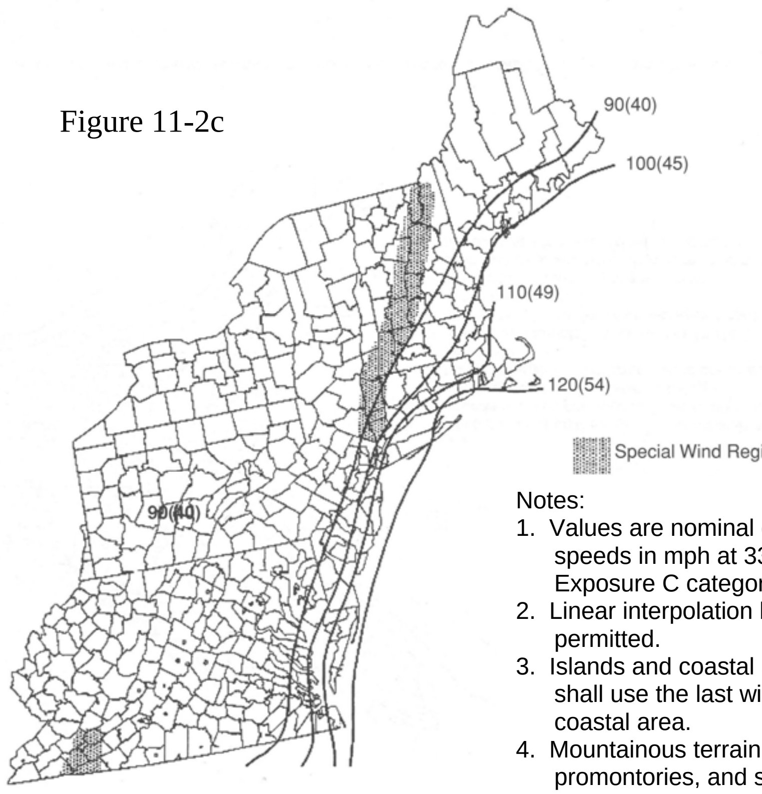


Location	V mph
Hawaii	105
Puerto Rico	145
Guam	170
Virgin Islands	145
American Samoa	125

Notes:
1. Values are nominal design 3-second gust wind speeds in miles per hour at 33 ft. above gound for Exposure C category.
2. Linear interpolation between wind contours is permitted.
3. Islands and coastal area outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.

FIGURE 11-2b: EXTREME WIND SPEED IN MILES PER HOUR
AT 33 FT. ABOVE GROUND
(50-year mean recurrence interval)

Figure 11-2c



Notes:
1. Values are nominal design 3-second gust wind speeds in mph at 33 ft above ground for Exposure C category.
2. Linear interpolation between wind contours is permitted.
3. Islands and coastal area outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.

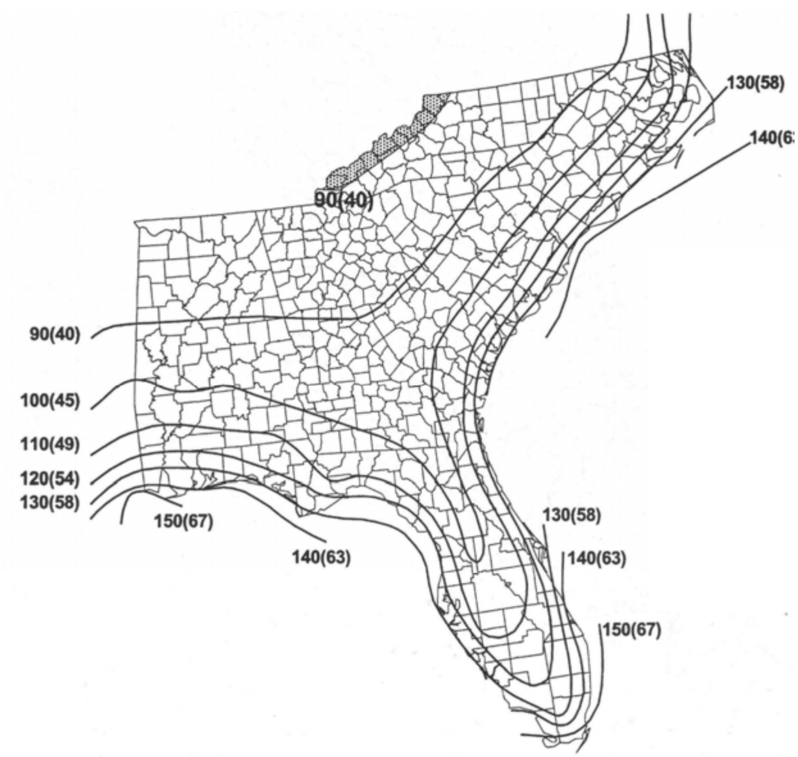


Figure 11-2d

FIGURES 11-2c,11-2d: EXTREME WIND SPEED IN MILES PER HOUR AT 33 FT.ABOVE GROUND FOR THE NORTHEAST AND SOUTHEAST
(50-year mean recurrence interval)

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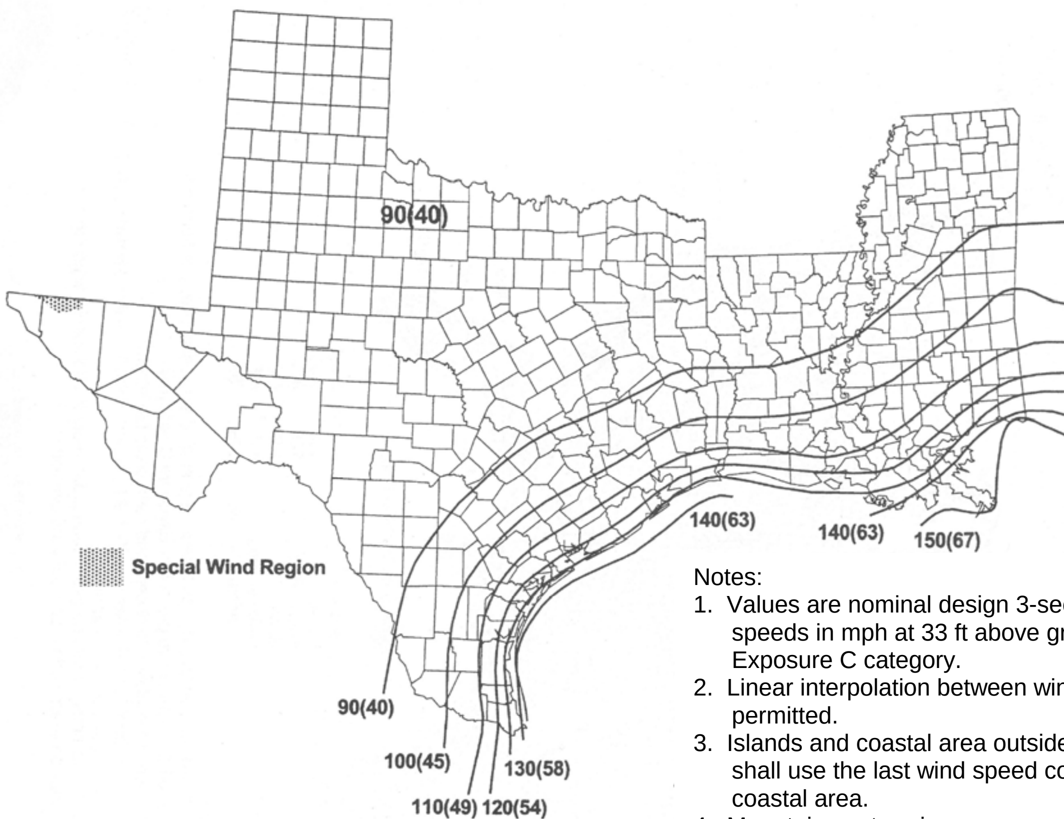
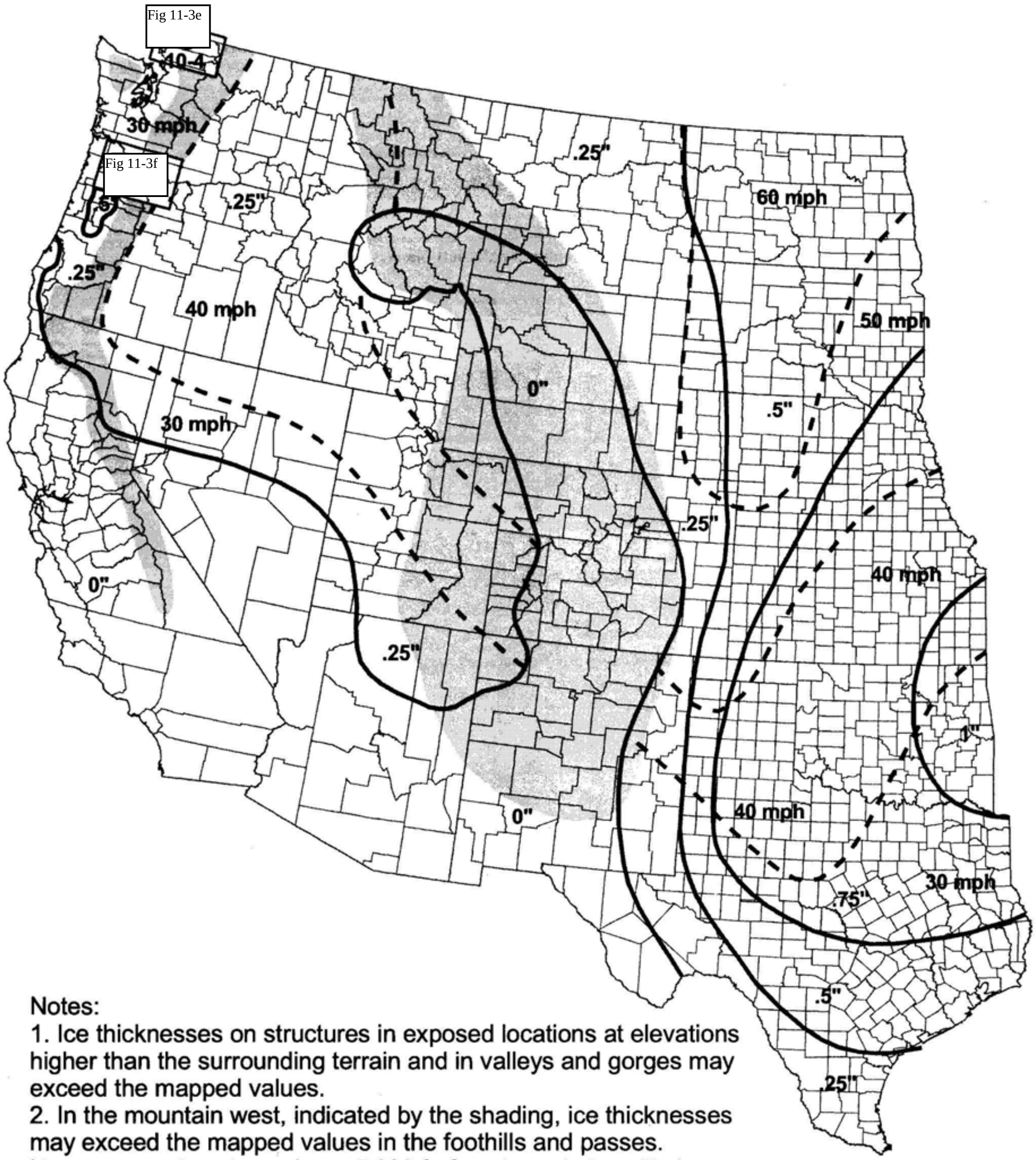


Notes:
1. Values are nominal design 3-second gust wind speeds in mph at 33 ft above ground for Exposure C category.
2. Linear interpolation between wind contours is permitted.
3. Islands and coastal area outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.

FIGURES 11-2e: EXTREME WIND SPEED IN MILES PER HOUR AT 33 FT ABOVE GROUND FOR TEXAS, LOUISIANA AND MISSISSIPPI
(50-year mean recurrence interval)

11.2.4 <u>Extreme Ice with Concurrent Wind Loads</u>: The NESC requires that structures over 60 ft. be designed to withstand the ice and wind loads associated with the Uniform Ice Thickness and Concurrent Wind Speed specified in NESC Figure 250-3 and in Figures 11-3a to 11-3d of this bulletin; however, it is recommended that all transmission lines meet these requirements. Required values for temperature, ice and wind are listed in Table 11-1.



Notes:
1. Ice thicknesses on structures in exposed locations at elevations higher than the surrounding terrain and in valleys and gorges may exceed the mapped values.
2. In the mountain west, indicated by the shading, ice thicknesses may exceed the mapped values in the foothills and passes. However, at elevations above 5,000 ft, freezing rain is unlikely.
3. In the Appalachian Mountains, indicated by the shading, ice thicknesses may vary significantly over short distances.

FIGURE 11-3a: UNIFORM ICE THICKNESS DUE TO FREEZING RAIN WITH CONCURRENT 3-SECOND GUST WIND SPEEDS (50 yr. mean recurrence)

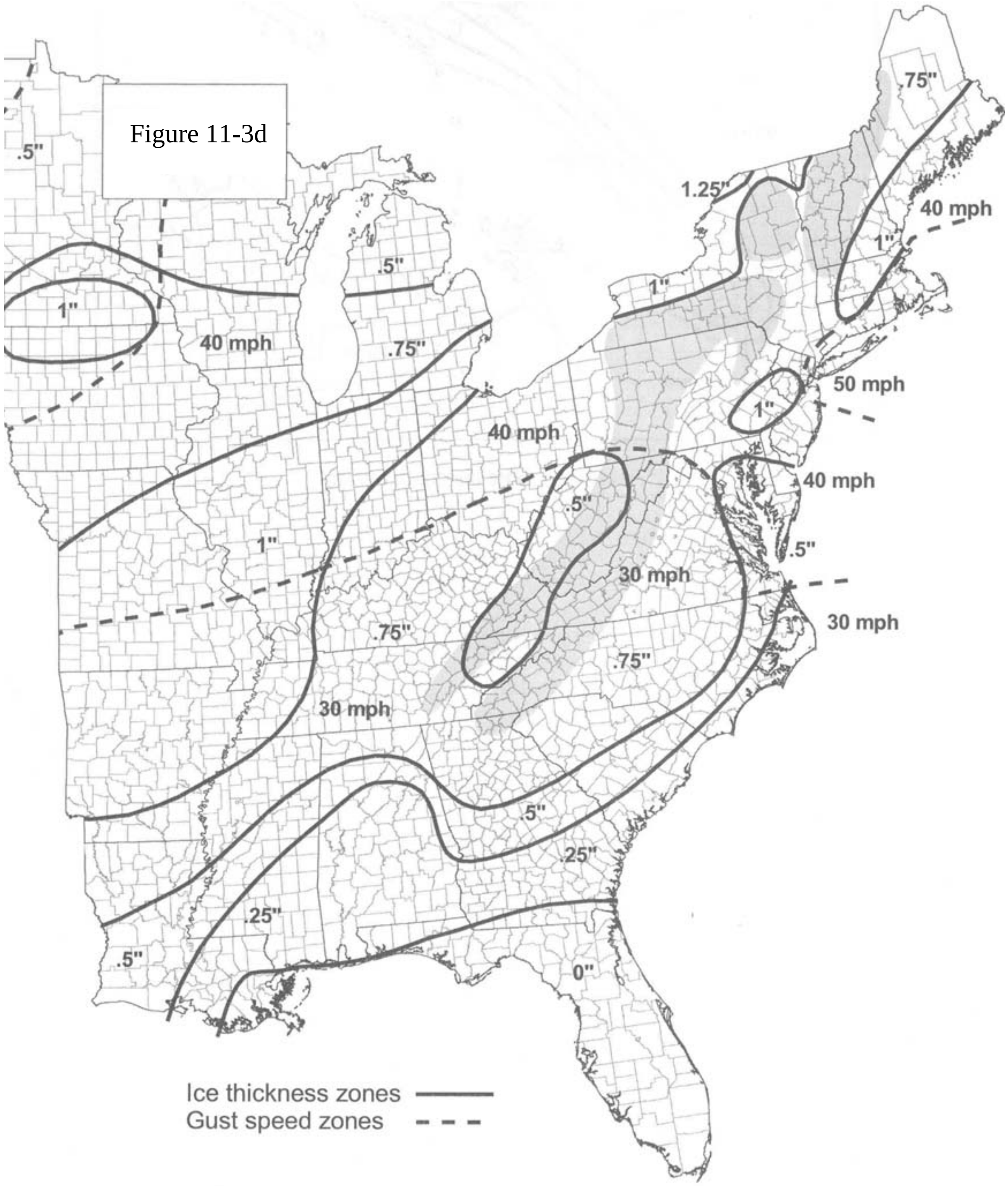


FIGURE 11-3b: UNIFORM ICE THICKNESS DUE TO FREEZING RAIN WITH CONCURRENT 3-SECOND GUST WIND SPEEDS (50 yr. mean recurrence)

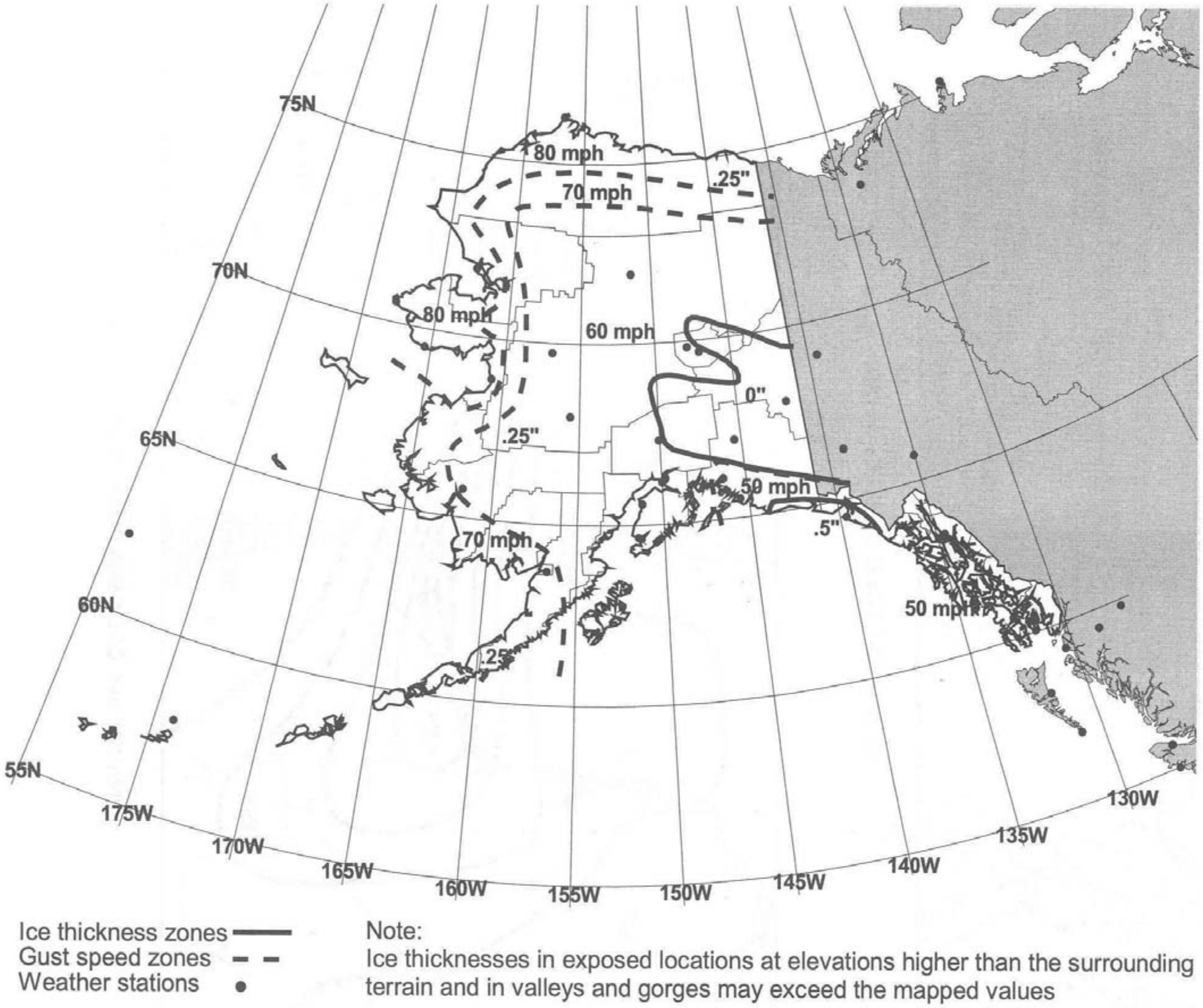


FIGURE 11-3c: UNIFORM ICE THICKNESS DUE TO FREEZING RAIN WITH CONCURRENT 3-SECOND GUST WIND SPEEDS FOR ALASKA
(50 year mean recurrence interval)

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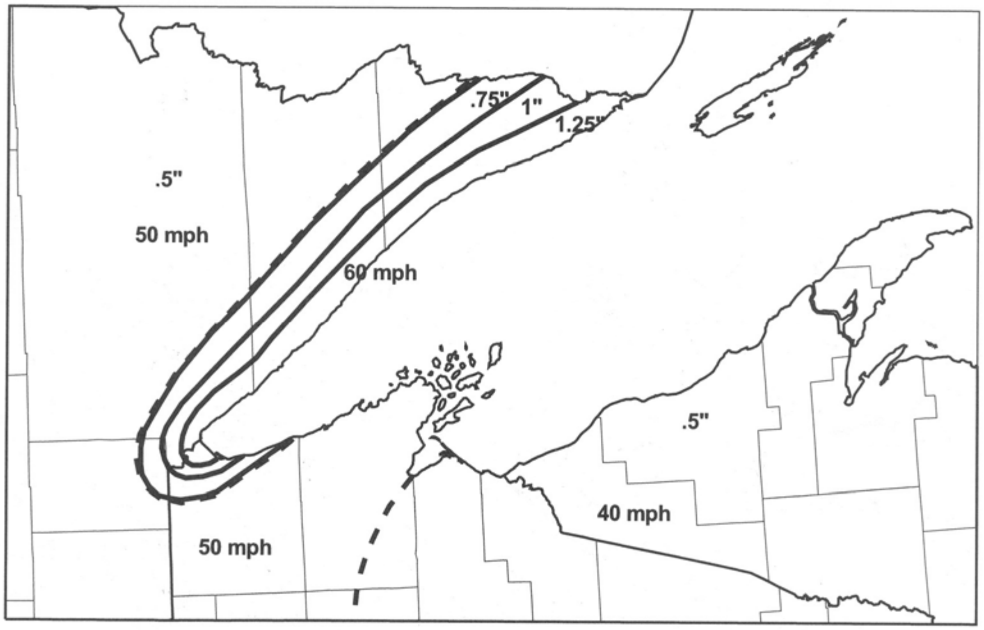

FIGURE 11-3d: UNIFORM ICE THICKNESS DUE TO FREEZING RAIN WITH CONCURRENT 3-SECOND GUST WIND SPEEDS FOR LAKE SUPERIOR (50 yr. mean recurrence)

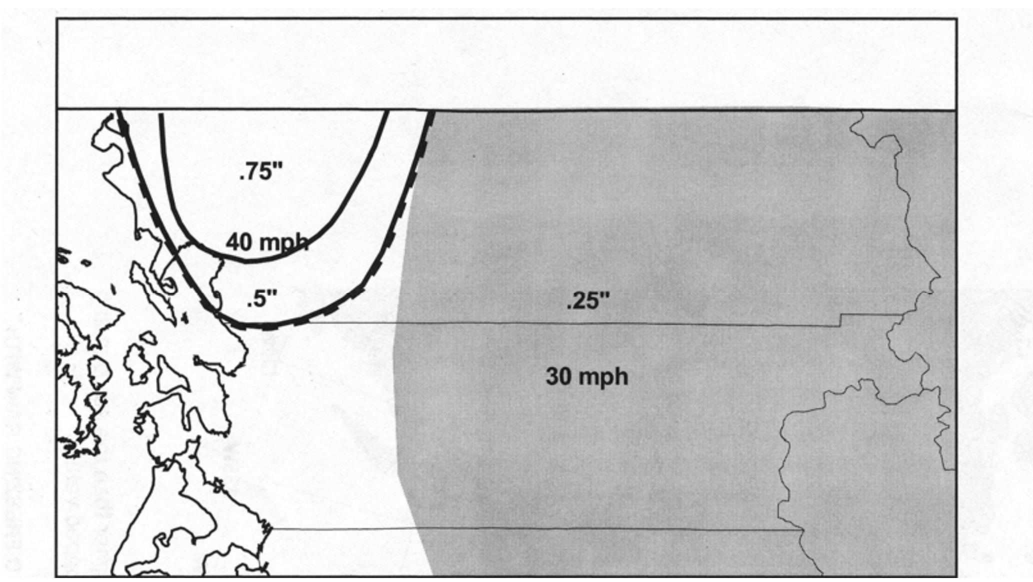

FIGURE 11-3e: UNIFORM ICE THICKNESS DUE TO FREEZING RAIN WITH CONCURRENT 3-SECOND GUST WIND SPEEDS FOR FRASER VALLEY DETAIL (50 yr. mean recurrence)

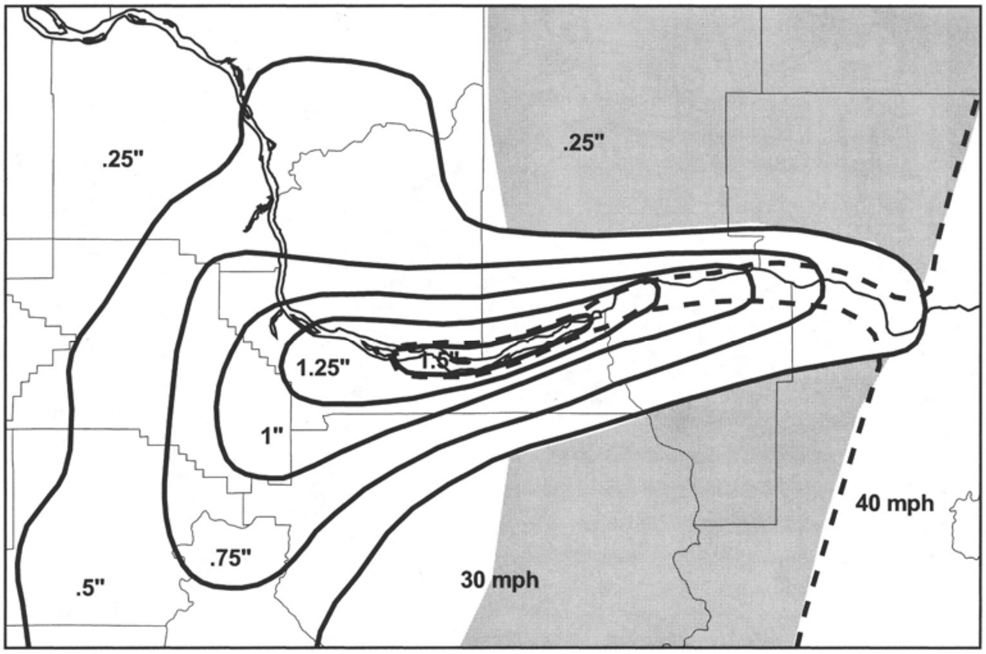

FIGURE 11-3f: UNIFORM ICE THICKNESS DUE TO FREEZING RAIN WITH CONCURRENT 3-SECOND GUST WIND SPEEDS FOR COLUMBIA RIVER GOUGE (50 yr. mean recurrence)

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11.2.5 <u>Longitudinal Loads</u>: Unbalanced longitudinal loads on a line may occur because of:

- Unequal wind load and/or differential ice conditions on equal or unequal spans
- Construction and maintenance activities
- A broken wire
- Stringing loads
- A change in ruling span

Traditionally, standard tangent wood pole structures have not been designed for broken conductor longitudinal loads and have relied on the restraining capacity of deadends. The 2002 edition of the NESC recommends that structures having a longitudinal strength capability be provided at reasonable intervals along the line.

Several methods to reduce the risk of cascading transmission line structures due to broken wires have been recommended in the American Society of Civil Engineers (ASCE) Manual and Report on Engineering Practice No. 74 "Guidelines for Electrical Transmission Line Structural Loading," copyright 1991. They are summarized below.

<u>Method 1, Install "Stop" Structures at Specified Intervals:</u> This method consists of placing deadend structures, longitudinal guys, or regular tangent structures designed to resist deadend loads at intervals along the line to limit the number of cascading structures to a manageable number. This method is most practical for H-frames or narrow-based lattice towers which do not possess enough inherent longitudinal capacity to resist longitudinal loads. In these cases, stop structures are used because the cost to strengthen each structure to resist cascading may be high and the addition of guys at each structure may not be desirable.

Method 2, Install Release Mechanisms**:** Slip or release-type suspension clamps may be used as "fuses" to limit the longitudinal loads applied by broken wires. This is actually very similar to Method 1. The major difference between Method 1 and this Method is that "fuses" are used to minimize the unbalanced loads used to design each structure. The structures also have to be capable of withstanding construction and maintenance loads without endangering line crew personnel. Where heavy ice buildups are frequent, this could be an insurmountable problem. As such, this method is not recommended in areas of heavy ice, since unbalanced ice loads could result in unexpected failures.

Method 3, Design All Structures for Broken Wire Loads: Rigid lattice towers, guyed tangents (guyed in four directions) and single-shaft pole structures have an inherent longitudinal capacity. In many instances, such structures can be economically designed to resist longitudinal loads. The loads are typically based on the "residual static load" (RSL). The RSL is a load at a wire support after breaking one phase or a ground wire under every day conditions (no ice, no wind, 60ºF). Considerations in determining the RSL include insulator swing, structure deflection and suspension clamp slippage. Some designers have used 60 percent to 70 percent of the every day tension for conductors and 100 percent of the every day tension for ground wires. The suggested longitudinal loading consists of applying RSLs in one direction to a nominal one-third of conductor support points or to one (or both) ground wire support point(s). The suggested vertical loading consists of one-half or more of the vertical load(s) imposed by the broken wire(s) along with all of the vertical loads imposed by the other intact wires. Although every structure is designed to resist cascading, in the event of the catastrophic loss of a single structure, localized failures in adjacent structures should be expected.

A blend of Methods 2 and 3 would involve designing the main body of the structure (or pole) for slightly larger longitudinal loads than those used for the design of the support arms and/or ground wire peak. The idea is to limit the loads applied to the body of the structure (or pole) by "sacrificing" the arms or ground wire peak, thereby reducing the number of poles damaged from a broken wire event and decrease the likelihood of an unmanageable cascade. If such a event occurred, it could result in damage to several (perhaps numerous) support arms and/or ground wire peaks.

11.2.6 Example of Extreme Wind Calculations: A proposed 161 kV line using the TH-10 structure is expected to have spans ranging from 501 to 900 feet and to be composed of structures with wood poles 60 to 90 feet high. The line is expected to be located in northern Mississippi and will have a 795 26/7 ACSR conductor. Calculate the extreme wind load to be used in the design.

Extreme wind calculations are made for wind on the wires and wind on the structure. For wind on the wires, the engineer should calculate the wind on the overhead groundwires and the wind on the conductors. For wind on the overhead groundwires, a review of Table 11-4 indicates that 0.9 to 0.85 is to be used for the combined factor of $\mathbf{k_Z * G_{RF}}$' for spans 501 to 1000 feet and for wire heights 52 feet to 79 feet above ground (for structures using 60 to 90 foot poles). The conductors on the TH-10 are located approximately 13 feet from the top of the pole. The height from the ground to the conductors at the structure will range from 39 to 63 feet above ground. . For wind on the conductors, review of Table 11-4 indicates that values of 0.9 to 0.79 may be used as the combined factor of '$\mathbf{k_Z * G_{RF}}$' for spans 501 to 900 and for wire heights 39 to 63. (Poles are 52 feet to 79 feet above ground).

For wind on the structures, use Table 11-5. For structures of heights 52 to 79 feet above ground, Table 11-5 indicates that the combined '$\mathbf{k_Z * G_{RF}}$' factor for the structure is 1.02.

Wind pressure (psf) on the overhead groundwires:

$p = 0.00256 * V^2 * k_z * G_{RF}$

$p = 0.00256 * 90^2 * 0.9$

p = 18.66 psf; use 19 psf in design

Wind pressure (psf) on the conductors:

$p = 0.00256 * V^2 * k_z * G_{RF}$

$p = 0.00256 * 90^2 * 0.9$

p = 18.66 psf; use 19 psf in design

Wind pressure (psf) on the structure:

$p = 0.00256 * V^2 * k_z * G_{RF}$

$p = 0.00256 * 90^2 * 1.02$

p = 21.15 psf; use 22 psf in design

For 21 psf, the unit trnasverse load on the conductor p_t = 1.9390 lbs/ft (Appendix B)
Therefore, for 19 psf, the unit load will be 1.7543 lbs/ft (or 1.9390x19/21)

11.2.7 Example of Extreme Ice/Wind Calculations:

Using the same example line in the previous paragraph (11.2.6), the line located in northern Mississppi has a combined ice and wind load of .75inch of ice and a 30 psf wind. Calculate the transverse and vertical unit loads on the conductor.

For the transverse unit load:
The diameter of the conductor including ice = 1.108 in (Appendix B) + (.75x2) = 2.608 in..
The unit wind load on the conductor p_t = 30 lbs/ft^2 x 2.608 inches/12in/ft x 1ft = 6.520 lbs/ft

For the vertical unit load:
The vertical unit load, w_c, is the dead weight of the conductor plus the ice load per foot of conductor = 1.0940 lbs/ft + $[3.1416((1.108+(2x.75))^2 – (1.108)^2)/4/144 \times 1 \text{ ft}] \times 57 \text{ lbs/ft}^3$ = 2.8269 lbs/ft

11.3 Load Factors for New Construction: Agency transmission lines are to be built to Grade B construction. In Table 11-6, the columns under the Rural Utilities Service headings give the recommended minimum load factors to be applied to the light, medium, and heavy loading districts of the NESC and also the recommended strength factors to be applied in the design of guys, anchors, crossarms, and structures.

Recommended load factors and strength factors to be applied to extreme wind loadings are in Table 11-7. The factors are intended to take into account approximations made in the design and analysis.

11.4 Application of Load Factors and Strength Factors: In the application of the load factors and strength factors, the objective is to design a structure with resistance greater than the maximum load expected during the lifetime of the structure and to design the structure with an acceptable level of safety and reliability. The use of load factors and strength factors can be expressed as follow:

$$\O R \geq (LF)Q \qquad \text{Eq. 11-3}$$

where:

R	=	measure of material strength or resistance
Ø	=	a strength factor, less than 1.0
Q	=	load
LF	=	load factor, greater than 1.0

'Ø' is a multiplier which limits the resistance, R, and accounts for the variability of the resistance property. '(LF)' is a multiplier that compensates for uncertainty in the load or assumptions made in the analysis. 'Ø' and '(LF)' may be based on statistics, past engineering judgment, past practice, or may be legislated.

The traditional view of a safety factor (or load factor) may be expressed as 'LF' divided by 'Ø'.

Tables 11-6 and 11-7 are based on the relationship defined in Equation 11-3. In previous editions of this bulletin, the method using the load factors was used. That method has been dropped from this bulletin.

11.4.1 Example Calculation Showing the Use of Strength and Load Factors:
A Douglas fir, 80 ft. tangent pole is to sustain a 750 lbs. transverse load two feet from the top. Assume this load is based on NESC heavy loading district loads. What class pole should be used for this construction? The pole is embedded 10 feet. The length of the moment arm used to calculate the induced moment at groundline is 68 feet.

In this case, R is the moment capacity of the pole at groundline and 'Q' is the horizontal load (750 lbs.). Using the strength factors (Ø) and load factors (LF) from Table 11-6, Equation 11-3 becomes:

$$\O R \geq (LF)Q$$

$$0.65M_{\text{Moment capacity at the groundline}} \geq 2.50(750\text{ lbs})(68\text{ feet})$$

$$M_{\text{Moment capacity at the groundline}} \geq 196{,}154\text{ ft.-lbs}$$

The pole should have a moment capacity of 196 ft-kips at the groundline. A class 3 Douglas fir pole would provide this moment capacity at the groundline.

11.4.2 Additional Examples Showing the Application of Loads and the Use of Strength and Load Factors: Chapters 13 and 14 demonstrate the application of strength and load factors in the structural analyses examples.

TABLE 11-6
RECOMMENDED LOAD FACTORS AND STRENGTH FACTORS
TO BE APPLIED TO NESC DISTRICT LOADS
(Grade B New Construction)
(NESC Tables 253-1 and 261-1A) (Note 5)

FACTORS	NESC	RUS
LOAD FACTORS		
Vertical Loads	1.50	1.50
Transverse Loads		
Wind	2.50	2.50
Wire Tension	1.65	1.65
Longitudinal Loads		
At crossings		
General	1.10	1.33
Deadends	1.65	1.65
Elsewhere		
General	1.00	1.33
Deadends	1.65	1.65
STRENGTH FACTORS (Note 3)		
Steel and Prestressed Concrete Structures	1.00	1.00
Wood Poles (Note 4)	0.65	0.65
Wood Crossarms (Note 4)	0.65	0.50
Guy Wire Assemblies	0.90	0.65 (Note 1)
Guy Anchors and Foundations	1.00	0.65
Guy Attachment Assemblies (includes guy hardware)	1.00	0.65 (Note 2)
Conductor Support Hardware (Note 6)	1.00	1.00

Notes:

1. A value different than 0.65 may be used, but should not exceed 0.9.
2. This strength factor of 0.65 may be increased for steel and prestressed concrete poles.
3. It is recognized that structures will experience some level of deterioration after installation. These strength factors are for new construction.
4. For wood structures, when the deterioration reduces the structure strength to 2/3 of that required when installed, the wood structure should be replaced or rehabilitated. If the structure or structure component is replaced, the structure or structure component needs to meet the strength for the original grade of construction. The rehabilitated portions of the structures have to be greater that 2/3 of that required when installed for the life of the line.
5. When calculating the additional moment due to deflection, deflections should be calculated using loads prior to application of the load factor.
6. Conductor Support Hardware is any hardware not a part of the structure, guy assembly, or guy attachment. Conductor support hardware may be splices, extension links, insulator string yokes, y-clevis balls, ball hooks, deadend clamps, etc.

TABLE 11-7
RECOMMENDED LOAD FACTORS AND STRENGTH FACTORS
TO BE APPLIED TO EXTREME WIND LOADS (Rule 250C of the NESC)
AND TO EXTREME WIND/ICE LOADS (Rule 250D of the NESC)
(Grade B New Construction)
(NESC Tables 253-1 and 261-1A) (Note 5)

FACTORS	**NESC**	**RUS**
LOAD FACTORS		
Vertical Loads	1.00	1.10
Transverse Loads		
Wind	1.00	1.10
Wire Tension	1.00	1.00
Longitudinal Loads		
At crossings		
General	1.00	1.00
Deadends	1.00	1.10
Elsewhere		
General	1.00	1.00
Deadends	1.00	1.10
STRENGTH FACTORS (Note 3)		
Steel and Prestressed Concrete Structures	1.00	1.00
Wood Poles (Note 4)	0.75	0.75
Wood Crossarms (Note 4)	0.75	0.65
Guy Wire Assemblies	0.90	0.65 (Note 1)
Guy Anchors and Foundations	1.00	0.65
Guy Attachment Assemblies (includes guy hardware, bracket and guy attachment assemblies)	Not Specified	0.65 (Note 2)
Conductor Support Hardware (Note 6)	0.80	0.80

Notes:
1. A value different than 0.65 may be used, but should not exceed 0.90.
2. This strength factor of 0.65 may be increased for steel and prestressed concrete poles.
3. It is recognized that structures will experience some level of deterioration after installation. These strength factors are for new construction.
4. For wood structures, when the deterioration reduces the structure strength to 2/3 of that required when installed, the wood structure should be replaced or rehabilitated. If the structure or structure component is replaced, the structure or structure component needs to meet the strength for the original grade of construction. The rehabilitated portions of the structures have to be greater that 2/3 of that required when installed for the life of the line.
5. When calculating the additional moment due to deflection, deflections should be calculated using loads prior to application of the load factor.
6. Conductor Support Hardware is any hardware not a part of the structure, guy assembly, or guy attachment. Conductor support hardware may be splices, extension links, insulator string yokes, y-clevis balls, ball hooks, deadend clamps, etc.

12. FOUNDATION STABILITY OF DIRECT-EMBEDDED POLES

12.1 General: Every structure standing above ground is subjected to lateral forces. In the case of direct-embedded wood, steel or prestressed concrete transmission structures, it is desirable to depend on the earth to resist lateral forces. The embedded portion of a pole provides this resistance by distributing the lateral load over a sufficient area of soil. A properly selected embedment depth should prevent poles from kicking out. With time, single poles may not remain plumb. Leaning of single pole structures is sometimes permitted, provided excessive angular displacements are avoided, pole strength is adequate considering additional loads from the pole being out of plum and adequate clearances are maintained.

The lateral forces to which wood transmission structures are subjected are primarily forces due to wind and wire tension loads due to line angles. Longitudinal loads due to deadending or uniform ice on unequal spans should be examined to see how they affect embedment depths. Normally, flexible transmission structures are stabilized longitudinally by the overhead ground wire and phase conductors.

Bearing and lateral earth capacity of soils depend on soil types and soil characteristics such as internal friction, cohesion, unit weight, moisture content, gradation of fines, consolidation and plasticity. Most soils are a combination of a cohesive soil (clay) and cohesionless soil (sand).

12.2 Site Survey

12.2.1 Soil Borings: Depending on the transmission line and knowledge of the soil conditions along the corridor, soil borings may or may not be taken. If the line is composed of H2 or higher class wood poles, or equivalent strength steel or concrete poles, the engineer may elect to take soil borings. The decision to take borings will also depend on existing soil information. Variation of the soil will determine the frequency of the borings. Borings might also be considered at unguyed angle structures and deadend structures composed of steel or concrete poles.

12.2.2 Embedment Depths: In deciding embedment depths for many typical agency borrower wood pole construction, economics dictate that few, if any, soil borings be taken when data and experience from previous lines are available. Numerous soil conditions will be encountered in the field. Although the soil conditions may closely resemble each other, the soils may have a wide range of strengths. The engineer, therefore, has to identify areas or conditions where pole embedment depths in soil may have to be greater than the minimum depth of 10 percent, plus 2 feet.

Areas where the designer needs to consider additional embedment depths include (but are not limited to):

- Low areas near streams, rivers, or other bodies of water where a high water table or a fluctuating water table is probable. Poles in a sandy soil with a high water table may "kick" out. Due to the lubricating action of water, frictional forces along the surface area of embedded poles are reduced. The legs of H-frames may "walk" out of the ground if neither sufficient depth nor bog shoes are provided to resist uplift. Guy anchors may fail if the design capacity does not consider the submerged weight of the soil.

- Areas where the soil is loose such as soft clay, poorly compacted sand, pliable soil, or soil which is highly organic in nature.

- Locations where higher safety is desired. This may be at locations of unguyed small angle structures where a portion of the load is relatively permanent in nature, or at river, line, or road crossings.

- Locations where poles are set adjacent to or on steep grades.

- Locations where more heavily loaded poles are used.

- Locations where underground utilities such as water or sewer will be located next to the pole.

12.2.3 Field Survey: A field survey is necessary in order to judge whether a soil is "good," "average," or "poor." There are several economical methods to make a field survey for wood transmission lines. The engineer may use a hand auger, light penetrometer, or torque probe. The meaning of terms such as firm, stiff, soft, dense, and loose may not always be clear. Table 12-1 will help to clarify these terms:

TABLE 12-1
CLASSIFICATION OF SOILS BASED ON FIELD TESTS

Term	Field Test
Very soft	Squeezes between fingers when fist is closed
Soft	Easily molded by fingers
Firm	Molded by strong pressure of fingers
Stiff	Dented by strong pressure of fingers
Very Stiff	Dented only slightly by finger pressure
Hard	Dented only slightly by pencil point
Term	Field Test
Loose	Easily penetrated with a 1/2 in. reinforcing rod pushed by hand
Firm	Easily penetrated with a 1/2 in. reinforcing rod driven with a 5 lb. hammer
Dense	Penetrated 1 ft. with a 1/2 in. reinforcing rod with a 5 lb. Hammer
Very dense	Penetrated only a few inches with a 1/2 in. reinforcing rod driven with a 5 lb. hammer

12.3 Pole Stability

12.3.1 Wood Poles: In addition to local experience with wood poles, the graphs in Figures 12-1 through 12-3 may be used to approximate embedment depths. To use the charts, good, average, and poor soils have to be defined. The following are proposed as descriptions of good, average, and poor soils:

Good: Very dense, well graded sand and gravel, hard clay, dense, well graded, fine and coarse sand.

Average: Firm clay, firm sand and gravel, compact sandy loam.

Poor: Soft clay, poorly compacted sands (loose, coarse, or fine sand), wet clays and soft clayey silt

The graphs in Figures 12-1 through 12-3 are based on Equation 12-1:

$$P = \frac{S_e D_e^{3.75}}{L - 2. - .662 D_e} \qquad \text{Eq. 12-1}$$

where:

P = horizontal force in pounds 2 feet from the top that will overturn the pole
S_e = Soil constant
140 for good soils
70 for average soils
35 for poor soils
D_e = embedment depth of pole in feet.
L = total length of pole in feet.

Embedment depth can be determined once an equivalent horizontal load 2 feet from the top is calculated. This horizontal load is calculated by dividing the total ground line moment by the lever arm to 2 feet from the top of the pole.

Equation 12-1 is taken from "Effect of Depth of Embedment on Pole Stability," Wood Preserving News, Vol X, No. 11, November, 1932.

Some general observations can be made concerning wood pole embedment depths:

- The rule of thumb of "10 percent + 2 ft." is adequate for most wood pole structures in good soil and not subjected to heavy loadings.
- For Class 2 and larger class poles and poles of heights less than 60 ft., pole embedment depths should be increased 2 ft. or more in poor soil (single pole structures).
- For Class 2 and larger class poles and poles of heights less than 40 ft., pole embedment depths should be increased 1-2 ft. in average soil (single pole structures).
- For H-frame wood structures, "10 percent + 2 ft." seems to be adequate for lateral strengths. Embedment depths are often controlled by pullout resistance.

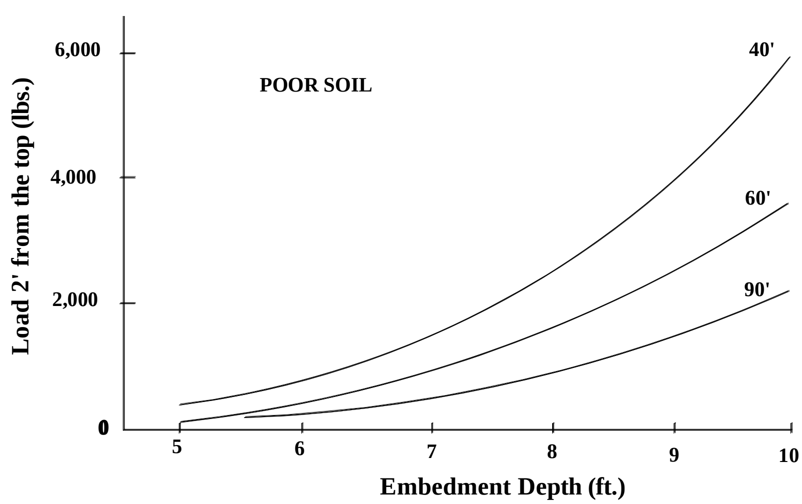


FIGURE 12-1: EMBEDMENT DEPTHS IN POOR SOIL

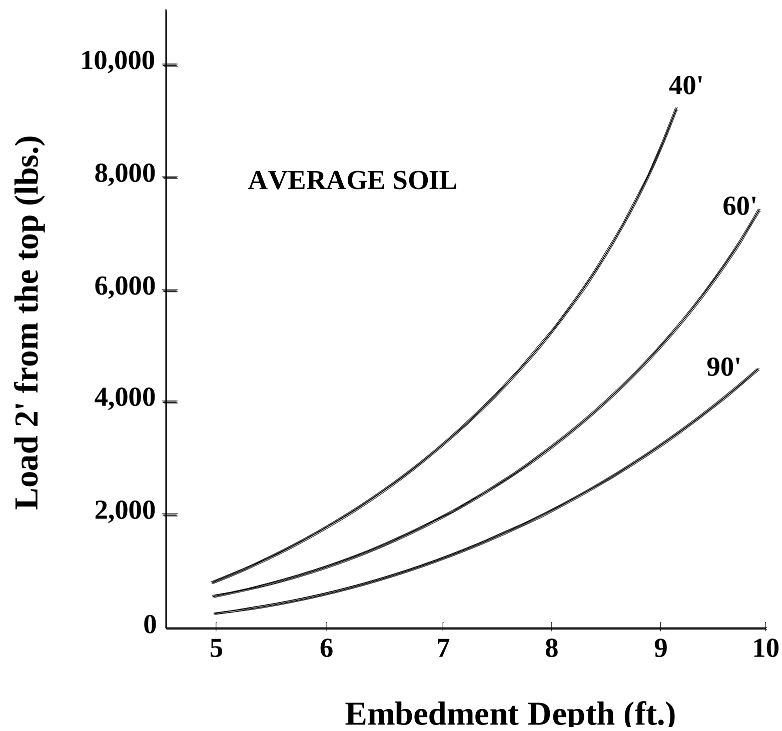


FIGURE 12-2: EMBEDMENT DEPTHS IN AVERAGE SOIL

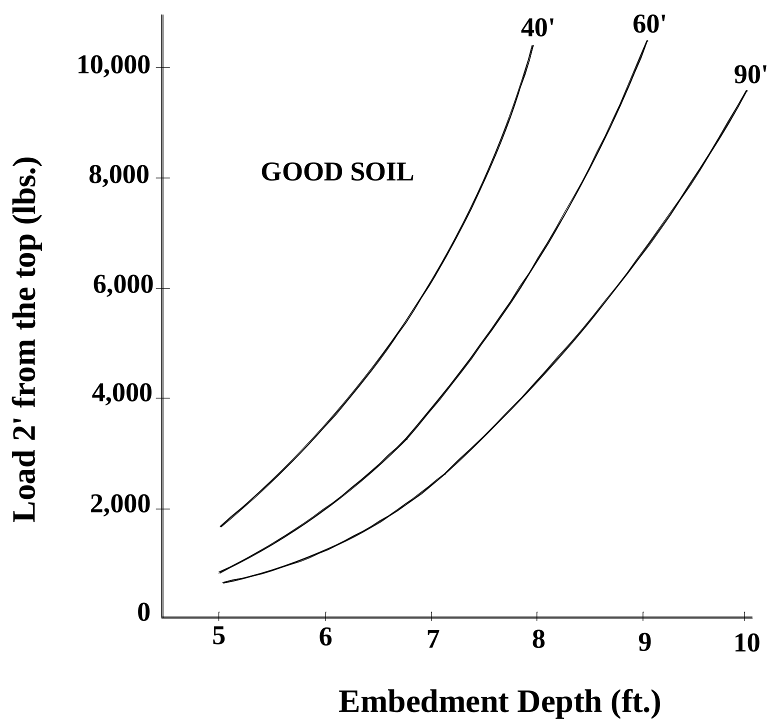


FIGURE 12-3: EMBEDMENT DEPTHS IN GOOD SOIL

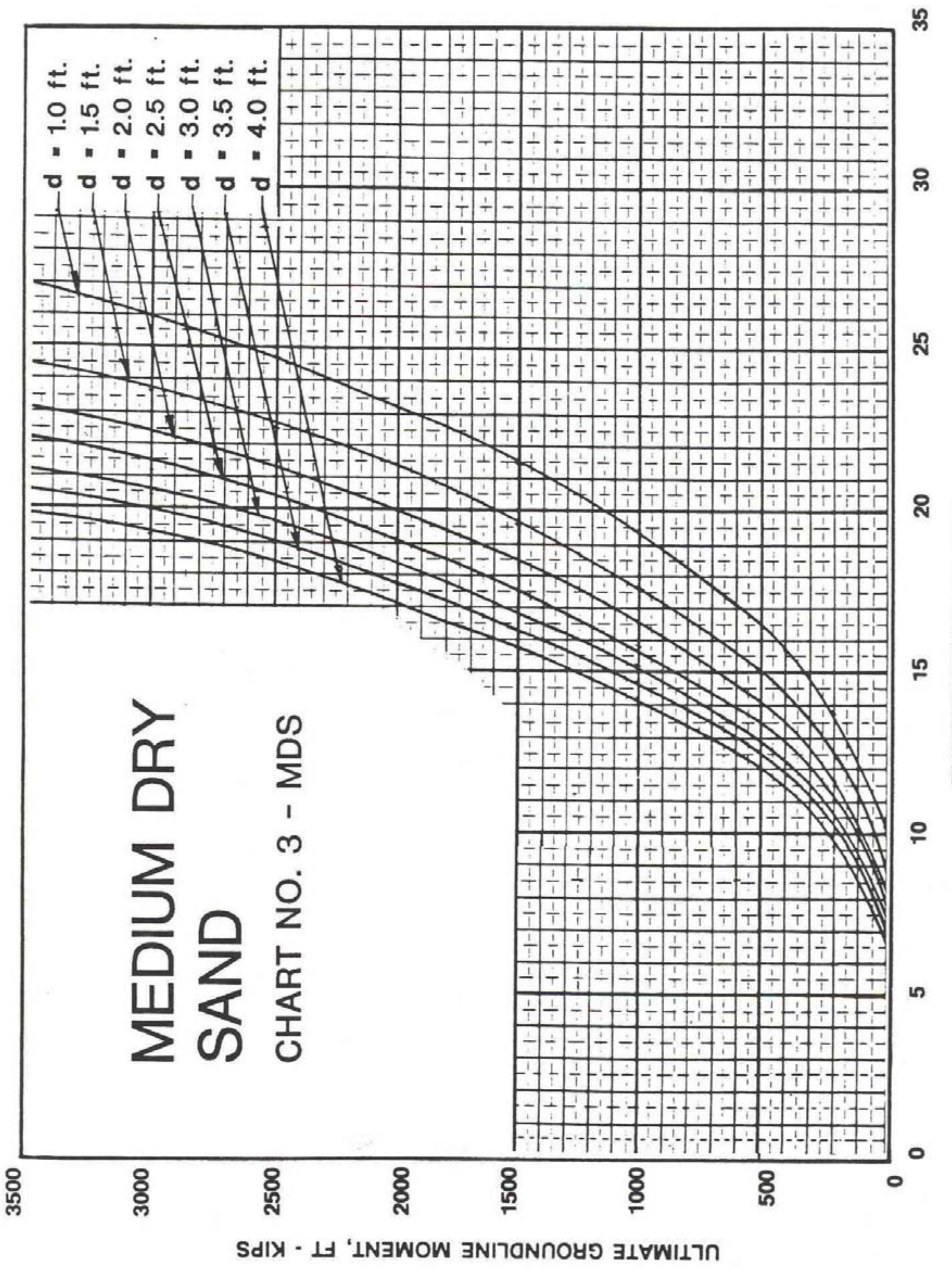


FIGURE 12-4: EMBEDMENT CHART FOR MEDIUM DRY SAND
AGENCY BULLETIN 1724E-205 "EMBEDMENT DEPTHS FOR CONCRETE AND STEEL POLES"

12.3.2 <u>Direct Embedded Steel and Concrete Poles</u>: In agency Bulletin 1724E-205, “Embedment Depths for Concrete and Steel Poles,” embedment charts are provided for concrete and steel transmission poles sustaining relatively large overturning moments. The information in Bulletin 1724E-205 may be used to approximate embedment depths for cost estimates, to make preliminary selection of embedment depths and to verify or check selection of embedment depths based on other or more exact methods. Sample calculations illustrating the use of the embedment charts and illustrating the use of design methods for those occasions when the charts cannot be used, are also provided in Bulletin 1724E-205.

In that bulletin, nine embedment charts have been developed for nine soil types. These charts show embedment depths for pole diameters ranging from 1.0 to 4.0 feet and ultimate moments at groundline up to 3500 ft-kips. A sample chart for medium sand is shown in Figure 12-4 of this bulletin.

Several computer programs exist for determining embedment depths for steel and concrete poles. Such programs may provide a more efficient selection of embedment depths in preliminary design and their use should be considered in any final design.

12.3.3 <u>Replumbing</u>: If a search of previous experience in an area indicates that single pole lines have had to be replumbed, there are several methods which should be considered in order to reduce the frequency of replumbing of a new line to be located in the same area. These methods are as follows:

- Use a lower grade species of wood in order to increase embedment diameters. For instance, embedment diameters for Class 1 Western red cedar poles will be greater than embedment diameters for Douglas fir.
- Use aggregate backfill.
- Install a pole key with or without a pole toe of crushed stone, gravel, or concrete.
- Embed one foot deeper (or more).
- In the case of more heavily loaded steel and prestressed concrete poles, consideration should be given to the use of concrete backfill.

12.4 <u>Bearing Capacity</u>: To prevent a guyed pole from continually sinking into the ground due to induced vertical loads, the pole butt should provide sufficient bearing surface area. If little soil information is available, local building codes (Table 12-2) might be helpful in determining allowable bearing capacities. These values are usually conservative and reflect the hazards associated with differential deflection in a building. Fortunately, transmission lines can sustain deflections on the order of several times that of buildings without detrimentally affecting their performance. The bearing capacity of guyed poles is not as critical as that for buildings. Good engineering judgment and local experience should be used in determining if bearing capacities of a certain soil will be exceeded by guyed poles. Table 12-3 suggests ranges of ultimate bearing capacities.

TABLE 12-2
PRESUMPTIVE ALLOWABLE BEARING CAPACITIES, ksf

Soil Description	Chicago 1966	Atlanta 1950	Uniform Building Code 1964
Clay, very soft	0.5	2.0	1.5
Clay, soft	1.5	2.0	1.5
Clay, ordinary	2.5	4.0	
Clay, medium stiff	3.5		2.5
Clay, stiff	4.5	4.0	
Clay, hard	6.0		8.0
Sand, compact and clean	5.0		
Sand, compact and silty	3.0		
Inorganic silt, compact	2.5		1.5
Sand, loose and fine			1.5
Sand, loose and coarse, or sand-gravel mixture, or compact and fine			2.5
Gravel, loose, and compact coarse sand		8.0	8.0
Sand-gravel, compact		12.0	8.0
Hardpan, cemented sand, cemented gravel	12.0	20.0	
Soft rock			
Sedimentary layered rock (hard shale, sandstone, siltstone)		30.0	
Bedrock	200.0	200.0	

TABLE 12-3
SUGGESTED RANGES OF PRESUMPTIVE
ULTIMATE BEARING CAPACITIES, psf*

Specific Description (Dry)	psf
Clay, soft	2000 - 6000
Clay, ordinary	6000 - 9000
Clay, stiff	12000
Clay, hard	15000
Sand, loose	4500
Sand, compact and silty	9000
Sand, compact and clean	15000
Hardpan	40000
General Description (Dry)	
Poor Soil	1500 - 4000
Average Soil	5000 – 9000
Good soil	12000 - 18000

Note:
Ultimate values are based on three times allowable. The values in the table are considered approximate. For more accurate bearing capacity values, bearing capacity equations should be used.

12.5 <u>Uplift</u>: When H-frame structures with X-braces are subject to overturning forces, one leg will be in compression and one leg in tension. The skin friction assumed in design should be based on past experience encountered by the engineer, experience of nearby lines, and the results of the field survey. The following may be appropriate for average soil:

- If the soil is wet or subject to frequent wettings, an ultimate skin friction not greater than 100 psf should probably be assumed;

- If native soil is used as backfill, an ultimate skin friction between 100 and 500 psf should be assumed, provided the soil is not subject to frequent wettings;

- If an aggregate backfill is used, an ultimate skin friction between 250 and 1000 psf may be possible;

- Pole "bearing" shoes increase uplift capacity of a dry hole with natural backfill on the order of 2 to 2.5 times. The use of aggregate backfill with bearing shoes is usually not necessary provided the native backfill material is of relatively good material; and

- In many cases, double cross-braced H-frame structures may require uplift shoes.

12.6 <u>Construction - Backfill</u>: Lateral and uplift resistance of wood poles will depend not only on type of soil, moisture content of the soil, depth of setting, but also on how well the backfill has been tamped.

All water should be removed before backfilling. If native backfill material is to be used, it should be free of grass, weeds, and other organic materials. If the dirt removed from the hole is too wet or has frozen, dry, unfrozen material should be obtained for the backfill. Where the earth removed from the hole is unsuitable as backfill, special backfill should be specified by the engineer. Drawing TM-101 included in agency Bulletins 1728F-810 and 811 suggests a gradation of aggregate to be used as backfill material.

When backfilling, the soil should be placed and compacted in shallow layers (approximately 6 inch layers). Each layer should be compacted until the tamp makes a solid sound as the earth is struck. Power tamping is preferred using two power tampers and one shoveler. The importance of proper compaction of the backfill cannot be overemphasized. Insufficient tamping is a common source of trouble and has been the cause of some failures.

13. STRUCTURES

13.1 Economic Study: During preliminary planning stages of lines above 161 kV, studies should be made to evaluate the economics of different types of structures as related to conductor size. In most instances, for lines of 230 kV and below, wood structures have historically been the economical choice. However, in more heavily loaded situations (larger wires, longer spans) steel and prestressed concrete structures may be more economical than wood, especially considering the long-term maintenance costs associated with wood structures. In some instances, other types of material have been used because of environmental or meteorological constraints. For voltages 345 kV and above, it may be difficult to obtain long span construction utilizing wood, due to height or strength reasons.

In most instances, for lines 230 kV and below, an economic study can help to determine structure configuration, base pole class (wood, steel or prestressed concrete) and height.

Factors which limit structure spans include:

a. Strength: Horizontal spans are limited by crossbrace, poles, etc. Vertical spans are limited by crossarms, structure strength. For H-frame structures, horizontal and vertical spans are also limited by pullout resistance for H-frame structures.

b. Conductor Separation: Conductor separation is intended to provide adequate space for line crew personnel on poles, prevention of contact and flashover between conductors.

c. Clearances-to-Ground: Limits on spans are directly related to height of structures.

d. Insulator Swing: The ratio of horizontal to vertical span will be limited by insulator swing and clearance to structure.

Historically, preliminary cost estimates have been usually based on level ground spans. With the advent of computer-automated line design and optimization software, preliminary cost estimates can now be performed using a preliminary profile digitized from the United States Geological Survey (USGS) topographic maps or from other sources. An economic study should consider material costs, cost of foundations and erection, different structure heights, hardware costs, and right-of-way costs. The estimates are intended to give borrowers an idea as to relative rankings of various structure types and configurations such as steel lattice, steel pole, prestressed concrete pole, and wood H-frame or single pole. However, in the decision-making process, the manager may want to consider as part of the evaluation such intangibles as importance of the line to the power system, appearance, material availability, and susceptibility to environmental attack. In some areas, State or local constraints may ignore economics and specify the type of structure to be used.

The level ground span used to develop preliminary cost estimates in the economic study is determined from clearance-to-ground and structure strength. Developing a graph, as shown in Figure 13-1, is one means of determining the level ground span (points A and B). Structure cost per mile can be related to pole height and class of poles as shown in Figure 13-2. To keep the cost down, the line design should be based on one tangent structure type and one or two pole classes for the majority of the line. For H-frame structures, the engineer should consider double crossbraced structures, as well as single crossbraced structures.

With the help of computer automated line design and optimization software, an economic study can be accomplished almost concurrently with the line design. If a land profile is available, or developed from USGS maps, the line designer may want to use optimization software to help determine the most economic line design. With such software, different structure types and materials and different conductor types can be evaluated. An advantage of optimization software is the use of the actual terrain (rather than level ground span) or a good approximation of the terrain. Optimization algorithms can fit structure height and type to the terrain, and can make use of different structure heights and configurations. The major disadvantage of optimization software is that it requires input and analysis of large amounts of data.

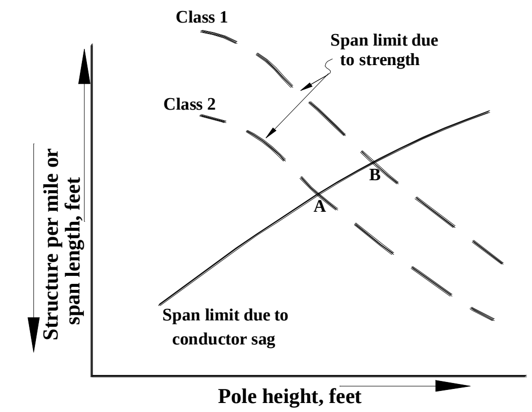


FIGURE 13-1: SELECTION OF LEVEL GROUND SPAN

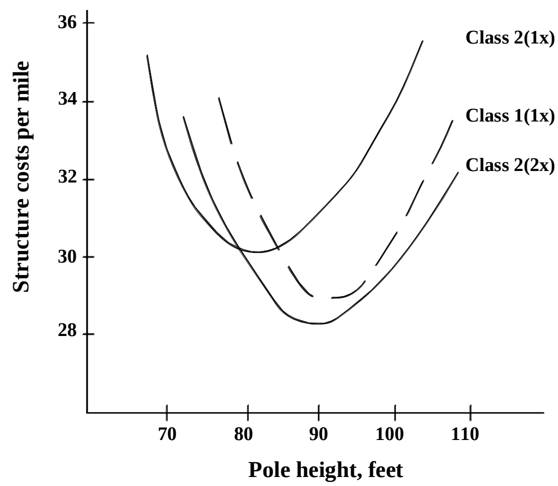


FIGURE 13-2: STRUCTURE COST PER MILE RELATED TO POLE HEIGHT

13.2 <u>Steel and Concrete Structures - General Design Considerations</u>: Rural Utilities Service provides several bulletins on design considerations for steel and concrete pole structures.

- 1724E-204, "Guide Specifications for Steel Single Pole and H-Frame Structures,"
- 1724E-214, "Guide Specification for Standard Class Steel Transmission Poles,"
- 1724E-206, "Guide Specification for Spun, Prestressed Concrete Poles and Concrete Pole Structures,"
- 1724E-216, "Guide Specification for Standard Class Spun, Prestressed Concrete Transmission Poles."

The bulletins include sample purchase specifications, design considerations, and suggested drawings and example design calculations.

13.3 Wood Structures - General Design Considerations

13.3.1 Stress Limitations: The structural stress limitations set forth in Table 13-1 are recommended for transmission lines using agency standard wood pole construction. These values assume that the wood has not deteriorated due to decay occurring in the manufacturing process.

TABLE 13-1
DESIGNATED STRESSES FOR POLES

Kind of Wood	Modulus of Elasticity x 1000 (psi)	Designated Ultimate Bending Stress (M.O.R.)* (psi)
Western larch	1710	8400
Southern yellow pine	1800	8000
Douglas fir	1920	8000
Lodgepole pine	1340	6600
Jack pine	1220	6600
Red (Norway) pine	1800	6600
Ponderosa pine	1260	6000
Western red cedar	1120	6000
Northern white cedar	800	4000

*M.O.R. = Modulus of Rupture

Douglas fir and Southern yellow pine (SYP) are used for crossarms. Southern yellow pine has four species which are long leaf (most popular species), loblolly, shortleaf, and slash. The coast type Douglas fir is the only type which should be used when specifying Douglas fir for crossarms. Table 13-2 gives strength properties to be used in crossarm design.

TABLE 13-2
DESIGNATED STRESSES FOR CROSSARMS

Kind of Wood	Modulus of Elasticity x 1000 (psi)	Designated Ult. Bending Stress (M.O.R.)* (psi)	End Grain Max Crushing Strength (psi)	Across Grain Stress (psi)	Shear Parallel to Grain (psi)
Douglas fir	1920	7400	7420	910	1140
SYP	1800	7400	7070	1000	1310

*M.O.R. = Modulus of Rupture

13.3.2 Preservative Treatment: The decay of poles results from fungi and other low forms of plant life which attack untreated poles or poles with insufficient preservative. Damage by insect attack (termites, ants, and wood borers) is also associated with decay. When preservative retention is low, wood cannot resist attacks by fungi and insects. There are two general classes of preservative treatment.

Oil-Borne Using Creosote, Penta and Copper Naphthenate in Petroleum**:** Creosote oil was the predominant preservative for poles on rural systems until about 1947. Post-war shortages prompted the introduction of pentachlorophenol (penta) and copper naphthenate dissolved in the fuel oils, and other preservatives.

Waterborne Using Arsenates of Copper**:** Poles using waterborne arsenates of copper (CCA, ACA and ACZA) are green in appearance. These preservatives were developed before World War II and have proven very effective as wood preservatives around the world. For species and amounts of treatment, refer to agency Bulletin 1728F-700, “Specification for Wood Poles, Stubs, and Anchor Logs.”

13.3.3 <u>Structure Designations for Single Wood Pole Structures</u>: Single pole wood structures are mainly limited in use to 115 kV and below. The six primary standard single pole structures utilized by Rural Utilities Service borrowers are designated as:

- TP - pin or post insulators
- TPD - pin or post insulators, double circuit
- TS - suspension insulators, crossarm construction
- TSD - suspension insulators, crossarms, double circuit
- TSZ - suspension insulators, "wishbone" arm construction
- TU - suspension insulators, steel upswept arm construction

13.4 <u>Design Calculations for Single Wood Pole Structures</u>

13.4.1 <u>Maximum Horizontal Span Limits of Single Wood Pole Structures</u>: The following conditions should be taken into account when determining horizontal spans as limited by pole strength for tangent structures:

- Wind on the conductors and OHGW is the primary load. 75 to 90 percent of the horizontal span will be determined by this load.

- Wind on the structure will affect the horizontal span by 5 to 15 percent.

- Unbalanced vertical load will increase ground-line moments. For single circuit structures, one phase is usually left unbalanced. The vertical load from the conductor will induce moments at the groundline and will affect horizontal span lengths by 2 to 10 percent.

- P-delta (P-δ) moments will also increase induced ground line moments. As a transverse load is applied to a structure, the structure will deflect. This deflection will offset the vertical load an additional amount " δ " causing an additional moment of the vertical weight times this deflection. This additional moment due to deflection is a secondary effect. An approximate method for taking into account the p-δ moments is given in section 13.4.2.

For wood structures, depending on the taper of the pole, the maximum stress may theoretically occur above the ground level. The general rule of thumb is that if the diameter at ground level is greater than one and a half times the diameter where the net pull is applied, the maximum stress occurs above the ground level. Even if the point of maximum stress occurs above the groundline for single base wood pole structures, one can assume that spans are based on groundline moments in accordance with Exception 1 in NESC Rule 261A.2. Exception 1 states: “When installed, naturally grown wood poles acting as single-based structures or unbraced multiple-pole structures, shall meet the requirements of Rule 261A.2a without exceeding the permitted stress level at the ground line for unguyed poles or at the points of attachment for guyed poles.”

The strength of the crossarm has to be checked to determine its ability to withstand all expected vertical and longitudinal loads. When determining bending stress in crossarms, moments are calculated at the through bolt, without considering the strength of the brace. The vertical force is determined by the vertical span under those conditions which yield the maximum vertical weight. The strength of two crossarms will be twice the strength of one crossarm. When considering the strength of the crossarm to withstand longitudinal loadings, reduction in the moment capacity due to bolt holes should be taken into account.

Equation 13-1 is the general equation for determining the moment induced in the pole from the applied loads represented in Figure 13-3. This equation may be used to determine the maximum horizontal span as demonstrated in the example in Paragraph 13.4.2.

$$\phi M_A = M_g = (LF)M_{wp} + (LF)M_{wc} + (LF)M_{vo} + (LF)M_{p-\delta} \qquad \text{Eq. 13-1}$$

where:

ϕ = strength factor, see Chapter 11

M_A = F_bS, the ultimate groundline moment capacity of the pole, ft-lbs. For moment capacities of wood poles at the groundline, (see Appendix F);
F_b = designated ultimate bending stress (M.O.R.)
S = section modulus of the pole at the groundline (see Appendix H).

LF = load factor associated with the particular load

M_g = induced moment at the ground line

Other symbols are defined by Equations 13-2, 13-3, 13-4, 13-5.

When estimating the load carrying capacity of a pole using manual methods, it is difficult to assess the additional moment due to deflection. Equations 13-5 and 13-6 provide an approximate way to calculate the additional moment due to defection. Because $M_{p\text{-}\delta}$ is a function of the vertical span (VS), the engineer should make an assumption about the relationship between the vertical and horizontal span (HS). In Equations 13-4 and 13-5, the relationship used is: VS = 1.25HS.

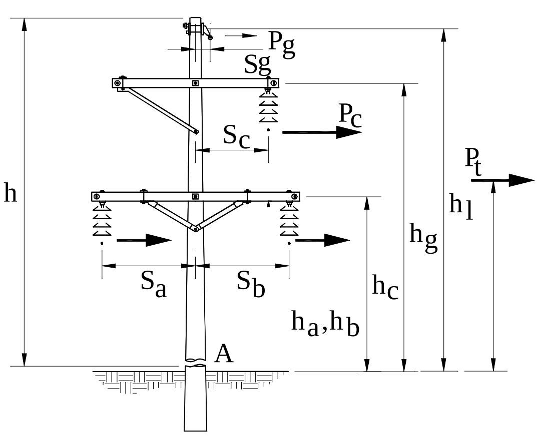


FIGURE 13-3: TS TYPE STRUCTURE

Refer to Figure 13-3 when considering the equations and symbols that follow.

a. M_{wp} = groundline moment due to wind on the pole

$$M_{wp} = \frac{(F)(2d_t + d_a)(h)^2}{72} \qquad \text{Eq. 13-2}$$

where:

F = wind pressure, psf

d_t = diameter of pole at top, inches

d_a = diameter of pole at groundline, inches

h = height of pole above groundline, feet

b. M_{wc} = groundline moment due to wind on the wires

$$M_{wc} = p_t(h_1)HS \qquad \text{Eq. 13-3}$$

where:

HS = horizontal span, feet

h_1 = moment arm of p_t, feet; in the example,

$$h_1 = \frac{(h_a)(p_c)+(h_b)(p_c)+(h_c)(p_c)+(h_g)(p_g)}{P_t} \qquad \text{Eq. 13-3a}$$

p_t = sum of transverse unit wire loads, lbs/ft; in example, $p_t = 3\ p_c + p_g$ single circuit, single pole structures

c. M_{vo} = groundline moment due to unbalanced vertical load

$$M_{vo} = 1.25HS(w_c s_t + w_g s_g) + W_i s_t \qquad \text{Eq. 13-4}$$

where:

s_g = Horizontal distance from center of pole to ground wire (positive value on one side of the pole, negative on the other), feet

s_t = $s_a + s_b + s_c$, where s_a , s_b ,and s_c are horizontal distances from center of pole to conductors (positive value on one side of the pole, negative on the other), feet

w_c = weight of the conductor per unit length, lbs./ft.

w_g = weight of overhead groundwire per unit length, lbs./ft.

W_i = weight of insulators, lbs.

d. $M_{p-\delta}$ = groundline moment due to pole deflection

$$M_{p-\delta} = 1.25HS(w_t)\delta_{imp} \qquad \text{Eq. 13-5}$$

where:

w_t = total weight per unit length of all wires, lbs./ft.

δ_{imp} = improved estimate of deflection of the structure, ft.

$$\delta_{imp} = \left(\frac{(6.78(p_t)(HS)(h_c)^3 144)}{E(d_a)^3(d_1)}\right)\delta_{mag} \qquad \text{Eq. 13-6}$$

E = modulus of elasticity, psi

d_a = diameter of pole at location "A" (groundline), inches

d_1 = diameter of pole at height "h_1" inches

δ_{mag} = deflection magnifier, no units, (assume 1.15 initially)

h_c = effective height to the conductors, feet

HS = horizontal span, feet

p_t = total transverse load per unit length of all wires, lbs./ft.

After substitutions of M_{wp}, M_{wc}, M_{vo}, and $M_{p\delta}$ have been made into Eq.13-1, the equation can be reduced to a quadratic equation (below) and solved for the horizontal span. (See Paragraph 13.4.2 for an example of how the calculation of HS is carried out.)

$$a(HS)^2 + b(HS) + c = 0$$

$$HS = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \qquad \text{Eq. 13-7}$$

Once "HS" has been calculated, check the assumption of $\delta_{mag} = 1.15$:

$$\delta_{mag} = \frac{1}{1 - \frac{1.25HS(W_t)}{P_{cr}}} \qquad \text{Eq. 13-8}$$

(See Chapter 14 for calculations of P_{cr})

13.4.2 Example of Maximum Horizontal Spans: Determine the maximum horizontal span for the 69 kV TSS-1 wood structure (Figure 13-4). Terrain is predominantly level, flat, and open. ("s_g" is negligible; see Equation 13-4). Location and magnitude of resultant loads are indicated in Figure 13-5.

Given:

NESC Heavy Loading	
Extreme wind	19 psf on the wires
	22 psf on the structure
Extreme Ice with Concurrent Wind(EI&W)	4 psf, 1 inch radial ice
Pole:	Western red cedar
Conductor:	266.8 kcmil, 26/7 ACSR (Partridge)
Ground wire:	3/8" H.S.S.

Conductor loads, lbs./ft:

	Heavy	High Wind	EI&W
Transverse	0.5473	1.0165	.8808
Vertical	1.0776	0.3673	2.402

Ground wire loads, lbs./ft:

	Heavy	High Wind	EI&W
Transverse	0.4533	0.5700	.7868
Vertical	0.8079	0.2730	1.9667

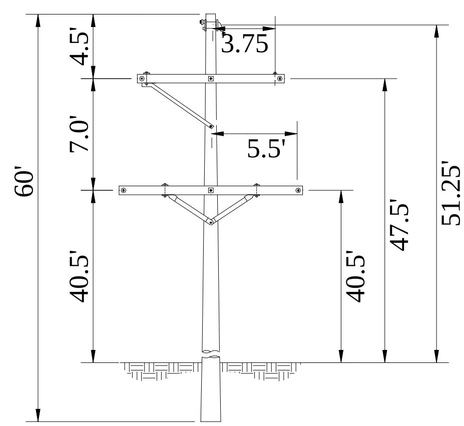


FIGURE 13-4: TSS-1 STRUCTURE

Other information:

F_b(pole)	=	6000 psi
F_b (crossarm)	=	7400 psi
S(groundline)	=	458 in^3
S(crossarm)	=	22.7 in^3
Wt. of insulator	=	58 lbs.
Dia. (top)	=	8.59 in.
Dia. (groundline)	=	16.72 in.
p_t(total unit load)	=	3(0.5473)+.4533 = 2.10 lbs./ft.
w_t(total unit load)	=	3(1.0776)+0.8079 = 4.41 lbs./ft
P_{cr}(critical buckling load)	=	17,900 lbs. (see chapter 14 for fix–free condition), ℓ=44.6 ft., E=1.12 E 06 psi d_a = 9.63 in., d_g = 16.72 in., I_a=422 in^4

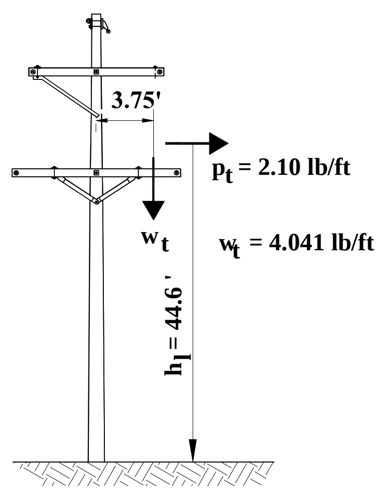


FIGURE 13-5:
APPLICATION OF FORCES
(HEAVY LOADING)

<u>Solution for Maximum Horizontal Span Considering P-δ moments</u>**:** A comparison of unit loads with load factors indicates that the Heavy Loading District Loads control design. Therefore, for Heavy Loading, the moments for Equation 13-1 are calculated.

a. $M_{wp} = \frac{4[(2)(8.59+16.72)](52)^2}{6(12)}$

$= 5{,}100\ ft - lbs.$

b. $M_{wc} = (2)(0.5473)(40.5)HS + (0.5473)(47.5)HS + (0.4533)(51.25)HS$

$= 93.5HS$

c. $M_{vo} = [(3.75)(1.0776) - .8075(.5)]HS(1.25) + W_i s_t$

$= 4.45HS + 217$

d $M_{p\delta} = (1.25)(HS)(4.041)\delta_{imp}$

$$\delta_{imp} = \frac{6.78(2.095)(HS)(44.6)^3(144)}{(1.12E06)(16.72)^3(9.63)}\delta_{mag}$$

$\delta_{imp} = .003558(1.15)HS$

$\delta_{imp} = .0041HS$

$M_{p\delta} = (1.25)(4.041)(HS)(.0041)(HS)$

$= .0207(HS)^2$

e. $\phi M_a = (LF)M_{wp} + (LF)M_{wc} + (LF)M_{vo} + (LF)M_{p\delta}$

$(.65)(229,000) = (2.5)(5{,}100) + (2.5)(93.5)HS + 1.5(4.45)HS + 1.5(217) + 1.5(.0207)HS^2$

$148{,}524 = (2.5)(5{,}100) + (1.5)(187) + (2.5)(93.5)HS + 1.5(5.56)HS + 1.5(.0207)HS^2$

$.0311HS^2 + 241.32HS - 135{,}820 = 0$

f. $a(HS)^2 + b(HS) + c = 0$

$.0311(HS)^2 + 241.32(HS) - 135{,}775 = 0$

$$HS = \frac{-241.32 + \sqrt{241.32^2 - 4(.0311)(-135{,}775)}}{2(.0311)}$$

$HS = 527\ \text{feet}$

g. Once the HS has been calculated, the assumption of 1.15 as the magnifier should be checked. Pcr = 17,900 assuming fixed free conditions (See Chapter 14).

$$\delta \text{mag} = \frac{1}{1 - \frac{(W_t)1.25HS}{P_{cr}}} = 1.15$$

$$\delta \text{mag} = \frac{1}{1 - \frac{(4.0407)(1.25)(525)}{17{,}900}}$$

.

$= 1.175$ Recalculate assuming 1.17 as the deflection magnifier, HS = 529 feet.

h. Lateral Stability: The Equivalent load 2 feet from the top is approximately 4400 lbs. From Figure 12-2 (average soil), the embedment depth for a 4400 lb. load 2 feet from the top is between 8 and 8.5 feet. Lines nearby have performed well with the standard embedment depths. Engineering judgment dictates that an 8 foot embedment depth for the 60 foot pole will be sufficient.

13.4.3 Maximum Vertical Span for TP and TS Pole Top Assemblies: To determine the vertical span, the moment capacity of the arm at the pole is calculated.

Calculations for these structures are:

$$VS = \frac{\phi M_{x-arm} - (LF)(W_i)(s_c)}{(LF)(w_c)(s_c)} \qquad \text{Eq. 13-9}$$

where:

$M_{x\text{-}arm}$	=	F_bS, moment capacity of the arm, ft-lbs.
F_b	=	the designated bending stress.
S	=	the section modulus of the arm (see Appendix G.)
w_c	=	weight of the conductor per unit length, lbs./ft.
s_c	=	moment arm, meters (feet).
W_i	=	insulator weight, lbs.
VS	=	vertical span, meters (feet).

Example of Vertical Span Calculations for TS Pole Top Assembly (Heavy Loading):

w_c = 1.0776 lbs./ft., see Figure 13-4, S = 22.7 in^3, ϕ = .50 and LF = 1.5 Heavy Loading District,

$$VS = \frac{0.50M_a - (LF)(W_i)(s_c)}{(LF)(w_c)(s_c)}$$

a. $M_a = F_bS$

$M_a = 7400(22.7)/12$

$= 14{,}000\ ft - lbs$

b. $W_i = 50 lbs.$

$$VS = \frac{(0.50)(14{,}000) - (1.5)(50)(5.5)}{(1.5)(1.0776)(5.5)}$$

$$= 741\ ft.$$

Check vertical span for extreme ice with concurrent wind,

w_c = 2.4092 lbs./ft., ϕ = 1.0 and LF = 1.1 for extreme ice with concurrent wind

$$VS = \frac{(1.0)(14{,}000) - (1.1)(50)(5.5)}{(1.1)(2.4092)(5.5)}$$

$$= 939\ ft.$$

13.4.4 <u>Span Calculations for TSZ Pole Top Assembly</u>: The TSZ structure is a wishbone-type crossarm assembly. It is intended for use on transmission lines where conductor jumping due to ice unloading and/or conductor galloping are problems. The wishbone provides additional vertical and horizontal offset between phases in order to reduce the possibilities of phase-to-phase faulting due to ice unloading or galloping.

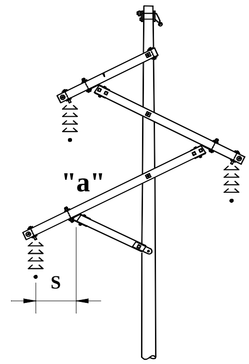


FIGURE 13-6: TSZ-1 POLE TOP ASSEMBLY

Since the crossarms of the wishbone are not horizontal, the vertical span is related to the horizontal span. The maximum vertical load (W_C) the TSZ-1single crossarm assembly can withstand is 3,400 lbs. at any conductor position. By calculating moments at point "a" on the assembly, horizontal and vertical spans are related. Span limited by pole strength are calculated in the same manner as the TP and TS structures.

<u>Example of Span Calculations for Wishbone Pole Top Assemblies</u>**:** Determine the maximum horizontal and vertical spans for the pole top assembly of the 69 kV TSZ-1 pole top assembly (Figure 13-7).

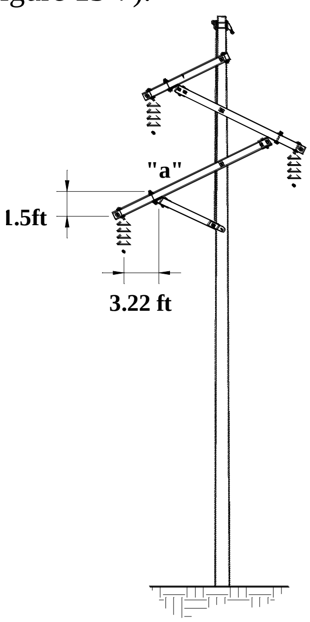


FIGURE 13-7: TSZ-1 EXAMPLE

<u>Given</u>:

Loadings:	NESC heavy loading district
Wires	
Conductor:	266.8 kcmil, 26/7 ACSR (Partridge)
OHGW:	3/8" H.S.S
Pole:	S.Y.P. (70-1)

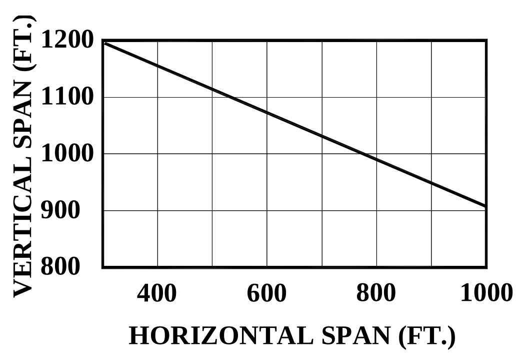


FIGURE 13-8: HS vs. VS FOR TSZ-1

<u>Solution:</u>

Moment capacity of crossarm at "a":

$M_a = W_c(s)$

$M_a = 3{,}400(3.22)$

$= 10{,}950$ ft-lbs.

Horizontal and vertical span:

The relationship between the horizontal and vertical spans is obtained by summing moments about point 'a'.

$$2.5(.5473)(1.5)HS+1.5(1.0776)(3.22)VS+1.5(50)(3.22) = (0.50)(10{,}950) \text{ ft-lbs.}$$

$$2.05HS+5.21VS = 5234 \text{ ft-lbs.}$$

For HS = VS, Span = 720 ft. See Figure 13-8 for application chart.

13.4.5 <u>Span Calculations for TU-1 Pole Top Assembly</u>: These assemblies have steel upswept arms. With these arms, vertical spans are related to horizontal spans and a graph can be made to relate horizontal and vertical spans. Spans limited by pole strength are calculated in the same manner as the TP and TS structures.

<u>Example of Span Calculations for Steel Davit Arm Construction</u>**:** For the 138 kV structure in Figure 13-9, plot the horizontal versus vertical span for steel davit arms.

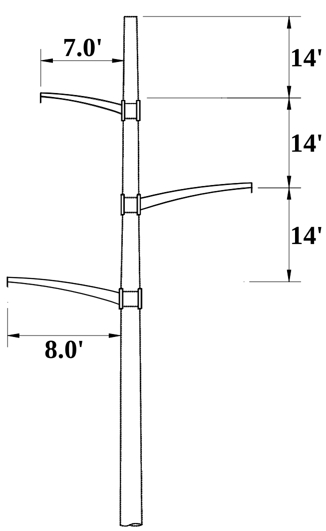


FIGURE 13-9: TU-1 STRUCTURE

<u>Given</u>:

Loadings:	NESC Heavy Loading
	High Wind 19 psf on the wires
Wires:	
Conductor:	477 kcmil, 26/7 ACSR
OHGW:	3/8" H.S.S
Pole:	S.Y.P. (70-1)

Conductor loads:	Heavy Ldg	High wind	EI&W
Transverse	0.6193	1.3585	0.8808
Vertical	1.5014	0.6570	2.4092

Manufacturers catalog data for crossarms:

Rated Ultimate Vert. load (W_c)	s, length	R, rise
3000	8.0	2.7
3000	7.0	2.5

Weight of insulators (W_i): 102 lbs.

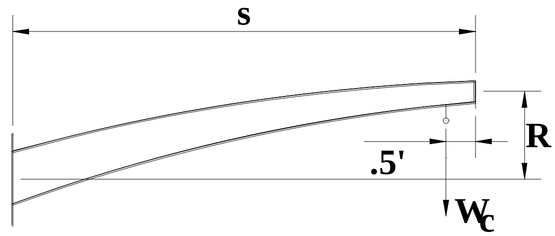


FIGURE 13-9a: DAVIT

Solution:

For the 8.0' davit arm, the moment capacity of the arm at the pole (Figure 13-9a):

$$\begin{aligned} M_a &= W_c(s) \\ &= (3000)(8.0) \\ &= 24{,}000 \text{ ft-lbs.} \end{aligned}$$

An equation for the vertical and horizontal spans can be developed. Since the arm is steel, a strength factor (ϕ) of 1.0 is used.

$$2.5(0.6193)(2.7)HS+1.5(1.5014)(8.0)VS+1.5(102)(8.0) = (1.0)(24{,}000) \text{ ft-lbs.}$$
$$4.1803HS+18.017VS = 22{,}776 \text{ ft-lbs.}$$

For the 7.0' davit arm, the moment capacity of the arm at pole:

$$\begin{aligned} M_a &= W_c(s) \\ &= (3000)(7.0) \\ &= 21{,}000 \text{ ft-lbs} \end{aligned}$$

An equation for the vertical and horizontal spans can be developed:

$$2.5(0.6193)(2.5)HS+1.5(1.5014)(7.0)VS+1.5(102)(7.0) = (1.0)(21{,}000) \text{ ft-lbs.}$$
$$3.87HS+15.77VS = 19{,}929 \text{ ft-lbs.}$$

In this example for the NESC heavy loading district loads, the magnitude of the vertical span is not sensitive to the horizontal span (as shown in Figure 13-10). For horizontal spans between 400 and 1000 feet, the vertical span for the 8 foot arm as well as the 7 foot arm should be limited to 1018 feet (for design purposes, use 1000 feet). Spans limited by the extreme winds are not a factor in this example.

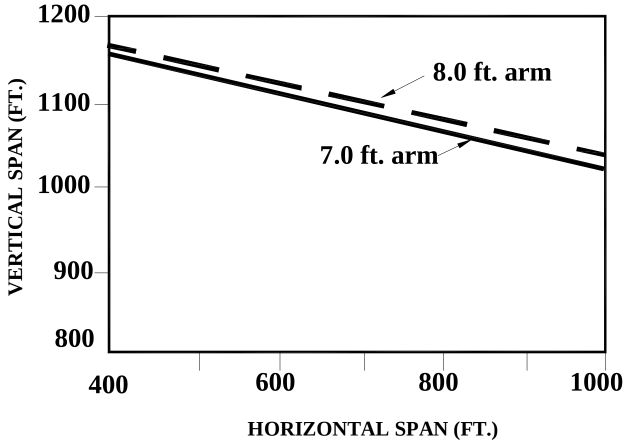


FIGURE 13-10: VS vs. HS FOR TUS-1 STRUCTURE OF EXAMPLE 13-3

13.5 <u>Design Calculations for Wood H-Frame Structures</u>

13.5.1 <u>General</u>: There are various techniques available for analysis of H-frame structures:

- Classical indeterminate structural analysis.
- Matrix methods of structural analysis.
- Approximate methods (explained in this section and subsequent sections).

In analyzing a statically indeterminate structure by approximate procedures, one assumption is made for each degree of indeterminacy. These assumptions are based on logical interpretations of how the structure will react to a given loading. For the H-frame with knee and V-braces, we can assume that the structure will behave as shown in Figure 13-11.

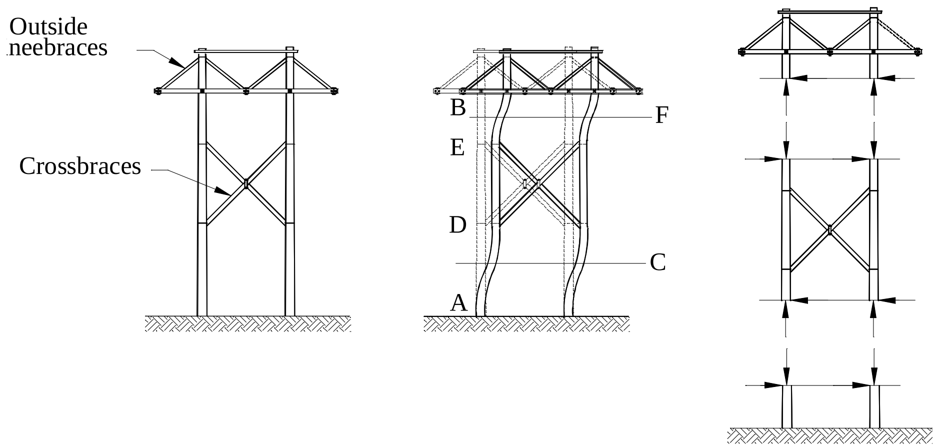
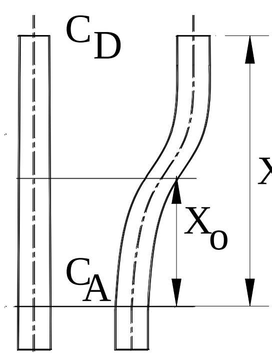


FIGURE 13-11: ASSUMED H-FRAME BEHAVIOR

At some point in the poles, there will be an inflection point (a point of zero moment). If the pole or column is uniform in cross section, it is common to assume that the inflection point is located midway between points of bracing, shown as a dotted line in Figure 13-11. However, since the pole is tapered, the following relationship may be used to determine the location of the inflection point (see Figure 13-12, Equation 13-10 and Appendix H for application chart).



$$\frac{x_o}{x} = \frac{C_A\left(2C_A + C_D\right)}{2\left(C_A{}^2 + C_A C_D + C_D{}^2\right)} \qquad \text{Eq. 13-10}$$

where:

C_A = circumference at base
C_D = circumference at top

FIGURE 13-12: LOCATION OF POINT OF CONTRAFLEXURE

By applying the same reasoning, the inflection point can be located on the other column. Locating the inflection point on each column, and hence the point of zero moment, entails two assumptions for the frame. Since the frame is statically indeterminate to the third degree, a third assumption has to be made. A common third assumption is that the shear in the columns is distributed equally at the inflection points. The shear in the columns is equal to the horizontal force on the structure above the level under consideration.

For a less rigid support, the inflection point moves toward the less rigid support. Two conclusions can be made:

- For a pole rotating in the ground, the inflection point "C" below the crossbraces, is lowered. The lowering of the inflection point inreasing the moment induced in the pole at the connection of the lower crossbrace. Since the amount of rotation of a base is difficult to determine, the usual design approach is to always assume a rigid base.

- For H-frames with outside kneebraces only, the point of inflection 'F'above the crossbrace (shown in Figure 13-11) is higher than the point of inflection for four kneebraces. This higher point of inflection increases the moment in the pole at the upper crossbrace-pole connection. For the H-frame with outside kneebraces only, the designer may make one of two assumptions:

  (1) When determining induced moments in the poles, the outside kneebraces are ignored and no point of inflection exists between the crossbrace and the crossarm. This is a conservative assumption and assumes that the purpose of outside braces is to increase vertical spans only.

  (2) It can be assumed that the point of inflection occurs at the crossarm. This assumption will be used in the equations and examples which follow.

13.5.2 <u>Crossbraces</u>: The primary purpose of wood X-bracing for H-frame type structures is to increase horizontal spans by increasing structure strength. Additional benefits achieved by crossbracing include possible reduction of right-of-way costs by eliminating some guys and reduction of lateral earth pressures. For an efficient design, several calculations should be made in order to correctly locate the crossbrace.

The theoretical maximum tensile or compressive load which the wood crossbrace will be able to sustain will largely be dependent on the capacity of the wood brace to sustain a compressive load. Drawing TM-110, X-brace Assembly of Bulletins 1728F-810 and 811, is to be used for the 115, 138, 161 kV, and 230 kV tangent structures. The crossbrace dimension is 3-3/8" x 4-3/8" for the 115 kV structure, 3-3/8" x 5-3/8" for 138 kV and 161 kV structures. The dimensions of this X-brace for the TH-230 structure are 3-5/8" x 7-1/2" (minimum).

The maximum compressive load which a wood X-brace is able to sustain is determined by:

$$P_{cr} = \frac{A(\pi^2)E}{\left(\frac{k\ell}{r}\right)^2} \qquad \text{Eq. 13-11}$$

where:

- P_{cr} = maximum compressive load, lbs.
- A = area, in^2
- E = modulus of elasticity, psi.
- $k\ell$ = effective unbraced length, in.
- r = radius of gyration, in. which will give you the maximum $k\ell/r$ ratio; $k\ell$ and r must be compatible for the same axis

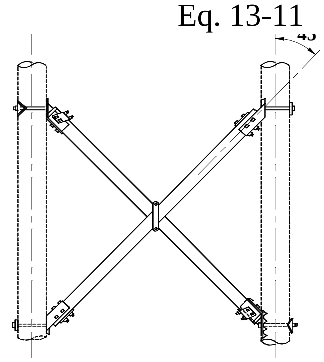


FIGURE 13-13: CROSSBRACE

For an assumed 1 foot diameter pole, the following theoretical values apply:

TABLE 13-3
CROSSBRACE CAPACITIES

Crossbrace	A Area (in^2)	r Least Radius of Gyration (in.)	L Distance C_L to C_L of Poles (ft.)	0.5L/0.707 less 1' for Pole Dia., (in.)	$\frac{kl}{r}$	P_{cr} for E = 1.8 x 10^6 (lbs.)
TM-110						
3-3/8" x 4-3/8"	14.77	0.9743	12.5	97.6	100.2	26,100
3-3/8" x 5-3/8"	18.14	0.9743	15.5	123.1	126.3	20,200
TM-110A						
3-5/8" x 7-1/2"	27.19	1.05	19.5	157	149.5	21,600

The calculations included in Table 13-3 do not reflect the capacity of the hardware. RUS Specifications for Double Armed and Braced Type Crossarm Assemblies (138 kV and 161 kV), and RUS Specifications for Double Armed and Braced Type Crossarm Assemblies (230 kV) require X-braces to withstand a tension or compression loading of 20,000 lbs. This ultimate value correlates with the above theoretical ultimate loads in the table. It is recommended that 20,000 lbs. (ultimate) be used for design purposes, since this value assures one that the crossbrace will sustain the indicated load.

For the 115 kV structure (TH-1AA) it is recommended that 20,000 lbs. be used as the ultimate load the crossbrace is able to sustain. The hardware for the crossbrace is the same as the hardware used with 138 kV and 161 kV structures.

13.5.3 <u>V-Braces</u>: The primary purpose of two V-braces on the outside of the poles is to increase vertical spans. Two V-braces on the inside will increase horizontal spans. Four V-braces increase both horizontal and vertical spans. The various bracing arrangements and their designations for 161 kV structures are shown in Figure 13-14.

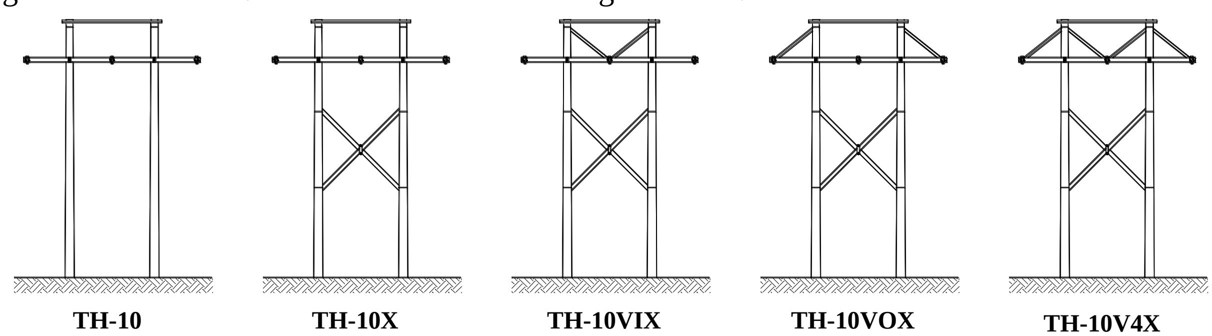


FIGURE 13-14: POLE TOP BRACING ARRANGEMENTS
('X' added to the pole top assembly nomenclature refers to crossbrace)

RUS Specifications for Double Armed and Braced Type Crossarm Assemblies (138 kV and 161 kV) specifies the following minimum strength requirements for the various pole top assemblies:

<u>Maximum vertical load (at any conductor position)</u>

TH-10	8,000 lbs.
TH-10VO	14,000 lbs.
TH-10V4	14,000 lbs.

<u>Maximum transverse conductor load (total)</u>

TH-10VO	15,000 lbs.
TH-10V4	15,000 lbs.

<u>Maximum tension or compression in V-brace</u>
20,000 lbs.

RUS Specifications for Double Armed and Braced Type Crossarm Assemblies (230 kV) specifies the following minimum strength requirements for the TH-230 pole top assembly:

<u>Maximum vertical load (at any conductor position)</u>

TH-230	10,000 lbs.

<u>Maximum transverse conductor load (total)</u>

TH-230	15,000 lbs.

<u>Maximum tension or compression in V-brace</u>

TH-230	20,000 lbs.

When determining maximum vertical and horizontal spans as limited by H-frame top assemblies, the above minimum strengths may be used as guidance.

13.5.4 <u>Structure Analysis of H-frames</u>: Equations 13-16 to 13-22 are used for calculating forces in the various members of H-frame structures. As part of the structural analysis, span limitations due to strength of the pole top assembly (Equations 13-12 to 13-15) should be considered and suggested methods follow. Appropriate load factors and strength factors should be applied in the respective equations.

<u>Outside V-Braces</u>**:** An H-frame structure with two outside V-braces in figure 13-14 (and shown in greater detail in Figure 13-19) needs further explanation. A structure with two outside V-braces has less rigidity above the crossbrace than a structure with than four V-braces. The location of the point of contraflexure is difficult to determine. Equation 13-10, which calculates the moment (M_E) at the top of the crossbrace assumes that the point of contraflexure exists at the crossarm. However, when using Equation 13-12 to determining span limitations due to strength of the pole top assembly, a point of contraflexure is assumed between the top of the crossbrace and the crossarm.

The maximum vertical span is determined for the maximum horizontal span.

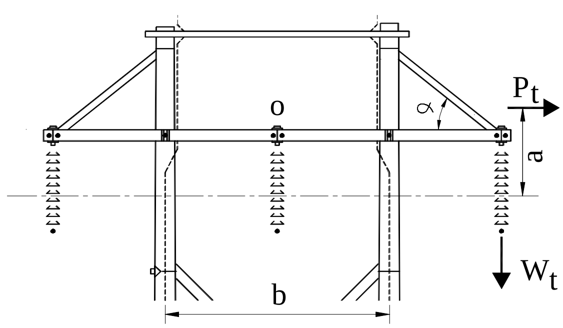


FIGURE 13-15: POLE TOP ASSEMBLY WITH TWO OUTSIDE BRACES

Ultimate force in the brace is:

$$\frac{(LF)W_t}{\sin\alpha} + \frac{(LF)P_t(a)}{(b)\sin\alpha} \le (\phi)20{,}000 \cdot lbs \qquad \text{Eq. 13-12}$$

where:

W_t = total vertical load at the phase wire, locations, lbs.,
$W_t = VS(w_c)+W_i$,
VS = vertical span, ft.
w_c = weight load per foot of conductor, lbs./ft.
W_i = total weight of the insulators, lbs.

P_t = total transverse load, lbs.
$P_t = (HS)(3p_c+2p_g)$ where
HS = horizontal span, ft.
p_c = wind load per foot of conductor, lbs./ft.
p_g = wind load per foot of overhead ground wire, lbs./ft.

a = distance from the point of contraflexure to equivalent force, ft.
b = distance between poles, ft.
LF = load factor
α = angle the brace makes with the crossarm

Two Inside V-Braces**:** Pole bending moment, uplift, and force in the X-brace may be calculated in the same manner as when four braces are used. Crossarm strength controls the maximum vertical span.

Force in the braces is:

$$\frac{(LF)W_t}{2\sin\alpha} + \frac{(LF)P_t(a)}{(b)\sin\alpha} \le (\phi)20{,}000.lbs \qquad \text{Eq. 13-13}$$

Crossarm bending moment, $(\phi)M_o$ is:

$$(\phi)M_o = \frac{(LF)W_t(b)}{2} \qquad \text{Eq. 13-14}$$

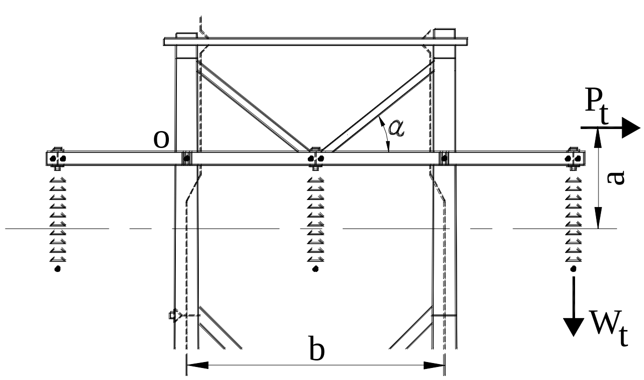


FIGURE 13-16: POLE TOP ASSEMBLY WITH INSIDE BRACES

Four V-Braces**:** The following equations can be used to determine the maximum vertical span as limited by four V-braces, given the maximum horizontal span:

For four V-braces, force in the outside braces is:

$$\frac{(LF)W_t}{\sin\alpha} \leq (\phi)20{,}000\,lbs \qquad \text{Eq. 13-15}$$

Force in the inside braces is:

$$\frac{(LF)W_t}{2\sin\alpha} + \frac{(LF)P_t(a)}{(b)\sin\alpha} \leq (\phi)20{,}000\,lbs \qquad \text{from Eq. 13-13}$$

13.5.5 Abbreviations: In Equations 13-16 to 13-23, all units should be consistent. The following abbreviations apply:

D_e	=	embedment depth
F	=	wind pressure on a cylindrical surface, psf
F_s	=	presumptive skin friction value, psf
HS	=	horizontal span, ft.
M_a	=	moment capacity of crossarm
M_n	=	moment capacity at the indicated location 'n', ft-lb. includes moment reduction due to bolt hole, i.e., $M_n = M_{cap}-M_{bh}$.
LF	=	load factor (see Chapter 11 of this bulletin)
Q_u	=	ultimate bearing resistance of the soil, psf
R_n	=	reaction at the indicated location,"n," lbs.
U	=	dummy variable
V	=	dummy variable
V_n	=	induced axial force at the indicated location, lbs.
VS	=	vertical span, ft.
W_c	=	weight of conductors (plus ice, if any),lbs.
W_g	=	weight of OHGW (plus ice, if any),lbs.
W_i	=	total weight of the insulators
W_{l-p}	=	weight of a line person
W_p	=	weight of pole, lbs.
W_t	=	total weight equal to weight of conductors (plus ice, if any, W_C) plus weight of insulators,W_i.
W_1	=	total resistance due to skin friction around the embedded portion of the pole, lbs.
W_2	=	total bearing resistance of the soil, lbs.
X	=	dummy variable
Y	=	dummy variable
a	=	distance from P_t to the point of contraflexure above the crossbrace for an H-frame structure with pole top bracing. Ft.
b	=	spacing of the poles of an H-frame, ft.
d_{avg}	=	average diameter of pole between groundline and butt, ft.
d_{bt}	=	diameter of pole at butt, ft.
d_n	=	diameter at location "n," ft.
d_t	=	diameter of pole at top, ft.

f_s = calculated skin friction value, psf
h_n = length as indicated, ft.
P_t = total horizontal force per unit length due to wind on the conductors and overhead ground wire, lbs./ft.
s_n = distance as shown, ft.
w_c = weight per unit length of the conductors (plus ice, if any), lbs./ft.
w_g = weight per unit length of overhead ground wire (plus ice, if any), lbs./ft.
ϕ = strength factor (see Chapter 11 of this bulletin)

13.5.6 <u>Equations for Structure 1 (Figure 13-17)</u>: For this structure, the horizontal span is reduced by 10 % to take into account P-delta (P-δ)moments (i.e. 0.90 in Equation 13-16). For a more detailed analysis, see Equation 13-1 for single poles.

$$HS_A = \left((\phi)M_A - \frac{(LF)(F)(h)^2(2d_t + d_a)}{6} \right) / \left(\frac{(LF)(p_t)(h_1)}{2} \right)(0.90) \qquad \text{Eq. 13-16}$$

$$R_A = (LF)(W_g + 3/2W_t + W_p) \qquad \text{Eq. 13-17}$$

$$VS = \frac{(\phi)M_a - (LF)(W_i)(s)}{w_c(s)(LF)} \qquad \text{Eq. 13-18}$$

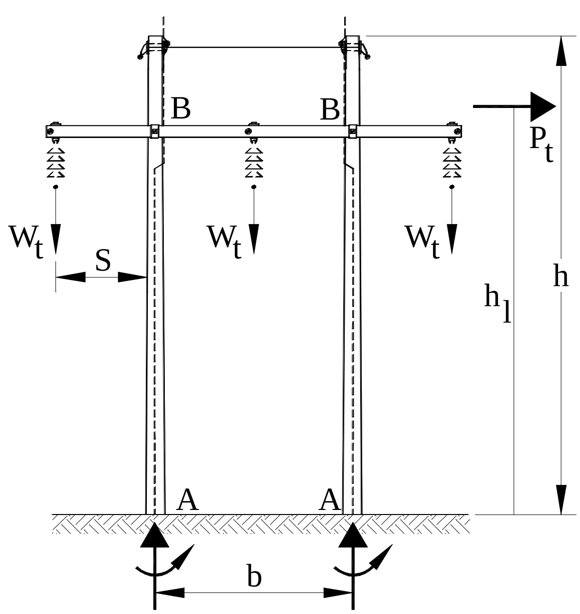


FIGURE 13-17: STRUCTURE 1

13.5.7 Equations for Structure 2 (Figure 13-18):

$$HS_B = \left((\phi)M_B - \frac{(LF)(F)(y_1)^2(2d_t + d_b)}{6} \right) / (LF)(p_g)(y_1) \quad \text{Eq. 13-19a}$$

$$HS_E = \left((\phi)M_E - \frac{(LF)(F)(y)^2(2d_t + d_e)}{6} \right) / \frac{(LF)(p_t)(y_o)}{2} \quad \text{Eq. 13-19b}$$

$$HS_D = \left((\phi)M_D - \frac{(LF)(F)(h - x_o)(x_1)(d_t + d_c)}{2} \right) / \frac{(LF)(p_t)(x_1)}{2} \quad \text{Eq. 13-19c}$$

$$HS_A = \left((\phi)M_A - \frac{(LF)(F)(h - x_o)(x_o)(d_t + d_c)}{2} \right) / \frac{(LF)(p_t)(x_o)}{2} \quad \text{Eq. 13-19d}$$

For crossbrace:

$$HS_x = \left((\phi)28{,}300(b) - 2(LF)(F)(h - x_o)^2(2d_t + d_c)/6\right)/(LF)(p_t)(h_2) \quad \text{Eq. 13-19e}$$

For uplift:

$$HS(p_t)(h_2) - VS(w_g)(b) - 1.5VS(w_c)(b) = W_1(b) + W_p(b) + X - Y \quad \text{Eq. 13-19f}$$

For bearing:

$$HS(p_t)(h_2) + VS(w_g)(b) + 1.5VS(w_c)(b) = W_2(b) - W_p(b) + X - Y + (w_1)(b) \quad \text{Eq. 13-19g}$$

where:

$$W_1 = F_s(D_e)(d_{avg})\pi / S.F. \quad \text{Eq. 13-19h}$$

$$W_2 = (\pi\, d_{bt}^{\,2} / 4)(Q_u) / S.F. \quad \text{Eq. 13-19i}$$

$$X = (F)(h - x_o)(d_t + d_c)(x_o) \quad \text{Eq. 13-19j}$$

$$Y = 2(F)(h)^2(2d_t + d_a)/6 \quad \text{Eq. 13-19k}$$

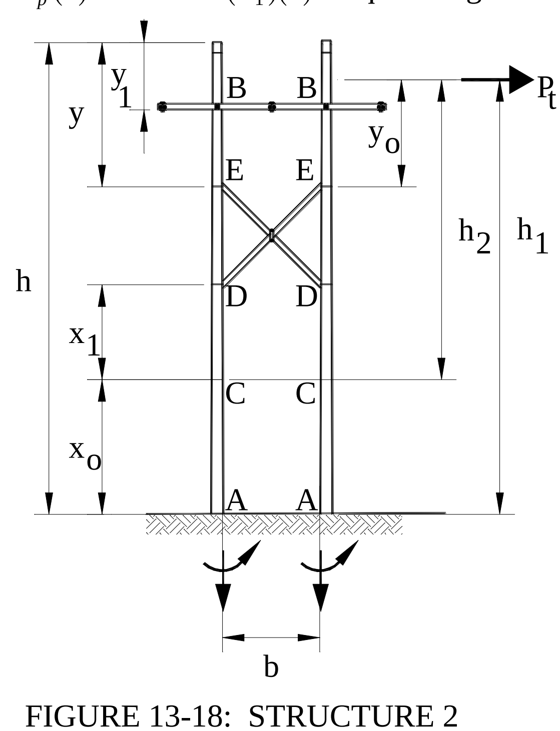


FIGURE 13-18: STRUCTURE 2

13.5.8 Equations for Structure 3 (Figure 13-19):

$$HS_E = \left((\phi)M_E - \frac{(LF)(F)(y_1)(z)(d_t + d_b)}{2} \right) / \frac{(LF)(p_t)(z)}{2} \qquad \text{Eq. 13-20}$$

HS_D, HS_A = same as structure #2.

For crossbrace, uplift and bearing: same as structure #2

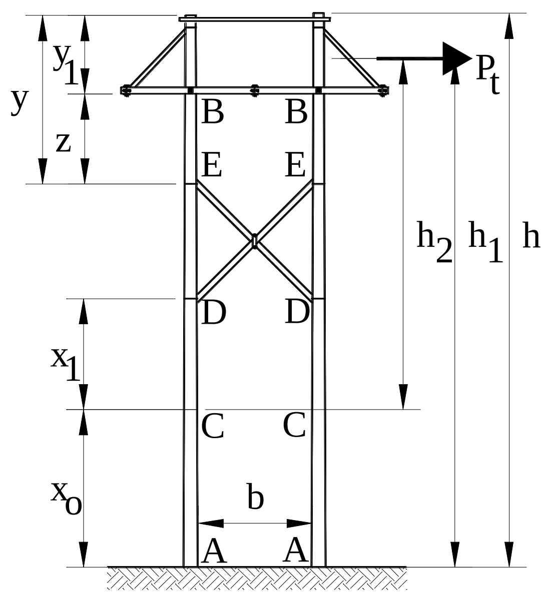


FIGURE 13-19: STRUCTURE 3

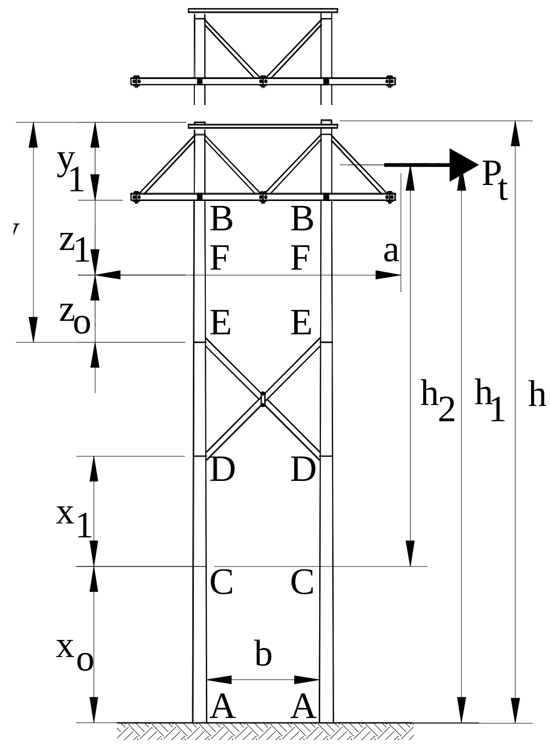


FIGURE 13-20: STRUCTURE 4

13.5.9 Equations for Structure 4 (Figure 13-20):

$$HS_B = \left((\phi)M_B - \frac{(LF)(F)(y - z_o)(d_t + d_f)(z_1)}{2} \right) / \frac{(LF)(p_t)(z_1)}{2} \qquad \text{Eq. 13-21a}$$

$$HS_E = \left((\phi)M_E - \frac{(LF)(F)(y - z_o)(d_t + d_f)(z_o)}{2} \right) / \frac{(LF)(p_t)(z_o)}{2} \qquad \text{Eq. 13-21b}$$

HS_D, HS_A = same as structure #2.

For uplift and bearing: same as structure #2.

For crossbrace:

$$HS_x = ((\phi)28{,}300(b) - U + V)/[(LF)(p_t)(h_2 - a)] \qquad \text{Eq. 13-21c}$$

where:

$$U = 2(LF)(F)(h - x_o)^2(2d_t + d_c)/6 \qquad \text{Eq. 13-21d}$$

$$V = 2(LF)(F)(y - z_o)^2(2d_t + d_f)/6 \qquad \text{Eq. 13-21e}$$

13.5.10 Equations for Structure 5 (Figure 13-21):

For crossbrace:

$$HS_x = \left((\phi)56{,}500(b) - 2(LF)(F)(h - x_o)^2(2d_t + d_c)/6\right)/\left[(LF)(p_t)(h_2)\right] \qquad \text{Eq. 13-22}$$

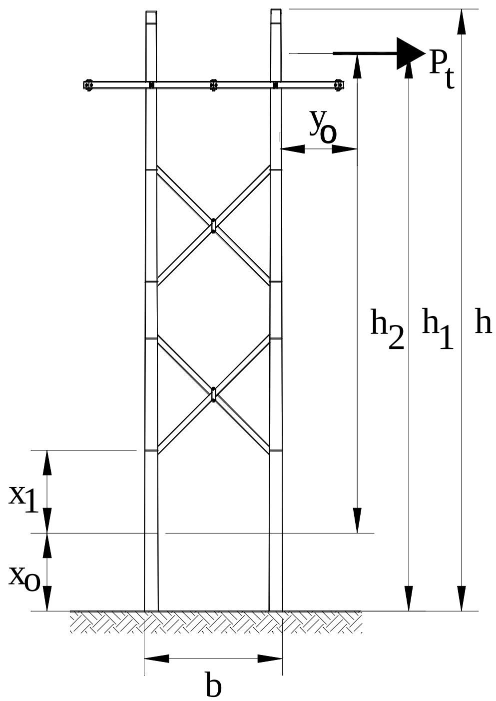


FIGURE 13-21: STRUCTURE 5

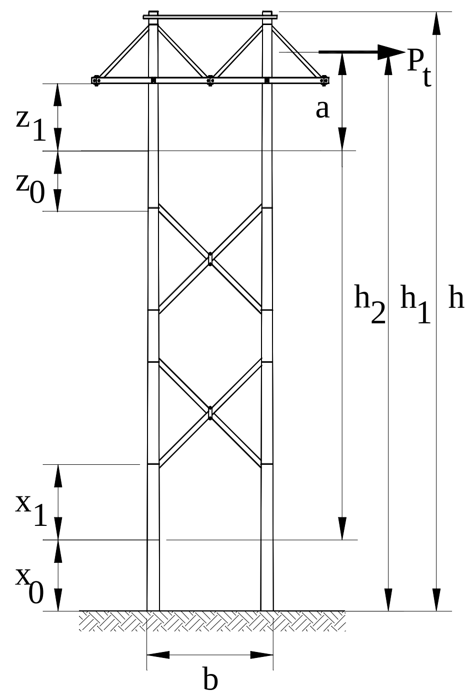


FIGURE 13-22: STRUCTURE 6

13.5.11 Equations for Structure 6 (Figure 13-22):

For crossbrace:

$$HS_x = \left((\phi)56{,}500(b) - U + V\right)/\left[(LF)(p_t)(h_2 - a)\right] \qquad \text{Eq. 13-23}$$

where:

U, V = same as structure #4

13.6 Example of an H-frame Analysis: For the 161 kV structure shown in Figure 13-23, determine the horizontal span based on structure strength and uplift and plot the horizontal versus vertical span for the pole top assembly.

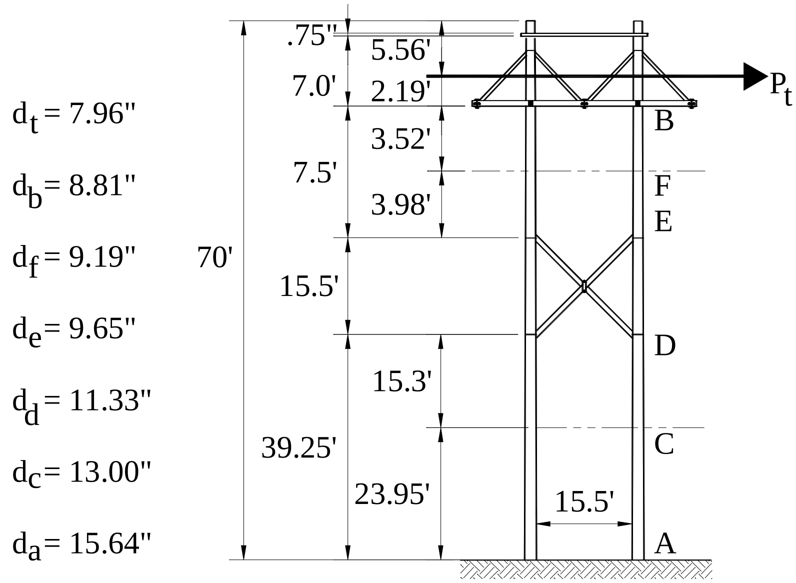


FIGURE 13-23: EXAMPLE OF AN H-FRAME

13.6.1 Given:

NESC heavy loading	
High winds -	19 psf on the wires and 22 psf on the structure
Heavy ice -	1" radial ice
Extreme ice with concurrent wind	1" radial ice with 4 psf wind
Pole:	Douglas fir 80-2
Conductor:	ACSR 795 kcmil 26/7
OHGW:	7/16 E.H.S.
Ruling Span:	800 ft.

Conductor Loads	Heavy Ldg District	High Wind	Heavy Ice	EI&W
Transverse Loads	0.7027 lbs./ft.	1.7543 lbs./ft.	0	1.0360
Vertical Loads	2.0938 lbs./ft.	1.0940 lbs./ft.	3.7154 lbs./ft.	3.7154
Tension	10,400 lbs.	---	14,000 lbs	

OHGW Loads	Heavy Ldg District	High Wind	Heavy Ice	EI&W
Transverse Loads	0.4783 lbs./ft.	0.6888 lbs./ft.	0	.8116
Vertical Loads	0.9803 lbs./ft.	0.3990 lbs./ft.	2.1835 lbs./ft.	2.1835
Tension	5,900 lbs.	---	7,500 lbs.	

Soil: Average. Presumptive skin friction (ultimate) of 250 psf for predominantly dry soil areas and using native backfill; 500 psf when aggregate backfill is used.

13.6.2 <u>Solution for Heavy Loading District Loads</u>: Maximum horizontal span based on structure strength:

a. Equivalent load p_t :

$$p_t = 2p_g + 3p_c$$
$$= 2(0.4783) + 3(0.7027)$$
$$= 3.065\ lbs/ft.$$

b. Determine location of equivalent load p_t :

$$\text{Distance from top} = \frac{2p_g(0.75) + 3p_c(7.75)}{p_t}$$
$$= 5.56\,ft.$$

c. Determine location of $x_{o,}\ x_1,\ z_0$ and z_1 for the X-brace location shown.

All diameters, d_n, determined by Appendix F, and ratio x_o/x_1 or z_o/z determined by Appendix H.

For $x_o,\ x_1$:

$$\frac{d_d}{d_a} = \frac{11.33}{15.64} = 0.72$$
$$\therefore \frac{x_o}{x} = 0.61$$
$$x_o = 0.61(39.25)$$
$$x_o = 23.9\,ft.$$
$$x_1 = 15.3\,ft.$$
and $d_c = 13.0\ in.$

For $z_o,\ z_1$:

$$\frac{d_d}{d_e} = \frac{8.81}{9.65} = .91$$
$$\therefore \frac{z_o}{z} = 0.53$$
$$z_o = 0.53(7.5)$$
$$z_o = 3.98\,ft.$$
$$z_1 = 3.52\,ft.$$
and $d_f = 9.19\ in.$

d. Find the horizontal span limited by pole strength at B (see Figure 13 - 23) using Equation 13 - 21a :

$$HS_B = (\phi)M_B - \frac{(LF)(F)(y - z_o)(d_t + d_f)(z_1)}{2} / \frac{(LF)(p_t)(z_1)}{2}$$

a. $M_B = 44{,}700\ ft - lbs.$

b. $HS_B = \left((0.65)44{,}700 - \frac{2.5(4)(15.25 - 3.98)(0.663 + 0.766)(3.52)}{2} \right) / \left(\frac{2.5(3.065)(3.52)}{2} \right)$

$= 2{,}133\ ft.$

e. Horizontal span limited by pole strength at E :

$$HS_E = (\phi)M_E - \frac{(LF)(F)(y - z_o)(d_t + d_f)(z_o)}{2} / \frac{(LF)(p_t)(z_o)}{2}$$

a. $M_E = M_{cap} - M_{bh}$

$M_E = 58{,}800 - 8{,}400\ ft. - lbs.$

$M_E = 50{,}400\ ft. - lbs$

(M_{bh} from Appendix F)

b. $HS_E = \left((0.65)(50{,}400) - \frac{2.5(4)(15.25 - 3.98)(0.663 + 0.766)(3.98)}{2} \right) / \left(\frac{2.5(3.065)(3.98)}{2} \right)$

$= 2{,}127\ ft.$

f. For horizontal span limited by pole strength at locations D and A, similar calculations can be made. The results are as follows :

$HS_D = 811\ ft.$

$HS_A = 1664\ ft.$

g. For horizontal span limited by strength of the crossbrace :

$$HS_X = ((\phi)28{,}300(b) - U + V) / [(OLF)(p_t)(h_2 - a)]$$

where :

$$U = 2(LF)(F)(h - x_o)^2 (2d_t + d_c) / 6$$

$$V = 2(LF)(F)(y - z_o)^2 (2d_t + d_f) / 6$$

$U = 2(2.5)(4)(70 - 23.9)^2 (2(0.663) + 1.083) / 6$

$= 17{,}065\ ft - lbs.$

$V = 2(2.5)(4)(15.25 - 3.98)^2 (2(0.663) + .766) / 6$

$= 885\ ft - lbs.$

$HS_X = [(0.65)28{,}300(15.5) - 17{,}065 + 885] / [(2.5)(3.065)(34.78)]$

$= 1009\ ft.$

13.6.3 Solution for Heavy Loading District Loads - Maximum span limited by pole top assembly follows:

a. From Equation 13-15.

$$\frac{(LF)W_t(VS)}{\sin\alpha} \le (\phi)20{,}000.lbs$$

$$VS = \frac{10{,}000\sin 39^\circ - 1.5(135)}{2.0938(1.5)}$$

$$= 1938\ ft.$$

b. From Equation 13-13:

$$\frac{(LF)W_c(VS)}{2\sin\alpha} + \frac{(LF)p_t(a)(HS)}{b\sin\alpha} \le (\phi)20{,}000\ lbs.$$

$$\frac{1.5(2.0938)(VS)}{2\sin 39^\circ} + \frac{2.5(3.065)(2.19+3.52)(HS)}{15.5\sin 39^\circ} \le (0.50)20{,}000\ lbs.$$

$$2.49VS + 4.48HS \le 10{,}000\ lbs.$$

(For VS equal to the HS, the vertical span is 1,435 ft.)

13.6.4 Solution for Heavy Loading District Loads - Maximum span limited by uplift follows:

Assume dry native backfill, safety factor of 4.

$$HS(p_t)(h_2) - VS(w_g)(b) - 1.5VS(w_c)(b) = W_1(b) + W_p(b) + X - Y$$

where:

$$W_1 = F_s(D)(d_{avg})\pi / SF$$

$$= 2649\ lbs.$$

W_p = Wt. of one pole and half the weight of pole top assembly and crossbrace.

$$= 4200 + 800/2 = 4600\ lbs.$$

$$X = F(h - x_o)(d_t + d_c)(x_o)$$

$$= 7705\ ft - lbs.$$

$$Y = 2(F)(h^2)(2d_t + d_a)/6$$

$$= 17{,}182\ ft - lbs.$$

The equation is as follows:

$$124.13HS - 63.88VS = 102{,}900$$

(For VS = 0, maximum HS = 830 ft.)

13.6.5 Check for extreme ice and concurrent wind: Span limitations based on pole strength and crossbrace strength is controlled by NESC Heavy Loading conditions. The unit conductor loads when load factors and strength factors accounted for, are greater for the Heavy Loading District load than for the EI&W as shown below:

	NESC	> EI&W
Transverse load:	7027(2.5)/.65 > 1.0360/.65 lbs/ft	
	2.7027 > 1.5938 lbs/ft.	
	NESC	> EI&W
Vertical load:	2.0938(1.5)/.65 > 3.7154 lbs/ft	
	4.8318 > 3.7154 lbs/ft	

13.6.6 <u>Check for Extreme Wind Conditions</u>: Although **s**pan limitations based on pole strength and crossbrace strength is controlled by NESC Heavy Loading conditions, span limitations based on uplift is controlled by the extreme wind condition.

<u>For Dry Native Backfill</u>**:** For an assumed safety factor of 1.5, the following equation result:

222.2HS - 25.4VS = 142,862
(For VS=0, maximum HS=640 ft.)

<u>For Aggregate Backfill</u>**:** For an assumed safety factor of 1.5, the following equation results:

222.2HS - 25.4VS = 252,400
(For VS=0, maximum HS=1,135 ft.)

When considering uplift, it may be prudent to base calculations on the minimum vertical span as limited by insulator swing.

13.6.7 <u>Summary of Span Limitations</u>:

<u>Horizontal Span limits</u>**:**

HS_A = 1664 ft.
HS_D = 811 ft.
HS_E = 2127 ft.
HS_B = 2133 ft.
HS_x = 1009 ft.

<u>Dry native backfill</u>:
For a VS = 0, the HS (limited by uplift) = 640 ft.

<u>Aggregate backfill</u>:
For a VS = 0, the HS (limited by uplift) = 1,135 ft.

<u>Vertical Span limited by Heavy District Loads</u>**:**

$VS_{poletop}$ = 1,435 ft., max. (For VS =HS)

A more efficient design could be achieved by moving the crossbrace.

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14. GUYED STRUCTURES

14.1 Introduction: When a pole structure is guyed, loading on the poles is due to the combined action of vertical and horizontal forces. Vertical forces on the pole include the vertical component of the tension on the guy(s) and the weight of the conductors and insulators. Horizontal forces include transverse due to wire tension at angle structures, horizontal wind forces, and vertical and longitudinal forces from deadending.

Bisector guys are used on small angle structures, whereas head and back guys are used on large angle structures and double deadends. Angles between 10 and 45 degrees may be turned on what is called a "running" angle structure, utilizing bisector guys. Above 45 degrees, unequal stresses will be set up in the conductor where it attaches to the suspension insulator clamp. The sharper the angle or bend in the conductor at the clamp, the more unequal the stresses will be. Any unbalanced longitudinal wire tensions loads on double deadend and large angle structures can be more effectively carried by head and back guys. For large angle structures, the transverse load due to wire tension loads will be a heavy and permanent. Therefore, head and back guys will be more effective in carrying this load.

Figure 14-1 shows a deadend structure in which the conductors are connected to the structure by strain insulators.

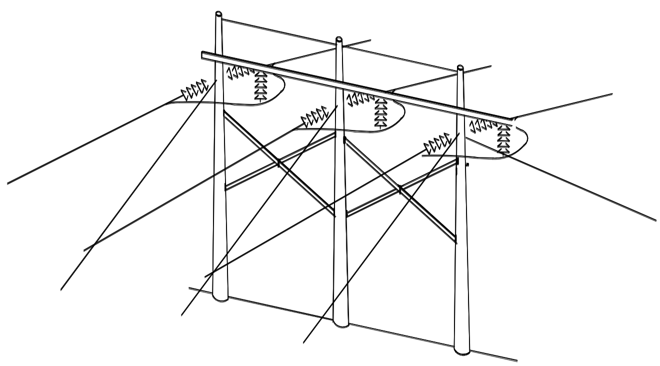


FIGURE 14-1: DEADEND STRUCTURE
(Head and back guys shown)

Deadend structures include:

- Ordinary deadend structures that need only be designed to withstand the load resulting from the difference in tensions of the conductor for the forward and back spans. This condition occurs where there is a change in ruling spans.
- Full deadend structures in which guys and anchors are designed to withstand the resultant load when the conductors are assumed to be broken or slack on one side of the structure. As mentioned in Chapter 10, it is suggested that full deadend structures be located at intervals of five to ten miles to prevent progressive cascading-type failures.

In general for wood structures, guys and anchors should be installed at deadends, angles, long spans where pole strength is exceeded, and at points of excess unbalanced conductor tension. The holding power and condition of the soil (whether wet or dry, packed or loose, disturbed or undisturbed, etc.) and the ability of the pole to resist buckling and deflection should be considered. Unguyed steel and concrete pole structures are sometimes used at angles and deadends to avoid the use of guys. In these cases, careful consideration needs to be made of the structure and foundation design and deflection.

14.2 Load Factors: In Chapter 11, Tables 11-6 and 11-7 give recommended minimum load factors (LF) associated with the design guys and anchors. Table 14-1 summarizes the application of the load factors and strength factors for guys and anchors.

TABLE 14-1
APPLICATION OF LOAD AND STRENGTH FACTORS FOR GUYED STRUCTURES
(GUYS AND ANCHORS)

Loading Districts:					
NESC	(2.50)(a+b)	+ 1.65c	=	G cosβ ≤ (0.9)G_u cosβ	
Recommended	(2.50)(a+b)	+ 1.65c	=	G cosβ ≤ (ϕ)G_u cosβ	(See table 11-6 of this bulletin for ϕ)
Extreme Winds and Extreme Ice with Concurrent Winds:					
NESC	(1.00)(a+b)	+ 1.00c	=	G cosβ ≤ (0.9)G_u cosβ	
Recommended	(1.10)(a+b)	+ 1.100c	=	G cosβ ≤ (ϕ)G_u cosβ	(See table 11-7 of this bulletin for ϕ)

Where:

a	=	Transverse wind load on the conductor
b	=	Transverse wind load on the pole
c	=	Transverse component of wire tension load.
A_u	=	Rated anchor capacity
G	=	The calculated force in the guy, considering guy lead. The rated breaking strength of the guy wire (G_u) and the anchor capacity (A_u) multiplied by their respective strength factor must equal or exceed this value.
G_u	=	Rated breaking strength of the guy wire
ϕ	=	Strength factor; see table 11-7 of this bulletin
cosβ	=	Guy slope with horizontal groundline

14.2.1 Longitudinal Strength: Longitudinal strength is applicable to crossings and locations where unequal spans and unequal vertical loadings may occur. Required longitudinal strength of wood tangent structures at crossings is defined by NESC Rule 261A2. The rule states that wood tangent structures which meet transverse strength requirements without guys, shall be considered as having the required longitudinal strength, provided that the longitudinal strength of the structure is comparable to the transverse strength of the structure. If there is an angle in the line, the wood structure will have the required longitudinal strength provided:

- The angle is not over 20 degrees,
- The angle structure is guyed in the plane of the resultant conductor tensions, and
- The angle structure has sufficient strength to withstand, without guys, the transverse loading which would exist if there were no angle at that structure (with the appropriate load factors and strength factors applied).

14.2.2 Distribution Underbuild: Guying and anchors for distribution underbuild are to comply with NESC Grade B provisions. Refer to Chapter 16 for additional information concerning underbuild.

14.3 Clearances: Recommended clearances to be maintained between any phase conductor and guy wires are indicated in Table 14-2. Refer to Chapter 7 for further details.

TABLE 14-2
RECOMMENDED MINIMUM CLEARANCES IN INCHES
FROM CONDUCTOR TO SURFACE OF STRUCTURE OR TO GUY WIRES (Note A)

Nominal Voltage, Phase to Phase,kV	**34.5**	**46**	**69**	**115**	**138**	**161**	**230**
Standard Number of 5-3/4”x10” Insulators on Tangent Structures	**3**	**3**	**4**	**7**	**8**	**10**	**12**
Max. Operating Voltage, Phase to Phase, kV	34.5	46	72.5	120.8	144.9	169.1	241.5
Max. Operating Voltage, Phase to Ground, kV	19.9	26.6	41.8	69.7	83.7	97.6	139.4
Wind Condition	**Clearance, in.**						
NO WIND CLEARANCE							
Min. clearance to guy at no wind (Notes A, B)	19	19	25	42	48	60	71
MODERATE WIND CLEARANCE (based on NESC Rule 235E, Table 235-6)							
Min. clear. to structure at 6 psf of wind (Notes C, D)	9	11	16	26	30	35	50
Min. clear. to jointly used structures and a 6 psf of wind (Notes C, D)	11	13	18	28	32	37	52
Min. clearance to anchor guys at 6 psf (Notes C, D)	13	16	22	34	40	46	64
HIGH WIND CLEARANCE							
Min. clearance to guys at high wind	3	3	5	10	12	14	20

Notes:
(A) If insulators in excess of the standard number for tangent structures are used, the no-wind clearance value given should be increased by 6 in. for each additional bell. For instance, extra insulation in the form of additional insulator bells may be used on steel structures where grounding is a problem or the structures are located in high isokeraunic areas. In these instances, the no wind clearances should be increased. If excess insulators are needed for contamination purposes only, the additional clearance is not necessary
(B) For post insulators, the no-wind clearance to structure or guy is the length of the post insulator.
(C) A higher wind may be assumed if deemed necessary.
(D) The following values should be added as appropriate where the altitude exceeds 3300 feet

Additional inches of clearance per 1000 feet of altitude above 3300 feet:

Nominal Voltage, KV	34.5	46	69	115	138	161	230
Clearance to structure	0	0	0.14	0.43	0.57	0.72	1.15
Clearance to guy	0	0	017	0.53	0.72	0.90	1.44

14.4 Design

14.4.1 Bisector Guys: For structures utilizing bisector guys, the guys have to be designed to sustain the resultant transverse load due to longitudinal wire tension loads in Table 14-1:

$$c = 2\,(T)\,(\sin \theta/2)$$

where:
T = maximum design tension, lbs.
θ = line angle

The transverse load (a) due to wind on the conductors for an angle structure is given as:

$$a = (p)\,(HS)\,(\cos \theta/2)$$

where:
p = wind load in lbs./ft.
HS = horizontal span, ft.
θ = line angle; cos θ/2 is usually set equal to one

Wind on the structure may be converted to a horizontal force (b) at the point of guy attachment.

14.4.2 Head and Back Guys: Wood pole deadends, double deadends, and large angle structures will normally require head and back guys. For tangent deadends and double deadends, the transverse strength of the structure must be sufficient to carry the appropriate wind load. In some cases, bisector guys or crossbraces may have to be used to meet transverse strength requirements. The tension in the guy should take into account the slope of the guy.

14.5 Pole Strength: Once the tension in the guy wire has been calculated, the compressive strength of the pole should be calculated and checked to see if the pole selected will be adequate for the intended use.

14.5.1 Stability Concept: The selection of structural members is based on three characteristics: strength, stiffness, and stability. When considering a guyed wood, steel or concrete pole, it is important that the designer check the stability of the structure for the expected loadings.

For an example of stability, consider the axial load carrying capabilities of the rods in Figure 14-2. The rod on the left is unquestionably “more stable” to axial loads than the rod on the right. Consideration of material strength alone is not sufficient to predict the behavior of a long slender member. As an example, the rod on the right might be able to sustain 1000 lbs axial load when considering strength (ultimate compressive stress times area), but could only sustain 750 lbs. when considering stability of the system. The rod on the right is more likely to become laterally unstable through sidewise buckling.

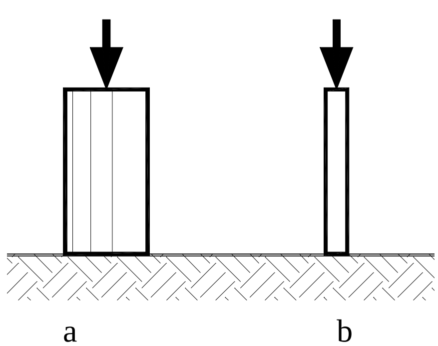


FIGURE 14-2: COMPARISON OF RODS TO SHOW STABILITY CONCEPT

14.5.2 <u>Critical Column Loads</u>: In transmission structures, the guyed pole acts as a column, sustaining axial loads induced in the pole from vertical guy components. The taller the pole, the less load the guyed pole can sustain in compression before the structure becomes "unstable".

Stability of a column can be thought of in one of two ways:

a. The column is unstable when the axial force would cause large lateral defections even when the lateral load was very small.

b. When a column subjected to an axial force, a small deflection may be produced. The column is considered stable if the deflection disappears when the lateral force is removed, and the bar returns to its straight form. If the axial force (P) is gradually increased, a condition is reached in which the straight form of equilibrium becomes unstable and a small lateral force will produce a deflection which does not disappear when the lateral force is removed. The "critical" load is then the axial force which causes buckling or collapses due to any bowing or lateral disturbance.

14.5.3 <u>Calculation of Buckling Loads</u>: For long slender columns, the critical buckling load is determined by the general equation:

$$P_{cr} = \frac{\pi^2 EI}{(k\ell)^2}$$

(P_{cr} is independent of the yield stress of the material).

where:

P_{cr} = critical buckling load, lbs. or kips
E = modulus of elasticity, psi
I = moment of inertia, in^4
$k\ \ell$ = the effective unbraced length of the column; kl depends on restraint end conditions of the column.

Where for the various end conditions of the column, P_{cr} is idealized in Figure 14-3 below:

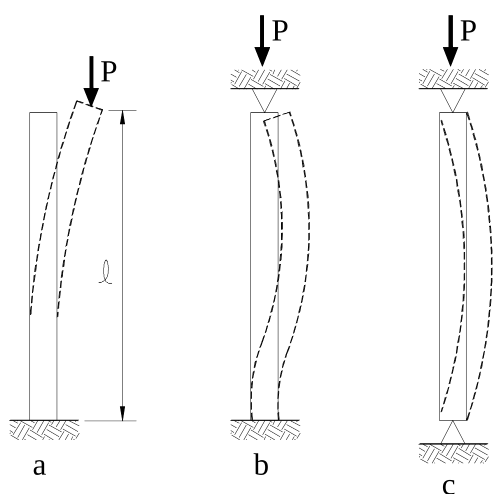


FIGURE 14-3: EFFECTIVE UNBRACED LENGTH FOR VARIOUS END CONDITIONS

Assumptions made in the above calculations:

- The column is perfectly straight initially.
- The axial load is concentrically applied at the end of the column.
- The column is assumed to be perfectly elastic.
- Stresses do not exceed the proportional limit.
- The column is uniform in section properties.

14.5.4 Buckling of Guyed Steel and Concrete Poles: For guyed steel and concrete poles, all the assumptions in paragraph 14.5.3 are violated. As such, the engineer will often ask the pole manufacturer to check the axial capacity of the pole. The engineer must give the pole manufacturer information concerning guy size and strength, yield stress, guy locations, and guy leads. In the case of steel poles, the pole manufacturer should also check the capacity of the guy attachments. It is recommended that in the case of concrete poles, the pole manufacturer should design the guy attachment or at least check the capacity of the pole and attachment when the owner has selected the hardware.

14.5.5 Buckling of Guyed Wood Poles: For a guyed wood poles, all the assumptions in paragraph 14.5.3 are also violated. As such, the engineer must apply appropriate safety factors to account for realistic cases and the variability of wood. Equations for buckling of a wood column with no taper follow:

Conditions	Fixed – Free End Figure 14-3a	Fixed – Pinned End Figure 14-3b	Pinned – Pinned End Figure 14-3c
For a column with no taper	$P_{cr} = \frac{\pi^2 EI}{4\ell^2}$	$P_{cr} = \frac{2\pi^2 EI}{\ell^2}$	$P_{cr} = \frac{\pi^2 EI}{\ell^2}$

One method of calculating the buckling capacity of a tapered wood column was developed by Gere and Carter. This method modifies the critical buckling load as follows:

$$P_{cr} = P_A P^*$$

$$P^* = \left(\frac{d_g}{d_a}\right)^{\alpha}$$

where:

P_A = Critical load for a uniform column with circular cross sections having diameter d (at guy attachment), lbs.

P^* = A multiplier dependent on the end conditions of the column, lbs.

E = Modulus of Elasticity, psi

I_A = Moment of Inertia at the guy attachment, in^4

d_g = Diameter at the groundline, in.

d_a = Diameter at the point of guy attachment, in.

ℓ = Distance from the groundline to the point of guy attachment, in.

α = An exponent that is a function of shape of the column

For tapered round columns, the equations become:

Conditions	Fixed – Free End	Fixed – Pinned End	Pinned – Pinned End
For a tapered column (circular cross section)	$P_{cr} = \frac{\pi^2 EI_A}{4\ell^2}\left(\frac{d_g}{d_a}\right)^{2.7}$	$P_{cr} = \frac{2\pi^2 EI_A}{\ell^2}\left(\frac{d_g}{d_a}\right)^{2.0}$	$P_{cr} = \frac{\pi^2 EI_A}{\ell^2}\left(\frac{d_g}{d_a}\right)^{2.0}$

When using the Gere and Carter method for the NESC district loads with load factors, strength factors between 0.65 to 0.5 respectively are recommended. The resulting safety factor will be between 2.5 and 3.0. For extreme wind loads, it is recommended that strength factors between 0.65 and 0.5 be used, resulting in a safety factor between 1.5 and 2.0. For deadends, lower strength factors (or higher safety factor) should be used.

14.5.6 <u>General Application Notes</u>: For unbraced guyed single poles at small and medium angles structures using bisector guys, certain assumptions are made as to the end constraints. In the direction of the bisector guy, the structure appears to be pinned at the point of the guy attachment and fixed at the base. However, 90° to the bisector guy, the structure appears to be a cantilevered column. Since the conductors and phase wires offer some constraint, the actual end conditions may be assumed to be between fixed-free and fixed-pinned (Figure 14-4a). When checking buckling, it is suggested that the end conditions of pinned-pinned be assumed.

Buckling Mode	End Conditions	
	Bisector Guyed	In-Line Guyed
Longitudinally	pinned-pinned	pinned-fixed
Transversely	pinned-fixed	pinned-fixed

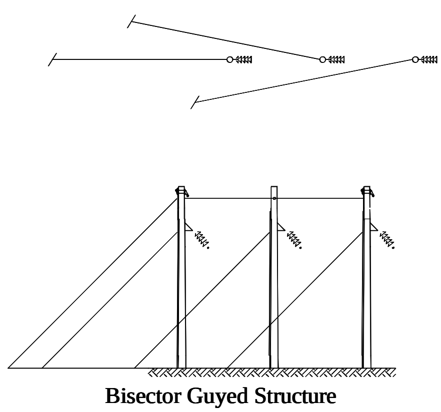


FIGURE 14-4a

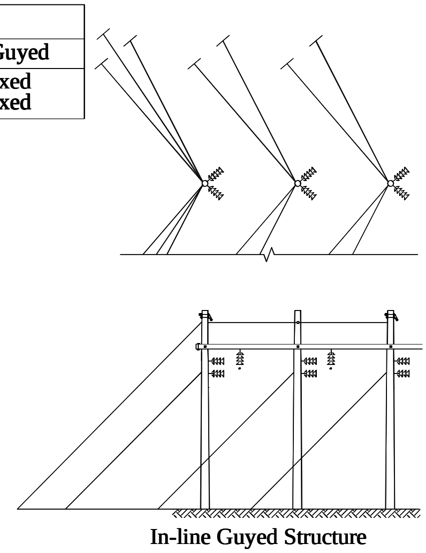


FIGURE 14-4b

FIGURE 14-4: END CONDITIONS FOR BISECTOR AND IN-LINE GUYED STRUCTURES

For in-line guyed poles at medium angles and large angle deadends, the structure appears to be pinned at the point of guyed attachment and fixed at the base in both directions (Figure 14-4b). For in-line guyed poles at tangent deadends without side guys, it is suggested that fixed-free be assumed.

In many instances, axial loads are applied intermittently along the pole. In Figure 14-5a, the static wire and phase wire are guyed at their respective locations. The axial loads acting on the pole on the left are applied as shown in Figure 14-5b.

In such instances, the usual engineering practice is to assume an unbraced length from the groundline to the lowest guy attachment and the induced axial load in the pole equal to the sum of all axial loads included by the vertical component of the guys.

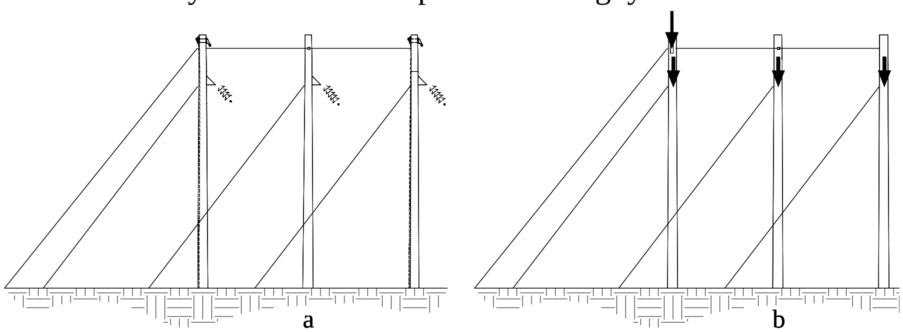


FIGURE 14-5: AXIAL LOADS INDUCED IN A POLE

When the structure is considered to be a double deadend or large angle, the poles, guys, and anchors must sustain the full deadend load with an appropriate load factor. For the tangent double deadend shown in Figure 14-6, the poles must sustain the maximum axial load which might occur if all phase conductors on one side of the structure were removed (see Figure 14-6a and 14-6b). However, to “double account” the loads, as shown in Figure 14-6c would be too conservative.

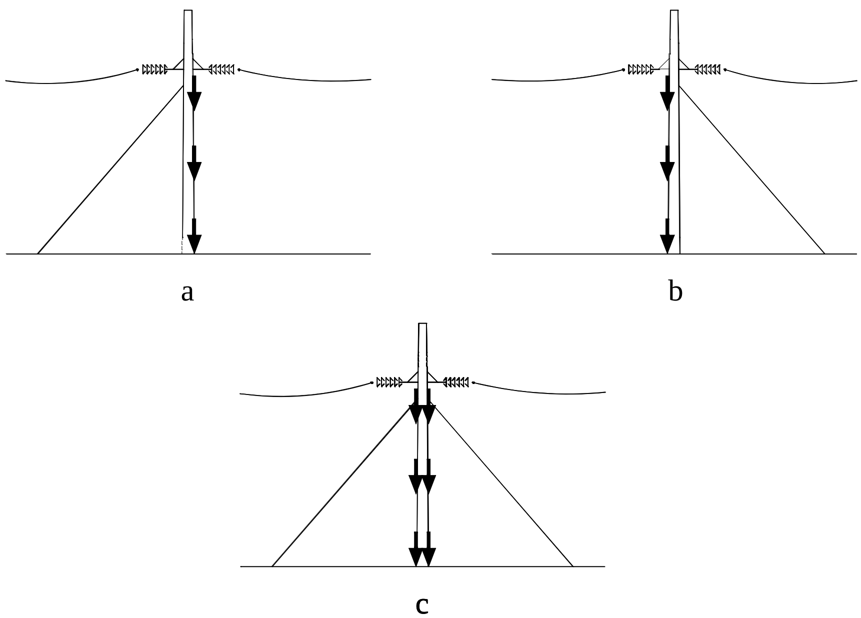


FIGURE 14-6: REPRESENTATION OF AXIAL LOADS (a & b)
AND DOUBLE ACCOUNTING LOADS (c)

For wood pole lines, deadends and large angle structures will often require a higher class pole than that used as the base class pole for the line. Ways to control or reduce the pole class needed at deadends and large angles include:

- Relocate and/or increase the height of tangent structures adjacent to guyed angle and deadends. This would allow the use of shorter poles with guyed structures, and as a result would allow use a lower class pole with no sacrifice in safety.

- Decrease the guy slope. This will decrease the vertical load component pole.

As a note, angle and deadend structures usually comprise about 5 percent of the total structures of a line. Use of conservative safety factors for these critical structures results in a greater overload margin without significantly affecting the total cost of the transmission line.

The engineer should consider guying single pole structures used for small angles, even if the pole has adequate strength to carry the load. Wood poles have a tendency to "creep" with time when subjected to a sustained load. For steel or concrete poles, the engineer should also consider the use of guyed poles at angles or deadend structures. Use of guys will prevent unguyed steel and concrete poles from having large diameters at the groundline and will reduce the cost of foundations.

14.6 Anchors: The holding power of the anchor will largely depend on whether the soil is wet or dry, packed or loose, disturbed or undisturbed. Since soils vary considerably between locations, the holding power of an anchor will also vary considerably.

In areas with a fluctuating water table, the capacity of the anchors should take into account the submerged unit weight of the soil. If at any time the holding power of an anchor is questionable due to variable soil conditions, the anchor should be tested. The primary types of anchors include log anchors, plate anchors, power screw anchors, and rock anchors. The selection of the appropriate anchor will largely depend on the type of soil condition.

14.6.1 Log Anchor Assemblies: The two log anchors in the construction drawings (agency Bulletins 1728F-810 and 811, units TA-2L and 4L) are 8″ x 5′ - 0″ and 8″ x 8′ - 0″, and have an ultimate holding power of 16,000 lbs. and 32,000 lbs. These logs, using one or two anchor rods may be used in combination to provide sufficient holding power for guys. "Average" soil is considered to be medium dense, coarse sand and stiff to very stiff silts and clays. Log anchors should be derated or should not be used in soils of soft clay, organic material, saturated material, or loose sand or silt.

14.6.2 Plate Anchors: The plate anchor assembly TA-3P in Bulletins 1728F-810 and 811, is rated at an ultimate holding power of 16,000 lbs and 24,000 lbs. In firm soils, where the engineer would like to minimize digging, plate anchors may prove economical.

14.6.3 Power Screw Anchors: Screw anchors are being used more often because of their easy installation. They are most appropriate for locations where firm soils are at large depths. The screw anchor assembles TA-2H to TA-4H of Bulletins 1728F-810 and 811 should be installed per manufacturer's recommendations. In addition to the anchor unit being shown on the plan and profile, the capacity of the screw anchor should also be shown. Screw anchors have a higher safety factor than other types of anchors. This higher safety factor is reflected in Information Bulletin 202-1, "List of Materials Acceptable for Use on Systems of USDA Rural Development Electrification," by a reduced designated ultimate holding capacity (70 percent of the manufacturer's suggested holding capacity).

14.7 Drawings: A summary drawing should be prepared for each line, showing the arrangement of guys for each type of structure to be used. The drawing will greatly facilitate the review of the plan and profile, and simplify the construction of the line.

Guys required for various line angles are based on certain spans. Since actual spans will vary, the guying requirements shown will not be suitable for all conditions. Sometimes, it is desirable to make a guying guide for each angle structure which relates horizontal span to the angle of the line (see the example, paragraph 14.8).

The Guying Guide drawing also shows (1) points of attachment of the guy to the pole, (2) slope of the guys, (3) type of structure, and (4) guys and anchors required.

14.8 **Example**: Develop guying guides for TH-12 161 kV structure.

14.8.1 **Design Parameters**

General Loading and Structure Information**:**

NESC Heavy Loading		
Extreme Wind:	19 psf on wires,	22 psf on the structure
Heavy Ice:	1” radial	
Extreme Ice with Concurrent winds	1” radial	4 psf

Pole:	Douglas fir 80-2
Conductor:	795 kcmil 26/7 ACSR
Overhead ground wire:	7/16” E.H.S.
Ruling Span:	800 ft.
Guy Wire:	7/16” E.H.S.

Conductor Loads, lbs/ft:

	Heavy	High Wind	Heavy Ice	EI&W
Transverse	0.7027	1.7543	0	1.0360
Vertical	2.0938	1.0940	3.7154	3.7154
Conductor tensions	10,400 lbs.	NA	12940 lbs.	13240 lbs.

Overhead Ground Wire loads, lbs/ft**:**

	Heavy	High Wind	Heavy Ice	EI&W
Transverse	0.4783	0.6888	0	.8116
Vertical	0.9804	0.3990	2.1835	2.1835
OHGW tensions	5,900 lbs.	NA	7,500 lbs.	7800 lbs.

Guy wire: 7/16” E.H.S.

Ultimate tension (R.B.S.):	20,800 lbs.
Horizontal strength with 1/1 lead:	14,700 lbs.

Anchors: 8,000 lbs. and 16,000 lbs.

Ultimate Capacity:	16,000 lbs. and 32,000 lbs.
Horizontal strength with 1/1 lead:	11,300 lbs. and 22,600 lbs.

Soil: Average, presumptive ultimate bearing capacity approximately equal to 4000 psf.

14.8.2 Solution for Heavy Loading District:

a. Wind on the wires:

Conductor: $a = .7027\ (HS)\ (\cos \theta/2)$

OHGW: $a = .4783\ (HS)\ (\cos \theta/2)$

b. Wind on the pole: $b = 143$ lbs.

Here (b) is based on an 80-2 pole with the guy located 60 ft. from the ground. The equivalent horizontal load (b), at this location is determined by Mwp/lever arm.

b = 8590 ft.-lbs./60 ft.

c. Wire tension loads:

Conductor: $c = 2(10,400) \sin \theta/2$

OHGW: $c = 2(5,900) \sin \theta/2$

d. Equations from Table 14-1 of this bulletin:

General Equation:

$2.50(a+b) + 1.65c = G\cos\beta \leq .65G_u\cos\beta$ or

$2.50(a+b) + 1.65c = G\cos\beta \leq .65A_u\cos\beta$

For one conductor:

$2.50\ [(.7027)\ (HS)\ (\cos \theta/2) + (143)] + 1.65\ [2(10,400)\ (\sin \theta/2)] \leq .65G_u\ (\text{or } A_u) \cos\beta$

$358 + (1.757)\ (HS)\ (\cos \theta/2) + 34,320\ (\sin \theta/2) \leq .65G_u \cos\beta$ or $\leq .65A_u\cos\beta$

$550 + (2.703)\ (HS)\ (\cos \theta/2) + 52,800\ (\sin \theta/2) \leq G_u \cos\beta$ or $\leq A_u\cos\beta$

For one OHGW:

$2.50\ [(.4783)\ (HS)\ (\cos \theta/2) + (\text{neg.})] + 1.65\ [2(5,900)\ (\sin \theta/2)] \leq .65G_u\ (\text{or } A_u) \cos\beta$

$(1.196)\ (HS)\ (\cos \theta/2) + (19,470)\ (\sin \theta/2) \leq .65G_u \cos\beta$ or $\leq .65A_u\cos\beta$

$(1.840)\ (HS)\ (\cos \theta/2) + (29,954)\ (\sin \theta/2) \leq G_u \cos\beta$ or $\leq A_u\cos\beta$

Case 1: Using 1 guy wire and 1 anchor for the three conductors and 1 guy wire and 1 anchor for both OHGW, the following general equations result (1/1 leads).

For the 3 conductors:

$3(550) + 3(2.703)(HS)(\cos \theta/2) + 3(52800)(\sin \theta/2) \leq G_u \cos\beta$ or $\leq A_u\cos\beta$

$1650 + 8.109\ (HS)(\cos \theta/2) + (158,400)(\sin \theta/2) \leq 14,700$ lbs.(for guy)

$1650 + 8.109\ (HS)(\cos \theta/2) + (158,400)(\sin \theta/2) \leq 11,300$ lbs. (for anchor)

For the 2 OHGW's:

$2(1.840)(HS)(\cos \theta/2) + 2(29,954)(\sin \theta/2) \leq G_u \cos\beta$ or $\leq A_u\cos\beta$

$3.680(HS)(\cos \theta/2) + (59,908)(\sin \theta/2) \leq 14,700$ lbs. (for guy)

$3.680(HS)(\cos \theta/2) + (59,908)(\sin \theta/2) \leq 11,300$ lbs. (for anchor)

Case 2: Using 2 guy wires and 2 anchors for the three conductors and 1 guy wire and 1 anchor for both OHGW, the following general equations result (1/1 leads).

For the 3 conductors:

$1650 + (8.109)(HS)(\cos \theta/2) + (158,400)(\sin \theta/2) \leq (2)14,700$ lbs. (for guy)

1650 + (8.109)(HS)(cos θ/2) + (158,400)(sin θ/2) ≤ (2)11,300 lbs. (for anchor)

For the OHGW: (same as above)

See the Guying Guide at the end of this example for plots of controlling equations.

e. Checking for buckling of the poles. Since the outside poles carry the maximum axial load, it is necessary only to examine this pole. Longitudinal buckling is considered since this condition is the critical case. Weight of the conductor and OHGW is included in the calculations.

The following example calculations are for Case 1 above.
The maximum axial load which various poles can sustain can be calculated for various heights of structures. The Gere and Carter method is used to calculate P_{cr} below:

Pole Class & Height	Unbraced Length, ℓ Ground to Lowest Guy Attachment, ft.	d_g in.	d_a in.	I_A At Point d_a ($\pi d^4/64$) in^4	$P_{cr} = \frac{\pi^2 EI_A}{\ell^2}\left(\frac{d_g}{d_a}\right)^{2.0}$ pinned-pinned assumed lbs.
60-1	42	15.03	9.83	458	79935
60-2		14.09	9.14	343	60733
60-3		13.15	8.44	249	45108
80-1	60	16.72	9.76	445	47784
80-2		15.64	9.05	329	35948
80-3		14.55	8.35	239	26485

Assuming that horizontal spans are equal to the vertical span, the previous equations in item d above be revised to include the weight of the conductor and OHGW on the outside pole. The total axial load in the pole is the sum of the axial loads induced in the pole from guying the three conductors and two OHGW, and the vertical weight of the OHGW and conductor. Half of the vertical load from the outside phase is carried by the middle pole and other half is carried by the outside pole. For this example, since the guy leads are 1 to 1, the vertical axial load from the guy wire will be equal to the horizontal component of the guy wire.

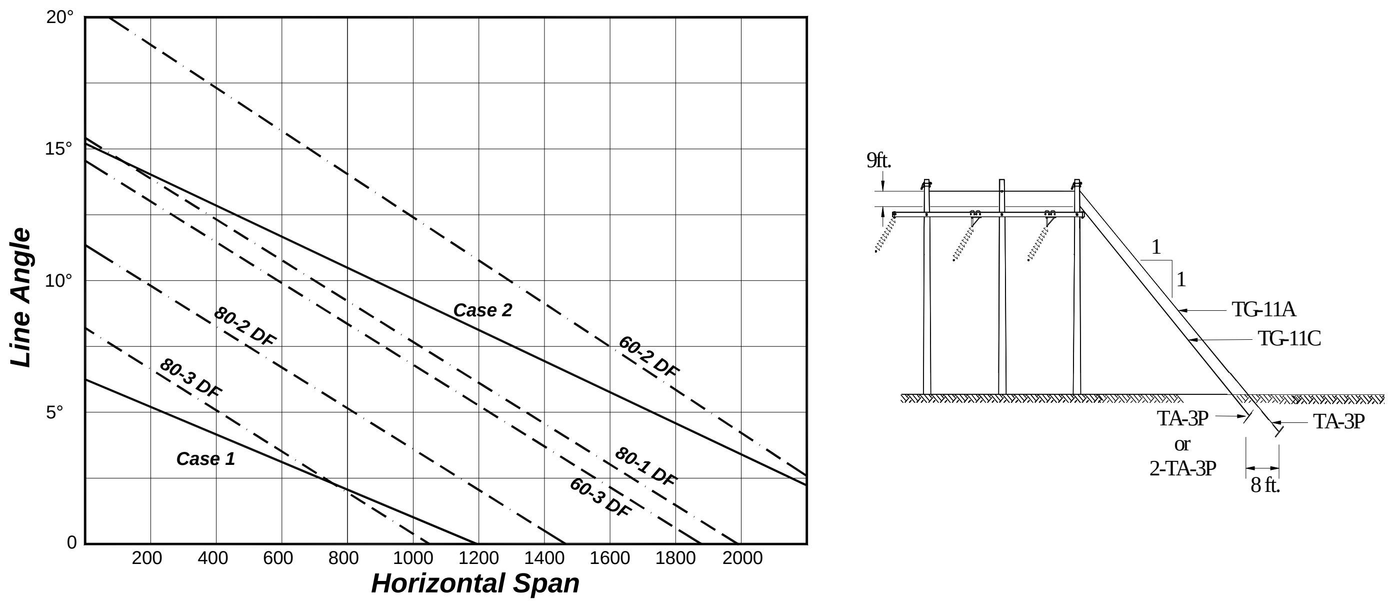
	Wire Weight +	Induced Axial Load, Guying 3 conductors and 2 OHGW's			
Cond.	1.5(.5)(2.0938)HS+	8.109(HS)(cos θ/2)	+1652	+158,400(sinθ/2)	
OHGW	1.5(.9804)HS +	3.680(HS)(cos θ/2)		+ 59,908(sinθ/2)	
Total	(3.0401)HS +	11.789(HS)(cos θ/2)	+1652	+218,300(sinθ/2)	≤ .65P_{cr}

GUYING GUIDE

Structure:	TH – 12	Ruling Span	800 ft.
Conductor Type:	795 26/7	Max. Tension (L, M, H):	10,400 lbs.
OHGW Type:	7/16″ E. H. S.	Max. Tension (L, M, H):	5,900 lbs.
Guy Wire Type	7/16″ E. H. S	Ultimate Strength	20.800 lbs.

Heavy Loading District

p_C:	0.7027 lbs./ft.	p_g:	0.4783 lbs/ft.
w_C:	2.0938 lbs./ft.	w_g:	0.9804 lbs/ft.



Line Angle chart/drawing

Case 1
For OHGW: TG - 11A, TA - 3P
For conductor: TG - 11A, TA - 3P

Total guys and anchors:
(2) TG - 11A
(2) TA - 3P

Limitation: TA-3P to conductor

Case 2
For OHGW: TG – 11A, TA-3P
For conductor: TG – 11C, (2)TA - 3P

Total guys and anchors:
1 - TG – 11A
1 - TG – 11C
3 - TA – 3P

Limitation: TA - 3P to conductor

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15. HARDWARE

15.1 General: Hardware for transmission lines can be separated into conductor-related hardware and structure-related hardware.

Conductor-Related Hardware**:** For many transmission lines, the conductor may constitute the most expensive single component of investment. Yet, this is the one component which is most exposed to danger and most easily damaged. In the design of any line, appropriate emphasis should be given to mechanical and electrical demands on the design of conductor-related hardware used to support, join, separate, and reinforce the overhead conductor and overhead groundwire. Conductor motion hardware is used to diminish damage to the overhead conductors from vibration. Selection and proper installation of conductor accessories will have considerable influence on the operation and maintenance of a transmission line. Electrical, mechanical, and material design considerations are generally involved in the design of conductor support hardware and conductor motion hardware.

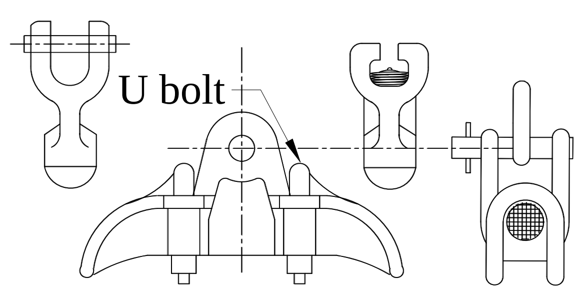
Structure Related Hardware**:** This includes any hardware necessary to frame a structure, to accommodate guying and other types of pole attachments to the structure and to provide necessary conductor-to-structure clearances. As structure–related hardware items are the connecting pieces for structural members, proper selection of this hardware is necessary to assure structure strength. At the same time, proper selection of structure-related hardware includes use of designs that are static proof or incorporate static proof aids to help minimize possible radio and television interference emanations from the line (see Appendix I).

Selection of conductor-related and structure-related hardware should consider corrosion and the damage and degradation of strength and visual esthetics that corrosion can cause. In addition to selecting hardware made of materials that are less likely to corrode, the designer should be certain that the materials selected are compatible with one another and will not corrode when in contact with each other.

15.2 Conductor-Related Hardware

15.2.1 Suspension Clamps: Contoured suspension clamps are designed to match the conductor diameter in order to guard against conductor ovaling and excessively high compressive stresses on the conductor. Suspension clamps may be made from galvanized malleable iron or forged steel. Aluminum liners are recommended for aluminum conductors. Copper liners are recommended for copper conductors only. The connector fitting will usually be either a socket or clevis (see Figure 15-1). When using clamps with liners on conductors covered by armor rods, designers should select clamps that have the proper seating diameter for the effective diameter of the conductor and armor rod. Liners can be expected to add 1/10 inch to the conductor diameter. There are a few clamps made for large line angles (up to 120^{o}). However, these clamps are available only for small conductor sizes. When a transmission line with large conductors has to make a turn along its route, strain clamps should be used. In the case of medium angles (greater than a 30 degree line angle) double suspension clamps connected to a yoke plate may be needed to make a gradual turn.

FIGURE 15-1: SUSPENSION CLAMP WITH CLEVIS OR BALL AND SOCKET TYPE OF CONNECTION



Cushioned suspension clamps are sometimes used to support the conductor and reduce the static and bending stresses in the conductor. Cushioned suspension clamps are further explained in the conductor motion hardware section (Section 15.3).

15.2.2 <u>Clamp Top Clamps</u>: Clamp top clamps for vertical and horizontal post insulators are popular because of they are simple to install. The clamps, made of malleable iron or aluminum alloy, are mounted on a metal cap. The clamp itself is composed of a removable trunion cap screw (keeper piece) and a trunion saddle piece (Figure 15-2).

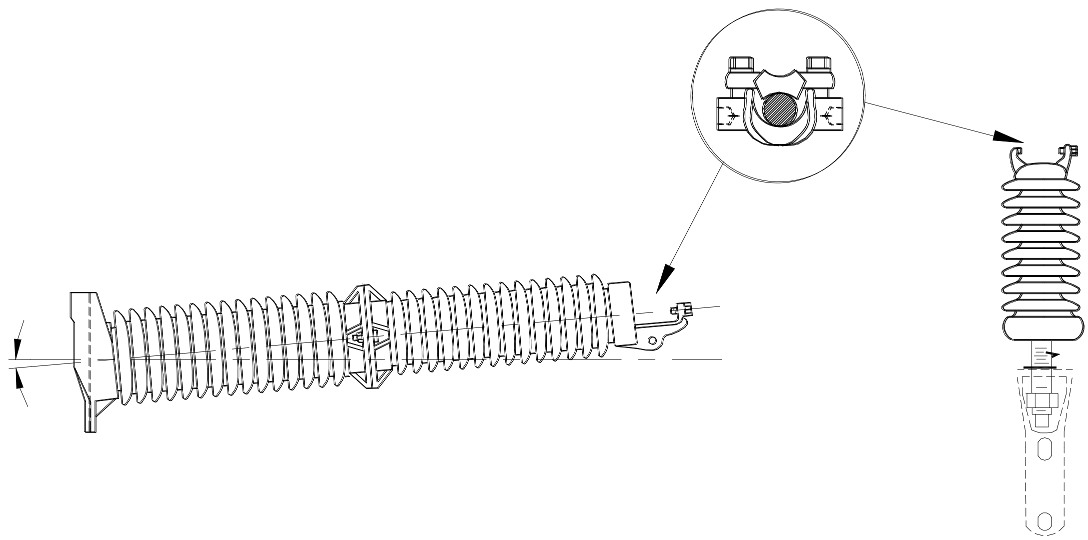


FIGURE 15-2: POST TYPE INSULATOR WITH STRAIGHT LINE TRUNION CLAMPS

Straight line clamps are designed to hold conductors without damage on tangent and line angles of up to approximately 15°. The maximum acceptable vertical angle (each side of clamp) is considered to be approximately 15° with the horizontal. Since the keeper piece of the clamp is not designed to provide the support for upward loading, this clamp should not be used where uplift conditions could occur. Angle clamps are available which are designed to take up to a 60° line angle. However, when line angles are greater than 15° to 20°, suspension insulators should be used. The designer should coordinate with the trunion clamp manufacturer concerning the compatibility of the clamp design for longitudinal loads on the line.

15.2.3 <u>Tied Supports</u>: A large portion of lower voltage construction involves tying conductors to pin and post insulator supports. Hand ties (Figure 15-3) are occasionally vulnerable to loosening from various forces and motion from differential ice buildup, ice dropping, galloping, and vibration. Factory formed ties with secure fit, low stress concentration and uniformity of installation may eliminate mechanical difficulties and radio interference problems associated with loose tie wires.

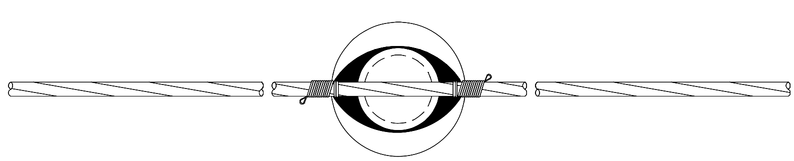


FIGURE 15-3: TOP GROOVE HAND TIE

15.2.4 Deadend Clamps: Deadending a conductor may be accomplished by using formed type deadends, automatic deadends, bolted deadends or compression type deadends (See Figures 15-4a and 15-4b). Because of the strength limitations of formed and automatic deadends, these types are limited to primarily small conductor sizes and distribution line use. The two basic methods of deadending a transmission conductor are by use of bolted deadend clamps and by compression type deadend clamps.

Deadend clamps, or strain clamps as they are sometimes called, are made from three basic types of material as follows:

Aluminum Alloy Type:

General Notes: This type is corrosion resistant. It minimizes power losses, minimizes hysteresis and eddy currents, minimizes excessive conductor heating in the conductor clamping area and is lightweight. This clamp is the most widely used.

Application: No armor rods or tape are required. Clamps are to be used with ACSR or all aluminum conductors. These clamps are not to be used with copper or copperclad conductors.

Malleable Iron:

General Notes: This clamp is somewhat lightweight. The range of conductor sizes is limited.

Application: Clamps are to have aluminum or copper liners. Clamps with copper liners are to be used for copper or copper-clad conductors. Clamps with aluminum liners are used for ACSR and other aluminum composite type conductors

Forged Steel:

General Notes: Forged steel clamps are heavy in weight.

Application: Clamps may be used with all aluminum, copper or ACSR conductors. Clamps are to have aluminum or copper liners. Clamps with copper liners are to be used for copper or copper-clad conductors. Clamps with aluminum liners are used for ACSR and other aluminum composite type conductors.

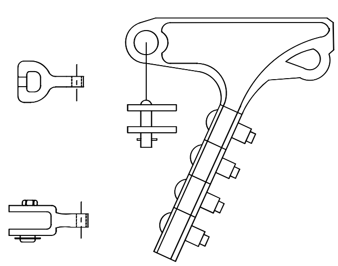


FIGURE 15-4a: TYPICAL BOLTED DEADEND CLAMP

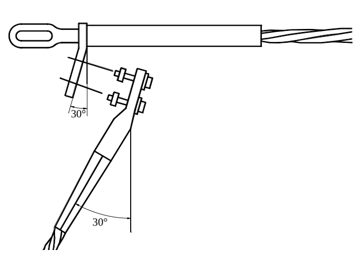


FIGURE 15-4b: TYPICAL COMPRESSION DEADEND

The ultimate strength of the body of the bolted clamps should meet or exceed the ultimate strength of the conductor the clamp is designed to hold. The holding power of a bolt type or compression type clamp should meet the following criteria:

- Clamps have to be capable of holding at least 90 percent of the strength of the largest conductor for which the clamp is designed to hold in a short-time load.
- Clamps have to hold a sustained load of 75 percent of the strength of the conductor for 3 days.

For bolted type clamps, the amount of torque to tighten the bolts depends on the size of the bolt. Torque will range from 300 in-lbs. for 3/8" bolts to 400 in.-lbs. for 5/8" bolts. Clamps should also meet certain corrosion resistance tests and heat cycling tests.

Suspension and deadend clamps for use on high voltage transmission lines are specially designed to control corona. Designs usually involve providing smooth and rounded surfaces rather than sharp edges and by placing all the clamp nuts and studs within the protection of the electrical shield.

Installation of compression splices, deadend clamps, and bolted deadend clamps should follow the manufacturer's recommendations.

15.2.5 Splices: Conductor splices may be automatic compression type splices, formed type splices, or crimp compression type splices. For most transmission conductors, the crimped compression type splice is used because of its high strength capabilities. Splices should meet the same strength, corrosion resistance and heat cycling requirements as the deadend clamps.

15.2.6 Strain Yokes: Two or more insulator strings may be connected in parallel by using yokes to:

- Provide the strength needed to sustain heavy loads at deadend structures;
- Increase the safety factor for long-span river crossings; and
- Make a gradual turn at large angles.

Usually, it is more economical to supply higher strength rated insulators than to use yokes. One disadvantage to using higher strength rated insulators (36,000 lbs and higher) is that the ball and socket size changes for porcelain insulators which will require other related hardware to be coordinated.

15.2.7 Insulators: Mechanical and electrical requirements of insulators are discussed in Chapter 8. Where suspension insulators are exposed to salt sprays or corrosive industrial emissions, insulators using enlarged pin shafts or corrosion intercepting sleeves are recommended to prolong the life of the insulator pins. Use of corroision intercepting sleeves provide an air space between the pin and the cement. With this design, corrosion can attack the expandable long-lived sleeve. Any increase in the volume of the rust line only distorts the sleeve. However, without the sleeve, bursting stresses would be imposed on the adjacent porcelain. Other types of insulators have enlarged shafts near the cement lines which provide additional sacrificial metal for corrosion.

On lower voltage lines, pin and post type insulators are mounted on structure crossarms. The side and top wire grooves generally limit the size of the conductor with armor rods that can be installed to a maximum of 4/0 and 336.4 kcmil ACSR.

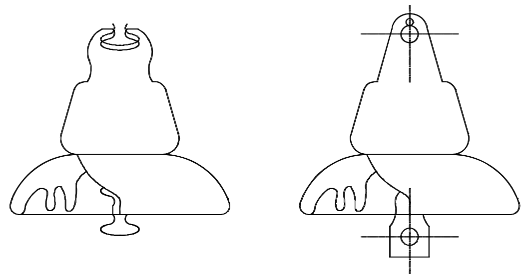


FIGURE 15-5: SUSPENSION INSULATORS
(Ball and Socket Type, Left, and Clevis-Eye Type, Right)

15.2.8 <u>Fittings</u>: Fittings used to attach the insulator to the structure may include hooks, "Y" ball/clevis, ball eyes, ball clevises and chain, anchor or vee shackles. The "C" hooks suggested on agency standard construction drawings are the self locking hooks. With the insulator cap in place, the opening of the hook is sufficiently restricted so that accidental disconnection cannot occur. Fittings should meet or exceed the ANSI M&E ratings of the insulators. Various fitting types are shown in Figure 15-6, 15-7 and 15-8.

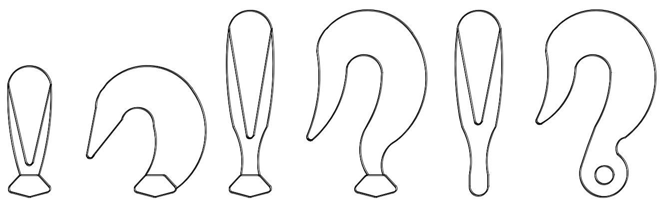


FIGURE 15-6: DIFFERENT TYPES OF HOOKS
(Self Locking "C" Hook, Left; Ball Hook, Middle, Clevis Type Hook, Right)

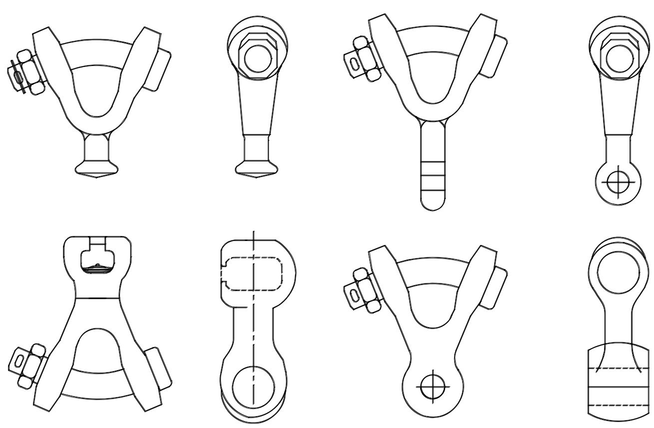


FIGURE 15-7: VARIOUS TYPES OF BALL AND CLEVIS "Y" CONNECTIONS

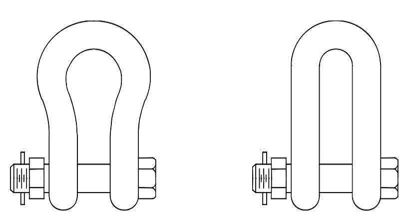


FIGURE 15-8: ANCHOR SHACKLE (Left); CHAIN SHAKLE (Right)

15.3 Conductor Motion Hardware

15.3.1 Aeolian Vibration: All conductors are in some state of vibration, varying from extremely slight to temporarily severe. Selection of the proper hardware to improve conductor life will depend on the degree of vibration. Suspension clamps do not restrict vibration, but these clamps should be designed to keep to a minimum the effect of such vibration on the conductor. Methods to reduce the effects that aeolian vibration has on lines include the following:

Armor Rods**:** Armor rods (Figure 15-9) should be used on lines in areas where mild vibrations may occur. Armor rods, wrenched or preformed, are helical layers of round rods which are installed over the conductor at the points of attachment to the supporting structures. The primary purpose of armor rods is to provide additional rigidity to the conductor at its point of support. The use of armor rods accomplishes:

- Alleviating changes of mechanical stress buildup at the point of support by providing a gentler slope of curvature for the incoming conductor,
- Increasing conductor life from fatigue failure by increasing the flexural rigidity of the conductor, and reducing bending stresses in the conductor,
- Protecting the conductor from flashover damage and mechanical wear at the points of support.

In laboratory tests, the placement of armor rods on the conductor has allowed the conductor to withstand considerably more vibration cycles without fatigue failure. Tests such as these show that there is a significant reduction in stress afforded through the use of armor rods.

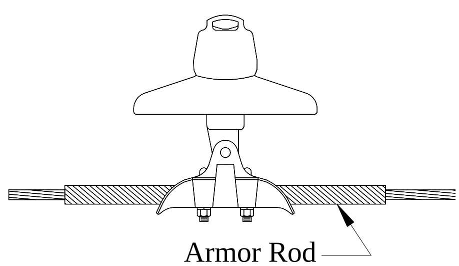


FIGURE 15-9: ARMOR RODS USED WITH SUSPENSION INSULATORS

Cushioned Suspension Units**:** These units use resilient cushioning in conjunction with armor rods to further reduce the static and dynamic bending stresses in the conductor (See Figures 15-10a and 15-10b). With this cushioning, the compressive clamping force is decreased, thereby reducing stress concentration notches. For line angles greater than 30^o, single support units should be replaced with double units. When considering longitudinal loads for a line using cushioned suspension units, the designer should consider that the units have a slip load of approximately 20 percent of the rated breaking strength of the conductor. A disadvantage to cushioned suspension units is that it is very difficult to remove or install these units with hot line tools.

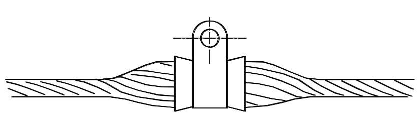


FIGURE 15-10a:
CUSHIONED SUSPENSION UNIT

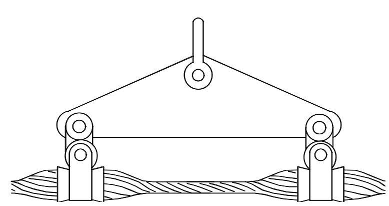


FIGURE 15-10b:
DOUBLE CUSHIONED SUSPENSION
(For Line Angles Greater Than 30º)

<u>Dampers</u>**:** These are used in areas of severe vibration. They act to attenuate aeolian vibration amplitudes and thereby reduce the dynamic bending stress at hardware locations and extend conductor life. Suspension dampers (figure 15-11) make use of the connecting cables between weights to dissipate the energy supplied to the damper. Use of spiral dampers (Figure 15-12) is limited to small conductor sizes (Figure 15-12).

When a vibration wave passes the damper location, the clamp of a suspension type damper oscillates up and down, causing flexure of the damper cable and creating relative motion between the damper clamp and damper weights. Stored energy from the vibration wave is dissipated to the damper in the form of heat. For a damper to be effective, its response characteristics should be consistent with the frequencies of the conductor on which it is installed. Dampers of various designs are available from a number of manufactures. The number of dampers required, as well as their location in the span should be determined by consultation with the damper manufacturer.

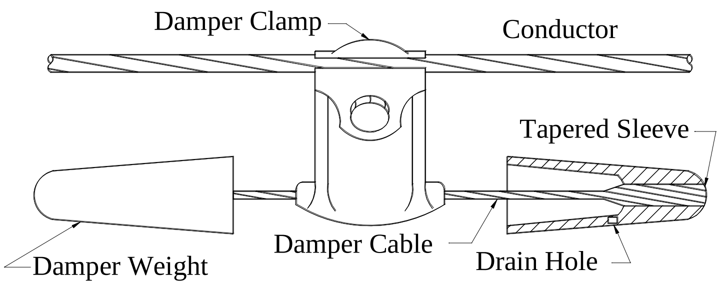


FIGURE 15-11: TYPICAL SUSPENSION DAMPER

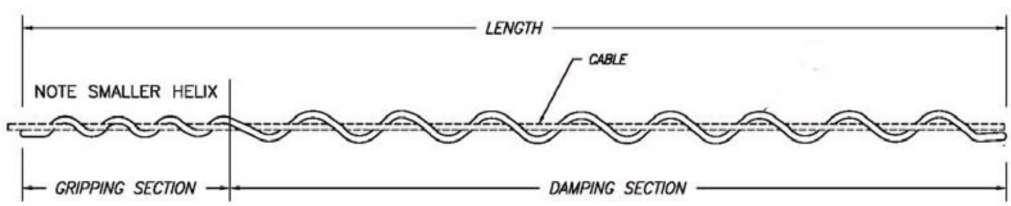


FIGURE 15-12: SPIRAL VIBRATION DAMPER FOR SMALL CONDUCTORS

Application of armor rods, cushion suspension or dampers or a combination thereof should be on a case-by-case basis. A certain item should not be used merely because it has given satisfactory performance in another location.

If prevailing wind conditions and the terrain are such that vibration will occur most of the time, some form of vibration protection should be investigated. Dampers should be selected on the basis of the frequencies one expects to encounter in the terrain that must be traversed. The engineer should not specify a certain type of damper or armor rod simply because everyone else is using them. An improperly located damper can affect the amount of protection and ability of the damper to suppress the damaging effects of aeolian vibration.

Armor rods are meant to be reinforcement items, not dampers. Vibrations are passed on through the conductor clamp basically without any attenuation, and then dissipated in the supporting structure. If the structure is made of steel and if fatigue can be a problem then use of dampers along with armor rods should be investigated. However, care should be exercised in selecting the distance between the ends of the armor rods and the dampers, if both are to be used.

15.3.2 <u>Galloping</u>: Hazards associated with galloping conductors include:

- Contact between phases or between phase conductors and ground wires,
- Racking of the structure,
- Possible mechanical damage at supports.

Aerodynamic drag dampers and interphase spacers are used to limit the amplitude of the conductor during galloping. Historically, effectiveness of anti-galloping devices has been erratic.

15.3.3 <u>Bundled Conductors</u>: Bundled connectors are not used very often on transmission lines under 230 kV but are often economically justified above 230 kV. Bundled conductors can experience aeolian vibration, galloping, corona vibration, and subconductor oscillation. For a bundled conductor with spacers, aeolian vibration may be reduced by a factor of 10. However, galloping of ice coated conductors will occur more readily and more severely on bundled lines than on single conductors in the same environment.

Subconductor oscillation, though, has caused a major share of the problems to date. It is caused by one conductor lying in the wake of an upstream conductor and thereby being excited to vibrate in a nearly horizontal ellipse. Damage has consisted of conductor wear as well as spacer deterioration and breakage. To reduce subconductor oscillation, subspan length or the distance between spacers should be kept below 250 feet.

The primary purpose of spacers is to reduce the probability of conductor contact and magnitude of vibration. Spacers may be rigid, articulated or flexible. They may be open-coil and closed-coil springs, and wire rope and steel strand connecting members. Spacers should grip bundled conductors securely to avoid abrasion of the subconductors and to prevent conductor entanglement during strong winds.

15.3.4 <u>Insulator Swing</u>: Occasionally, tie-down weights are used to control conductor position by preventing excessive uplift and swinging. A line should not be designed to use tie-down weights as a means of preventing the conductor from swinging into the structure. Sometimes due to a low Vertical/Horizontal span ratio, weights may have to be used on an occasional structure. Two types of tie down weights are shown in Figure 15-13.

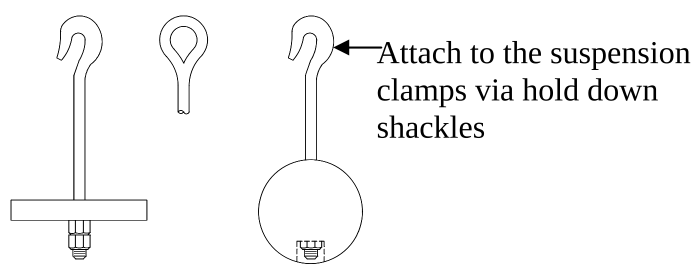
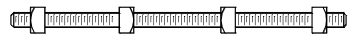


FIGURE 15-13: DISC WEIGHTS (Left), BALL WEIGHTS (Right)

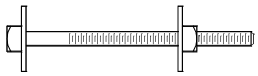
15.4 <u>Structure Related Hardware for Wood Structures</u>

15.4.1 <u>Fasteners</u>: Threaded rods and machine bolts are frequently used on wood transmission structures (Figure 15-14). A static-proof bolt has a washer securely fixed to the head of the bolt and is furnished with washer nuts. Variations of the static-proof bolt include shoulder eye bolts with round or curved washers welded to the eye, forged shoulder eye bolts and forged eye bolts. MF type locknuts, used in conjunction with a regular nut or washer nut, form a solid unit which does not loosen from vibration and helps to maintain a static proof installation. The strengths and tensile stress areas of bolts conforming to ANSI C135.1 are shown in the Table 15-1.

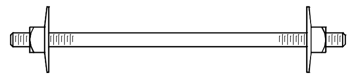
Machine Bolt



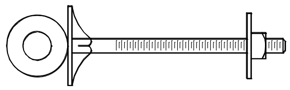
Double Arming Bolt,
Fully Threaded



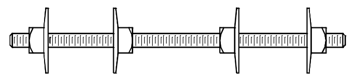
Static Proof Bolt
With Forged Washer
Nut



Static Proof Double End
Bolts



Shoulder Eye Bolt
with Curved
Washer



Static Proof
Double Arming Bolts

MF type Locknut

FIGURE 15-14: FASTENERS

TABLE 15-1
STRENGTHS OF ANSI C135.1 MACHINE BOLTS, DOUBLE ARMING BOLTS, AND DOUBLE END BOLTS

Machine Bolt Diameter in.	Tensile Stress Area sq. in.	Minimum Tensile Strength lbs.
1/2	0.142	7,800
5/8	0.226	12,400
3/4	0.334	18,350
7/8	0.462	25,400
1	0.606	33,500

Lag screws (Figure 13-5) are sometimes used in lieu of bolts when shear loads are small. A lag screw with fettered edges is driven into the wood and maintains its holding power with cone shaped threads. When lag screws are used, the moment capacity of the wood pole is reduced in the same manner as a bolt hole reduces moment capacity.

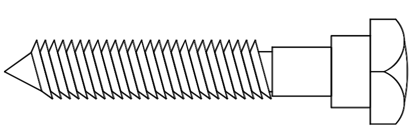
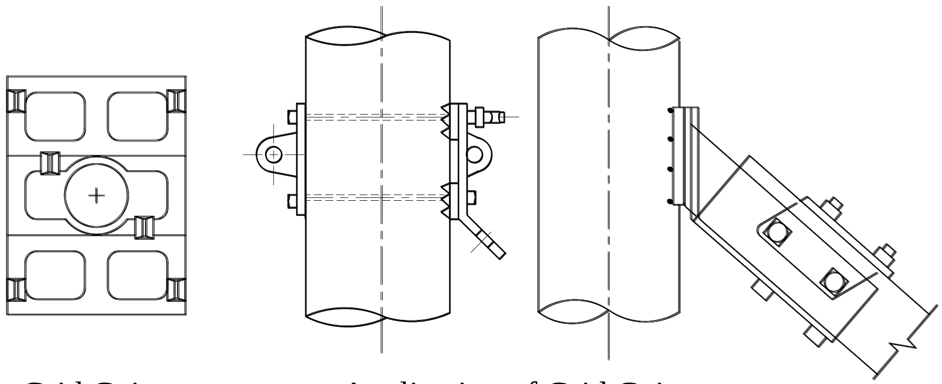


FIGURE 15-15: LAG SCREW

Anti-split bolts help prevent the propagation of checking and splitting at the end of crossarms. A three inch edge distance should be provided between the anti-split bolt and the edge of the arm.

15.4.2 <u>Framing Fittings</u>: The primary purpose for using grid gains is to reduce bolt hole slotting by distributing the shear load of the bolt over a large wood area. The specially shaped teeth of the grid gain press into the wood surface and offer maximum resistance to movement both with and across the grain of the wood. The use of grid gains will strengthen bolt connections and are recommended anytime a bolt must carry large shear loads. Two applications of grid gains are shown in Figure 15-16.

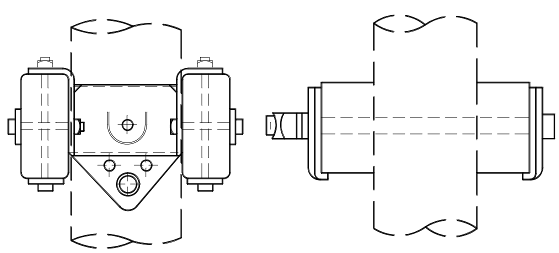


Grid Gains   Application of Grid Gains

FIGURE 15-16: GRID GAINS

The gain plate (between a pole and a crossarm) and the reinforcing plate (on the outside of an arm) provide additional metal bearing surface for transfer of the vertical load from the crossarm to the crossarm mounting bolt. The gain plate eliminates a potential decay area between two wood contact areas. A reinforcing plate, also called a ribbed tie plate, will prevent the crossarm from splitting or checking when the nut is tightened.

When double crossarms are used to allow longer vertical spans or to increase longitudinal strength capabilities, spacer fittings Figure 15-17 are needed to separate the crossarms and to provide a point of attachment for suspension insulators. If fixed spacers are used, poles should be gained. Since the standard fixed spacing sizes are 7-1/2”, 9”, 10-1/2”, and 12”, the crossarm may be bowed ±1/2 inch. The brand on the butt and face of the pole should include proper designation of the fixed spacer size. Adjustable spacers will fit a range of pole diameters. When they are used the pole need not be gained.



Spacer Fitting   Reinforcing Plate and Gain Plate

FIGURE 15-17: SPACER FITTING, REINFORCING PLATE AND GAIN PLATE

15.4.3 <u>Swing Angle Brackets</u>: Swing angle brackets are used to provide increased clearance between phase conductors and the structure to which the conductors are attached (Figure 15-18). These brackets cab be mounted horizontally or vertically. The two primary types of angle brackets are the rod type for light loads, and angle iron type for heavier loads.

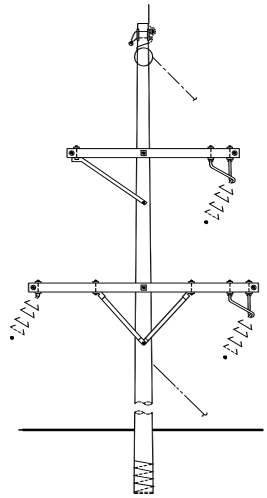


FIGURE 15-18: SMALL ANGLE STRUCTURE WITH SWING ANGLE BRACKETS

15.4.4 <u>Guy Attachments</u>: The primary types of guy attachments used on wood transmission line structures include the wrap guy, guying plates, pole eye plates, guying tees, and pole bands. Other types of guy attachments such as formed straps, angle bolt eyes, and goat hooks are used primarily on distribution lines. Guy attachments are used to attach the insulators to the structure as well as providing a means of guying the structure.

15.5 <u>Structure Related Hardware for Concrete and Steel Structures</u>: Much of the structure related hardware used on wood construction may be appropriate to use on steel or concrete structures. However, hardware items with grid teeth, such as grid gains or guy attachments with grid teeth, are not appropriate for use on steel or concrete structures. Likewise, lag screws and gain plates are not used on steel and concrete poles. Since steel and concrete poles do not shrink and swell with age and weather, spring washers may not be needed to keep the hardware tight over time.

In many instances, higher strength bolts are used with steel or concrete poles. Bolts such ASTM A325, Specification for High-Strength Bolts for Structural Steel Joints, may be specified instead of the ANSI C135 bolts. Table 15-2 gives the strength ratings for bolts conforming to ASTM Standard A325.

TABLE 15-2
STRENGTHS OF ASTM A325
HEAT TREATED, HIGH STRENGTH BOLTS

Machine Bolt Diameter in.	Tensile Stress Area sq. in.	Minimum Tensile Strength lbs.	Minimum Yield Strength lbs.
1/2	0.142	17,500	13,050
5/8	0.226	27,100	20,800
3/4	0.334	40,100	30,700
7/8	0.462	55,450	42,500
1	0.606	72,700	55,570

Proper selection and design of end fittings and guy attachments is necessary to obtain the necessary capacity. For example, for steel structures, it may be necessary to use reinforcing washers on the backside of a guy attachment or end fitting to prevent the nut or bolt head from pulling through the wall of the steel pole. Selection of hardware should be coordinated with the steel pole supplier or concrete pole supplier to obtain the capacity and performance desired. Selection of hardware should also consider proper fit with other hardware.

When using standard class concrete or steel poles, the owner should provide the pole manufacturer with the load capabilities, attachment method, and attachment location of all appurtenances. The pole manufacture should verify that the pole will not have a localized strength problem at the attachment point. Items to consider if standard class steel or concrete poles are guyed include:

- Localized buckling at the guy attachment,
- Field holes in the wrong locations,
- Unexpected torsion on the pole due to the fact that the pole is not round and the correct guy plate location does not fall on one of the pole's flat surfaces, and
- Sliding of the slip joint under heavy conductor loads.

In the use of concrete and steel structures, a means for climbing the structure should be provided. The NESC Rule 261N states the requirements for climbing devices and attachments to the structure. Based on this requirement, it is recommended that step bolts, removable steps, ladders, and each attachment to the pole be designed to support a minimum of a 300-pound worker and equipment multiplied by a 2.0 load factor. The load should be applied at the outer edge of the step or bolt and should be supported without permanent deformation. Refer to agency Bulletins 1724E-204, -206, -214, and -216, for additional guidelines on the use of concrete and steel structures.

15.6 Corrosion of Hardware: Corrosion may be defined as the destruction of metal by a chemical or electro-chemical reaction with its environment. Certain industrial and sea coast environments accelerate the rate of corrosion. Parameters which stimulate corrosion include air (oxygen) dissolved in water, airborne acids, sulphur compounds (from cinders, coke, coal dust,) salt dissolved in water, corona, etc.

Any two dissimilar metals when placed together in the presence of an electrolyte form a simple battery. One metal becomes an anode, sacrificing itself to the other metal which becomes the cathode. One method to reduce the rate of corrosion is to select metals which are compatible with one another. Table 15-3 details the galvanic voltage of various metals commonly used for transmission line hardware. The greater the algebraic difference between the metals selected, the more rapid the rate of corrosion will be of the more electronegative metal selected.

TABLE 15-3
GALVANIC TABLE OF VARIOUS METALS

Silver	+.79
Copper	+.34
Lead	-.13
Tin	-.15
Iron	-.35
Chromium	-.47
Zinc	-.77
Aluminum	-1.337

As an example, when malleable iron suspension clamps are used, aluminum liners should be furnished in order to reduce the rate of corrosion of the aluminum conductor. As another example, the selection of staples to be used on the pole ground wire must be compatible material to the ground wire (see Drawing TM-9 in Bulletins 1728F-810 and 1728F-811).

Other methods of reducing the rate of corrosion are to galvanize tin plate, paint or cover metals with corrosion inhibitors. The life of used metals can be prolonged by increasing metal thickness.

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16. UNDERBUILD

16.1 General: Placing of underbuild distribution or communications circuits on transmission lines is a practice that is becoming more prevalent as available rights-of-way decrease. Although underbuild distribution lines increase the initial cost of a transmission line, common sharing of a right-of-way is sometimes necessary in order to build the line.

The following factors should be considered in designing a common use line: hazards to personnel and property, costs, difficulties of construction, operation and maintenance. Adequate structure arrangement and conductor separation should be provided to minimize the possibility of conductor contacts, and to provide safe working conditions. Adequate electrical protection involves prompt and positive de-energization of power circuits in the event of conductor contact or flashover. Obtaining and maintaining a low ground resistance to earth is desirable to limit the magnitude of voltage rise, duration of hazardous voltage, and lightning damage.

16.2 Addition of Distribution Underbuild to an Existing Transmission Line: Distribution circuits can be added to existing transmission structures only if the original transmission structure was designed for the new particular underbuild facilities or the total structure facilities meets the current edition of the NESC.

16.3 Strength Requirements: Standard distribution construction is required to meet NESC Grade C construction in accordance with 7 CFR Part 1724. However, underbuild distribution on transmission circuits, with the exception of the crossarms, are to be built to meet all requirements of NESC Grade B construction. This means that the loading on the pole due to the distribution circuits has to be calculated using NESC Grade B overload capacity factor and strength factors, It also means that all guying for the underbuild must meet the guying requirements for transmission. Distribution crossarms on transmission structures may be designed for NESC Grade C construction, except at angles where they have to be designed for NESC Grade B construction.

16.4 Line-to-Ground Clearances: Since the lowest conductors on a transmission line with underbuild will usually be those of the distribution circuits, the clearances to ground and clearances in crossing situations will in most instances be limited by the requirements stipulated in the NESC for distribution circuits.

The problem of providing satisfactory clearance becomes more involved when multiple distribution circuits or conductors cross on the same structure. In these instances, very careful attention need to be given to the allowable clearance in Section 23 of the NESC.

Particular attention should be given to the use of reduced size distribution neutrals since the clearance to ground for the neutral, by virtue of its increased sag and position on the pole or crossarm, may be the controlling factor for pole height. In some cases, it may be more economical to increase the size of the neutral to reduce its sag.

16.5 Separation Between Transmission and Underbuild Distribution Circuits: The clearances discussed in this section are intended to provide not only operating clearances but also sufficient working clearances. A distribution line worker has to be able to access and work on the distribution underbuild without encroaching upon the required safety (zone) clearances of the transmission conductors.

16.5.1 Horizontal Separation: The horizontal separation at the support between the lowest transmission conductor(s) and the highest distribution conductor(s) or neutral should be at least 1 foot if possible as illustrated in Figure 16-1.

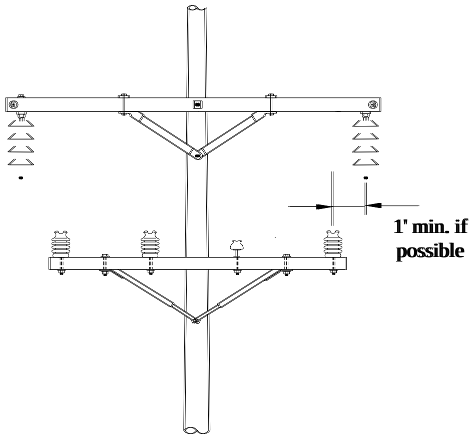

FIGURE 16-1: HORIZONTAL SEPARATION REQUIREMENTS BETWEEN TRANSMISSION AND UNDERBUILD

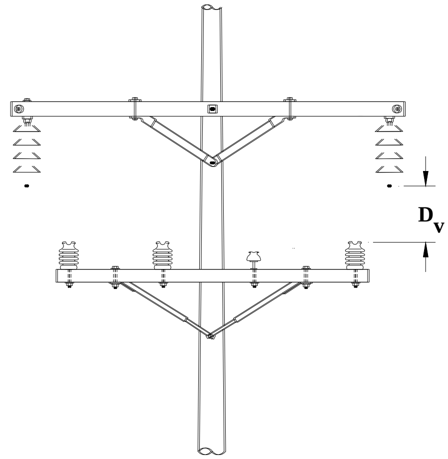

FIGURE 16-2: VERTICAL SEPARATION REQUIREMENTS AT STRUCTURE FOR UNDERBUILD

16.5.2 <u>Vertical Clearance to Underbuild at Supports</u>: Recommended minimum vertical clearances between the transmission conductors and the underbuild conductors at the support are shown in Table 16-1. These clearances apply regardless of the amount of horizontal separation between transmission and underbuild conductors (see Figure 16-2).

16.5.3 <u>Vertical Clearance to Underbuild at any Point in the Span</u>: Recommended minimum vertical clearances at any point along the span are shown in Table 16.1.

These clearances apply for the condition below which yields the least separation between the upper and lower conductor.

a. An upper conductor final sag at a temperature of 32°, no wind, with radial thickness of ice for the applicable loading district;
b. An upper conductor final sag at a temperature of 167ºF;
c. Upper conductor final sag at a maximum design temperature, no wind. For high voltage bulk transmission lines of major importance to the system, consideration should be given to the use of 212ºF as the maximum design conductor temperature.

The sag of the underbuild conductor to be used is the final sag, at the same ambient temperature as the upper conductor without electrical loading and without ice loading.

If the transmission line or portion thereof is at an altitude which is greater than 3300 feet, an additional clearance (as indicated in Table 16-1) has to be added to both clearances at the structure (Category 1) and clearances at the midspan point (Category 2).

16.5.4 <u>Additional Clearance Requirements for Communication Underbuild</u>: For communication underbuild, the low point of the transmission conductors at final sag, 60˚ F, no wind, should not be lower than a straight line joining the points of support of the highest communication underbuild.

TABLE 16-1
RECOMMENDED MINIMUM VERTICAL CLEARANCES TO DISTRIBUTION OR COMMUNICATION UNDERBUILD ON TRANSMISSION LINES IN FEET
(Circuits may be of the same or different utilities)
(Based on NESC Rule 235 and Table 235-5)

Transmission Nominal voltage, Phase to Phase	**kV_{L-L}**	**34.5**	**46**	**69**	**115**	**138**	**161**	**230**
Max. Operating Voltage, Phase to Phase	kV_{L-L}	36.2	48.3	72.5	120.8	144.9	169.1	241.5
Max. Operating Voltage, Phase to Ground	kV_{L-G}	20.2	27.9	41.8	69.7	83.7	97.6	139.4
Vertical Clearances Between Transmission and Distribution Conductors		**Clearances in Feet**						
1. Clearance at the support from point of suspension of transmission conductor to point of suspension of underbuild distribution or communication conductor. Nominal underbuild voltage in kV line-to-line: (Note A)								
a. 25 kV and below (including communications conductors)		4.7	5	5.4	6.4	6.8	7.3	8.7
b. 34.5 kV		4.9	5.2	5.6	6.5	7.0	7.5	8.9
2. Clearance at any point in span from transmission conductor to underbuild conductor. Nominal underbuild voltage in kV line-to-line (Note A):								
a. 25 kV and below (including communications conductors)		3.7	3.8	4.2	5.2	5.6	6.1	7.5
b. 34.5 kV		3.8	4.0	4.3	5.4	5.8	6.3	7.7
Vertical Clearances Between Transmission Conductors and Distribution Structures		**(See Table 4-2)**						
ALTITUDE CORRECTION TO BE ADDED TO VALUES ABOVE								
Additional feet of clearance per 1000 feet of altitude above 3300 feet			0.02	0.02	0.05	0.06	0.08	0.12
Note: (A) An additional .5 feet of clearance is added to the NESC clearance to obtain the recommended design clearances.								

16.5.5 Span Length and Clearance to Underbuild: The conditions of either Paragraph 16.5.2 or Paragraph 16.5.3 above will dictate what the minimum clearance to underbuild at the structure should be. If the clearance to an underbuild is dictated by Paragraph 16.5.3 of this section, the clearance at the structure would have to be increased. Vertical separation at the structure may depend upon the relative sags of transmission and underbuild conductors. Since the span length has an effect on relative sags, the resulting maximum span as limited by vertical clearance to underbuild should be calculated to ensure that the vertical separation at the support is correct for each span.

The formula for maximum span as limited by clearance to underbuild is:

$$L_{max} = (RS)\sqrt{\frac{A-B}{S_\ell - S_u}} \qquad \text{Eq. 16-1}$$

where:

L_{max} = maximum span in feet
RS = ruling span in feet
A = allowable separation at midspan in feet
B = vertical separation at supports in feet
S_ℓ = underbuild sag at the same ambient temperature as the transmission conductor, final, in feet
S_u = transmission conductor sag at condition resulting in least separation to underbuild, final sag, in feet

16.6 <u>Climbing Space</u>: Climbing space through the lower circuits should be preserved on one side of the pole or in one quadrant from the ground to the top of the pole as required by the NESC. Working space should be provided in the vicinity of crossarms. Jumpers should be kept short enough to prevent their being displaced into the climbing space.

16.7 <u>Overhead Ground Wires and Distribution Neutrals</u>: Standard distribution underbuild construction has its own neutral. This neutral may be tied to the transmission pole ground wire in order to improve its grounding. Depending on the characteristic of the circuits, a common ground or a separate ground is acceptable. If separate grounds are used, the pole ground wires should be located on opposite sides of the pole. Similar materials should be used for both the transmission pole ground wire and for the distribution pole ground wire and ground rod. For example, if copper is used for the transmission pole ground, then copper and/or copperclad should be used for the distribution ground rod and pole ground wire. Use of similar materials will reduce the possibility of galvanic corrosion. Likewise, the distribution anchors and transmission anchors should be of similar material as the ground rods and wire used for the pole butt wraps.

For distribution underbuild on concrete transmission poles, the neutral may be tied to the external pole ground using a compression connector in locations where the neutral is to be grounded. A lead from the pole ground should then be tied to a separate ground rod via a compression connector six inches to one foot above the ground level. Similarly, in the case of steel poles, there may be situations where the neutral of the distribution underbuild is to be grounded. In these instances, the pole may be used as the ground path but not as a ground electrode. A grounding connector mounted on the pole needs to be specified just below the location of the neutral on the pole. The ground pad near the ground line should then be used to connect a driven ground rod to the pole.

16.8 <u>Addition of Poles for Underbuild</u>: There may be structures where it is either desirable or necessary to transfer distribution circuits to separate poles. Such situations include:

- Large Line Angles (Figure 16-3)
- Deadends
- Tap-offs
- Sectionalizing Structures
- Substation Approaches
- Transformers or Regulators (Figure 16-4)
- Capacitors

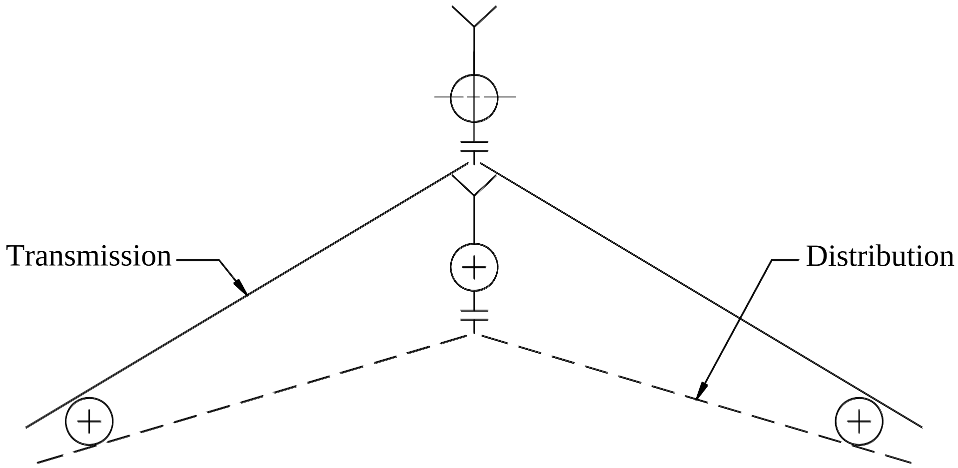

FIGURE 16-3: TRANSFERENCE OF THE DISTRIBUTION CIRCUIT
TO A SEPARATE POLE AT A LARGE ANGLE

Location of transformers on structures carrying both transmission and distribution lines should be avoided. Not only does the transformer create an unbalanced load on the structure, but the additional conductors necessary for service drops may make working on the structure hazardous to personnel. A ground rod should be installed at every pole location with a transformer and the transformer grounded per NESC requirements.

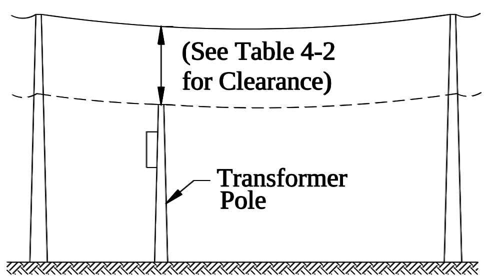

FIGURE 16-4: USE OF A SEPARATE POLE TO MOUNT
A DISTRIBUTION TRANSFORMER

16.9 <u>Guying</u>: The need to provide additional guys to compensate for the effect of underbuild on structures is readily apparent. However, there are locations where special attention has to be given to the guying being proposed. One example is a common use pole with a line tap.

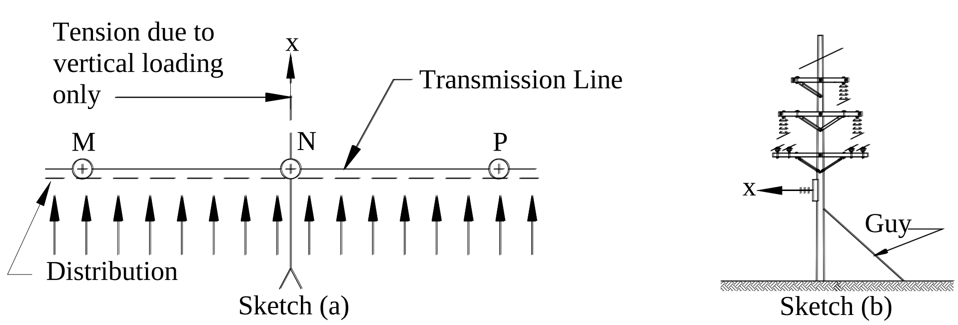

FIGURE 16-5: GUYING DISTRIBUTION UNDERBUILD

For winds perpendicular to the transmission line, the guying described in Figure 16-5 may be insufficient. This will be true if consideration has been given only to underbuild deadend tension shown as forces (x) in the figure. The maximum transverse load acts on half the sum of adjacent spans, (MN+NP)/2, of the transmission and distribution circuits.

These forces have to be added to the tensions of tap conductors in order to determine the proper amount of guying required. If winds are parallel to the transmission line, the deadend loading of the tap is larger and this load should be used. Guying of the distribution underbuild is to meet Grade B construction.

A general rule is that where the transmission circuit or the distribution circuit requires guys, both circuits should be guyed. The guys should be designed to carry the entire transverse load on the structure at maximum loading conditions. All drawings should show location and slope of guys to assure adequate clearances when guys are required. Positions of guys should be clear from other hardware or electrical connections, such as connectors between neutral and pole ground wire. Where guys may pass close to conductors, minimum clearances in accordance with Table 4-2 should be met.

16.10 <u>Example: Maximum Span as Limited by Clearance to Underbuild</u>: A 69 kV single pole transmission is to be built with a 25 kV underbuild distribution circuit. Determine maximum span as limited by clearance between transmission conductors and underbuild.

16.10.1 <u>Given</u>:

- Vertical separation between transmission and distribution conductors at the structure is 11.0 ft.
- Ruling span: 300 ft.
- NESC Heavy loading district
- Conditions for the conductor:
    a. Transmission conductor is at 32°F with ½" ice while the distribution conductor is at an ambient temperature of 0°F during the winter.
    b. Transmission conductor is at 212°F maximum design temperature while the distribution conductor is at an ambient temperature of 0°F during the winter.
    c. Transmission conductor is at 212°F maximum design temperature while the distribution conductor is at an ambient temperature of 90°F during the summer.

	Transmission Conductor 477 kcmil 26/7 ACSR		Distribution Conductor 4/0 6/1 ACSR	
	Loading Condition	Final sag (ft.)	Ambient Temp.	Final sag (ft.)
(a)	32ºF, 1/2" ice	4.40	0°F	1.60
(b)	212ºF	6.73	0°F	1.60
(c)	212ºF	6.73	90°F	3.98

16.10.2 <u>Solution</u>:

From Table 16-1 the required vertical clearance at midspan between the transmission and distribution conductors is 4.2 feet.

Next, calculate the separation between the upper and lower conductor for each loading condition given above:

(a) 11’ - 4.40’ + 1.60’ = 8.20’
(b) 11’ - 6.73’ + 1.60’ = 5.87’
(c) 11’ - 6.73’ + 3.98’ = 8.25’

The condition (b) results in the least separation between the transmission and underbuild conductors; therefore, the condition (b) conductor sag values will be used in the following equation:

$$L_{max} = (RS)\sqrt{\frac{A-B}{S_\ell - S_u}} \qquad \text{Eq. 16-1}$$

Substituting:

RS = 300
A = 4.2
B = 11
S_ℓ = 1.60
= 6.73

$$L_{max} = (300)\sqrt{\frac{4.2-11}{1.60-6.73}}$$

L_{max} = 345 feet

The maximum span as limited by the separation between the transmission conductors and the distribution underbuild is 345 feet.

For situations where greater span lengths are necessary, the separation at the structure should be increased. In addition, consideration should be given for the effects of ice jumping as described in Section 6.3 of this manual.

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APPENDIX A

TRANSMISSION LINE DESIGN DATA SUMMARY SHEET AND SUPPORTING INFORMATION

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TRANSMISSION LINE DESIGN DATA SUMMARY

I. GENERAL INFORMATION

BORROWER:			DATE:
LINE IDENTIFICATION:			
VOLTAGE		LENGTH	
TRANSMISSION	UNDERBUILD	TRANSMISSION	UNDERBUILD
___________kV	___________kV	___________mi.	___________mi.
TYPE OF TANGENT STRUCTURE:		BASE POLE: ____________HT. ____________CL	
DESIGNED BY:			

II. CONDUCTOR DATA

	TRANSMISSION	OHGW	UNDERBUILD	COMMON NEUTRAL
SIZE *(kcmil or in.)*				
STRANDING				
MATERIAL				
DIAMETER *(in)*				
WEIGHT *(lbs./ft.)*				
RATED STRENGTH *(lbs.)*				

III. DESIGN LOADS (Wires)

		TRANSMISSION *(lbs./ft.)*	OHGW *(lbs./ft.)*	UNDERBUILD *(lbs./ft.)*	COMM.NEUTRAL *(lbs./ft.)*
NESC:_________________LOADING DISTRICT					
a. ICE: ________in.	Vertical.				
b. WIND ON ICED COND. ____psf	Transverse				
c. CONSTANT K ___________	Resultant + K				
HEAVY ICE*(NO WIND)* ______in.	Vertical.				
HIGH WIND*(NO ICE)* ______psf	Transverse				
EXTREME HIGH WIND/ICE					
ICE: ________in.	Vertical.				
WIND ON ICED COND. ____psf	Transverse				

IV. SAG & TENSION DATA

SPANS AVERAGE*(EST)* ___________ft MAXIMUM*(EST)* ___________ft.. RULING*(EST)* ____________ft.

SOURCE OF SAG-TENSION DATA:	TRANSMISSION		OHGW		UNDERBUILD		COMM.NEUTRAL	
TENSIONS *(% RATED STRENGTH)*	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
NESC a. UNLOADED (0˚ 15˚ 30˚) _____˚F								
NESC b. LOADED (0˚ 15˚ 30˚) _____˚F								
MAXIMUM ICE 32 ˚F								
HIGH WIND (NO ICE) _____˚F								
UNLOADED LOW TEMPERATURE _____˚F								
SAGS *(FT)*								
NESC DISTRICT LOADED _____˚F								
UNLOADED HIGH TEMP(120˚FOR OHGW &U.B.)___˚F								
MAXIMUM ICE 32˚F								
LOADED 1/2" ICE, NO WIND 32˚F								

V. CLEARANCES

MINIMUM CLEARANCES TO BE MAINTAINED AT:____

CLEARANCES IN FEET	RAILROADS	HIGHWAY	CULTIVATED FIELDS			ADDITIONAL . ALLOWANCE
TRANSMISSION						
UNDERBUILD						

VI. RIGHT OF WAY

WIDTH _____________ FT. *(MIN.)* _____________ FT. *(MAX.)*

VII. CONDUCTOR MOTION DATA

HISTORY OF CONDUCTOR GALLOPING:

HISTORY OF AEOLIAN VIBRATION:

a. TYPE OF VIBRATION DAMPERS USED *(IF ANY)*

b. TYPE OF ARMOR RODS USED *(IF ANY)*

VIII. INSULATION

NO. OF THUNDERSTORM DAYS/YR______________ELEV.ABOVE SEA LEVEL (MIN, MAX, ft.)____________________

CONTAMINATION EXPECTED?_____________MAX EST. FOOTING RESISTANCE___________Ω SHIELD ANGLE __________°

STRUCTURE TYPE	STRUCTURE DESIGNATION	NO. OF BELLS / POLYMER / PIN OR POST	60 HZ DRY FLASHOVER	INSULATOR SIZE (DIAMETER & LENGTH)	SML / M & E RATING / POST STRENGTH	OTHER
TANGENT						
ANGLE						
STRAIN STRUC						

IX. INSULATOR SWING

CRITERIA: (1)_________PSF ON BARE CONDUCTOR AT __________(6 psf MIN) FOR ___________________in. CLEARANCE

(2)_________PSF HIGH WIND ON BARE CONDUCTOR AT ___________° F FOR _______________in. CLEARANCE

ALLOWABLE SWING ANGLE:			ANGLE IN DEGREES			
	STRUCTURE. TYPE	NO. OF INSULATORS.	6 psf MIN. WIND(1)	HIGH WIND (2)	NO WIND	OTHER

X. ENVIRONMENTAL AND METEORLOGICAL DATA

TEMPERATURE: MIN__________° MAX.__________° AVERAGE YEARL LOW _____________°	EXTREME 10 SEC. WIND GUSTS *(mph):* 10 YR. ___________ 50 YR.__________ 100 YR___________
MAXIMUM HEIGHT OF SNOW ON THE GROUND UNDER THE CONDUCTOR*(ft.)*:	DESCRIBE TERRAIN AND CHARACTERISTICS OF SOIL
CORROSIVENESS OF ATMOSPHERE:	

XI. STRUCTURE DATA (FOR SINGLE POLES AND H-FRAMES)

POLE MATERIAL:______________________________
ARM MATERIAL: Trans_________________________
Underbuild_________________________

TYPE OF FOUNDATION: TANGENT:____________ANGLE:____________
DEADEND_________________GUYED STRUCTURES____________

TANGENT STRUCTURE TYPE___________________ SUMMARY OF SPANS *(ft.)* FOR TANGENT STRUCT.	BASE POLE _____FT.____CL	OTHER HEIGHTS/CLASSES AND BRACING		
LEVEL GROUND SPAN				
MAX. HORIZON. SPAN LIMITED BY STRUCTURE STRENGTH				
MAX. VERTICAL SPAN LIMITED BY STRUCTURE STRENGTH				
MAX. HORIZONTAL SPAN LIMITED BY COND. SEPARATION				
MAX. SPAN LIMITED BY UNDERBUILD				
MAX. SPAN LIMITED BY GALLOPING				

EMBEDMENT DEPTH
FOR BASE POLE:__________________________

PRESERVATIVE OF WOOD POLE (*TYPE &RETENT*.)________________________
CORROSION PROTECTION FOR STEEL POLES ____________________________

GUYING: TYPE OF ANCHORS: ___________________________ GUY SIZE AND R.B.S.:__________________________________

XII. LINE DESCRIPTION

TANGENTS_________________%	LIGHT ANGLES ______________%	AVERAGE NUMBER OF LINE ANGLES PER mi. ______________________
MEDIUM ANGLES____________%	DEADEND & HEAVY ANGLES______________%	MAXIMUM DISTANCE BETWEEN FULL DEADENDS (*mi.*)___________________

INSTRUCTIONS FOR FILLING OUT SAMPLE SUMMARY SHEET

I. GENERAL INFORMATION

BORROWER – Agency borrower designation.

DATE – Date when design data was completed.

LINE IDENTIFICATION – The name of the line, usually expressed in terms of the line's endpoints. If the line design is "project design data" that is to be used for several line designs, the term "project design data" should be entered.

VOLTAGE – Nominal line-to-line voltage of both transmission and underbuild distribution circuit in kV. If there is no underbuild, fill in N. A. (not appropriate)

LENGTH – Self-explanatory.

TYPE OF TANGENT STRUCTURE – Give agency designation for tangent structure type used (for example, "TH-10"). If the structure is not a standard agency structure, the word "special" should be filled in.

BASE POLE – The height and class of pole used most widely in line.

DESIGNED BY – Individual and/or firm doing the designing.

II. CONDUCTOR DATA

SIZE – For conductors, size in AWG numbers or kcmil. For steel wire, diameter in inches.

STRANDING – Number of strands. For ACSR conductor, give aluminum first, steel second. For example: 26/7.

MATERIAL – Indicate conductor or wire type. For example, ACSR, 6201;or EHS (extra high strength steel).

DIAMETER – Diameter of conductor, in.

WEIGHT – Weight per foot of bare conductor, lbs/ft.

RATED STRENGTH – Standard rated strength of conductor.

III. DESIGN LOADS

NESC LOADING DISTRICT – Indicate the National Electrical Safety Code loading district on which design is based. Use "H" for heavy, "M" for medium, and "L" for light loading district.

a. Ice – Radial in. of ice on conductor for loading district specified.
b. Wind – Wind force in lbs. for loading district specified.
c. Constant "K" – Constant from NESC to be added to resultant of horizontal and vertical load (at standard loading district condition) for determining conductor sags and tensions.

HEAVY ICE – (no–wind, in.) – Radial thickness (in.) of ice conductor for the heavy icing condition for which line is designed (if any).

HIGH WIND – (no ice – psf) – The high wind value in lbs/sq. ft. for which the line is designed.

COMBINED EXTREME ICE/WIND – The loadings associated with the 50 yr extreme ice/wind from the figures in 11.3 of this bulletin. The radial thickness of ice and the unit loads should be given for the vertical loads. The high wind associated with the radial thickness of ice should be given for the tansverse loads as well as the unit loads.

LOADING TABLE - Conductor or wire loads in lbs. per linear ft. for conditions indicated at left.

IV. SAG & TENSION DATA

SPANS – AVG., MAX., and RULING – Self-explanatory.

SOURCE OF SAG-TENSION DATA – Self-explanatory.

TENSION TABLE – Initial and final tension values in percent of rated strength at loading conditions indicated on the left should be given. In those boxes where there is a dotted line in the center, the specified tension limiting values (in percent) should be given above the line. The actual resulting tension value (in percent) should be given below the line. For all other boxes the tension value should be the actual resulting value (in percent). The details of loading condition should be filled in on the left as follows:

a. Unloaded (0º, 15º, 30º) – Indicate appropriate temperature. Heavy loading district will be 0ºF, medium will be 15ºF, light will be, 30ºF.
b. NESC Loaded (0º, 15º, 30º) – Specify appropriate temperature.
c. Maximum Ice – Use the same maximum radial ice as indicated in the DESIGN LOADS section.
d. High Wind – Use the same value as in the DESIGN LOAD section.
e. Unloaded Low Temperature – Specify lowest temperature that can be expected to occur every winter.

SAG TABLE – Specify initial and/or final sags in ft. for conditions indicated. Specify maximum conductor operation temperature in the appropriate box on the left. Sags for the overhead ground wire and underbuild conductors are for a temperature of 120ºF.

Note: When sag and tension calculations are done, tension limits are usually specified at several conditions. However, only one of the conditions will usually control, resulting in tensions, at the other conditions, that are lower than the limit.

V. CLEARANCES

MINIMUM CLEARANCES TO BE MAINTAINED AT – Specify maximum sag condition at which minimum clearances are to be maintained. Generally, it will be at the high temperature condition but it may be possible for the sag at NESC loading (H, M, L) to be the controlling case.

CLEARANCE TABLE – Indicate clearance which will be used for plan and profile and design. Extra boxes are for special situations.

VI. RIGHT-OF-WAY WIDTH

Indicate width value used. If more than one value is used, give largest and smallest value.

VII. CONDUCTOR MOTION DATA

HISTORY OF CONDUCTOR GALLOPING – Indicate if conductor galloping has ever occurred in the area and how often it can be expected.

HISTORY OF AEOLIAN VIBRATION – Indicate whether or not the line is in an area prone to aeolian vibration.

a. Type of Vibration Dampers Used (if any) – Self-explanatory.
b. Type of Armor Rods Used (if any) – Indicate whether standard armor rods, cushioned suspension units or nothing is used.

VIII. INSULATION

NUMBER OF THUNDERSTORM DAYS/YEAR – Self -explanatory.

ELEVATION ABOVE SEA LEVEL (min., max., ft.) – Give the altitude in ft. above sea level of the minimum and maximum elevation points of the line

CONTAMINATION EXPECTED? – Indicate contamination problems which may affect the performance of the insulation. The following are recommended terms: None, Light, Medium, Heavy, Sea Coast Area.

MAXIMUM ESTIMATED FOOTING RESISTANCE. – Give the estimated maximum electrical footing resistance (in ohms) expected to be encountered along the length of the line. Where the footing resistance is high, the value to which the footing resistance will be reduced, by using special measures, should be indicated by putting this value in parentheses. For example, 70(20).

SHIELD ANGLE – If the basic tangent structure being used is not a standard structure, its shield angle should be given.

INSULATION TABLE – For the structure type indicated, the structure numerical designation and the number of suspension bells should be given. If post insulators are used instead of suspension, the word “post” or “pin” should be put in the second column. If nonceramic insulators are used, indicate ‘susp-nci’ or ‘post-nci’. The 60 Hz dry flashover value for the entire string of insulators (or post) should be given. The column “insulator size” should contain the diameter and length of the insulator. For suspension bell, the M&E strength should be given. For post insulator, the ultimate cantilever strength should be entered. For nonceramic insulators suspension or posts, give the SML ratings.

IX. INSULATOR SWING

CRITERIA – Self-explanatory

INSULATOR SWING TABLE – For the primary structures used in the line and the number of insulators used, the insulator swing angles under the 6 lb. minimum condition, the high wind condition and under the no wind condition should be given.. Angles measured from a vertical through the point of insulator string suspension away from structure should be indicated by following them with an asterisk (*).

X. ENVIRONMENTAL & METEORLOGICAL DATA

TEMPERATURE – The minimum, maximum, and average yearly low temperature recorded in the area of the line should be given.

MAXIMUM HEIGHT OF SNOW ON GROUND UNDER CONDUCTOR (ft.) – Self-explanatory.

CORROSIVENESS OF ATMOSPHERE – Indicate corrosiveness of the atmosphere by severe, moderate, or light.

EXTREME 10 SEC WIND GUSTS – Give the annual extreme wind with mean recurrence intervals of 10, 50, and 100 years. For 50 year, see Figures 11-2a to 11-2d of Chapter 11. For 10 year, see paragraph 7.2.3 of Chapter 7.

DESCRIBE TERRAIN & CHARACTER OF SOIL – A brief description should be given as to whether the terrain is flat, hilly, rolling piedmont, or mountainous. Indicate whether the soil firmness is good, average, or poor. Give approximate depth of ground water table. Describe corrosiveness of soil.

XI. STRUCTURE DATA (For single poles and H-frames)

POLE MATERIAL – Indicate wood, steel, or concrete. If wood, indicate species.

ARM MATERIAL – If a crossarm is used, indicate wood, steel or fiberglass..

TYPE OF FOUNDATION – For tangent, angle, or deadend structures, indicate direct embedded or caisson for the majority of the structures within each type. For example, if most of the angle and deadends are unguyed, indicate the predominant foundation for each type.

STRUCTURE TABLE The various maximum span values should be given for the base pole and structure configuration. Values should also be given for other pole heights, wood classes or standard steel/concrete pole classes, bracing and configurations that are expected to be commonly used.

a. **Level Ground Span** – Give the maximum span for height of pole, limited by clearance to ground only.
b. **Maximum Horizontal Span Limited by Structure Strength** – For single pole structures, give the maximum span as limited by pole strength. For H-frame structures, the effect of the bracing must be included. If vertical post insulators are used, their maximum horizontal span value should be included if it is less than that of the rest of the structure, and should be indicated as such by placing the term “ins” after the value. If underbuild is to be used on the line, its effect should be included.

c. **Maximum Vertical Span Limited by Structure Strength –** Give the maximum vertical span limited by either crossarm strength, crossarm brace strength, or horizontal post insulator strength. If horizontal post insulators are the limiting factor, the term “ins” should be placed after the span value. If the structure is such that the maximum horizontal span affects the maximum vertical span, the assumed maximum horizontal span should be the value shown in the “maximum horizontal span” box.
d. **Maximum Horizontal Span Limited by Conductor Separation –** Give the maximum span value from Equation 6-1 or 6-2 in Chapter 6 of this bulletin.
e. **Maximum Span Limited by Underbuild –** Give the maximum span limited by separation between underbuild conductors, or between underbuild and transmission conductors, whichever is more limited.
f. **Maximum Span Limited by Galloping –** Give the maximum span that can be allowed before galloping ellipses touch.

EMBEDMENT DEPTH – Indicate the pole embedment depth used. If the standard values are used, indicate “standard”. If other values are use, indicate by how much they differ from the standard value. For example, std. + 2 ft.

PRESERVATIVE FOR WOOD POLES – Type and retention level of preservative.

CORROSION PROTECTION FOR STEEL POLES – Indicate weathering steel, galvanized steel, or painted.

GUYING – Indicate whether log, screw or other anchors are used and the predominant anchor capacity. For example: Log, 8,000/16,000 lbs. The diameter, type and rated breaking strength (rbs) of the guy strand should be given.

XII. LINE DESCRIPTION

For the respective structures types, indicate the percentage of the total number of structures used. Calculate the average number of line angles per mile and give the maximum distance in miles between full deadends: (“Full” deadends refer to strain type structures that are designed to remain standing if all conductors and overhead ground wires are cut on either side of the structure.)

SUGGESTED OUTLINE FOR
DESIGN DATA SUMMARY BOOK

Given below is a suggested outline for a Design Data Summary Book. The outline is primarily intended for lines of 230 kV Generally, a well prepared design data book should include all the material indicated below. However, some judgment should be used in submitting more or less information as deemed appropriate.

I. Transmission Line Design Data Summary

II. General Information

- A. Line identification, description and role in system
- B. Description of terrain and weather
- C. Design criteria and applicable codes and standards
- D. Selection of conductor and OHGW
  - 1. Selection of conductor and OHGW type
  - 2. Selection of conductor and OHGW size/
    Economic conductor analysis
- E. Determination of maximum conductor temperature
- F. Selection of structure type and average height
  - 1. Economic evaluation of alternate structures
  - 2. Selection of optimum structure height
- G. Construction cost estimate

III. Supporting Calculations to Part I

- A. Conductor sag and tension tables (computer printout and source)
- B. OHGW sag and tension values (computer printout and source)
- C. Vertical and horizontal clearances and ROW width
- D. Insulation considerations
- E. Level ground span

F. Maximum span limited by conductor separation

1. Horizontal separation

2. Vertical and diagonal separation

G. Maximum span limited by underbuild (if applicable)

H. Galloping analysis

I. Unguyed structure strength calculations

1. Maximum horizontal span limited by pole strength, ‘X’ bracing, poles (including post insulators; if applicable)

2. Maximum vertical span limited by structure strength

3. Loading trees for steel or concrete structures; selection method for standard class poles

4. Hardware limitations

5. Insulator strength requirements

6. Foundation type; embedment depths; selection method; soil information

J. Guyed structure calculations

1. Minimum spacing of anchors

2. Guy and anchor calculations and application charts

3. Maximum axial loads for guyed pole

4. Guy attachments and their strengths

5. Arrangement of guys and anchors and application guides

K. Sample insulator swing calculations and application charts for all structures

L. Diagrams for all non-standard structures or assemblies anticipated for use on the line

M. Sag-clearance template if a CADD program is not used for the plan-profile

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APPENDIX B

CONDUCTOR TABLES

CONDUCTOR MECHANICAL LOADING TABLES

The tables that follow give horizontal, vertical, and resultant vector loads on conductors and overhead ground wires under standard NESC loading district conditions, high wind conditions, and heavy ice conditions.

ACSR CONDUCTORS
NESC DISTRICT LOADINGS

NAME	SIZE	STRAND	LIGHT .00" ICE, 9 LB., K=.05 VERT. LB/FT.	TRANS LB/FT.	RESULTANT LB/FT.	MEDIUM .25" ICE, 4 LB. WIND, K=.20 VERT. LB/FT.	TRANS LB/FT.	RESULTANT LB/FT.	HEAVY .5" ICE, 4 LB. WIND, K=.30 VERT. LB/FT.	TRANS LB/FT.	RESULTANT LB/FT.	ULTIMATE STRENGTH LBS.	DIAM. IN.	WT./FT. LBS.
RAVEN	1/0	6/1	0.1452	0.2985	0.3819	0.3467	0.2993	0.6580	0.7036	0.4660	1.1439	4380	0.398	0.1452
QUAIL	2/0	6/1	0.1831	0.3353	0.4320	0.3998	0.3157	0.7094	0.7719	0.4823	1.2102	5310	0.447	0.1831
PIGEON	4/0	6/1	0.2309	0.3765	0.4917	0.4647	0.3340	0.7723	0.8539	0.5007	1.2899	6620	0.502	0.2309
PENGUIN	266.8	6/1	0.2911	0.4223	0.5629	0.5439	0.3543	0.8491	0.9520	0.5210	1.3853	8350	0.563	0.2911
WAXWING	266.8	18/1	0.2894	0.4568	0.5907	0.5565	0.3697	0.8681	0.9789	0.5363	1.4162	6880	0.609	0.2894
PARTRIDGE	336.4	26/7	0.3673	0.4815	0.6556	0.6446	0.3807	0.9486	1.0774	0.5473	1.5084	11300	0.642	0.3673
MERLIN	336.4	18/1	0.3653	0.5130	0.6798	0.6557	0.3947	0.9653	1.1015	0.5613	1.5363	8680	0.684	0.3653
LINNET	336.4	26/7	0.4630	0.5408	0.7619	0.7649	0.4070	1.0664	1.2222	0.5737	1.6501	14100	0.721	0.4630
ORIOLE	397.5	30/7	0.5271	0.5558	0.8160	0.8352	0.4137	1.1320	1.2987	0.5803	1.7225	17300	0.741	0.5271
CHICKADEE	397.5	18/1	0.4316	0.5573	0.7548	0.7403	0.4143	1.0484	1.2045	0.5810	1.6373	9940	0.743	0.4316
IBIS	397.5	26/7	0.5469	0.5873	0.8525	0.8680	0.4277	1.1677	1.3446	0.5943	1.7701	16300	0.783	0.5469
LARK	397.5	30/7	0.6228	0.6045	0.9179	0.9511	0.4353	1.2460	1.4348	0.6020	1.8560	20300	0.806	0.6228
PELICAN	477.	18/1	0.5180	0.6105	0.8506	0.8488	0.4380	1.1551	1.3350	0.6047	1.7656	11800	0.814	0.5180
FLICKER	477.	24/7	0.6145	0.6345	0.9333	0.9552	0.4487	1.2554	1.4514	0.6153	1.8765	17200	0.846	0.6145
HAWK	477.	26/7	0.6570	0.6435	0.9696	1.0015	0.4527	1.2990	1.5014	0.6193	1.9241	19500	0.858	0.6570
HEN	477.	30/7	0.7470	0.6623	1.0483	1.0992	0.4610	1.3920	1.6069	0.6277	2.0251	23800	0.883	0.7470
OSPREY	556.5	18/1	0.6040	0.6593	0.9441	0.9550	0.4597	1.2599	1.4614	0.6263	1.8900	13700	0.879	0.6040
PARAKEET	556.5	24/7	0.7170	0.6855	1.0420	1.0789	0.4713	1.3773	1.5962	0.6380	2.0190	19800	0.914	0.7170
DOVE	556.5	26/7	0.7660	0.6953	1.0845	1.1319	0.4757	1.4278	1.6533	0.6423	2.0737	22600	0.927	0.7660
EAGLE	556.5	30/7	0.8720	0.7148	1.1775	1.2460	0.4843	1.5368	1.7754	0.6510	2.1910	27800	0.953	0.8720
KINGBIRD	636.	18/1	0.6910	0.7050	1.0372	1.0610	0.4800	1.3645	1.5864	0.6467	2.0131	15700	0.940	0.6910
ROOK	636.	24/7	0.8190	0.7478	1.1590	1.2067	0.4990	1.5058	1.7498	0.6657	2.1721	22000	0.997	0.8190
GOSBEAK	636.	26/7	0.8750	0.7425	1.1976	1.2605	0.4967	1.5548	1.8014	0.6633	2.2197	25200	0.990	0.8750
EGRET	636.	30/19	0.9880	0.7643	1.2991	1.3825	0.5063	1.6723	1.9325	0.6730	2.3463	31500	1.019	0.9880
CUCKOO	795.	24/7	1.0240	0.8190	1.3612	1.4412	0.5307	1.7358	2.0139	0.6973	2.4312	27900	1.092	1.0240
DRAKE	795.	26/7	1.0940	0.8310	1.4238	1.5162	0.5360	1.8081	2.0938	0.7027	2.5086	31500	1.108	1.0940
MALLARD	795.	30/19	1.2350	0.8550	1.5521	1.6671	0.5467	1.9545	2.2547	0.7133	2.6649	38400	1.140	1.2350
TERN	795.	45/7	0.8960	0.7973	1.2493	1.3042	0.5210	1.6044	1.8678	0.6877	2.2904	22100	1.063	0.8960
CONDOR	795.	54/7	1.0240	0.8198	1.3617	1.4415	0.5310	1.7362	2.0145	0.6977	2.4319	28200	1.093	1.0240
RAIL	954.	45/7	1.0750	0.8738	1.4353	1.5149	0.5550	1.8134	2.1103	0.7217	2.5302	25900	1.165	1.0750
CARDINAL	954.	54/7	1.2290	0.8970	1.5715	1.6785	0.5653	1.9712	2.2835	0.7320	2.6980	33800	1.196	1.2290
BUNTING	1192.5	45/7	1.3440	0.9765	1.7113	1.8265	0.6007	2.1227	2.4644	0.7673	2.8811	3200	1.302	1.3440
GRACKLE	1192.5	54/19	1.5330	1.0035	1.8822	2.0267	0.6127	2.3173	2.6758	0.7793	3.0870	41900	1.338	1.5330
BITTERN	1272.	45/7	1.4340	1.0088	1.8033	1.9299	0.6150	2.2255	2.5812	0.7817	2.9969	34100	1.345	1.4340
PHEASANT	1272.	54/19	1.6350	1.0365	1.9859	2.1424	0.6273	2.4323	2.8052	0.7940	3.2154	43600	1.382	1.6350
LAPWING	1590.	45/7	1.7920	1.1265	2.1667	2.3367	0.6673	2.6301	3.0368	0.8340	3.4492	42200	1.502	1.7920
FALCON	1590.	54/19	2.0440	1.1588	2.3996	2.6020	0.6817	2.8898	3.3155	0.8483	3.7223	54500	1.545	2.0440
CHUKAR	1780.	84/19	2.0740	1.2015	2.4469	2.6498	0.7007	2.9408	3.3810	0.8673	3.7904	51000	1.602	2.0740
BLUEBIRD	2156.	84/19	2.5110	1.3215	2.8875	3.1365	0.7540	3.4259	3.9175	0.9207	4.3242	60300	1.762	2.5110

ACSR CONDUCTORS
HIGH WIND LOADINGS

NAME	SIZE	STRAND	WT./FT LBS.	13 psf TRANS LB/FT	13 psf RESULTANT LB/FT	16 psf TRANS LB/FT	16 psf RESULTANT LB/FT	21 psf TRANS LB/FT	21 psf RESULTANT LB/FT	26 psf TRANS LB/FT	26 psf RESULTANT LB/FT	31 psf TRANS LB/FT	31 psf RESULTANT LB/FT	6 psf TRANS LB/FT	6 psf SWING ANGLE
RAVEN	1/0	6/1	0.1452	0.4312	0.4550	0.5307	0.5502	0.6965	0.7115	0.8623	0.8745	1.0282	1.0384	0.1990	53.88
QUAIL	2/0	6/1	0.1831	0.4843	0.5177	0.5960	0.6235	0.7823	0.8034	0.9685	0.9857	1.1548	1.1692	0.2235	50.67
PIGEON	4/0	6/1	0.2309	0.5438	0.5908	0.6693	0.7080	0.8785	0.9083	1.0877	1.1119	1.2968	1.3172	0.2510	47.39
PENGUIN	266.8	6/1	0.2911	0.6099	0.6758	0.7507	0.8051	0.9853	1.0274	1.2198	1.2541	1.4544	1.4833	0.2815	44.04
WAXWING	266.8	18/1	0.2894	0.6598	0.7204	0.8120	0.8620	1.0658	1.1043	1.3195	1.3509	1.5733	1.5996	0.3045	46.46
PARTRIDGE	336.4	26/7	0.3673	0.6955	0.7865	0.8560	0.9315	1.1235	1.1820	1.3910	1.4387	1.6585	1.6987	0.3210	41.15
MERLIN	336.4	18/1	0.3653	0.7410	0.8262	0.9120	0.9824	1.1970	1.2515	1.4820	1.5264	1.7670	1.8044	0.3420	43.11
LINNET	336.4	26/7	0.4630	0.7811	0.9080	0.9613	1.0670	1.2618	1.3440	1.5622	1.6293	1.8626	1.9193	0.3605	37.90
ORIOLE	397.5	30/7	0.5271	0.8028	0.9603	0.9880	1.1198	1.2968	1.3998	1.6055	1.6898	1.9143	1.9855	0.3705	35.10
CHICKADEE	397.5	18/1	0.4316	0.8049	0.9133	0.9907	1.0806	1.3003	1.3700	1.6098	1.6667	1.9194	1.9673	0.3715	40.72
IBIS	397.5	26/7	0.5469	0.8483	1.0093	1.0440	1.1786	1.3703	1.4754	1.6965	1.7825	2.0228	2.0954	0.3915	35.60
LARK	397.5	30/7	0.6228	0.8732	1.0725	1.0747	1.2421	1.4105	1.5419	1.7463	1.8541	2.0822	2.1733	0.4030	32.91
PELICAN	477.	18/1	0.5180	0.8818	1.0227	1.0853	1.2026	1.4245	1.5158	1.7637	1.8382	2.1028	2.1657	0.4070	38.16
FLICKER	477.	24/7	0.6145	0.9165	1.1034	1.1280	1.2845	1.4805	1.6030	1.8330	1.9333	2.1855	2.2702	0.4230	34.54
HAWK	477.	26/7	0.6570	0.9295	1.1383	1.1440	1.3192	1.5015	1.6389	1.8590	1.9717	2.2165	2.3118	0.4290	33.14
HEN	477.	30/7	0.7470	0.9566	1.2137	1.1773	1.3943	1.5453	1.7163	1.9132	2.0538	2.2811	2.4003	0.4415	30.58
OSPREY	556.5	18/1	0.6040	0.9523	1.1277	1.1720	1.3185	1.5383	1.6526	1.9045	1.9980	2.2708	2.3497	0.4395	36.04
PARAKEET	556.5	24/7	0.7170	0.9902	1.2225	1.2187	1.4139	1.5995	1.7529	1.9803	2.1061	2.3612	2.4676	0.4570	32.51
DOVE	556.5	26/7	0.7660	1.0043	1.2630	1.2360	1.4541	1.6223	1.7940	2.0085	2.1496	2.3948	2.5143	0.4635	31.18
EAGLE	556.5	30/7	0.8720	1.0324	1.3514	1.2707	1.5411	1.6678	1.8820	2.0648	2.2414	2.4619	2.6118	0.4765	28.65
KINGBIRD	636.	18/1	0.6910	1.0183	1.2306	1.2533	1.4312	1.6450	1.7842	2.0367	2.1507	2.4283	2.5247	0.4700	34.22
ROOK	636.	24/7	0.8190	1.0801	1.3555	1.3293	1.5614	1.7448	1.9274	2.1602	2.3102	2.5756	2.7027	0.4985	31.33
GOSBEAK	636.	26/7	0.8750	1.0725	1.3842	1.3200	1.5837	1.7325	1.9409	2.1450	2.3166	2.5575	2.7030	0.4950	29.50
EGRET	636.	30/19	0.9880	1.1039	1.4815	1.3587	1.6799	1.7833	2.0387	2.2078	2.4188	2.6324	2.8117	0.5095	27.28
CUCKOO	795.	24/7	1.0240	1.1830	1.5646	1.4560	1.7800	1.9110	2.1681	2.3660	2.5781	2.8210	3.0011	0.5460	28.07
DRAKE	795.	26/7	1.0940	1.2003	1.6241	1.4773	1.8383	1.9390	2.2263	2.4007	2.6382	2.8623	3.0643	0.5540	26.86
MALLARD	795.	30/19	1.2350	1.2350	1.7466	1.5200	1.9585	1.9950	2.3463	2.4700	2.7615	2.9450	3.1935	0.5700	24.78
TERN	795.	45/7	0.8960	1.1516	1.4591	1.4173	1.6768	1.8603	2.0648	2.3032	2.4713	2.7461	2.8886	0.5315	30.68
CONDOR	795.	54/7	1.0240	1.1841	1.5654	1.4573	1.7811	1.9128	2.1696	2.3682	2.5801	2.8236	3.0035	0.5465	28.09
RAIL	954.	45/7	1.0750	1.2621	1.6579	1.5533	1.8890	2.0388	2.3048	2.5242	2.7435	3.0096	3.1958	0.5825	28.45
CARDINAL	954.	54/7	1.2290	1.2957	1.7858	1.5947	2.0133	2.0930	2.4272	2.5913	2.8680	3.0897	3.3251	0.5980	25.95
BUNTING	1192.5	45/7	1.3440	1.4105	1.9483	1.7360	2.1955	2.2785	2.6454	2.8210	3.1248	3.3635	3.6221	0.6510	25.84
GRACKLE	1192.5	54/19	1.5330	1.4495	2.1098	1.7840	2.3522	2.3415	2.7987	2.8990	3.2794	3.4565	3.7812	0.6690	23.58
BITTERN	1272.	45/7	1.4340	1.4571	2.0444	1.7933	2.2962	2.3538	2.7562	2.9142	3.2479	3.4746	3.7589	0.6725	25.13
PHEASANT	1272.	54/19	1.6350	1.4972	2.2169	1.8427	2.4635	2.4185	2.9193	2.9943	3.4116	3.5702	3.9267	0.6910	22.91
LAPWING	1590.	45/7	1.7920	1.6272	2.4205	2.0027	2.6874	2.6285	3.1812	3.2543	3.7151	3.8802	4.2740	0.7510	22.74
FALCON	1590.	54/19	2.0440	1.6738	2.6419	2.0600	2.9020	2.7038	3.3894	3.3475	3.9222	3.9913	4.4842	0.7725	20.70
CHUKAR	1780.	84/19	2.0740	1.7355	2.7043	2.1360	2.9772	2.8035	3.4873	3.4710	4.0434	4.1385	4.6291	0.8010	21.12
BLUEBIRD	2156.	84/19	2.5110	1.9088	3.1542	2.3493	3.4387	3.0835	3.9766	3.8177	4.5694	4.5518	5.1985	0.8810	19.33

ACSR CONDUCTORS
MISCELLANEOUS LOADINGS

					0.75 INCH ICE	1PSF	1 INCH ICE	1PSF	1.25 INCH ICE	1PSF
			DIAM.	WT./FT	WT./FT	TRANS	WT./FT	TRANS	WT./FT	TRANS
NAME	SIZE	STRAND	IN.	LBS.	LBS.	LB/FT	LBS.	LB/FT	LBS.	LB/FT
RAVEN	1/0	6/1	0.398	0.1452	1.2159	0.1582	1.8837	0.1998	2.7069	0.2415
QUAIL	2/0	6/1	0.447	0.1831	1.2995	0.1623	1.9825	0.2039	2.8210	0.2456
PIGEON	4/0	6/1	0.502	0.2309	1.3986	0.1668	2.0987	0.2085	2.9543	0.2502
PENGUIN	266.8	6/1	0.563	0.2911	1.5157	0.1719	2.2348	0.2136	3.1093	0.2553
WAXWIN	266.8	18/1	0.609	0.2894	1.5569	0.1758	2.2903	0.2174	3.1791	0.2591
PARTRID	336.4	26/7	0.642	0.3673	1.6656	0.1785	2.4092	0.2202	3.3083	0.2618
MERLIN	336.4	18/1	0.684	0.3653	1.7027	0.1820	2.4594	0.2237	3.3716	0.2653
LINNET	336.4	26/7	0.721	0.4630	1.8349	0.1851	2.6031	0.2268	3.5268	0.2684
ORIOLE	397.5	30/7	0.741	0.5271	1.9177	0.1868	2.6921	0.2284	3.6220	0.2701
CHICKADI	397.5	18/1	0.743	0.4316	1.8241	0.1869	2.5991	0.2286	3.5296	0.2703
IBIS	397.5	26/7	0.783	0.5469	1.9767	0.1903	2.7641	0.2319	3.7071	0.2736
LARK	397.5	30/7	0.806	0.6228	2.0740	0.1922	2.8686	0.2338	3.8187	0.2755
PELICAN	477.	18/1	0.814	0.5180	1.9767	0.1928	2.7738	0.2345	3.7264	0.2762
FLICKER	477.	24/7	0.846	0.6145	2.1030	0.1955	2.9101	0.2372	3.8726	0.2788
HAWK	477.	26/7	0.858	0.6570	2.1567	0.1965	2.9675	0.2382	3.9337	0.2798
HEN	477.	30/7	0.883	0.7470	2.2700	0.1986	3.0886	0.2403	4.0626	0.2819
OSPREY	556.5	18/1	0.879	0.6040	2.1233	0.1983	2.9406	0.2399	3.9134	0.2816
PARAKEE	556.5	24/7	0.914	0.7170	2.2689	0.2012	3.0971	0.2428	4.0808	0.2845
DOVE	556.5	26/7	0.927	0.7660	2.3301	0.2023	3.1623	0.2439	4.1500	0.2856
EAGLE	556.5	30/7	0.953	0.8720	2.4603	0.2044	3.3006	0.2461	4.2964	0.2878
KINGBIRD	636.	18/1	0.940	0.6910	2.2672	0.2033	3.1035	0.2450	4.0952	0.2867
ROOK	636.	24/7	0.997	0.8190	2.4484	0.2081	3.3024	0.2498	4.3118	0.2914
GOSBEAK	636.	26/7	0.990	0.8750	2.4978	0.2075	3.3497	0.2492	4.3569	0.2908
EGRET	636.	30/19	1.019	0.9880	2.6379	0.2099	3.4987	0.2516	4.5150	0.2933
CUCKOO	795.	24/7	1.092	1.0240	2.7420	0.2160	3.6255	0.2577	4.6645	0.2993
DRAKE	795.	26/7	1.108	1.0940	2.8269	0.2173	3.7154	0.2590	4.7594	0.3007
MALLARD	795.	30/19	1.140	1.2350	2.9977	0.2200	3.8962	0.2617	4.9501	0.3033
TERN	795.	45/7	1.063	0.8960	2.5869	0.2136	3.4614	0.2553	4.4914	0.2969
CONDOR	795.	54/7	1.093	1.0240	2.7429	0.2161	3.6267	0.2578	4.6660	0.2994
RAIL	954.	45/7	1.165	1.0750	2.8610	0.2221	3.7673	0.2638	4.8290	0.3054
CARDINAL	954.	54/7	1.196	1.2290	3.0440	0.2247	3.9598	0.2663	5.0311	0.3080
BUNTING	1192.5	45/7	1.302	1.3440	3.2578	0.2335	4.2066	0.2752	5.3109	0.3168
GRACKLE	1192.5	54/19	1.338	1.5330	3.4804	0.2365	4.4404	0.2782	5.5559	0.3198
BITTERN	1272.	45/7	1.345	1.4340	3.3879	0.2371	4.3501	0.2788	5.4678	0.3204
PHEASAN	1272.	54/19	1.382	1.6350	3.6234	0.2402	4.5971	0.2818	5.7263	0.3235
LAPWING	1590.	45/7	1.502	1.7920	3.8924	0.2502	4.9034	0.2918	6.0698	0.3335
FALCON	1590.	54/19	1.545	2.0440	4.1845	0.2538	5.2088	0.2954	6.3886	0.3371
CHUKAR	1780.	84/19	1.602	2.0740	4.2676	0.2585	5.3097	0.3002	6.5072	0.3418
BLUEBIRD	2156.	84/19	1.762	2.5110	4.8538	0.2718	5.9457	0.3135	7.1930	0.3552

Transverse loadings are based on 1 psf on the indicated ice condition. Transverse loadings other than 1psf can be obtained by multiplying the transverse loading value in the table by the amount of the expected wind load

For example, the transverse load caused by a 6 psf wind on a 477 kcmil 26/7 conductor covered by 1 inch of radial ice is:

.2382(6) = 1.4292 lb/ft.

6201 ALUMINUM ALLOY CONDUCTORS
NESC DISTRICT LOADINGS

			LIGHT .00" ICE, 9 LB., K=.05			MEDIUM .25" ICE, 4 LB WIND, K=.20			HEAVY .5" ICE, 4 LB WIND, K=.30		
NAME	SIZE	STRAND	VERT. LB/FT	TRANS LB/FT	RESULTANT LB/FT	VERT. LB/FT	TRANS LB/FT	RESULTANT LB/FT	VERT. LB/FT	TRANS LB/FT	RESULTANT LB/FT
AZUSA	123.3	7	0.1157	0.2985	0.3701	0.3172	0.2993	0.6361	0.6741	0.4660	1.1195
ANAHEIM	155.4	7	0.1459	0.3353	0.4156	0.3626	0.3157	0.6807	0.7347	0.4823	1.1789
AMHERST	195.7	7	0.1837	0.3765	0.4689	0.4175	0.3340	0.7347	0.8067	0.5007	1.2495
ALLIANCE	246.9	7	0.2318	0.4223	0.5317	0.4846	0.3543	0.8003	0.8927	0.5210	1.3337
BUTTE	312.8	19	0.2936	0.4815	0.6140	0.5709	0.3807	0.8862	1.0037	0.5473	1.4432
CANTON	394.5	19	0.3703	0.5408	0.7054	0.6722	0.4070	0.9858	1.1295	0.5737	1.5668
CAIRO	465.4	19	0.4369	0.5873	0.7819	0.7580	0.4277	1.0704	1.2346	0.5943	1.6702
DARIEN	559.5	19	0.5252	0.6435	0.8806	0.8697	0.4527	1.1804	1.3696	0.6193	1.8031
ELOIN	652.4	19	0.6124	0.6953	0.9765	0.9783	0.4757	1.2878	1.4997	0.6423	1.9314
FLINT	740.8	37	0.6954	0.7433	1.0678	1.0812	0.4970	1.3900	1.6225	0.6637	2.0530
GREELEY	927.2	37	0.8704	0.8310	1.2534	1.2926	0.5360	1.5993	1.8702	0.7027	2.2979

6201 ALUMINUM ALLOY CONDUCTORS
HIGH WIND LOADINGS

				13 psf		16 psf		21 psf		26 psf		31 psf	
NAME	SIZE	STRAND	WT./FT LBS.	TRANS LB/FT	RESULTANT LB/FT	TRANS LB/FT	RESULTANT LB/FT	TRANS LB/FT	RESULTANT LB/FT	TRANS LB/FT	RESULTANT LB/FT	TRANS LB/FT	RESULTANT LB/FT
AZUSA	123.3	7	0.1157	0.4312	0.4464	0.5307	0.5431	0.6965	0.7060	0.8623	0.8701	1.0282	1.0347
ANAHEIM	155.4	7	0.1459	0.4843	0.5058	0.5960	0.6136	0.7823	0.7957	0.9685	0.9794	1.1548	1.1639
AMHERST	195.7	7	0.1837	0.5438	0.5740	0.6693	0.6941	0.8785	0.8975	1.0877	1.1031	1.2968	1.3098
ALLIANCE	246.9	7	0.2318	0.6099	0.6525	0.7507	0.7856	0.9853	1.0122	1.2198	1.2417	1.4544	1.4728
BUTTE	312.8	19	0.2936	0.6955	0.7549	0.8560	0.9050	1.1235	1.1612	1.3910	1.4216	1.6585	1.6843
CANTON	394.5	19	0.3703	0.7811	0.8644	0.9613	1.0302	1.2618	1.3150	1.5622	1.6055	1.8626	1.8990
CAIRO	465.4	19	0.4369	0.8483	0.9542	1.0440	1.1317	1.3703	1.4382	1.6965	1.7519	2.0228	2.0694
DARIEN	559.5	19	0.5252	0.9295	1.0676	1.1440	1.2588	1.5015	1.5907	1.8590	1.9318	2.2165	2.2779
ELOIN	652.4	19	0.6124	1.0043	1.1762	1.2360	1.3794	1.6223	1.7340	2.0085	2.0998	2.3948	2.4718
FLINT	740.8	37	0.6954	1.0736	1.2791	1.3213	1.4932	1.7343	1.8685	2.1472	2.2570	2.5601	2.6528
GREELEY	927.2	37	0.8704	1.2003	1.4827	1.4773	1.7147	1.9390	2.1254	2.4007	2.5536	2.8623	2.9917

6201 ALUMINUM ALLOY CONDUCTORS - MISCELLANEOUS LOADINGS

			0.75" ICE		1.0" ICE		1.25" ICE	
NAME	SIZE	STRAND	WT./FT LBS.	TRANS for 1psf LB/FT	WT./FT LBS.	TRANS for 1psf LB/FT	WT./FT LBS.	TRANS for 1psf LB/FT
AZUSA	123.3	7	1.1864	0.1582	1.8542	0.1998	2.6774	0.2415
ANAHEIM	155.4	7	1.2623	0.1623	1.9453	0.2039	2.7838	0.2456
AMHERST	195.7	7	1.3514	0.1668	2.0515	0.2085	2.9071	0.2502
ALLIANCE	246.9	7	1.4564	0.1719	2.1755	0.2136	3.0500	0.2553
BUTTE	312.8	19	1.5919	0.1785	2.3355	0.2202	3.2346	0.2618
CANTON	394.5	19	1.7422	0.1851	2.5104	0.2268	3.4341	0.2684
CAIRO	465.4	19	1.8667	0.1903	2.6541	0.2319	3.5971	0.2736
DARIEN	559.5	19	2.0249	0.1965	2.8357	0.2382	3.8020	0.2798
ELOIN	652.4	19	2.1765	0.2023	3.0087	0.2439	3.9964	0.2856
FLINT	740.8	37	2.3192	0.2076	3.1713	0.2493	4.1789	0.2909
GREELEY	927.2	37	2.6033	0.2173	3.4918	0.2590	4.5358	0.3007

Transverse Loadings other than 1 psf on the indicated ic
condition can be obtained by multiplying the transverse l
value in the table by the amount of the expected wind loa
per foot.

For example, the transverse load caused by a 6 psf wind
wind on a 559.5 kcmil conductor covered by 1 inch of rad

.2382(6) = 1.4292 lb/ft.

1350 ALUMINUM ALLOY CONDUCTORS
NESC DISTRICT LOADINGS

NAME	SIZE	STRAND	LIGHT .00" ICE, 9 LB., K=.05 VERT. LB/FT	TRANS LB/FT	RESULTANT LB/FT	MEDIUM .25" ICE, 4 LB WIND, K=.20 VERT. LB/FT	TRANS LB/FT	RESULTANT LB/FT	HEAVY .5" ICE, 4 LB WIND, K=.30 VERT. LB/FT	TRANS LB/FT	RESULTANT LB/FT	ULTIMATE STRENGTH LBS.	DIAM. IN.	WT./FT LBS.
POPPY	1/0	7	0.0991	0.2760	0.3433	0.2912	0.2893	0.6105	0.6388	0.4560	1.0849	1990	0.368	0.0991
ASTRE	2/0	7	0.1249	0.3105	0.3847	0.3313	0.3047	0.6501	0.6932	0.4713	1.1383	2510	0.414	0.1249
PHLOX	3/0	7	0.1575	0.3480	0.4320	0.3795	0.3213	0.6972	0.7569	0.4880	1.2006	3040	0.464	0.1575
OXLIP	4/0	7	0.1986	0.3915	0.4890	0.4386	0.3407	0.7554	0.8341	0.5073	1.2762	3830	0.522	0.1986
VALERIAN	250.	19	0.2347	0.4305	0.5403	0.4909	0.3580	0.8076	0.9025	0.5247	1.3439	4660	0.574	0.2347
DAISY	266.8	7	0.2505	0.4395	0.5559	0.5104	0.3620	0.8257	0.9257	0.5287	1.3661	4830	0.586	0.2505
LAUREL	266.8	19	0.2505	0.4448	0.5604	0.5126	0.3643	0.8289	0.9301	0.5310	1.3710	4970	0.593	0.2505
TULIP	336.4	19	0.3128	0.4995	0.6394	0.5976	0.3887	0.9128	1.0378	0.5553	1.4770	6150	0.666	0.3128
CANNA	397.5	19	0.3731	0.5430	0.7088	0.6759	0.4080	0.9895	1.1342	0.5747	1.5714	7110	0.724	0.3731
GOLDENTUFT	450.	19	0.4224	0.5775	0.7655	0.7395	0.4233	1.0521	1.2121	0.5900	1.6480	7890	0.770	0.4224
COSMOS	477.	19	0.4478	0.5948	0.7945	0.7721	0.4310	1.0842	1.2518	0.5977	1.6871	8360	0.793	0.4478
SYRINGA	477.	37	0.4478	0.5963	0.7957	0.7727	0.4317	1.0851	1.2530	0.5983	1.6885	8690	0.795	0.4478
DAHLIA	556.5	19	0.5220	0.6420	0.8774	0.8658	0.4520	1.1767	1.3651	0.6187	1.7988	9750	0.856	0.5220
MISTLETOE	556.5	37	0.5220	0.6435	0.8786	0.8665	0.4527	1.1776	1.3664	0.6193	1.8002	9940	0.858	0.5220
ORCHID	636.	37	0.5970	0.6885	0.9613	0.9601	0.4727	1.2702	1.4787	0.6393	1.9110	11400	0.918	0.5970
ARBUTUS	795.	37	0.7460	0.7695	1.1217	1.1427	0.5087	1.4508	1.6948	0.6753	2.1244	13900	1.026	0.7460
LILAC	795.	61	0.7460	0.7710	1.1228	1.1433	0.5093	1.4516	1.6961	0.6760	2.1258	14300	1.028	0.7460
ANEMONE	874.5	37	0.8210	0.8078	1.2017	1.2335	0.5257	1.5409	1.8015	0.6923	2.2300	15000	1.077	0.8210
CROCUS	874.5	61	0.8210	0.8085	1.2023	1.2339	0.5260	1.5413	1.8022	0.6927	2.2307	15800	1.078	0.8210
MAGNOLIA	954.	37	0.8960	0.8430	1.2802	1.3232	0.5413	1.6296	1.9058	0.7080	2.3330	16400	1.124	0.8960
GOLDENROD	954.	61	0.8960	0.8445	1.2813	1.3238	0.5420	1.6304	1.9070	0.7087	2.3344	16900	1.126	0.8960
HAWTHORN	1192.5	61	1.1190	0.9435	1.5137	1.5878	0.5860	1.8925	2.2121	0.7527	2.6366	21100	1.258	1.1190
NARCESSUS	1272.	61	1.1920	0.9750	1.5900	1.6739	0.6000	1.9782	2.3112	0.7667	2.7350	22000	1.300	1.1920
COREOPSIS	1590	61	1.4900	1.0898	1.8960	2.0194	0.6510	2.3218	2.7043	0.8177	3.1252	27000	1.453	1.4900

1350 ALUMINUM ALLOY CONDUCTORS
HIGH WIND LOADINGS

NAME	SIZE	STRAND	WT./FT LBS.	13 psf TRANS LB/FT	RESULTANT LB/FT	16 psf TRANS LB/FT	RESULTANT LB/FT	21 psf TRANS LB/FT	RESULTANT LB/FT	26 psf TRANS LB/FT	RESULTANT LB/FT	31 psf TRANS LB/FT	RESULTANT LB/FT	6 psf TRANS LB/FT	SWING ANGLE
POPPY	1/0	7	0.0991	0.3987	0.4108	0.4907	0.5006	0.6440	0.6516	0.7973	0.8035	0.9507	0.9558	0.1840	61.7
ASTER	2/0	7	0.1249	0.4485	0.4656	0.5520	0.5660	0.7245	0.7352	0.8970	0.9057	1.0695	1.0768	0.2070	58.9
PHLOX	3/0	7	0.1575	0.5027	0.5268	0.6187	0.6384	0.8120	0.8271	1.0053	1.0176	1.1987	1.2090	0.2320	55.8
OXLIP	4/0	7	0.1986	0.5655	0.5994	0.6960	0.7238	0.9135	0.9348	1.1310	1.1483	1.3485	1.3630	0.2610	52.7
DAISY	266.8	7	0.2505	0.6348	0.6825	0.7813	0.8205	1.0255	1.0557	1.2697	1.2941	1.5138	1.5344	0.2930	49.5
LAUREL	266.8	19	0.2505	0.6424	0.6895	0.7907	0.8294	1.0378	1.0676	1.2848	1.3090	1.5319	1.5523	0.2965	49.8
TULIP	336.4	19	0.3128	0.7215	0.7864	0.8880	0.9415	1.1655	1.2067	1.4430	1.4765	1.7205	1.7487	0.3330	46.8
CANNA	397.5	19	0.3731	0.7843	0.8686	0.9653	1.0349	1.2670	1.3208	1.5687	1.6124	1.8703	1.9072	0.3620	44.1
GOLDENTUFT	450.	19	0.4224	0.8342	0.9350	1.0267	1.1102	1.3475	1.4122	1.6683	1.7210	1.9892	2.0335	0.3850	42.3
COSMOS	477.	19	0.4478	0.8591	0.9688	1.0573	1.1483	1.3878	1.4582	1.7182	1.7756	2.0486	2.0970	0.3965	41.5
SYRINGA	477.	37	0.4478	0.8613	0.9707	1.0600	1.1507	1.3913	1.4615	1.7225	1.7798	2.0538	2.1020	0.3975	41.6
DAHLIA	556.5	19	0.5220	0.9273	1.0642	1.1413	1.2550	1.4980	1.5863	1.8547	1.9267	2.2113	2.2721	0.4280	39.3
MISTLETOE	556.5	37	0.5220	0.9295	1.0660	1.1440	1.2575	1.5015	1.5896	1.8590	1.9309	2.2165	2.2771	0.4290	39.4
ORCHID	636.	37	0.5970	0.9945	1.1599	1.2240	1.3618	1.6065	1.7138	1.9890	2.0767	2.3715	2.4455	0.4590	37.6
ARBUTUS	795.	37	0.7460	1.1115	1.3386	1.3680	1.5582	1.7955	1.9443	2.2230	2.3448	2.6505	2.7535	0.5130	34.5
LILAC	795.	61	0.7460	1.1137	1.3404	1.3707	1.5605	1.7990	1.9475	2.2273	2.3489	2.6557	2.7585	0.5140	34.6
ANEMONE	874.5	37	0.8210	1.1668	1.4267	1.4360	1.6541	1.8848	2.0558	2.3335	2.4737	2.7823	2.9009	0.5385	33.3
CROCUS	874.5	61	0.8210	1.1678	1.4275	1.4373	1.6553	1.8865	2.0574	2.3357	2.4758	2.7848	2.9033	0.5390	33.3
MAGNOLIA	954.	37	0.8960	1.2177	1.5118	1.4987	1.7461	1.9670	2.1615	2.4353	2.5949	2.9037	3.0388	0.5620	32.1
GOLDENROD	954.	61	0.8960	1.2198	1.5135	1.5013	1.7484	1.9705	2.1646	2.4397	2.5990	2.9088	3.0437	0.5630	32.1
HAWTHORN	1192.5	61	1.1190	1.3628	1.7634	1.6773	2.0163	2.2015	2.4696	2.7257	2.9464	3.2498	3.4371	0.6290	29.3
NARCESSUS	1272.	61	1.1920	1.4083	1.8451	1.7333	2.1036	2.2750	2.5684	2.8167	3.0585	3.3583	3.5636	0.6500	28.6
COREOPSIS	1590	61	1.1940	1.5741	1.9757	1.9373	2.2757	2.5428	2.8091	3.1482	3.3670	3.7536	3.9389	0.7265	31.3

1350 ALUMINUM ALLOY CONDUCTORS
MISCELLANEOUS LOADINGS

NAME	SIZE	STRAND	DIAM. IN.	WT./FT LBS.	.75 " ICE WT./FT LBS.	.75 " ICE TRANS for 1psf LB/FT	1.0 " ICE WT./FT LBS.	1.0 " ICE TRANS for 1psf LB/FT	1.25 " ICE WT./FT LBS.	1.25 " ICE TRANS for 1psf LB/FT
POPPY	1/0	7	0.368	0.0991	1.1418	0.1557	1.8003	0.1973	2.6142	0.2390
ASTRE	2/0	7	0.414	0.1249	1.2105	0.1595	1.8833	0.2012	2.7115	0.2428
PHLOX	3/0	7	0.464	0.1575	1.2898	0.1637	1.9781	0.2053	2.8218	0.2470
OXLIP	4/0	7	0.522	0.1986	1.3849	0.1685	2.0913	0.2102	2.9531	0.2518
VALERIAN	250.	19	0.574	0.2347	1.4695	0.1728	2.1920	0.2145	3.0700	0.2562
DAISY	266.8	7	0.586	0.2505	1.4965	0.1738	2.2228	0.2155	3.1044	0.2572
LAUREL	266.8	19	0.593	0.2505	1.5031	0.1744	2.2315	0.2161	3.1153	0.2578
TULIP	336.4	19	0.666	0.3128	1.6335	0.1805	2.3846	0.2222	3.2911	0.2638
CANNA	397.5	19	0.724	0.3731	1.7478	0.1853	2.5170	0.2270	3.4416	0.2687
GOLDENTUFT	450.	19	0.770	0.4224	1.8400	0.1892	2.6235	0.2308	3.5624	0.2725
COSMOS	477.	19	0.793	0.4478	1.8869	0.1911	2.6775	0.2328	3.6235	0.2744
SYRINGA	477.	37	0.795	0.4478	1.8888	0.1913	2.6800	0.2329	3.6266	0.2746
DAHLIA	556.5	19	0.856	0.5220	2.0199	0.1963	2.8300	0.2380	3.7956	0.2797
MISTLETOE	556.5	37	0.858	0.5220	2.0217	0.1965	2.8325	0.2382	3.7988	0.2798
ORCHID	636.	37	0.918	0.5970	2.1527	0.2015	2.9821	0.2432	3.9670	0.2848
ARBUTUS	795.	37	1.026	0.7460	2.4024	0.2105	3.2654	0.2522	4.2839	0.2938
LILAC	795.	61	1.028	0.7460	2.4043	0.2107	3.2679	0.2523	4.2870	0.2940
ANEMONE	874.5	37	1.077	0.8210	2.5250	0.2148	3.4039	0.2564	4.4382	0.2981
CROCUS	874.5	61	1.078	0.8210	2.5259	0.2148	3.4051	0.2565	4.4397	0.2982
MAGNOLIA	954.	37	1.124	0.8960	2.6438	0.2187	3.5373	0.2603	4.5862	0.3020
GOLDENROD	954.	61	1.126	0.8960	2.6457	0.2188	3.5398	0.2605	4.5893	0.3022
HAWTHORN	1192.5	61	1.258	1.1190	2.9918	0.2298	3.9269	0.2715	5.0175	0.3132

		LIGHT			MEDIUM			HEAVY			
		.00" ICE, 9 LB., K=.05			.25" ICE, 4 LB WIND, K=.20			.5" ICE, 4 LB WIND, K=.30			ULTIMATE
		VERT.	TRANS	RESULTANT	VERT.	TRANS	RESULTANT	VERT.	TRANS	RESULTANT	STRENGTH
SIZE	STRAND	LB/FT	LB/FT	LB/FT	LB/FT	LB/FT	LB/FT	LB/FT	LB/FT	LB/FT	LBS.
3/8	7	0.2730	0.2700	0.4340	0.4626	0.2867	0.7443	0.8077	0.4533	1.2262	10800
7/16	7	0.3990	0.3263	0.5654	0.6120	0.3117	0.8868	0.9804	0.4783	1.3908	14500
3/8	7	0.2730	0.2700	0.4340	0.4626	0.2867	0.7443	0.8077	0.4533	1.2262	15400
7/16	7	0.3990	0.3263	0.5654	0.6120	0.3117	0.8868	0.9804	0.4783	1.3908	20800
7 NO. 9		0.2076	0.2573	0.3806	0.3920	0.2810	0.6823	0.7318	0.4477	1.1578	12630
7 NO. 8		0.2618	0.2888	0.4398	0.4592	0.2950	0.7458	0.8121	0.4617	1.2341	15930
7 NO. 7		0.3300	0.3248	0.5130	0.5423	0.3110	0.8252	0.9101	0.4777	1.3278	19060

OVERHEAD GROUND WIRES
HIGH WIND LOADINGS

			13 psf		16 psf		21 psf		26 psf		31 psf		6 psf	
		WT./FT	TRANS	RESULTANT	TRANS	RESULTANT	TRANS	RESULTANT	TRANS	RESULTANT	TRANS	RESULTANT	TRANS	SWING
SIZE	STRAND	LBS.	LB/FT	LB/FT	LB/FT	LB/FT	LB/FT	LB/FT	LB/FT	LB/FT	LB/FT	LB/FT	LB/FT	ANGLE
3/8	7	0.2730	0.3900	0.4761	0.4800	0.5522	0.6300	0.6866	0.7800	0.8264	0.9300	0.9692	0.1800	33.4
7/16	7	0.3990	0.4713	0.6175	0.5800	0.7040	0.7613	0.8595	0.9425	1.0235	1.1238	1.1925	0.2175	28.6
3/8	7	0.2730	0.3900	0.4761	0.4800	0.5522	0.6300	0.6866	0.7800	0.8264	0.9300	0.9692	0.1800	33.4
7/16	7	0.3990	0.4713	0.6175	0.5800	0.7040	0.7613	0.8595	0.9425	1.0235	1.1238	1.1925	0.2175	28.6
7 NO. 9		0.2076	0.3716	0.4256	0.4573	0.5022	0.6003	0.6351	0.7432	0.7716	0.8861	0.9101	0.1715	39.6
7 NO. 8		0.2618	0.4171	0.4924	0.5133	0.5762	0.6738	0.7228	0.8342	0.8743	0.9946	1.0285	0.1925	36.3
7 NO. 7		0.3300	0.4691	0.5735	0.5773	0.6650	0.7578	0.8265	0.9382	0.9945	1.1186	1.1662	0.2165	33.3

OVERHEAD GROUND WIRES - MISCELLANEOUS LOADINGS

		0.75 " ICE		1.0 " ICE		1.25 " ICE	
		WT./FT	TRANS	WT./FT	TRANS	WT./FT	TRANS
SIZE	STRAND	LBS.	for 1psf LB/FT	LBS.	for 1psf LB/FT	LBS.	for 1psf LB/FT
3/8	7	1.3083	0.1550	1.9642	0.1967	2.7756	0.2383
7/16	7	1.5042	0.1613	2.1835	0.2029	3.0182	0.2446
3/8	7	1.3083	0.1550	1.9642	0.1967	2.7756	0.2383
7/16	7	1.5042	0.1613	2.1835	0.2029	3.0182	0.2446
7 NO. 9		1.2270	0.1536	1.8777	0.1953	2.6838	0.2369
7 NO. 8		1.3204	0.1571	1.9841	0.1988	2.8033	0.2404
7 NO. 7		1.4333	0.1611	2.1120	0.2028	2.9461	0.2444

Transverse Loadings other than 1 psf on the indicated ice condition can be obtained by multiplying the transverse loading value in the table by the amount of the expected wind load per foot.

For example, the transverse load caused by a 6 psf wind on 3/8" HIGH STRENGTH STEEL OHGW covered by 1 inch of radial ice is:

.1967(6) = 1.1802 lb/ft.

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APPENDIX C

INSULATION TABLES

TABLE C-1

FLASHOVER DATA FOR PORCELAIN STRING
5-3/4"X 10" STANDARD SUSPENSION INSULATORS

Units in string	60Hz Flashover-kV		Impulse Flashover, kV 1.5 X 50	
	Dry	Wet	Positive	Negative
2	155	90	250	250
3	215	130	355	340
4	270	170	440	415
5	325	215	525	495
6	380	255	610	585
7	435	295	695	670
8	485	335	780	760
9	540	375	860	845
10	590	415	945	930
11	640	455	1025	1015
12	690	490	1105	1105
13	735	525	1185	1190
14	785	565	1265	1275
15	830	600	1345	1360
16	875	630	1425	1440
17	920	660	1505	1530
18	965	690	1585	1615
19	1010	720	1665	1700
20	1055	750	1745	1785
21	1095	775	1820	1865
22	1135	800	1895	1945
23	1175	825	1970	2025
24	1215	850	2045	2105
25	1255	875	2120	2185

TABLE C-2

FLASHOVER DATA FOR SUSPENSION POLYMERS
(ANSI C29.12-1997)

	Electrical Values			
	Low Frequency flashover		Critical Impulse Flashover	
ANSI Class	Dry (kV)	Wet (kV)	Positive (kV)	Negative (kV)
60-1	365	310	610	585
60-2	410	350	675	670
60-3	470	415	780	760
60-4	485	455	860	845
60-5	560	490	925	930
60-6	620	545	1025	1015
60-7	670	580	1105	1105
60-8	720	620	1185	1190
60-9	810	690	1345	1360
60-10	900	755	1490	1530
60-11	925	795	1575	1600
60-12	980	830	1665	1700
60-13	1060	890	1825	1870
60-14	1345	1290	2530	2630

TABLE C-3

APPROXIMATE WEIGHTS AND LENGTHS OF
INSULATOR STRINGS USING STANDARD
5-3/4” x 10” SUSPENSION BELLS WITH A BALL HOOK*

Number of Insulators	Length of String (Includes Suspension Hardware), Ft.	Weight of String (Includes Suspension Hardware), Lbs.	Max. Voltage- for the Number of Insulators (Tangent)
3	2.00	45	34.5 kV, 46 kV
4	2.50	58	69 kV
5	3.00	71	
6	3.50	84	
7	3.92	96	115 kV
8	4.42	109	
9	4.92	122	
10	5.33	135	161 kV
11	5.83	147	
12	6.33	160	230 kV
13	6.83	173	
14	7.25	186	
15	7.75	198	
16	8.25	211	

*Exact length and weight will vary slightly depending upon conductor suspension hardware used.

APPENDIX D

AMPACITY, MVA, SURFACE GRADIENT TABLES

TABLE D-1
AMPACITY OF ACSR CONDUCTORS

Conductor Temperature			120ºF	167ºF	212ºF		
Summer ambient			104ºF	104ºF	104ºF		
Winter ambient			32ºF	32ºF	32ºF		
Wind (ft./sec.)			2	2	2	ft./sec.	

			Ampacity Summer Rating			**Ampacity Winter Rating**		
NAME	**SIZE**	**STRAND**	**120 Deg F**	**167 Deg F**	**212 Deg F**	**120 Deg F**	**167 Deg F**	**212 Deg F**
RAVEN	1/0	6/1	70	195	257	240	292	330
QUAIL	2/0	6/1	77	223	294	275	335	379
PIGEON	3/0	6/1	85	255	338	315	384	435
PENGUIN	4/0	6/1	92	291	386	357	439	497
WAXWING	266.8	18/1	110	359	478	442	543	616
PARTRIDGE	266.8	26/7	108	364	484	447	550	624
MERLIN	336.4	18/1	119	416	554	511	630	715
LINNET	336.4	26/7	117	420	561	517	637	724
ORIOLE	397.5	30/7	115	423	565	520	642	729
CHICKADEE	397.5	18/1	120	461	616	544	700	795
IBIS	397.5	26/7	122	466	624	574	708	806
LARK	397.5	30/7	120	469	629	578	714	812
PELICAN	477.	18/1	131	516	692	636	786	894
FLICKER	477.	24/7	128	521	699	641	793	902
HAWK	477.	26/7	127	522	701	644	796	906
HEN	477.	30/7	124	526	706	648	801	913
OSPREY	556.5	18/1	135	568	763	700	866	986
PARAKEET	556.5	24/7	130	573	771	706	874	996
DOVE	556.5	26/7	129	575	774	709	878	1000
EAGLE	556.5	30/7	126	579	779	713	884	1007
KINGBIRD	636.	18/1	136	617	815	761	943	1053
ROOK	636.	24/7	131	623	839	768	952	1085
GOSBEAK	636.	26/7	129	625	843	770	955	1089
EGRET	636.	30/19	125	629	849	776	962	1097
CUCKOO	795.	24/7	126	715	967	882	1096	1251
DRAKE	795.	26/7	123	718	972	886	1101	1257
MALLARD	795.	30/19	116	723	979	892	1110	1267
TERN	795.	45/7	131	709	959	874	1086	1240
CONDOR	795.	54/7	126	715	967	882	1096	1251
RAIL	954.	45/7	120	793	1076	978	1218	1393
CARDINAL	954.	54/7	112	800	1086	987	1229	1406
BUNTING	1192.5	45/7	84	908	1238	1121	1400	1604
GRACKLE	1192.5	54/19	65	927	1264	1144	1429	1637
BITTERN	1272.	45/7	61	944	1289	1165	1457	1670
PHEASANT	1272.	54/19	21	964	1317	1190	1489	1706
LAPWING	1590.	45/7		1079	1480	1330	1670	1919
FALCON	1590.	54/19		1103	1514	1361	1709	1963
CHUKAR	1780.	84/19		1168	1608	1440	1813	2085
BLUEBIRD	2156	84/19		1304	1803	1606	2030	2340

TABLE D-2: MVA LIMITS

			MVA LIMIT FOR 212 DEGREE F OPERATION AT THE INDICATED VOLTAGE (S = Summer; W = Winter)													
CONDUCTOR			34.5 kV		46 kV		69 kV		115 kV		138 kV		161 kV		230 KV	
NAME	SIZE & STRAND		S	W	S	W	S	W	S	W	S	W	S	W	S	W
RAVEN	1/0	6/1	15	20	20	26	31	39	51	66	61	79	72	92	102	132
QUAIL	2/0	6/1	18	23	23	30	35	45	59	75	70	91	82	106	117	151
PIGEON	3/0	6/1	20	26	27	35	40	52	67	87	81	104	94	121	134	173
PENGUIN	4/0	6/1	23	30	31	40	46	59	77	99	92	119	108	139	154	198
WAXWING	266.8	18/1	29	37	38	49	57	74	95	123	114	147	133	172	190	245
PARTRIDGE	266.8	26/7	29	37	39	50	58	75	96	124	116	149	135	174	193	249
MERLIN	336.4	18/1	33	43	44	57	66	85	110	142	132	171	155	199	221	285
LINNET	336.4	26/7	34	43	45	58	67	87	112	144	134	173	156	202	224	288
ORIOLE	397.5	30/7	34	44	45	58	68	87	113	145	135	174	158	203	225	290
CHICKADEE	397.5	18/1	37	48	37	48	74	95	123	158	147	190	172	222	246	317
IBIS	397.5	26/7	37	48	37	48	75	96	124	160	149	193	174	225	249	321
LARK	397.5	30/7	38	48	38	48	75	97	125	162	150	194	175	226	250	323
PELICAN	477.	18/1	41	53	41	53	83	107	138	178	165	214	193	249	276	356
FLICKER	477.	24/7	42	54	42	54	83	108	139	180	167	216	195	252	278	359
HAWK	477.	26/7	42	54	42	54	84	108	140	180	168	216	196	253	279	361
HEN	477.	30/7	42	55	42	55	84	109	141	182	169	218	197	254	281	364
OSPREY	556.5	18/1	46	59	46	59	91	118	152	196	182	236	213	275	304	393
PARAKEET	556.5	24/7	46	60	46	60	92	119	154	198	184	238	215	278	307	397
DOVE	556.5	26/7	46	60	46	60	93	120	154	199	185	239	216	279	308	398
EAGLE	556.5	30/7	47	60	47	60	93	120	155	201	186	241	217	281	310	401
KINGBIRD	636.	18/1	49	63	49	63	97	126	162	210	195	252	227	294	324	419
ROOK	636.	24/7	50	65	50	65	100	130	167	216	201	259	234	303	334	432
GOSBEAK	636.	26/7	50	65	50	65	101	130	168	217	201	260	235	304	336	434
EGRET	636.	30/19	51	66	51	66	101	131	169	219	203	262	237	306	338	437
CUCKOO	795.	24/7	58	75	58	75	116	150	193	249	231	299	270	349	385	498
DRAKE	795.	26/7	58	75	58	75	116	150	194	250	232	301	271	351	387	501
MALLARD	795.	30/19	59	76	59	76	117	151	195	252	234	303	273	353	390	505
TERN	795.	45/7	57	74	57	74	115	148	191	247	229	296	267	346	382	494
CONDOR	795.	54/7	58	75	58	75	116	150	193	249	231	299	270	349	385	498
RAIL	954.	45/7	64	83	64	83	129	166	214	277	257	333	300	388	429	555
CARDINAL	954.	54/7	65	84	65	84	130	168	216	280	260	336	303	392	433	560
BUNTING	1192.5	45/7	74	96	74	96	148	192	247	319	296	383	345	447	493	639
GRACKLE	1192.5	54/19	76	98	76	98	151	196	252	326	302	391	352	457	504	652
BITTERN	1272.	45/7	77	100	77	100	154	200	257	333	308	399	359	466	514	665
PHEASANT	1272.	54/19	79	102	79	102	157	204	262	340	315	408	367	476	525	680
LAPWING	1590.	45/7	88	115	88	115	177	229	295	382	354	459	413	535	590	764
FALCON	1590.	54/19	90	117	90	117	181	235	302	391	362	469	422	548	603	782
CHUKAR	1780.	84/19	96	125	96	125	192	249	320	415	384	498	448	581	640	831
BLUEBIRD	2156	84/19	108	140	108	140	215	280	359	466	431	559	503	653	718	932

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APPENDIX E

WEATHER DATA

TABLE E-1
WIND VELOCITIES AND PRESSURES

Actual Wind Velocity, mi/hr.	psf on a Cylindrical Surface	psf on a Flat Surface
35	3.1	4.8
40	4.0	6.3
45	5.2	8.1
49	6.0	9.6
50	6.4	10.0
55	7.7	12.0
60	9.0	14.1
65	10.8	16.9
70	12.5	19.5
75	14.4	22.5
80	16.4	28.9
85	18.5	32.3
90	20.7	36.1
95	23.1	40.0
100	25.6	44.1
105	28.2	48.4
110	31.0	53.0
115	33.9	57.7
120	36.9	63.1

*Based on:

$F = .00256V^2$ (for cylindrical surfaces)

Where:

F= wind force in pounds per square foot.

V= wind velocity in miles per hour.

TABLE E-2
CONVERSION FACTORS FOR OTHER
MEAN RECURRENCE INTERVALS

MRI (years)	Peak gust wind speed, V (mph)		
	Continental U.S.		
	V=85-100	V>100 (hurricane)	Alaska
500	1.23	1.23	1/18
200	1.14	1.14	1.12
100	1.07	1.07	1.06
50	1.00	1.00	1.00
25	0.93	0.88	0.94
10	0.84	0.74(76 mph min.)	0.87
5	0.78	0.66(60 mph min.)	0.81

Note:
Conversion factors for the column "V>100 (hurricane)" are approximate. For the MRI (mean recurrence interval) = 50 as shown, the actual return period, as represented by the design wind speed map in Figures 11-2a to 11-2d, varies from 50 to approximately 90 years. For an MRI = 500, the conversion factor is theoretically "exact" as shown.

TABLE E-3
PROBABLILITY OF EXCEEDING DESIGN WIND SPEEDS
DURING REFERENCE PERIOD

Annual Probablility P_a	Reference (Exposure) Period, *n* (years)					
	1	5	10	25	50	100
.04(1/25)	0.04	0.18	0.34	0.64	0.87	0.98
.02(1/50)	0.02	0.10	0.18	0.40	0.64	0.87
.01(1/100)	0.01	0.05	0.10	0.22	0.40	0.64
.005(1/200)	0.005	0.02	0.05	0.10	0.22	0.39

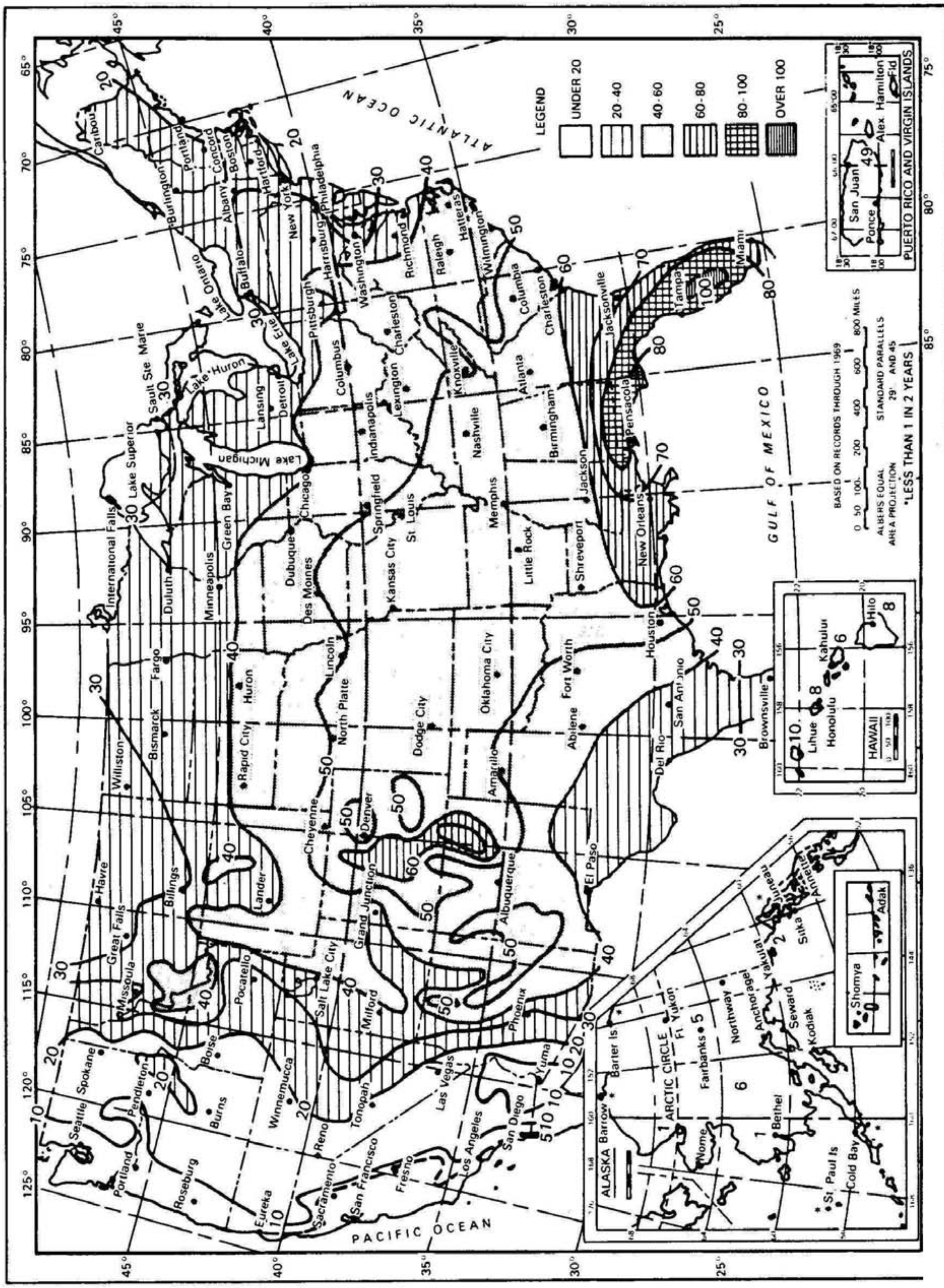


FIGURE E-1: ISOKERAUNIC LEVELS FOR THE UNITED STATES

APPENDIX F

POLE DATA

TABLE F-1
MOMENTS (FT-K) AT GROUNDLINE
DUE TO A 1 PSF WIND ON THE POLE

	6000 psi Western Red Cedar				6600 psi Lodgepole Pine			
Ht.	**Cl-H1**	**Cl-1**	**Cl-2**	**Cl-3**	**Cl-H1**	**Cl-1**	**Cl-2**	**Cl-3**
50	0.9	0.9	0.8	0.7		0.8	0.8	0.7
55	1.1	1.0	1.0	0.9		1.0	1.0	0.9
60	1.4	1.3	1.2	1.1		1.3	1.2	1.1
65	1.6	1.5	1.4	1.3		1.5	1.4	1.3
70	1.9	1.8	1.7	1.6		1.8	1.7	1.5
75	2.2	2.1	2.0	1.8		2.1	1.9	1.8
80	2.6	2.4	2.3	2.1		2.4	2.2	2.1
85	3.0	2.8	2.6	2.4		2.7	2.5	2.4
90	3.4	3.2	3.0	2.7		3.1	2.9	2.7
95	3.9	3.6	3.4			3.6	3.3	
100	4.4	4.1	3.8			4.0	3.7	

	8000 psi Douglas Fir and Southern Yellow Pine				8400 psi Western Larch			
Ht.	**Cl-H1**	**Cl-1**	**Cl-2**	**Cl-3**	**Cl-H1**	**Cl-1**	**Cl-2**	**Cl-3**
50	0.9	0.8	0.8	0.7	0.9	0.8	0.8	0.7
55	1.1	1.0	0.9	0.9	1.1	1.0	0.9	0.9
60	1.3	1.2	1.1	1.1	1.3	1.2	1.1	1.0
65	1.6	1.5	1.4	1.3	1.6	1.4	1.4	1.2
70	1.8	1.7	1.6	1.5	1.8	1.7	1.6	1.5
75	2.1	2.0	1.9	1.7	2.1	2.0	1.8	1.7
80	2.5	2.3	2.2	2.0	2.5	2.3	2.1	2.0
85	2.8	2.6	2.5	2.3	2.8	2.6	2.4	2.3
90	3.2	3.0	2.8	2.6	3.2	3.0	2.8	2.6
95	3.7	3.4	3.2		3.6	3.4	3.2	
100	4.2	3.9	3.6		4.1	3.9	3.6	

TABLE F-2
MOMENT CAPACITIES (FT-K) AT GROUNDLINE
For Western Red Cedar (6000 psi), Lodgepole Pine (6600 psi),
Douglas Fir and Southern Yellow Pine (8000 psi) and Western Larch (8400 psi)

6000 psi Western Red Cedar					6600 psi Lodgepole Pine				
Ht.	ClassH1	Class 1	Class 2	Class 3		Class 1	Class 2	Class 3	Ht.
50	222.2	186.1	154.2	126.2		186.9	153.9	125.1	50
55	245.4	206.9	172.7	137.9		202.5	167.8	137.2	55
60	270.4	229.3	192.7	150.4		225.5	182.5	150.2	60
65	297.1	246.7	202.4	163.7		243.4	198.2	159.0	65
70	317.7	265.1	218.6	177.9		262.4	214.8	173.4	70
75	339.4	284.4	235.7	192.9		282.4	232.4	188.8	75
80	362.2	304.8	253.8	203.1		303.4	251.0	205.1	80
85	386.1	326.2	266.0	219.6		317.5	263.6	216.1	85
90	411.1	348.6	285.6	230.7		340.4	283.8	227.5	90
95	441.6	367.3	301.9			368.0	300.5		95
100	473.4	395.5	326.6			387.8	317.7		100

8000 psi Douglas Fir & Southern Yellow Pine					8400 psi Western Larch				
Ht.	ClassH1	Class 1	Class 2	Class 3	ClassH1	Class 1	Class 2	Class 3	Ht.
50	220.3	187.2	152.1	121.7	222.4	183.9	148.7	123.0	50
55	246.4	204.2	167.1	134.7	243.6	201.1	163.8	136.4	55
60	266.8	222.3	183.0	148.7	264.3	219.4	179.9	145.4	60
65	288.4	241.5	200.0	163.5	294.4	238.9	203.5	160.4	65
70	311.2	261.9	218.1	179.4	318.0	259.5	215.3	176.4	70
75	335.3	283.4	230.3	190.2	333.8	281.3	227.7	187.3	75
80	360.6	306.2	250.2	201.5	359.6	296.1	247.8	198.7	80
85	387.2	321.5	263.7	213.3	386.7	320.0	261.5	210.6	85
90	405.2	337.5	285.5	225.5	405.0	336.2	275.8	229.9	90
95	438.0	357.3	303.2		438.3	365.6	301.5		95
100	461.5	387.3	321.5		462.1	386.7	319.9		100

TABLE F-3
POLE CLASSES

Wood poles are separated into 15 classes based on the minimum circumference of the pole 6 feet from the butt. The minimum circumferences have been calculated in order for each species (in a given class) to develop stresses approximately equal to those shown in the table. These stresses are developed at the groundline, when a horizontal load is applied 2 feet from the top of the pole. The horizontal loads used in these calculations are as follows:

Class	Horizontal Load (lbs.)
H6	11,400
H5	10,000
H4	8,700
H3	7,500
H2	6,400
H1	5,400
1	4,500
2	3,700
3	3,000
4	2,400
5	1,900
6	1,500
7	1,200
9	740
10	370

DOUGLAS FIR AND SOUTHERN YELLOW PINE
Ultimate Bending Stress – 8000 psi

55 ft. 55 ft.

	Class H1			Class 1				Class 2			Class 3			
Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)
0	9.23	66.92	51.5	8.59	58.01	41.5	0	7.96	49.74	33.0	7.32	42.10	25.7	0
1	9.36	68.87	53.7	8.72	59.73	43.4	1	8.08	51.25	34.5	7.43	43.41	26.9	1
2	9.50	70.84	56.1	8.85	61.48	45.3	2	8.20	52.79	36.1	7.55	44.75	28.2	2
3	9.63	72.84	58.5	8.97	63.26	47.3	3	8.32	54.34	37.7	7.66	46.11	29.4	3
4	9.76	74.87	60.9	9.10	65.05	49.3	4	8.44	55.93	39.3	7.78	47.49	30.8	4
5	9.90	76.93	63.4	9.23	66.88	51.4	5	8.56	57.53	41.0	7.89	48.89	32.1	5
6	10.03	79.01	66.0	9.35	68.73	53.6	6	8.68	59.16	42.8	8.00	50.31	33.6	6
7	10.16	81.12	68.7	9.48	70.60	55.8	7	8.80	60.81	44.6	8.12	51.75	35.0	7
8	10.30	83.26	71.4	9.61	72.5	58.0	8	8.92	62.48	46.4	8.23	53.20	36.5	8
9	10.43	85.43	74.3	9.73	74.42	60.4	9	9.04	64.17	48.3	8.34	54.68	38.0	9
10	10.56	87.63	77.1	9.86	76.37	62.8	10	9.16	65.89	50.3	8.46	56.18	39.6	10
11	10.70	89.85	80.1	9.99	78.35	65.2	11	9.28	67.63	52.5	8.57	57.71	41.2	11
12	10.83	92.10	83.1	10.11	80.35	67.7	12	9.40	69.40	54.4	8.69	59.25	42.9	12
13	10.96	94.38	86.2	10.24	82.37	70.3	13	9.52	71.18	56.5	8.80	60.81	44.6	13
14	11.10	96.69	89.4	10.37	84.42	72.9	14	9.64	72.99	58.6	8.91	62.39	46.3	14
15	11.23	99.02	92.7	10.49	86.50	75.6	15	9.76	74.82	60.9	9.03	63.99	48.1	15
16	11.36	101.39	96.0	10.62	88.60	78.4	16	9.88	76.68	63.1	9.14	65.61	50.0	16
17	11.49	103.78	99.4	10.75	90.73	81.3	17	10.00	78.55	65.5	9.25	67.25	51.9	17
18	11.63	106.19	102.9	10.87	92.88	84.2	18	10.12	80.45	67.9	9.37	68.92	53.8	18
19	11.76	108.64	106.5	11.00	95.05	87.1	19	10.24	82.37	70.3	9.48	70.60	55.8	19
20	11.89	111.12	110.1	11.13	92.26	90.2	20	10.36	84.32	72.8	9.59	72.30	57.8	20
21	12.03	113.62	113.9	11.25	99.48	93.3	21	10.48	86.29	75.4	9.71	74.03	59.9	21
22	12.16	116.15	117.7	11.38	101.73	96.5	22	10.60	88.28	78.0	9.82	75.77	62.0	22
23	12.29	118.71	121.6	11.51	104.01	99.7	23	10.72	90.29	80.7	9.94	77.53	64.2	23
24	12.43	121.29	125.6	11.63	106.31	103.1	24	10.84	92.32	83.4	10.05	79.32	66.4	24
25	12.56	123.90	129.7	11.76	108.64	106.5	25	10.96	94.38	86.2	10.16	81.12	68.7	25
26	12.69	126.55	133.9	11.89	110.99	110.0	26	11.08	96.46	89.1	10.28	82.95	71.0	26
27	12.83	129.21	138.1	12.01	113.37	113.5	27	11.20	98.57	92.0	10.39	84.79	73.4	27
28	12.96	131.91	142.5	12.14	115.78	117.1	28	11.32	100.69	95.0	10.50	86.66	75.9	28
29	13.09	134.64	146.9	12.27	118.20	120.8	29	11.44	102.84	98.1	10.62	88.55	78.3	29
30	13.23	137.39	151.4	12.39	120.66	124.6	30	11.56	105.01	101.2	10.73	90.45	80.9	30
31	13.36	140.17	156.0	12.52	123.14	128.5	31	11.68	107.21	104.4	10.85	92.38	83.5	31
32	13.49	142.98	160.8	12.65	125.64	132.4	32	11.80	109.42	107.6	10.96	94.33	86.1	32
33	13.63	145.81	165.6	12.77	128.17	136.4	33	11.92	111.66	111.0	11.07	96.29	88.9	33
34	13.76	148.68	170.5	12.90	130.72	140.5	34	12.04	113.92	114.3	11.19	98.28	91.6	34
35	13.89	151.57	175.5	13.03	133.30	144.7	35	12.16	116.21	117.8	11.30	100.29	94.4	35
36	14.03	154.49	180.6	13.15	135.91	149.0	36	12.28	118.52	121.3	11.41	102.32	97.3	36
37	14.16	157.44	185.8	13.28	138.54	153.3	37	12.40	120.85	124.9	11.53	104.36	100.3	37
38	14.29	160.41	191.0	13.41	141.19	157.8	38	12.52	123.20	128.6	11.64	106.43	103.2	38
39	14.42	163.42	196.4	13.53	143.87	162.3	39	12.64	125.58	132.3	11.75	108.52	106.3	39
40	14.56	166.45	201.9	13.66	146.58	166.9	40	12.76	127.97	136.1	11.87	110.63	109.4	40
41	14.69	169.51	207.5	13.79	149.31	171.6	41	12.89	130.40	140.0	11.98	112.76	112.6	41
42	14.82	172.60	213.2	13.91	152.07	176.3	42	13.01	132.84	144.0	12.10	114.91	115.8	42
43	14.96	175.71	219.0	14.04	154.85	181.2	43	13.13	135.31	148.0	12.21	117.08	119.1	43
44	15.09	178.85	224.9	14.17	157.66	186.1	44	13.25	137.79	152.1	12.32	119.27	122.5	44
45	15.22	182.02	230.9	14.29	160.49	191.2	45	13.37	140.31	156.3	12.44	121.48	125.9	45
46	15.36	185.22	237.0	14.42	163.34	196.3	46	13.49	142.84	160.5	12.55	123.71	129.4	46
47	15.49	188.45	243.3	14.55	166.23	201.5	47	13.61	145.40	164.9	12.66	125.96	132.9	47
48	15.62	191.70	249.6	14.67	169.13	206.8	48	13.73	147.98	169.3	12.78	128.24	136.5	48
49	15.76	194.98	256.0	14.80	172.07	212.2	49	13.85	150.58	173.8	12.89	130.53	140.2	49
50	15.82	196.64	259.3	14.87	173.62	215.1	50	13.91	152.04	176.3	12.96	131.88	142.4	50
51	15.89	198.31	262.6	14.94	175.19	218.0	51	13.98	153.50	178.8	13.03	133.25	144.6	51
52	15.96	199.98	265.9	15.00	176.76	221.0	52	14.05	154.97	181.4	13.09	134.62	146.9	52
53	16.02	201.66	269.3	15.07	178.34	223.9	53	14.11	156.45	184.0	13.16	136.00	149.1	53
54	16.09	203.34	272.7	15.14	179.92	226.9	54	14.18	157.94	186.6	13.23	137.38	151.4	54
55	16.16	205.04	276.1	15.20	181.52	230.0	55	14.25	159.43	189.3	13.29	138.77	153.7	55

DOUGLAS FIR AND SOUTHERN YELLOW PINE
Ultimate Bending Stress – 8000 psi

60 ft. 60 ft.

	Class H1			Class 1				Class 2			Class 3			
Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)
0	9.231	66.92	51.5	8.594	58.01	41.5	0	7.958	49.74	33.0	7.32	42.10	25.7	0
1	9.361	68.82	53.7	8.718	59.70	43.4	1	8.076	51.22	34.5	7.43	43.39	26.9	1
2	9.49	70.74	55.9	8.842	61.40	45.2	2	8.194	52.73	36.0	7.55	44.71	28.1	2
3	9.62	72.68	58.3	8.966	63.13	47.2	3	8.311	54.26	37.6	7.66	46.05	29.4	3
4	9.75	74.66	60.7	9.09	64.89	49.2	4	8.429	55.81	39.2	7.77	47.41	30.7	4
5	9.879	76.66	63.1	9.213	66.67	51.2	5	8.547	57.38	40.9	7.88	48.78	32.0	5
6	10.01	78.68	65.6	9.337	68.47	53.3	6	8.665	58.97	42.6	7.99	50.18	33.4	6
7	10.14	80.73	68.2	9.461	70.30	55.4	7	8.783	60.59	44.3	8.11	51.60	34.8	7
8	10.27	82.81	70.9	9.585	72.15	57.6	8	8.901	60.22	46.2	8.22	53.03	36.3	8
9	10.4	84.92	73.6	9.708	74.03	59.9	9	9.019	63.88	48.0	8.33	54.49	37.8	9
10	10.53	87.05	76.4	9.832	75.93	62.2	10	9.137	65.56	49.9	8.44	55.96	39.4	10
11	10.66	89.21	79.2	9.956	77.85	64.6	11	9.255	67.27	51.9	8.55	57.46	41.0	11
12	10.79	91.39	82.2	10.08	79.80	67.0	12	9.372	68.99	53.9	8.67	58.97	42.6	12
13	10.92	93.60	85.2	10.2	81.77	69.5	13	9.49	70.74	55.9	8.78	60.51	44.3	13
14	11.05	95.84	88.2	10.33	83.77	72.1	14	9.608	72.51	58.1	8.89	62.06	46.0	14
15	11.18	98.10	91.4	10.45	85.79	74.7	15	9.726	74.30	60.2	9.00	63.63	47.7	15
16	11.31	100.39	94.6	10.57	87.83	77.4	16	9.844	76.11	62.4	9.11	65.23	49.5	16
17	11.44	102.71	97.9	10.7	89.90	80.2	17	9.962	77.94	64.7	9.23	66.84	51.4	17
18	11.57	105.05	101.2	10.82	91.99	83.0	18	10.08	79.80	67.0	9.34	68.47	53.3	18
19	11.69	107.42	104.7	10.95	94.11	85.8	19	10.2	81.68	69.4	9.45	70.12	55.2	19
20	11.82	109.82	108.2	11.07	96.25	88.8	20	10.32	83.58	71.8	9.56	71.80	57.2	20
21	11.95	112.24	111.8	11.19	98.41	91.8	21	10.43	85.50	74.3	9.67	73.49	59.2	21
22	12.08	114.69	115.5	11.32	100.60	94.9	22	10.55	87.44	76.9	9.79	75.20	61.3	22
23	12.21	117.16	119.2	11.44	102.81	98.0	23	10.67	89.40	79.5	9.90	76.93	63.4	23
24	12.34	119.66	123.1	11.57	105.05	101.2	24	10.79	91.39	82.2	10.01	78.68	65.6	24
25	12.47	122.19	127.0	11.69	107.31	104.5	25	10.91	93.40	84.9	10.12	80.45	67.9	25
26	12.6	124.74	131.0	11.81	109.60	107.9	26	11.02	95.43	87.7	10.23	82.24	70.1	26
27	12.73	127.32	135.1	11.94	111.91	111.3	27	11.14	97.48	90.5	10.35	84.05	72.5	27
28	12.86	129.93	139.3	12.06	114.24	114.8	28	11.26	99.56	93.4	10.46	85.88	74.8	28
29	12.99	132.56	143.5	12.18	116.60	118.4	29	11.38	101.65	96.4	10.57	87.73	77.3	29
30	13.12	135.22	147.9	12.31	118.98	122.0	30	11.49	103.77	99.4	10.68	89.60	79.8	30
31	13.25	137.91	152.3	12.43	121.38	125.7	31	11.61	105.91	102.5	10.79	91.49	82.3	31
32	13.38	140.62	156.8	12.56	123.81	129.5	32	11.73	108.07	105.6	10.91	93.40	84.9	32
33	13.51	143.36	161.4	12.68	126.27	133.4	33	11.85	110.25	108.9	11.02	95.33	87.5	33
34	13.64	146.13	166.1	12.8	128.74	137.4	34	11.97	112.46	112.1	11.13	97.28	90.2	34
35	13.77	148.92	170.9	12.93	131.24	141.4	35	12.08	114.69	115.5	11.24	99.24	93.0	35
36	13.9	151.74	175.8	13.05	133.77	145.5	36	12.2	116.93	118.9	11.35	101.23	95.8	36
37	14.03	154.58	180.7	13.17	136.32	149.7	37	12.32	119.21	122.4	11.47	103.24	98.6	37
38	14.16	157.45	185.8	13.3	138.89	153.9	38	12.44	121.50	125.9	11.58	105.27	101.6	38
39	14.29	160.35	190.9	13.42	141.49	158.3	39	12.56	123.81	129.5	11.69	107.31	104.5	39
40	14.42	163.27	196.2	13.55	144.11	162.7	40	12.67	126.15	133.2	11.80	109.38	107.6	40
41	14.55	166.22	201.5	13.67	146.76	167.2	41	12.79	126.51	137.0	11.91	111.46	110.7	41
42	14.68	169.20	207.0	13.79	149.43	171.8	42	12.91	130.89	140.8	12.03	113.57	113.8	42
43	14.81	172.20	212.5	13.92	152.12	176.4	43	13.03	133.29	144.7	12.14	115.70	117.0	43
44	14.94	175.23	218.1	14.04	154.84	181.2	44	13.15	135.71	148.7	12.25	117.84	120.3	44
45	15.07	178.29	223.9	14.16	157.58	186.0	45	13.26	138.16	152.7	12.36	120.01	123.6	45
46	15.2	181.37	229.7	14.29	160.35	190.9	46	13.38	140.62	156.8	12.47	122.19	127.0	46
47	15.33	184.48	235.6	14.41	163.14	195.9	47	13.5	143.11	161.0	12.59	124.39	130.5	47
48	15.46	187.62	241.6	14.54	165.95	201.0	48	13.62	145.62	165.2	12.70	126.62	134.0	48
49	15.59	190.78	247.8	14.66	168.79	206.2	49	13.73	148.15	169.6	12.81	128.86	137.5	49
50	15.72	193.96	254.0	14.78	171.66	211.5	50	13.85	150.71	174.0	12.92	131.12	141.2	50
51	15.84	197.18	260.4	14.91	174.54	216.8	51	13.97	153.28	178.5	13.03	133.41	144.9	51
52	15.97	200.42	266.8	15.03	177.45	222.3	52	14.09	155.88	183.0	13.15	135.71	148.7	52
53	16.1	203.69	273.4	15.16	180.39	227.8	53	14.21	158.50	187.6	13.26	138.03	152.5	53
54	16.23	206.98	280.0	15.28	183.35	233.4	54	14.32	161.14	192.4	13.37	140.37	156.4	54
55	16.3	208.69	283.5	15.35	184.95	236.5	55	14.39	162.65	195.1	13.44	141.78	158.7	55

DOUGLAS FIR AND SOUTHERN YELLOW PINE
Ultimate Bending Stress – 8000 psi

60 ft. 60 ft.

	Class H1			Class 1				Class 2			Class 3			
Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)
56	16.37	210.40	287.0	15.41	186.57	239.6	56	14.46	164.17	197.8	13.50	143.20	161.1	56
57	16.43	212.13	290.5	15.48	188.19	242.8	57	14.52	165.69	200.5	13.57	144.62	163.5	57
58	16.5	213.86	294.1	15.55	189.82	245.9	58	14.59	167.22	203.3	13.64	146.05	166.0	58
59	16.57	215.59	297.7	15.61	191.46	249.1	59	14.66	168.75	206.1	13.70	147.48	168.4	59
60	16.63	217.33	301.3	15.68	193.10	252.3	60	14.73	170.29	209.0	13.77	148.92	170.9	60

DOUGLAS FIR AND SOUTHERN YELLOW PINE
Ultimate Bending Stress – 8000 psi

65 ft. 65 ft.

	Class H1			Class 1				Class 2			Class 3			
Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)
0	9.23	66.9	51.5	8.59	58.0	41.5	0	7.96	49.7	33.0	7.32	42.1	25.7	0
1	9.36	68.8	53.6	8.72	59.7	43.3	1	8.07	51.2	34.4	7.43	43.4	26.9	1
2	9.48	70.7	55.8	8.84	61.3	45.2	2	8.19	52.7	36.0	7.54	44.7	28.1	2
3	9.61	72.6	58.1	8.96	63.0	47.1	3	8.31	54.2	37.5	7.65	46.0	29.3	3
4	9.74	74.5	60.4	9.08	64.8	49.0	4	8.42	55.7	39.1	7.76	47.3	30.6	4
5	9.86	76.4	62.8	9.20	66.5	51.0	5	8.54	57.2	40.7	7.87	48.7	32.0	5
6	9.99	78.4	65.3	9.32	68.3	53.0	6	8.65	58.8	42.4	7.98	50.1	33.3	6
7	10.12	80.4	67.8	9.44	70.1	55.1	7	8.77	60.4	44.1	8.10	51.5	34.7	7
8	10.25	82.4	70.4	9.57	71.9	57.3	8	8.89	62.0	45.9	8.21	52.9	36.2	8
9	10.37	84.5	73.0	9.69	73.7	59.5	9	9.00	63.6	47.7	8.32	54.3	37.6	9
10	10.50	86.6	75.7	9.81	75.6	61.8	10	9.12	65.3	49.6	8.43	55.8	39.2	10
11	10.63	88.7	78.5	9.93	77.4	64.1	11	9.23	67.0	51.5	8.54	57.2	40.7	11
12	10.75	90.8	81.4	10.05	79.3	66.5	12	9.35	68.7	53.5	8.65	58.7	42.3	12
13	10.88	93.0	84.3	10.17	81.3	68.9	13	9.47	70.4	55.5	8.76	60.3	44.0	13
14	11.01	95.1	87.3	10.29	83.2	71.4	14	9.58	72.1	57.6	8.87	61.8	45.7	14
15	11.13	97.3	90.3	10.42	85.2	73.9	15	9.70	73.9	59.7	8.98	63.3	47.4	15
16	11.26	99.6	93.4	10.54	87.2	76.6	16	9.81	75.6	61.9	9.09	64.9	49.2	16
17	11.39	101.8	96.6	10.66	89.2	79.2	17	9.93	77.4	64.1	9.20	66.5	51.0	17
18	11.51	104.1	99.9	10.78	91.3	82.0	18	10.05	79.3	66.4	9.31	68.1	52.8	18
19	11.64	106.4	103.2	10.90	93.3	84.8	19	10.16	81.1	68.7	9.42	69.7	54.8	19
20	11.77	108.7	106.6	11.02	95.4	87.6	20	10.28	83.0	71.1	9.53	71.4	56.7	20
21	11.89	111.1	110.1	11.14	97.5	90.6	21	10.39	84.8	73.5	9.64	73.0	58.7	21
22	12.02	113.5	113.7	11.26	99.7	93.6	22	10.51	86.7	76.0	9.75	74.7	60.7	22
23	12.15	115.9	117.3	11.39	101.8	96.6	23	10.63	88.7	78.5	9.86	76.4	62.8	23
24	12.27	118.3	121.0	11.51	104.0	99.7	24	10.74	90.6	81.1	9.98	78.2	65.0	24
25	12.40	120.8	124.8	11.63	106.2	102.9	25	10.86	92.6	83.5	10.09	79.9	67.2	25
26	12.53	123.3	128.7	11.75	108.4	106.2	26	10.97	94.6	86.5	10.20	81.7	69.4	26
27	12.65	125.8	132.6	11.87	110.7	109.5	27	11.09	96.6	89.3	10.31	83.4	71.7	27
28	12.78	128.3	136.6	11.99	113.0	112.9	28	11.21	98.6	92.1	10.42	85.2	74.0	28
29	12.91	130.9	140.8	12.11	115.3	116.4	29	11.32	100.7	95.0	10.53	87.1	76.4	29
30	13.03	133.4	144.9	12.24	117.6	119.9	30	11.44	102.7	97.9	10.64	88.9	78.8	30
31	13.16	136.0	149.2	12.36	119.9	123.5	31	11.55	104.8	100.9	10.75	90.8	81.3	31
32	13.29	138.7	153.6	12.48	122.3	127.2	32	11.67	107.0	104.0	10.86	92.6	83.8	32
33	13.41	141.3	158.0	12.60	124.7	130.9	33	11.79	109.1	107.1	10.97	94.5	86.4	33
34	13.54	144.0	162.5	12.72	127.1	134.8	34	11.90	111.2	110.3	11.08	96.4	89.1	34
35	13.67	146.7	167.1	12.84	129.5	138.6	35	12.02	113.4	113.6	11.19	98.4	91.8	35
36	13.80	149.5	171.8	12.96	132.0	142.6	36	12.13	115.6	116.9	11.30	100.3	94.5	36
37	13.92	152.2	176.6	13.09	134.5	146.7	37	12.25	117.8	120.3	11.41	102.3	97.3	37
38	14.05	155.0	181.5	13.21	137.0	150.8	38	12.37	120.1	123.8	11.52	104.3	100.2	38
39	14.18	157.8	186.4	13.33	139.5	155.0	39	12.48	122.4	127.3	11.63	106.3	103.1	39
40	14.30	160.7	191.5	13.45	142.1	159.2	40	12.60	124.6	130.8	11.75	108.3	106.0	40
41	14.43	163.5	196.6	13.57	144.7	163.6	41	12.71	126.9	134.5	11.86	110.4	109.1	41
42	14.56	166.4	201.9	13.69	147.3	168.0	42	12.83	129.3	138.2	11.97	112.5	112.1	42
43	14.68	169.3	207.2	13.81	149.9	172.5	43	12.95	131.6	142.0	12.08	114.6	115.3	43
44	14.81	172.3	212.6	13.94	152.5	177.1	44	13.06	134.0	145.8	12.19	116.7	118.5	44
45	14.94	175.2	218.1	14.06	155.2	181.8	45	13.18	136.4	149.8	12.30	118.8	121.7	45
46	15.06	178.2	223.7	14.18	157.9	186.5	46	13.29	138.8	153.8	12.41	120.9	125.1	46
47	15.19	181.2	229.4	14.30	160.6	191.4	47	13.41	141.2	157.8	12.52	123.1	128.4	47
48	15.32	184.3	235.2	14.42	163.3	196.3	48	13.53	143.7	161.9	12.63	125.3	131.9	48
49	15.44	187.3	241.1	14.54	166.1	201.3	49	13.64	146.2	166.1	12.74	127.5	135.4	49
50	15.57	190.4	247.1	14.66	168.9	206.4	50	13.76	148.7	170.4	12.85	129.7	138.9	50
51	15.70	193.5	253.1	14.79	171.7	211.5	51	13.87	151.2	174.8	12.96	132.0	142.5	51
52	15.82	196.7	259.3	14.91	174.5	216.8	52	13.99	153.7	179.2	13.07	134.2	146.2	52
53	15.95	199.8	265.6	15.03	177.4	222.1	53	14.11	156.3	183.7	13.18	136.5	149.9	53
54	16.08	203.0	272.0	15.15	180.3	227.6	54	14.22	158.8	188.3	13.29	138.8	153.8	54
55	16.20	206.2	278.5	15.27	183.2	233.1	55	14.34	161.4	192.9	13.40	141.1	157.6	55

DOUGLAS FIR AND SOUTHERN YELLOW PINE
Ultimate Bending Stress – 8000 psi

65 ft. 65 ft.

	Class H1			Class 1				Class 2			Class 3			
Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)
56	16.33	209.5	285.1	15.39	186.1	238.7	56	14.45	164.1	197.6	13.51	143.5	161.6	56
57	16.46	212.7	291.8	15.51	189.0	244.4	57	14.57	166.7	202.4	13.63	145.8	165.6	57
58	16.58	216.0	298.5	15.63	192.0	250.1	58	14.69	169.4	207.3	13.74	148.2	169.6	58
59	16.71	219.3	305.4	15.76	195.0	256.0	59	14.80	172.1	212.2	13.85	150.6	173.8	59
60	16.78	221.1	309.1	15.82	196.6	259.3	60	14.87	173.6	215.1	13.91	152.0	176.3	60
61	16.84	222.9	312.8	15.89	198.3	262.6	61	14.94	175.2	218.0	13.98	153.5	178.8	61
62	16.91	224.6	316.6	15.96	200.0	265.9	62	15.00	176.8	221.0	14.05	155.0	181.4	62
63	16.98	226.4	320.3	16.02	201.7	269.3	63	15.07	178.3	223.9	14.11	156.5	184.0	63
64	17.05	228.2	324.1	16.09	203.3	272.7	64	15.14	179.9	226.9	14.18	157.9	186.6	64
65	17.11	230.0	328.0	16.16	205.0	276.1	65	15.20	181.5	230.0	14.25	159.4	189.3	65

DOUGLAS FIR AND SOUTHERN YELLOW PINE
Ultimate Bending Stress – 8000 psi

70 ft. 70 ft.

	Class H1			Class 1				Class 2			Class 3			
Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)
0	9.23	66.9	51.5	8.59	58.0	41.5	0	7.96	49.7	33.0	7.32	42.1	25.7	0
1	9.36	68.7	53.6	8.71	59.6	43.3	1	8.07	51.2	34.4	7.43	43.4	26.9	1
2	9.48	70.6	55.8	8.83	61.3	45.1	2	8.19	52.6	35.9	7.54	44.7	28.1	2
3	9.60	72.4	58.0	8.95	62.8	47.0	3	8.30	54.1	37.4	7.65	46.0	29.3	3
4	9.73	74.3	60.3	9.07	64.6	48.9	4	8.42	55.6	39.0	7.76	47.3	30.6	4
5	9.85	76.2	62.6	9.19	66.3	50.8	5	8.53	57.1	40.6	7.87	48.6	31.9	5
6	9.98	78.2	65.0	9.31	68.1	52.8	6	8.64	58.7	42.3	7.98	50.0	33.2	6
7	10.10	80.1	67.5	9.43	69.8	54.9	7	8.76	60.2	44.0	8.09	51.4	34.6	7
8	10.23	82.1	70.0	9.55	71.6	57.0	8	8.87	61.8	45.7	8.20	52.8	36.0	8
9	10.35	84.1	72.6	9.67	73.4	59.2	9	8.99	63.4	47.5	8.31	54.2	37.2	9
10	10.47	86.2	75.2	9.79	75.2	61.4	10	9.10	65.1	49.3	8.42	55.6	39.0	10
11	10.60	88.2	77.9	9.91	77.1	63.6	11	9.22	66.7	51.2	8.52	57.1	40.5	11
12	10.72	90.3	80.7	10.03	79.0	66.0	12	9.33	68.4	53.2	8.63	58.6	42.1	12
13	10.85	92.4	83.5	10.15	80.9	68.4	13	9.44	70.1	55.1	8.74	60.0	43.7	13
14	10.97	94.5	86.4	10.27	82.8	70.8	14	9.56	71.8	57.2	8.85	61.6	45.4	14
15	11.10	96.7	89.4	10.38	84.7	73.3	15	9.67	73.5	59.2	8.96	63.1	47.1	15
16	11.22	98.9	92.5	10.50	86.7	75.9	16	9.79	75.2	61.4	9.07	64.2	48.9	16
17	11.34	101.1	95.6	10.62	88.6	78.5	17	9.90	77.0	63.6	9.18	66.2	50.7	17
18	11.47	103.3	98.7	10.74	90.6	81.1	18	10.02	78.8	65.8	9.29	67.8	52.5	18
19	11.59	105.6	102.0	10.86	92.7	83.9	19	10.13	80.6	68.1	9.40	69.4	54.4	19
20	11.72	107.8	105.3	10.98	94.7	86.7	20	10.25	82.4	70.4	9.51	71.0	56.3	20
21	11.84	110.1	108.7	11.10	96.8	89.5	21	10.36	84.3	72.8	9.62	72.7	58.2	21
22	11.97	112.5	112.2	11.22	98.9	92.5	22	10.47	86.2	75.2	9.73	74.3	60.3	22
23	12.09	114.8	115.7	11.34	101.0	94.5	23	10.59	88.1	77.7	9.84	76.0	62.3	23
24	12.22	117.2	119.3	11.46	103.1	98.5	24	10.70	90.0	80.3	9.95	77.7	64.4	24
25	12.34	119.6	123.0	11.58	105.3	101.6	25	10.82	91.9	82.9	10.06	79.4	66.6	25
26	12.46	122.0	126.7	11.70	107.5	104.8	26	10.93	93.9	85.5	10.17	81.2	68.8	26
27	12.59	124.5	130.6	11.82	109.7	108.8	27	11.05	95.8	88.2	10.28	82.9	71.0	27
28	12.71	126.9	134.5	11.94	111.9	111.3	28	11.16	97.8	91.0	10.38	84.7	73.3	28
29	12.84	129.4	138.4	12.06	114.2	114.7	29	11.28	99.8	93.8	10.49	86.5	75.6	29
30	12.96	131.9	142.5	12.18	116.4	118.1	30	11.39	101.9	96.7	10.60	88.3	78.0	30
31	13.09	134.5	146.6	12.29	118.7	121.6	31	11.50	103.9	99.6	10.71	90.1	80.5	31
32	13.21	137.1	150.9	12.41	121.0	125.2	32	11.62	106.9	102.6	10.82	92.0	83.0	32
33	13.33	139.6	155.2	12.53	123.4	128.9	33	11.73	108.1	105.7	10.93	93.9	85.5	33
34	13.46	142.3	159.6	12.65	125.7	132.6	34	11.85	110.2	108.8	11.04	95.7	88.1	34
35	13.58	144.9	164.0	12.77	128.1	136.4	35	11.96	112.4	112.0	11.15	97.7	90.7	35
36	13.71	147.6	168.6	12.89	130.5	140.2	36	12.08	114.5	115.3	11.26	99.6	93.4	36
37	13.83	150.3	173.2	13.01	133.0	144.2	37	12.19	116.7	118.6	11.37	101.5	96.2	37
38	13.96	153.0	177.9	13.13	135.4	148.2	38	12.30	118.9	121.9	11.48	103.5	99.0	38
39	14.08	155.7	182.7	13.25	137.9	152.2	39	12.42	121.1	125.4	11.59	105.5	101.9	39
40	14.20	158.5	187.6	13.37	140.4	156.4	40	12.53	123.4	128.9	11.70	107.5	104.8	40
41	14.33	161.3	192.6	13.49	142.9	160.6	41	12.65	125.6	132.4	11.81	109.5	107.7	41
42	14.45	164.1	197.6	13.61	145.4	164.9	42	12.76	127.9	126.0	11.92	111.5	110.8	42
43	14.58	166.9	202.8	13.73	148.0	169.3	43	12.88	130.2	139.7	12.03	113.6	113.8	43
44	14.70	169.8	208.0	13.85	150.6	173.8	44	12.99	132.5	143.5	12.14	115.7	117.0	44
45	14.83	172.6	213.3	13.97	153.2	178.3	45	13.11	134.9	147.3	12.24	117.8	120.2	45
46	14.95	175.6	218.7	14.09	155.8	182.9	46	13.22	137.3	151.2	12.35	119.9	123.4	46
47	15.07	178.5	224.2	14.20	158.5	187.6	47	13.33	139.6	155.2	12.46	122.0	126.7	47
48	15.20	181.4	229.8	14.32	161.1	192.4	48	13.45	142.1	159.2	12.57	124.2	130.1	48
49	15.32	184.4	235.5	14.44	163.5	197.2	49	13.56	144.5	163.3	12.68	126.3	133.5	49
50	15.45	187.4	241.3	14.56	166.6	202.1	50	13.68	146.9	167.5	12.79	128.5	137.0	50
51	15.57	190.5	247.2	14.68	169.3	207.1	51	13.79	149.4	171.7	12.90	130.7	140.5	51
52	15.70	193.5	253.1	14.80	172.1	212.2	52	13.91	151.9	176.0	13.01	133.0	144.2	52
53	15.82	196.6	259.2	14.92	174.9	217.4	53	14.02	154.4	180.4	13.12	135.2	147.8	53
54	15.95	199.7	265.3	15.04	177.7	222.7	54	14.13	156.9	184.8	13.23	137.5	151.6	54
55	16.07	202.8	271.6	15.16	180.5	228.0	55	14.25	159.5	189.4	13.34	139.7	155.3	55

DOUGLAS FIR AND SOUTHERN YELLOW PINE
Ultimate Bending Stress – 8000 psi

70 ft. 70 ft.

	Class H1			Class 1				Class 2			Class 3			
Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)
56	16.19	206.0	278.0	15.28	183.3	233.4	56	14.36	162.0	194.0	13.45	142.1	159.2	56
57	16.32	209.1	284.4	15.40	186.2	239.0	57	14.48	164.6	198.6	13.56	144.4	163.1	57
58	16.44	212.3	291.0	15.52	189.1	244.6	58	14.59	167.2	203.4	13.67	146.7	167.1	58
59	16.57	215.6	297.6	15.64	192.0	250.2	59	14.71	169.9	208.2	13.78	149.1	171.1	59
60	16.69	218.8	304.4	15.76	195.0	256.0	60	14.82	172.5	213.1	13.89	151.4	175.3	60
61	16.82	222.1	311.2	15.88	198.0	261.9	61	14.94	175.2	218.1	14.00	153.8	179.4	61
62	16.94	225.4	318.2	16.00	200.9	267.8	62	15.05	177.9	223.1	14.11	156.3	183.7	62
63	17.06	228.7	325.2	16.11	203.9	273.9	63	15.16	180.6	228.2	14.21	158.7	188.0	63
64	17.19	232.0	332.4	16.23	207.9	280.0	64	15.28	183.3	233.4	14.32	161.1	192.4	64
65	17.26	233.9	336.3	16.30	208.9	283.5	65	15.35	185.0	236.5	14.39	162.7	195.1	65
66	17.32	235.7	340.2	16.37	210.4	287.0	66	15.41	186.6	239.6	14.46	164.2	197.8	66
67	17.39	237.5	344.2	16.43	212.1	290.5	67	15.48	188.2	242.8	14.52	165.7	200.5	67
68	17.46	239.3	348.1	16.50	213.9	294.1	68	15.55	189.8	245.9	14.59	167.2	203.3	68
69	17.52	241.2	352.2	16.57	215.6	297.7	69	15.61	191.5	249.1	14.66	168.8	206.1	69
70	17.59	243.0	356.2	16.63	217.3	301.3	70	15.68	193.1	252.3	14.73	170.3	209.0	70

DOUGLAS FIR AND SOUTHERN YELLOW PINE
Ultimate Bending Stress – 8000 psi

75 ft. 75 ft.

	Class H1			Class 1				Class 2			Class 3			
Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)
0	9.23	66.9	51.3	8.59	58.0	41.5	0	7.96	49.7	33.0	7.32	42.1	25.7	0
1	9.35	68.7	53.6	8.71	59.6	43.3	1	8.07	51.1	34.4	7.43	43.3	26.8	1
2	9.48	70.5	55.7	8.83	61.2	45.1	2	8.18	52.5	35.8	7.53	44.6	28.0	2
3	9.60	72.3	57.9	8.95	62.9	46.9	3	8.29	54.0	37.3	7.64	45.8	29.2	3
4	9.72	74.2	60.1	9.06	64.5	48.8	4	8.40	55.4	38.8	7.75	47.1	30.4	4
5	9.84	76.1	62.4	9.18	66.2	50.7	5	8.51	56.9	40.4	7.85	48.4	31.7	5
6	9.96	78.0	64.8	9.30	67.9	52.6	6	8.62	58.4	42.0	7.96	49.7	33.0	6
7	10.09	79.9	67.2	9.42	69.7	54.7	7	8.73	59.9	43.6	8.06	51.1	34.3	7
8	10.21	81.9	69.6	9.54	71.4	56.7	8	8.84	61.4	45.3	8.17	52.4	35.7	8
9	10.33	83.8	72.2	9.65	73.2	58.9	9	8.95	63.0	47.0	8.28	53.8	37.1	9
10	10.45	85.8	74.8	9.77	75.0	61.1	10	9.06	64.5	48.8	8.38	55.2	38.5	10
11	10.58	87.8	77.4	9.89	76.8	63.3	11	9.18	66.1	50.6	8.49	56.6	40.0	11
12	10.70	89.9	80.1	10.01	78.6	65.6	12	9.29	67.7	52.4	8.59	58.0	41.5	12
13	10.82	92.0	82.9	10.12	80.5	67.9	13	9.40	69.4	54.3	8.70	59.5	43.1	13
14	10.94	94.0	85.8	10.24	82.4	70.3	14	9.51	71.0	56.3	8.81	60.9	44.7	14
15	11.06	96.2	88.7	10.36	84.3	72.8	15	9.62	72.7	58.2	8.91	62.4	46.3	15
16	11.19	98.3	91.6	10.48	86.2	73.5	16	9.73	74.3	60.3	9.02	63.9	48.0	16
17	11.31	100.5	94.7	10.59	88.2	77.8	17	9.84	76.0	62.4	9.12	65.4	49.7	17
18	11.43	102.6	97.8	10.71	90.1	80.4	18	9.95	77.8	64.5	9.23	66.9	51.5	18
19	11.55	104.8	100.9	10.83	92.1	83.1	19	10.06	79.5	66.7	9.34	68.5	53.3	19
20	11.68	107.1	104.2	10.95	94.1	85.9	20	10.17	81.3	68.9	9.44	70.0	55.1	20
21	11.80	109.3	107.5	11.06	96.2	88.7	21	10.28	83.0	71.2	9.55	71.6	57.0	21
22	11.92	111.6	110.9	11.18	98.2	91.5	22	10.39	84.8	73.8	9.66	73.2	58.9	22
23	12.04	113.9	114.3	11.30	100.3	94.4	23	10.50	86.7	75.9	9.76	74.8	60.9	23
24	12.16	116.2	117.8	11.42	102.4	97.4	24	10.61	88.5	78.3	9.87	76.5	62.9	24
25	12.29	118.6	121.4	11.54	104.5	100.5	25	10.73	90.4	80.8	9.97	78.1	64.9	25
26	12.41	120.9	125.1	11.65	106.6	103.6	26	10.84	92.2	83.3	10.08	79.8	67.0	26
27	12.53	123.3	128.8	11.77	108.8	106.7	27	10.95	94.1	85.9	10.19	81.5	69.2	27
28	12.65	125.8	132.6	11.89	111.0	110.0	28	11.06	96.0	88.5	10.29	83.2	71.4	28
29	12.78	128.2	136.5	12.01	113.2	113.3	29	11.17	98.0	91.2	10.40	84.9	73.6	29
30	12.90	130.7	140.5	12.12	115.4	116.6	30	11.28	99.9	93.9	10.50	86.7	75.9	30
31	13.02	133.2	144.5	12.24	117.7	120.1	31	11.39	101.9	96.7	10.61	88.4	78.2	31
32	13.14	135.7	148.6	12.36	120.0	123.5	32	11.50	103.9	99.6	10.72	90.2	80.5	32
33	13.27	138.2	152.8	12.48	122.3	127.1	33	11.61	105.9	102.5	10.82	92.0	83.0	33
34	13.39	140.8	157.0	12.59	124.6	130.7	34	11.72	107.9	105.4	10.93	93.8	85.4	34
35	13.51	143.3	161.4	12.71	126.9	134.4	35	11.83	110.0	108.4	11.03	95.6	87.9	35
36	13.63	146.0	165.8	12.83	129.3	138.2	36	11.94	112.0	111.5	11.14	97.5	90.5	36
37	13.75	148.6	170.3	12.95	131.7	142.0	37	12.05	114.1	114.6	11.25	99.3	93.1	37
38	13.88	151.2	174.9	13.06	134.1	145.9	38	12.16	116.2	117.8	11.35	101.2	95.8	38
39	14.00	153.9	179.5	13.18	136.5	149.9	39	12.28	118.4	121.1	11.46	103.1	98.5	39
40	14.12	156.6	184.3	13.30	138.9	154.0	40	12.39	120.5	124.4	11.57	105.1	101.2	40
41	14.24	159.3	189.1	13.42	141.4	158.1	41	12.50	122.7	127.7	11.67	107.0	104.1	41
42	14.37	162.1	194.0	13.54	143.9	162.3	42	12.61	124.8	131.2	11.78	108.9	106.9	42
43	14.49	164.9	199.0	13.65	146.4	166.6	43	12.72	127.0	134.7	11.88	110.9	109.8	43
44	14.61	167.6	204.1	13.77	148.9	170.9	44	12.83	129.3	138.2	11.99	112.9	112.8	44
45	14.73	170.5	209.3	13.89	151.5	175.3	45	12.94	131.5	141.8	12.10	114.9	115.8	45
46	14.85	173.3	214.5	14.01	154.1	179.8	46	13.05	133.8	145.5	12.20	116.9	118.9	46
47	14.98	176.2	219.9	14.12	156.7	184.4	47	13.16	136.0	149.2	12.31	119.0	122.0	47
48	15.10	179.1	225.3	14.24	159.3	189.0	48	13.27	138.3	153.0	12.41	121.0	125.2	48
49	15.22	182.0	230.8	14.36	161.9	193.7	49	13.38	140.7	156.9	12.52	123.1	128.5	49
50	15.34	184.9	236.4	14.48	164.6	198.6	50	13.49	143.0	160.8	12.62	125.2	131.7	50
51	15.47	187.9	242.1	14.59	167.3	203.4	51	13.60	145.4	164.8	12.73	127.3	135.1	51
52	15.59	190.8	247.9	14.71	170.0	208.4	52	13.72	147.7	168.8	12.84	129.5	138.5	52
53	15.71	193.8	253.8	14.83	172.7	213.4	53	13.83	150.1	173.0	12.94	131.6	142.0	53
54	15.83	196.9	259.7	14.95	175.5	218.5	54	13.94	152.5	177.2	13.05	133.8	145.5	54
55	15.95	199.9	265.8	15.06	178.2	223.7	55	14.05	155.0	181.4	13.16	136.0	149.1	55

DOUGLAS FIR AND SOUTHERN YELLOW PINE
Ultimate Bending Stress – 8000 psi

75 ft. 75ft.

	Class H1			Class 1				Class 2			Class 3			
Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)
56	16.08	203.0	272.0	15.18	181.0	229.0	56	14.16	157.4	185.7	13.26	138.2	152.7	56
57	16.20	206.1	278.2	15.30	183.8	234.4	57	14.27	159.9	190.1	13.37	140.4	156.4	57
58	16.32	209.2	284.6	15.42	186.7	239.8	58	14.38	162.4	194.6	13.48	142.6	160.1	58
59	16.44	212.4	291.0	15.53	189.5	245.4	59	14.49	164.9	199.1	13.58	144.9	164.0	59
60	16.57	215.5	297.5	15.65	192.4	251.0	60	14.60	167.4	203.7	13.69	147.1	167.8	60
61	16.69	218.7	304.2	15.77	195.3	256.7	61	14.71	170.0	208.4	13.79	149.4	171.8	61
62	16.81	221.9	310.9	15.89	198.3	262.5	62	14.82	172.5	213.1	13.90	151.7	175.8	62
63	16.93	225.2	317.8	16.01	201.2	268.4	63	14.93	175.1	217.9	14.01	154.1	179.8	63
64	17.05	228.4	324.7	16.12	204.2	274.3	64	15.04	177.7	222.8	14.11	156.4	183.9	64
65	17.18	231.7	331.17	16.24	207.2	280.4	65	15.15	180.4	227.8	14.22	158.8	188.1	65
66	17.30	235.0	338.8	16.36	210.2	286.5	66	15.27	183.0	232.8	14.32	161.1	192.4	66
67	17.42	238.4	346.1	16.48	213.2	292.7	67	15.38	185.7	237.9	14.43	163.5	196.7	67
68	17.54	241.7	353.4	16.59	216.3	299.0	68	15.49	188.4	243.1	14.54	166.0	201.0	68
69	17.67	245.1	360.9	16.71	219.3	305.4	69	15.60	191.1	248.3	14.64	168.4	205.5	69
70	17.73	247.0	365.0	16.78	221.1	309.1	70	15.66	192.7	251.5	14.71	169.9	208.3	70
71	17.80	248.8	369.1	16.84	222.9	312.8	71	15.73	194.4	254.8	14.78	171.5	211.1	71
72	17.87	250.7	373.3	16.91	224.6	316.6	72	15.80	196.0	258.0	14.84	173.0	214.0	72
73	17.93	252.6	377.5	16.98	226.4	320.3	73	15.86	197.7	261.3	14.91	174.6	216.9	73
74	18.00	254.5	381.7	17.05	228.2	324.1	74	15.93	199.3	264.6	14.98	176.2	219.9	74
75	18.07	256.4	386.0	17.11	230.0	328.0	75	16.00	201.0	268.0	15.04	177.7	222.8	75

DOUGLAS FIR AND SOUTHERN YELLOW PINE
Ultimate Bending Stress – 8000 psi

80 ft. 80 ft.

	Class H1			Class 1				Class 2			Class 3			
Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)
0	9.231	66.92	51.5	8.594	58.01	41.5	0	7.958	49.74	33.0	7.321	42.10	25.7	0
1	9.351	66.68	53.5	8.711	59.59	43.3	1	8.067	51.12	34.4	7.424	43.29	26.8	1
2	9.472	70.46	55.6	8.827	61.19	45.0	2	8.177	52.52	35.8	7.528	44.50	27.9	2
3	9.592	72.27	57.8	8.943	62.81	46.8	3	8.287	53.93	37.2	7.631	45.73	29.1	3
4	9.713	74.09	60.0	9.059	64.45	48.7	4	8.396	55.37	38.7	7.734	46.98	30.3	4
5	9.833	75.94	62.2	9.175	66.12	50.6	5	8.506	56.83	40.3	7.837	48.24	31.5	5
6	9.954	77.81	64.5	9.291	67.80	52.5	6	8.616	58.30	41.9	7.941	49.52	32.8	6
7	10.07	79.71	66.9	9.407	69.51	54.5	7	8.726	59.80	43.5	8.044	50.82	34.1	7
8	10.19	81.63	69.3	9.523	71.23	56.5	8	8.835	61.31	45.1	8.147	52.13	35.4	8
9	10.31	83.57	71.8	9.64	72.98	58.6	9	8.945	62.84	46.8	8.25	53.46	36.8	9
10	10.44	85.53	74.4	9.756	74.75	60.8	10	9.055	64.39	48.6	8.353	54.81	38.2	10
11	10.56	87.51	77.0	9.872	76.54	63.0	11	9.164	65.96	50.46	8.457	56.17	39.6	11
12	10.68	89.52	79.6	9.988	78.35	65.2	12	9.274	67.55	52.2	8.56	57.55	41.1	12
13	10.8	91.55	82.4	10.1	80.18	67.5	13	9.384	69.16	54.1	8.663	58.94	42.6	13
14	10.92	93.61	85.2	10.22	82.04	69.9	14	9.493	70.78	56.0	8.766	60.36	44.1	14
15	11.04	95.68	88.0	10.34	83.91	72.3	15	9.603	72.43	58.0	8.87	61.79	45.7	15
16	11.16	97.78	90.9	10.45	85.81	74.7	16	9.713	74.09	60.0	8.973	63.23	47.3	16
17	11.28	99.91	93.9	10.57	87.73	77.3	17	9.822	75.78	62.0	9.076	64.70	48.9	17
18	11.4	102.05	96.9	10.68	89.67	79.8	18	9.932	77.48	64.1	9.179	66.18	50.6	18
19	11.52	104.22	100.0	10.8	91.63	82.5	19	10.04	79.20	66.3	9.283	67.68	52.4	19
20	11.64	106.41	103.2	10.92	93.61	85.2	20	10.15	80.94	68.5	9.386	69.19	54.1	20
21	11.76	108.62	106.5	11.03	95.61	87.9	21	10.26	82.70	70.7	9.489	70.72	55.9	21
22	11.88	110.86	109.8	11.15	97.63	90.7	22	10.37	84.47	73.0	9.592	72.27	57.8	22
23	12	113.12	113.1	11.27	99.68	93.6	23	10.48	86.27	75.3	9.696	73.83	59.7	23
24	12.12	115.40	116.6	11.38	101.74	96.5	24	10.59	88.09	77.7	9.799	75.41	61.6	24
25	12.24	117.71	120.1	11.5	103.83	99.5	25	10.7	89.92	80.2	9.902	77.01	63.5	25
26	12.36	120.03	123.7	11.61	105.94	102.5	26	10.81	91.77	82.7	10.01	78.62	65.6	26
27	12.48	122.38	127.3	11.73	108.07	105.6	27		93.64	85.2	10.11	80.25	67.6	27
28	12.6	124.76	131.0	11.85	110.22	108.8	28		95.54	87.8	10.21	81.90	69.7	28
29	12.72	127.15	134.8	11.96	112.39	112.0	29		97.44	90.5	10.31	83.57	71.8	29
30	12.84	129.57	138.7	12.08	114.58	115.3	30		99.37	93.1	10.42	85.25	74.0	30
31	12.96	132.01	142.6	12.19	116.80	118.7	31		101.32	95.9	10.52	86.94	76.2	31
32	13.09	134.48	146.6	12.31	119.03	122.1	32		103.29	98.7	10.62	88.66	78.5	32
33	13.21	136.96	150.7	12.43	121.29	125.6	33		105.27	101.6	10.73	90.39	80.8	33
34	13.33	139.47	154.9	12.54	123.57	129.2	34		107.28	104.5	10.83	92.14	83.2	34
35	13.45	142.01	159.1	12.66	125.87	132.8	35		109.30	107.4	10.93	93.90	85.6	35
36	13.57	144.56	163.4	12.78	128.19	136.5	36		111.34	110.5	11.04	95.68	88.0	36
37	13.69	147.14	167.8	12.89	130.53	140.2	37		113.40	113.6	11.14	97.48	90.5	37
38	13.81	149.74	172.3	13.01	132.89	144.0	38		115.48	116.7	11.24	99.30	93.0	38
39	13.93	152.36	176.8	13.12	135.27	147.9	39		117.58	119.9	11.35	101.13	95.6	39
40	14.05	155.01	181.5	13.24	137.68	151.9	40		119.70	123.1	11.45	102.98	98.3	40
41	14.17	157.68	186.2	13.36	140.10	155.9	41		121.84	126.5	11.55	104.84	100.9	41
42	14.29	160.37	191.0	13.47	142.55	160.0	42		123.99	129.8	11.66	106.72	103.7	42
43	14.41	163.09	195.8	13.59	145.02	164.2	43		126.17	133.3	11.76	108.62	106.5	43
44	14.53	165.82	200.8	13.7	147.51	168.5	44		128.36	136.7	11.86	110.54	109.3	44
45	14.65	168.58	205.8	13.82	150.02	172.8	45		130.57	140.3	11.97	112.47	112.2	45
46	14.77	171.37	210.9	13.94	152.55	177.2	46		132.80	143.9	12.07	114.42	115.1	46
47	14.89	174.17	216.1	14.05	155.10	181.6	47		135.05	147.6	12.17	116.39	118.1	47
48	15.01	177.00	221.4	14.17	157.68	186.2	48		137.32	151.3	12.28	118.37	121.1	48
49	15.13	179.85	226.8	14.29	160.27	190.8	49		139.61	155.1	12.38	120.37	124.2	49
50	15.25	182.73	232.3	14.4	162.89	195.5	50		141.91	159.0	12.48	122.38	127.3	50
51	15.37	185.62	237.8	14.52	165.53	200.3	51		144.24	162.9	12.59	124.42	130.5	51
52	15.49	188.54	243.4	14.63	168.19	205.1	52		146.58	166.9	12.69	126.47	133.7	52
53	15.61	191.49	249.2	14.75	170.87	210.0	53		148.95	170.9	12.79	128.53	137.0	53
54	15.73	194.45	255.0	14.87	173.57	215.0	54		151.33	175.0	12.9	130.61	140.4	54
55	15.86	197.44	260.9	14.98	176.29	220.1	55		153.73	179.2	13	132.71	143.8	55

DOUGLAS FIR AND SOUTHERN YELLOW PINE
Ultimate Bending Stress – 8000 psi

80 ft. 80 ft.

	Class H1			Class 1				Class 2			Class 3			
Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)
56	15.98	200.45	266.9	15.1	179.04	225.3	56	14.1	156.15	183.5	13.1	134.83	147.2	56
57	16.1	203.49	272.9	15.21	181.80	230.5	57	14.21	158.59	187.8	13.21	136.96	150.7	57
58	16.22	206.54	279.1	15.33	184.59	235.8	58	14.32	161.05	192.2	13.31	139.11	154.3	58
59	16.34	209.62	285.4	15.45	187.39	241.2	59	14.43	163.52	196.6	13.41	141.28	157.9	59
60	16.46	212.72	291.7	15.56	190.22	246.7	60	14.54	166.02	201.1	13.52	143.46	161.6	60
61	16.58	215.85	298.2	15.68	193.07	252.3	61	14.65	168.53	205.7	13.62	145.66	165.3	61
62	16.7	219.00	304.7	15.8	195.94	257.9	62	14.76	171.07	210.4	13.72	147.88	169.1	62
63	16.82	222.17	311.4	15.91	198.84	263.6	63	14.87	173.62	215.1	13.82	150.11	172.9	63
64	16.94	225.36	318.1	16.03	201.75	269.5	64	14.98	176.19	219.9	13.93	152.36	176.8	64
65	17.06	228.58	325.0	16.14	204.68	275.4	65	15.09	178.78	224.8	14.03	154.63	180.8	65
66	17.18	231.82	331.9	16.26	207.64	281.3	66	15.2	181.39	229.7	14.13	156.91	184.8	66
67	17.3	235.08	338.9	16.38	201.62	287.4	67	15.31	184.02	234.7	14.24	159.21	188.9	67
68	17.42	238.36	346.0	16.49	213.61	293.6	68	15.42	186.66	239.8	14.34	161.53	193.0	68
69	17.54	241.67	353.3	16.61	216.63	299.8	69	15.53	189.33	245.0	14.44	163.87	197.2	69
70	17.66	245.00	360.6	16.72	219.67	306.2	70	15.64	192.02	250.2	14.55	166.22	201.5	70
71	17.78	248.35	368.0	16.84	222.74	312.6	71	15.75	194.72	255.5	14.65	168.58	205.8	71
72	17.9	251.73	375.6	16.96	225.82	319.1	72	15.86	197.44	260.9	14.75	170.97	210.2	72
73	18.02	255.13	383.2	17.07	228.92	325.7	73	15.96	200.18	266.3	14.86	173.37	214.6	73
74	18.14	258.55	390.9	17.19	232.05	332.4	74	16.07	202.94	271.9	14.96	175.79	219.2	74
75	18.21	260.46	395.3	17.26	233.86	336.3	75	16.14	204.63	275.3	15.03	177.36	222.1	75
76	18.28	262.37	399.6	17.32	235.67	340.2	76	16.21	206.33	278.7	15.09	178.94	225.1	76
77	18.34	264.29	404.0	17.39	237.49	344.2	77	16.28	208.04	282.2	15.16	180.53	228.1	77
78	18.41	266.22	408.5	17.46	239.32	348.1	78	16.34	209.75	285.6	15.23	182.13	231.1	78
79	18.48	268.16	412.9	17.52	241.16	352.2	79	16.41	211.47	289.2	15.29	183.73	234.2	79
80	18.54	270.10	417.4	17.59	243.00	356.2	80	16.48	213.20	292.7	15.36	185.34	237.3	80

DOUGLAS FIR AND SOUTHERN YELLOW PINE
Ultimate Bending Stress – 8000 psi

85 ft. 85 ft.

	Class H1			Class 1				Class 2			Class 3			
Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)
0	9.23	66.92	51.5	8.59	58.01	41.5	0	7.96	49.74	33.0	7.32	42.10	25.7	0
1	9.35	68.66	53.5	8.71	59.55	43.2	1	8.06	51.08	34.3	7.42	43.26	26.8	1
2	9.47	70.42	55.6	8.82	61.10	44.9	2	8.17	52.44	35.7	7.52	44.45	27.9	2
3	9.59	72.20	57.7	8.93	62.67	46.7	3	8.28	53.82	37.1	7.62	45.64	29.0	3
4	9.71	74.00	59.9	9.05	64.26	48.4	4	8.38	55.22	38.6	7.72	46.86	30.2	4
5	9.83	75.82	62.1	9.16	65.88	50.3	5	8.49	56.63	40.1	7.82	48.09	31.4	5
6	9.94	77.67	64.4	9.27	67.51	52.2	6	8.60	58.07	41.6	7.93	49.33	32.6	6
7	10.06	79.53	66.7	9.38	69.16	54.1	7	8.71	59.52	43.2	8.03	50.60	33.8	7
8	10.18	81.42	69.1	9.50	70.84	56.1	8	8.81	60.99	44.8	8.13	51.87	35.1	8
9	10.30	83.34	71.5	9.61	72.53	58.1	9	8.92	62.47	46.4	8.23	53.17	36.5	9
10	10.42	85.27	74.0	9.72	74.24	60.2	10	9.03	63.98	48.1	8.33	54.48	37.8	10
11	10.54	87.23	76.6	9.84	75.98	62.3	11	9.13	65.50	49.8	8.43	55.80	39.2	11
12	10.66	89.20	79.2	9.95	77.73	64.4	12	9.24	67.04	51.6	8.53	57.14	40.6	12
13	10.78	91.21	81.9	10.06	79.50	66.7	13	9.35	68.60	53.4	8.63	58.50	42.1	13
14	10.90	93.23	84.6	10.17	81.29	68.9	14	9.45	70.18	55.3	8.73	59.88	43.6	14
15	11.01	95.27	87.4	10.29	83.11	71.2	15	9.56	71.77	57.2	8.83	61.27	45.1	15
16	11.13	97.34	90.3	10.40	84.94	73.6	16	9.67	73.38	59.1	8.93	62.67	46.7	16
17	11.25	99.43	93.2	10.51	86.79	76.0	17	9.77	75.01	61.1	9.03	64.09	48.2	17
18	11.37	101.54	96.2	10.63	88.67	78.5	18	9.88	76.66	63.1	9.13	65.53	49.9	18
19	11.49	103.68	99.3	10.74	90.56	81.0	19	9.99	78.33	65.2	9.24	66.98	51.5	19
20	11.61	105.83	102.4	10.85	92.47	83.6	20	10.09	80.01	67.3	9.34	68.45	53.3	20
21	11.73	108.01	105.6	10.96	94.40	86.3	21	10.20	81.71	69.5	9.44	69.94	55.0	21
22	11.85	110.21	108.8	11.08	96.36	88.9	22	10.31	83.43	71.7	9.54	71.44	56.8	22
23	11.96	112.44	112.1	11.19	98.33	91.7	23	10.41	85.17	73.9	9.64	72.96	58.6	23
24	12.08	114.68	115.5	11.30	100.32	94.5	24	10.52	86.93	76.2	9.74	74.49	60.5	24
25	12.20	116.95	118.9	11.41	102.34	97.3	25	10.63	88.70	78.6	9.84	76.04	62.3	25
26	12.32	119.24	122.4	11.53	104.37	100.3	26	10.73	90.49	80.9	9.94	77.60	64.3	26
27	12.44	121.55	126.0	11.64	106.42	103.2	27	10.84	92.30	83.4	10.04	79.18	66.3	27
28	12.56	123.88	129.7	11.75	108.49	106.3	28	10.95	94.13	85.9	10.14	80.78	68.3	28
29	12.68	126.24	133.4	11.87	110.59	109.4	29	11.05	95.97	88.4	10.24	82.39	70.3	29
30	12.80	128.62	137.2	11.98	112.70	112.5	30	11.16	97.84	91.0	10.34	84.02	72.4	30
31	12.92	131.02	141.0	12.09	114.83	115.7	31	11.27	99.72	93.6	10.44	85.67	74.6	31
32	13.03	133.44	144.9	12.20	116.99	119.0	32	11.37	101.61	96.3	10.54	87.33	76.7	32
33	13.15	135.88	148.9	12.32	119.16	122.3	33	11.48	103.53	99.1	10.65	89.00	79.0	33
34	13.27	138.35	153.0	12.43	121.35	125.7	34	11.59	105.47	101.8	10.75	90.69	81.2	34
35	13.39	140.84	157.2	12.54	123.56	129.2	35	11.69	107.42	104.7	10.85	92.40	83.5	35
36	13.51	143.35	161.4	12.66	125.80	132.7	36	11.80	109.39	107.6	10.95	94.13	85.9	36
37	13.63	145.89	165.7	12.77	128.05	136.3	37	11.91	111.38	110.5	11.05	95.87	88.3	37
38	13.75	148.44	170.1	12.88	130.32	139.9	38	12.02	113.38	113.5	11.15	97.62	90.7	38
39	13.87	151.02	174.5	12.99	132.62	143.6	39	12.12	115.41	116.6	11.25	99.40	93.2	39
40	13.99	153.62	179.0	13.11	134.93	147.4	40	12.23	117.45	119.7	11.35	101.18	95.7	40
41	14.10	156.24	183.6	13.22	137.26	151.2	41	12.34	119.51	122.9	11.45	102.99	98.3	41
42	14.22	158.89	188.3	13.33	139.61	155.1	42	12.44	121.59	126.1	11.55	104.81	100.9	42
43	14.34	161.55	193.1	13.45	141.99	159.1	43	12.55	123.68	129.3	11.65	106.64	103.6	43
44	14.46	164.24	197.9	13.56	144.38	163.1	44	12.66	125.80	132.7	11.75	108.49	106.3	44
45	14.58	166.95	202.8	13.67	146.79	167.2	45	12.76	127.93	136.1	11.85	110.36	109.0	45
46	14.70	169.69	207.8	13.78	149.23	171.4	46	12.87	130.08	139.5	11.95	112.25	111.8	46
47	14.82	172.44	212.9	13.90	151.68	175.7	47	12.98	132.25	143.0	12.06	114.15	114.7	47
48	14.94	175.22	218.1	14.01	154.15	180.0	48	13.08	134.43	146.6	12.16	116.06	117.6	48
49	15.06	178.02	223.3	14.12	156.64	184.3	49	13.19	136.63	150.2	12.26	117.99	120.5	49
50	15.17	180.04	228.7	14.24	159.16	188.8	50	13.30	138.86	153.9	12.36	119.94	123.5	50
51	15.29	183.69	234.1	14.35	161.69	193.3	51	13.40	141.09	157.6	12.46	121.90	126.6	51
52	15.41	186.55	239.6	14.46	164.24	197.9	52	13.51	143.35	161.4	12.56	123.88	129.7	52
53	15.53	189.44	245.2	14.57	166.81	202.6	53	13.62	145.63	165.2	12.66	125.88	132.8	53
54	15.65	192.35	250.9	14.69	169.41	207.3	54	13.72	147.92	169.2	12.76	127.89	136.0	54
55	15.77	195.28	256.6	14.80	172.02	212.1	55	13.83	150.23	173.1	12.86	129.92	139.2	55

DOUGLAS FIR AND SOUTHERN YELLOW PINE
Ultimate Bending Stress – 8000 psi

85 ft. 85 ft.

	Class H1			Class 1				Class 2			Class 3			
Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)
56	15.89	198.24	262.5	14.91	174.65	217.0	56	13.94	152.56	177.2	12.96	131.96	142.5	56
57	16.01	201.22	268.4	15.03	177.30	222.0	57	14.04	154.91	181.3	13.06	134.02	145.9	57
58	16.13	204.22	274.4	15.14	179.98	227.0	58	14.15	157.27	185.5	13.16	136.09	149.3	58
59	16.24	207.24	280.5	15.25	182.67	232.2	59	14.26	159.65	189.7	13.26	138.18	152.7	59
60	16.36	210.28	286.7	15.36	185.38	237.3	60	14.36	162.05	194.0	13.36	140.29	156.2	60
61	16.48	213.35	293.0	15.48	188.12	242.6	61	14.47	164.47	198.3	13.47	142.41	159.8	61
62	16.60	216.44	299.4	15.59	190.87	248.0	62	14.58	166.91	202.8	13.57	144.55	163.4	62
63	16.72	219.55	305.9	15.70	193.64	253.4	63	14.68	169.36	207.2	13.67	146.71	167.1	63
64	16.84	222.68	312.5	15.81	196.43	258.9	64	14.79	171.83	211.8	13.77	148.88	170.8	64
65	16.96	225.83	319.1	15.93	199.25	264.5	65	14.90	174.32	216.4	13.87	151.06	174.6	65
66	17.08	229.01	325.9	16.04	202.08	270.1	66	15.00	176.83	221.1	13.97	153.27	178.4	66
67	17.19	232.21	332.7	16.15	204.93	275.9	67	15.11	179.36	225.9	14.07	155.48	182.3	67
68	17.31	235.43	339.7	16.27	207.80	281.7	68	15.22	181.90	230.7	14.17	157.72	186.2	68
69	17.43	238.68	346.7	16.38	210.70	287.6	69	15.33	184.46	235.6	14.27	159.97	190.2	69
70	17.55	241.94	353.9	16.49	213.61	293.6	70	15.43	187.04	240.5	14.37	162.23	194.3	70
71	17.67	245.23	361.1	16.60	216.54	299.6	71	15.54	189.64	245.6	14.47	164.52	198.4	71
72	17.79	248.54	368.4	16.72	219.49	305.8	72	15.65	192.25	250.7	14.57	166.81	202.6	72
73	17.91	251.87	375.9	16.83	222.47	312.0	73	15.75	194.88	255.8	14.67	169.13	206.8	73
74	18.03	255.23	383.4	16.94	225.46	318.3	74	15.86	197.54	261.1	14.78	171.46	211.1	74
75	18.15	258.60	391.0	17.06	228.47	324.7	75	15.97	200.20	266.4	14.88	173.80	215.5	75
76	18.26	262.00	398.8	17.17	231.50	331.2	76	16.07	202.89	271.8	14.98	176.17	219.9	76
77	18.38	265.42	406.6	17.28	234.56	337.8	77	16.18	205.60	277.2	15.08	178.54	224.3	77
78	18.50	268.87	414.6	17.39	237.63	344.4	78	16.29	208.32	282.7	15.18	180.94	228.9	78
79	18.62	272.33	422.6	17.51	240.72	351.2	79	16.39	211.06	288.3	15.28	183.35	233.4	79
80	18.69	274.29	427.2	17.57	242.56	355.2	80	16.46	212.78	291.9	15.35	184.95	236.5	80
81	18.75	276.26	431.8	17.64	244.41	359.3	81	16.53	214.52	295.4	15.41	186.57	239.6	81
82	18.82	278.23	436.4	17.71	246.27	363.4	82	16.59	216.25	299.0	15.48	188.19	242.8	82
83	18.89	280.21	441.1	17.77	248.13	367.5	83	16.66	218.00	302.7	15.55	189.82	245.9	83
84	18.96	282.20	445.8	17.84	250.00	371.7	84	16.73	219.75	306.3	15.61	191.46	249.1	84
85	19.02	284.19	450.5	17.91	251.88	375.9	85	16.79	221.51	310.0	15.68	193.10	252.3	85

DOUGLAS FIR AND SOUTHERN YELLOW PINE
Ultimate Bending Stress – 8000 psi

90 ft. 90 ft.

	Class H1			Class 1				Class 2			Class 3			
Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)
0	9.23	66.92	51.5	8.59	58.01	41.5	0	7.96	49.74	33.0	7.32	42.10	25.7	0
1	9.35	68.61	53.4	8.70	59.51	43.2	1	8.06	51.07	34.3	7.42	43.24	26.7	1
2	9.46	70.32	55.4	8.81	61.02	44.8	2	8.17	52.42	35.7	7.52	44.39	27.8	2
3	9.58	72.05	57.5	8.92	62.55	46.5	3	8.28	53.79	37.1	7.62	45.56	28.9	3
4	9.69	73.80	59.6	9.03	64.10	48.3	4	8.38	55.18	38.5	7.72	46.75	30.1	4
5	9.81	75.57	61.8	9.14	65.67	50.0	5	8.49	56.59	40.0	7.81	47.95	31.2	5
6	9.92	77.36	64.0	9.25	67.25	51.9	6	8.59	58.01	41.5	7.91	49.17	32.4	6
7	10.04	79.17	66.2	9.36	68.86	53.7	7	8.70	59.45	43.1	8.01	50.40	33.6	7
8	10.16	81.00	68.6	9.47	70.49	55.6	8	8.81	60.91	44.7	8.11	51.65	34.9	8
9	10.27	82.86	70.9	9.58	72.13	57.6	9	8.91	62.39	46.3	8.21	52.91	36.2	9
10	10.39	84.73	73.3	9.69	73.80	59.6	10	9.02	63.88	48.1	8.31	54.19	37.5	10
11	10.50	86.63	75.8	9.80	75.48	61.7	11	9.12	65.39	49.7	8.40	55.48	38.9	11
12	10.62	88.55	78.3	9.91	77.18	63.8	12	9.23	66.92	51.5	8.50	56.79	40.2	12
13	10.73	90.48	80.9	10.02	78.90	65.9	13	9.34	68.47	53.3	8.60	58.11	41.7	13
14	10.85	92.44	83.6	10.13	80.64	68.1	14	9.44	70.04	55.1	8.70	59.45	43.1	14
15	10.96	94.42	86.3	10.24	82.40	70.3	15	9.55	71.62	57.0	8.80	60.81	44.6	15
16	11.08	96.42	89.0	10.35	84.14	72.6	16	9.66	73.22	58.9	8.90	62.18	46.1	16
17	11.20	98.45	91.8	10.46	85.97	75.0	17	9.76	74.84	60.9	9.00	63.56	47.7	17
18	11.31	100.49	94.7	10.57	87.79	77.3	18	9.87	76.47	62.9	9.09	64.96	49.2	18
19	11.43	102.55	97.7	10.68	89.62	79.8	19	9.97	78.13	64.9	9.19	66.38	50.9	19
20	11.54	104.64	100.6	10.79	91.48	82.3	20	10.08	79.80	67.0	9.29	67.81	52.5	20
21	11.66	106.74	103.7	10.90	93.35	84.8	21	10.19	81.49	69.2	9.39	69.25	54.2	21
22	11.77	108.87	106.8	11.01	95.24	87.4	22	10.29	83.19	71.5	9.49	70.71	55.9	22
23	11.89	111.02	110.0	11.12	97.15	90.0	23	10.40	84.92	73.6	9.59	72.19	57.7	23
24	12.00	113.19	113.2	11.23	99.08	92.7	24	10.50	86.66	75.9	9.69	73.68	59.5	24
25	12.12	115.38	116.5	11.34	101.03	95.5	25	10.61	88.42	78.2	9.78	75.19	61.3	25
26	12.24	117.59	119.9	11.45	103.00	98.3	26	10.72	90.20	80.5	9.88	76.71	63.2	26
27	12.35	119.82	123.3	11.56	104.98	101.1	27	10.82	91.99	83.0	9.98	78.25	65.1	27
28	12.47	122.07	126.8	11.67	106.99	104.1	28	10.93	93.80	85.4	10.08	79.80	67.0	28
29	12.58	124.35	130.4	11.78	109.01	107.0	29	11.03	95.63	87.9	10.18	81.37	69.0	29
30	12.70	126.64	134.0	11.89	111.05	110.0	30	11.14	97.48	90.5	10.28	82.95	71.0	30
31	12.81	128.96	137.7	12.00	113.12	113.1	31	11.25	99.35	93.1	10.38	84.55	73.1	31
32	12.93	131.30	141.5	12.11	115.20	116.3	32	11.35	101.23	95.8	10.47	86.16	75.2	32
33	13.05	133.65	145.3	12.22	117.30	119.5	33	11.46	103.13	98.5	10.57	87.79	77.3	33
34	13.16	136.03	149.2	12.33	119.42	122.7	34	11.57	105.05	101.2	10.67	89.43	79.5	34
35	13.28	138.43	153.2	12.44	121.56	126.0	35	11.67	106.99	104.1	10.77	91.09	81.8	35
36	13.39	140.85	157.2	12.55	123.71	129.4	36	11.78	108.94	106.9	10.87	92.77	84.0	36
37	13.51	143.29	161.3	12.66	125.89	132.8	37	11.88	110.91	109.8	10.97	94.46	86.3	37
38	13.62	145.76	165.5	12.77	128.08	136.3	38	11.99	112.90	112.8	11.07	96.16	88.7	38
39	13.74	148.24	169.7	12.88	130.30	139.9	39	12.10	114.91	115.8	11.16	97.88	91.1	39
40	13.85	150.75	174.0	12.99	132.53	143.5	40	12.20	116.93	118.9	11.26	99.62	93.5	40
41	13.97	153.27	178.4	13.10	134.78	147.1	41	12.31	118.98	122.0	11.36	101.37	96.0	41
42	14.09	155.82	182.9	13.21	137.05	150.9	42	12.41	121.04	125.2	11.46	103.13	98.5	42
43	14.20	158.39	187.4	13.32	139.34	154.7	43	12.52	123.12	128.5	11.56	104.91	101.0	43
44	14.32	160.97	192.0	13.43	141.65	158.5	44	12.63	125.21	131.7	11.66	106.71	103.7	44
45	14.43	163.58	196.7	13.54	143.98	162.5	45	12.73	127.32	135.1	11.75	108.52	106.3	45
46	14.55	166.21	210.5	13.65	146.33	166.4	46	12.84	129.45	138.5	11.85	110.35	109.0	46
47	14.66	168.87	206.3	13.76	148.69	170.5	47	12.94	131.60	142.0	11.95	112.19	111.7	47
48	14.78	171.54	211.3	13.87	151.08	174.6	48	13.05	133.77	145.5	12.05	114.05	114.5	48
49	14.89	174.23	216.3	13.98	153.48	178.8	49	13.16	135.95	149.1	12.15	115.92	117.4	49
50	15.01	176.95	221.3	14.09	155.90	183.0	50	13.26	138.16	152.7	12.25	117.81	120.2	50
51	15.13	179.68	226.5	14.20	158.34	187.4	51	13.37	140.37	156.4	12.35	119.71	123.2	51
52	15.24	182.44	231.7	14.31	160.80	191.7	52	13.48	142.61	160.1	12.44	121.63	126.1	52
53	15.36	185.22	237.0	14.42	163.28	196.2	53	13.58	144.87	164.0	12.54	123.56	129.2	53
54	15.47	188.01	242.4	14.53	165.78	200.7	54	13.69	147.14	167.8	12.64	125.51	132.2	54
55	15.59	190.83	247.9	14.64	168.30	205.3	55	13.79	149.43	171.8	12.74	127.48	135.3	55

DOUGLAS FIR AND SOUTHERN YELLOW PINE
Ultimate Bending Stress – 8000 psi

90 ft. 90 ft.

	Class H1			Class 1				Class 2			Class 3			
Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dia. (in.)	Area (sq. in.)	Moment (ft-k)	Dist. (ft.)
56	15.70	193.67	253.4	14.75	170.84	210.0	56	13.90	151.74	175.8	12.84	129.45	138.5	56
57	15.82	196.54	259.1	14.86	173.39	214.7	57	14.01	154.06	179.8	12.94	131.45	141.7	57
58	15.93	199.42	264.8	14.97	175.96	219.5	58	14.11	156.41	183.9	13.04	133.46	145.0	58
59	16.05	202.32	270.6	15.08	178.56	224.4	59	14.22	158.77	188.1	13.13	135.48	148.3	59
60	16.17	205.25	276.5	15.19	181.17	229.3	60	14.32	161.14	192.4	13.23	137.52	151.7	60
61	16.28	208.19	282.5	15.30	183.80	234.3	61	14.43	163.54	196.7	13.33	139.58	155.1	61
62	16.40	211.16	288.5	15.41	186.45	239.4	62	14.54	165.95	201.0	13.43	141.65	158.5	62
63	16.51	214.14	294.7	15.52	189.12	244.6	63	14.64	168.39	205.5	13.53	143.74	162.0	63
64	16.63	217.15	300.9	15.63	191.81	249.8	64	14.75	170.84	210.0	13.63	145.84	165.6	64
65	16.74	220.18	307.2	15.74	194.52	255.1	65	14.85	173.30	214.5	13.73	147.95	169.2	65
66	16.86	223.23	313.6	15.85	197.24	260.5	66	14.96	175.79	219.2	13.82	150.09	172.9	66
67	16.97	226.30	320.1	15.96	199.99	265.9	67	15.07	178.29	223.9	13.92	152.23	176.6	67
68	17.09	229.40	326.7	16.07	202.75	271.5	68	15.17	180.81	228.6	14.02	154.40	180.4	68
69	17.21	232.51	333.4	16.18	205.53	277.1	69	15.28	183.35	233.4	14.12	156.57	184.2	69
70	17.32	235.64	340.1	16.29	208.34	282.8	70	15.38	185.90	238.3	14.22	158.77	188.1	70
71	17.44	238.80	347.0	16.40	211.16	288.5	71	15.49	188.47	243.3	14.32	160.97	192.0	71
72	17.55	241.97	353.9	16.51	214.00	294.4	72	15.60	191.07	248.3	14.41	163.20	196.0	72
73	17.67	245.17	361.0	16.62	216.86	300.3	73	15.70	193.67	253.4	14.51	165.44	200.1	73
74	17.78	248.39	368.1	16.73	219.73	306.3	74	15.81	196.30	258.6	14.61	167.69	204.2	74
75	17.90	251.63	375.3	16.84	222.63	312.4	75	15.92	198.94	263.9	14.71	169.96	208.3	75
76	18.01	254.89	382.6	16.95	225.55	218.5	76	16.02	201.61	269.2	14.81	172.24	212.6	76
77	18.13	258.17	390.1	17.06	228.48	324.7	77	16.13	204.28	274.6	14.91	174.54	216.8	77
78	18.25	261.47	397.6	17.17	231.43	331.1	78	16.23	206.98	280.0	15.01	176.86	221.2	78
79	18.36	264.79	405.2	17.28	234.41	337.5	79	16.34	209.70	285.5	15.10	179.19	225.5	79
80	18.48	268.14	412.9	17.39	237.40	343.9	80	16.45	212.43	291.1	15.20	181.53	230.0	80
81	18.59	271.50	420.7	17.50	240.41	350.5	81	16.55	215.18	296.8	15.30	183.89	234.5	81
82	18.71	274.89	428.6	17.61	243.44	357.2	82	16.66	217.95	302.5	15.40	186.27	239.0	82
83	18.82	278.30	436.6	17.72	246.49	363.9	83	16.76	220.73	308.4	15.50	188.66	243.7	83
84	18.94	281.72	444.6	17.83	249.55	370.7	84	16.87	223.53	314.3	15.60	191.07	248.3	84
85	19.01	283.72	449.4	17.89	451.43	374.9	85	16.94	225.31	318.0	15.66	192.71	251.5	85
86	19.07	285.72	454.1	17.96	253.31	379.1	86	17.00	227.09	321.8	15.73	194.35	254.8	86
87	19.14	287.72	458.9	18.03	255.20	383.4	87	17.07	228.88	325.6	15.80	196.01	258.0	87
88	19.21	289.73	463.7	18.09	257.10	387.6	88	17.14	230.67	329.4	15.86	197.67	261.3	88
89	19.27	291.76	468.6	18.16	259.00	391.9	89	17.20	232.48	333.3	15.93	199.34	264.6	89
90	19.34	293.78	473.5	18.23	260.91	396.3	90	17.27	234.29	337.2	16.00	201.02	268.0	90

MOMENT REDUCTION DUE TO A
BOLT HOLE IN A POLE

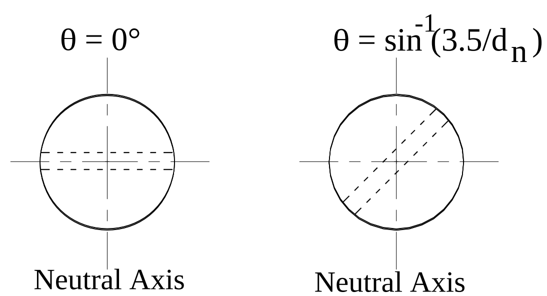
The reduction in moment capacity of a pole caused by a bolt hole is calculated by the equation:

$$M_{bh} = \frac{(F_b(b)(b^2 \sin^2\theta + d_n^{\ 2} \cos^2 \theta)}{72(1000)}$$

where:

F_b	=	Ultimate fiber stress of the wood (psi)
d_n	=	Pole diameter at location 'n' (inches)
b	=	Width of hole, taken as bolt diameter plus 1/16 inch (inches)
M_{bh}	=	Reduction in strength (ft-kips)

The drawings below explain the Pole Moment Reduction table which follows:



The Pole Moment Reduction table which follows is based on 1000 psi for the fiber stress. For any species of wood, this number should be multiplied by the fiber stress of the wood divided by 1000.

TABLE F-4
POLE MOMENT (ft-k) REDUCTION
DUE TO BOLT HOLES FOR 1000 psi FIBER STRESS

POLE	3/4 in. *		7/8 in. *		1 in. *	
DIAM	0 DEGREES	THETA	0 DEGREES	THETA	0 DEGREES	THETA
9	0.914	0.78	1.055	0.897	1.195	1.017
9.1	0.934	0.93	1.078	1.078	1.222	1.222
9.2	0.955	0.96	1.102	1.102	1.249	1.249
9.3	0.976	0.98	1.126	1.126	1.276	1.276
9.4	0.997	1.00	1.151	1.151	1.304	1.304
9.5	1.018	1.02	1.175	1.175	1.332	1.332
9.6	1.040	1.04	1.200	1.200	1.360	1.360
9.7	1.062	1.06	1.225	1.225	1.388	1.388
9.8	1.084	1.08	1.251	1.251	1.417	1.417
9.9	1.106	1.11	1.276	1.276	1.446	1.446
10	1.128	1.13	1.302	1.302	1.476	1.476
10.1	1.151	1.15	1.328	1.328	1.505	1.505
10.2	1.174	1.17	1.355	1.355	1.535	1.535
10.3	1.197	1.20	1.381	1.381	1.566	1.566
10.4	1.221	1.22	1.408	1.408	1.596	1.596
10.5	1.244	1.24	1.436	1.436	1.627	1.627
10.6	1.268	1.27	1.463	1.463	1.658	1.658
10.7	1.292	1.29	1.491	1.491	1.690	1.690
10.8	1.316	1.32	1.519	1.519	1.721	1.721
10.9	1.341	1.34	1.547	1.547	1.753	1.753
11	1.365	1.37	1.576	1.576	1.786	1.786
11.1	1.390	1.39	1.604	1.604	1.818	1.818
11.2	1.416	1.42	1.633	1.633	1.851	1.851
11.3	1.441	1.44	1.663	1.663	1.884	1.884
11.4	1.467	1.47	1.692	1.692	1.918	1.918
11.5	1.492	1.49	1.722	1.722	1.952	1.952
11.6	1.518	1.52	1.752	1.752	1.986	1.986
11.7	1.545	1.54	1.782	1.782	2.020	2.020
11.8	1.571	1.57	1.813	1.813	2.055	2.055
11.9	1.598	1.60	1.844	1.844	2.090	2.090
12	1.625	1.63	1.875	1.875	2.125	2.125
12.1	1.652	1.65	1.906	1.906	2.161	2.161
12.2	1.680	1.68	1.938	1.938	2.196	2.196
12.3	1.707	1.71	1.970	1.970	2.233	2.233
12.4	1.735	1.74	2.002	2.002	2.269	2.269
12.5	1.763	1.76	2.035	2.035	2.306	2.306
12.6	1.792	1.79	2.067	2.067	2.343	2.343
12.7	1.820	1.82	2.100	2.100	2.380	2.380
12.8	1.849	1.85	2.133	2.133	2.418	2.418
12.9	1.878	1.88	2.167	2.167	2.456	2.456
13	1.907	1.91	2.201	2.201	2.494	2.494
13.1	1.937	1.94	2.235	2.235	2.532	2.532
13.2	1.966	1.97	2.269	2.269	2.571	2.571
13.3	1.996	2.00	2.303	2.303	2.610	2.610
13.4	2.026	2.03	2.338	2.338	2.650	2.650
13.5	2.057	2.06	2.373	2.373	2.689	2.689
13.6	2.087	2.09	2.408	2.408	2.729	2.729
13.7	2.118	2.12	2.444	2.444	2.770	2.770
13.8	2.149	2.15	2.480	2.480	2.810	2.810
13.9	2.180	2.18	2.516	2.516	2.851	2.851
14	2.212	2.21	2.552	2.552	2.892	2.892
14.1	2.244	2.24	2.589	2.589	2.934	2.934
14.2	2.275	2.28	2.626	2.626	2.976	2.976
14.3	2.308	2.31	2.663	2.663	3.018	3.018
14.4	2.340	2.34	2.700	2.700	3.060	3.060
14.5	2.373	2.37	2.738	2.738	3.103	3.103
14.6	2.405	2.41	2.776	2.776	3.146	3.146
14.7	2.439	2.44	2.814	2.814	3.189	3.189
14.8	2.472	2.47	2.852	2.852	3.232	3.232
14.9	2.505	2.51	2.891	2.891	3.276	3.276
15	2.539	2.54	2.930	2.930	3.320	3.320

*BOLT HOLE = BOLT DIAMETER + 1/16 in.

TABLE F-5
VOLUMES FOR DOUGLAS FIR AND
SOUTHERN YELLOW PINE POLES, (cu. ft.)

Height	Pole Classes			
ft.	H1	1	2	3
50	44.1	39.3	34.1	24.4
55	51.2	45.0	39.2	33.7
60	58.0	51.1	44.6	38.6
65	65.2	57.2	50.5	43.8
70	72.8	64.5	56.7	49.3
75	80.9	71.8	62.3	54.4
80	89.5	79.6	69.3	59.7
85	98.5	86.6	75.6	65.2
90	106.6	93.9	83.3	71.1

TALBE F-6
POLE WEIGHTS FOR DOUGLAS FIR (TREATED)
(50 pcf assumed) (lbs.)

Height	Pole Classes			
ft.	H1	1	2	3
50	2200	1970	1700	1220
55	2560	2250	1960	1690
60	2900	2560	2230	1930
65	3260	2860	2530	2190
70	3640	3225	2840	2470
75	4050	3590	3120	2720
80	4480	3980	3470	2990
85	4930	4330	3780	3260
90	5330	4700	4170	3560

TABLE F-7
POLE WEIGHTS FOR SOUTHERN YELLOW PINE (TREATED)
(60 pcf assumed) (lbs.)

Height	Pole Classes			
ft.	H1	1	2	3
50	2650	2360	2050	1470
55	3070	2700	2350	2020
60	3480	3070	2680	2320
65	3900	3430	3030	2630
70	4370	3870	3400	2960
75	4850	4300	3740	3260
80	5380	4780	4160	3580
85	5910	5200	4540	3910
90	6400	5630	5000	4270

APPENDIX G

CROSSARM DATA

MOMENT CAPACITIES OF STANDARD CROSSARM SIZES

The following table gives moment capacities ($M_{XX,}$ M_{YY}) of standard size crossarms for transmission structures in RUS Form 805. The moment capacities are based on the dressed size of the arms and a modulus of rupture of 7400 psi. M_{XX} is the moment resistance for vertical and M_{YY} is the moment resistance for longitudinal loads. Section moduli are also given for the respective axis.

TABLE G-1
CROSSARM SIZES AND MOMENT CAPACITIES

Crossarm Size	S_{XX}(in^3)	M_{XX}(ft-k)	S_{YY}(in^3)	M_{YY} (ft-k)
3-5/8 x 9-3/8	49.9	30.8	18.9	11.7
(2) 3-5/8 x 9-3/8	99.8	61.6	37.8	23.3
3-5/8 x 5-5/8	17.7	10.9	11.2	6.9
(2) 3-5/8 x 5-5/8	35.3	21.8	22.5	13.9
4-1/8 x 5-1/8	16.7	10.3	13.3	16.5
(2) 4-1/8 x 5-1/8	33.3	20.6	26.7	16.5
4-5/8 x 5-5/8	22.7	14.0	18.6	11.5
(2) 5/8 x 5-5/8	45.4	28.0	37.1	22.9
5-3.8 x 7-5/8	49.2	30.4	34.5	21.2
5-5/8 x 7-3/8	48.2	29.7	36.6	22.5

Example: Determine the maximum vertical span for a TSS-1L (69 kV)

Given: Conductor: 266.8 26/7 ACSR
Ldg. Dist: Heavy
Cond. Wt. (w_c): 1.0776 lbs./ft.
Insulator wt. (W_i): 51 lbs.
Moment arm(s): 5.5 ft.

Procedure: Moment capacity of TSS-1L arm (4-5/8" x 5-5/8") is 14.0 ft-k.

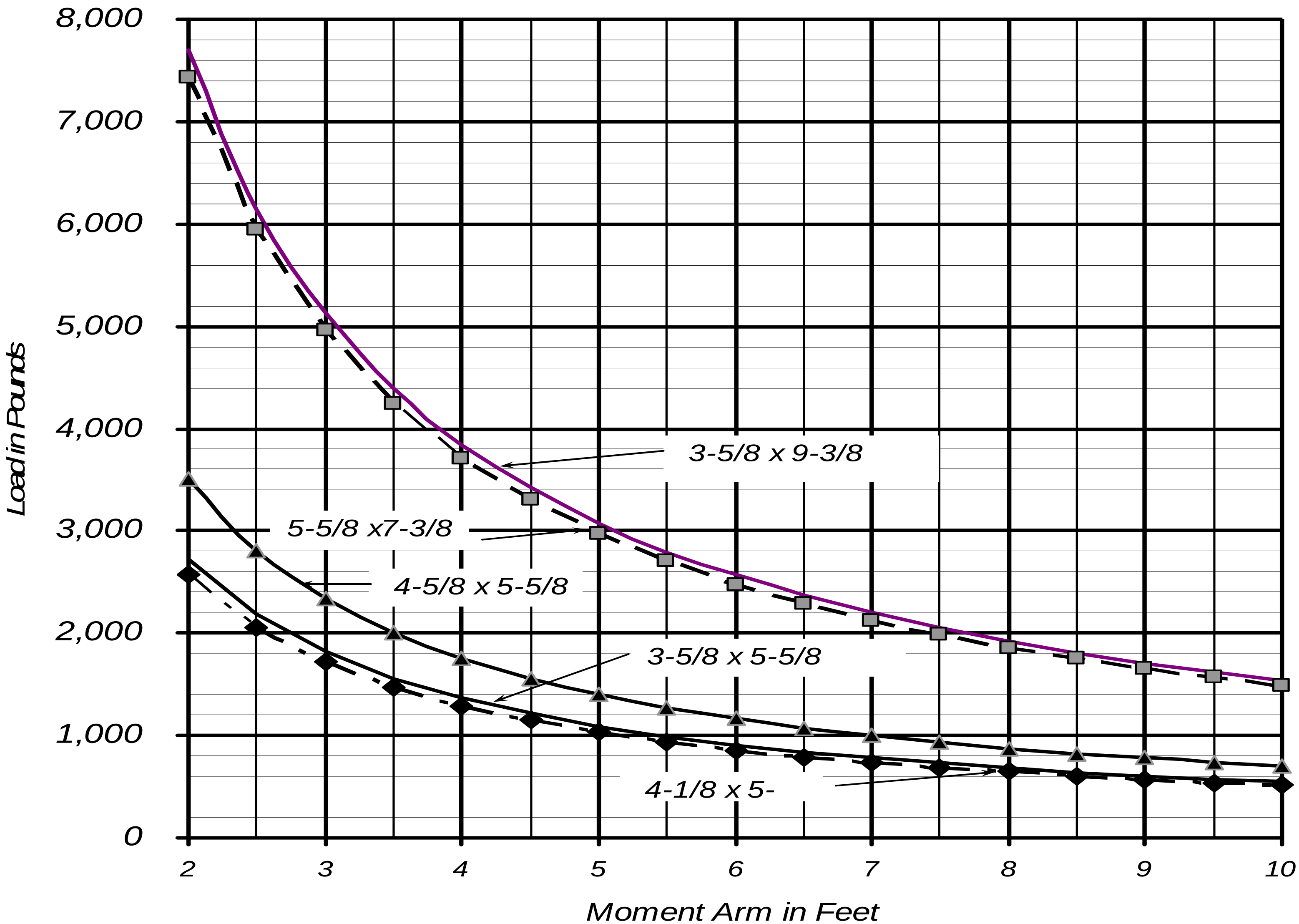
$$V.S. = \frac{\phi M_a - (OLF)\,(W_i)\,(s)}{(OLF)\,(W_c)\,(s)}$$

$$= \frac{(0.50)(14{,}000) - 1.5\,(51)\,(5.5)}{(1.5)\,(1.0776)\,(5.5)}$$

$$= 740\ ft.$$

FIGURE G-1

Crossarm Loading Chart - Maximum Permitted Vertical Loads of Various Sizes of Douglas Fir Crossarms (A fiber stress of 7400 x 0.5 or 3700 psi is assumed)



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APPENDIX H

MISCELLANEOUS STRUCTURAL DATA

TABLE H-1
PROPERTIES OF COMMON SECTIONS

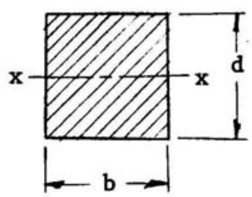
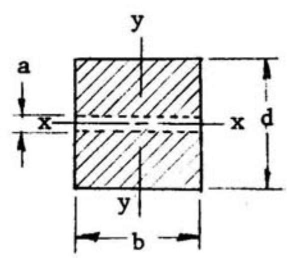
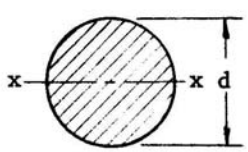
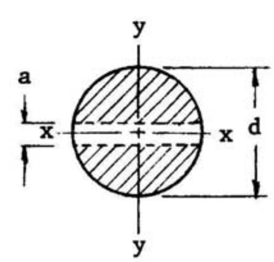
A = area (in^2, cm^2)	I_{y-y} = moment of inertia about the y-y axis	S_{y-y} = section modulus about the y-y axis
I_{x-x} = moment of inertia about the x-x axis (in^4, cm^4)	S_{x-x} = section modulus about the x-x axis (in^3, cm^3)	r_{x-x} = radius of gyration of x-x axis (in., cm)
	$A = bd$ $I_{x-x} = \frac{bd^3}{12}$	$S_{x-x} = \frac{bd^2}{6}$ $r_{x-x} = \frac{d}{\sqrt{12}}$
	$A = b(d - a)$ $I_{x-x} = \frac{b(d^3 - a^3)}{12}$ $S_{x-x} = \frac{b(d^3 - a^3)}{6d}$	$r_{x-x} = \sqrt{\frac{d^2 + ad + a^2}{12}}$ $I_{y-y} = \frac{(d - a)(b)^3}{12}$ $S_{y-y} = \frac{(d - a)(b)^2}{6}$
	$A = \frac{\pi d^2}{4} = \pi R^2$ $I_{x-x} = \frac{\pi d^4}{64} = \frac{\pi R^4}{4}$	$S_{x-x} = \frac{\pi d^3}{32} = \frac{\pi R^3}{4}$ $r = \frac{d}{4} = \frac{R}{2}$
	$A = \frac{\pi d^2}{4} - da$ $I_{x-x} = \frac{\pi d^4}{64} - \frac{da^3}{12}$ $S_{x-x} = \frac{\pi d^3}{32} - \frac{da^2}{6}$	$I_{y-y} = \frac{\pi d^4}{64} - \frac{ad^3}{12}$ $S_{y-y} = \frac{\pi d^3}{32} - \frac{ad^2}{6}$

FIGURE H-1
CURVE FOR LOCATING PLANE OF CONTRAFLEXURE
IN X-BRACED H-FRAME STRUCTURES

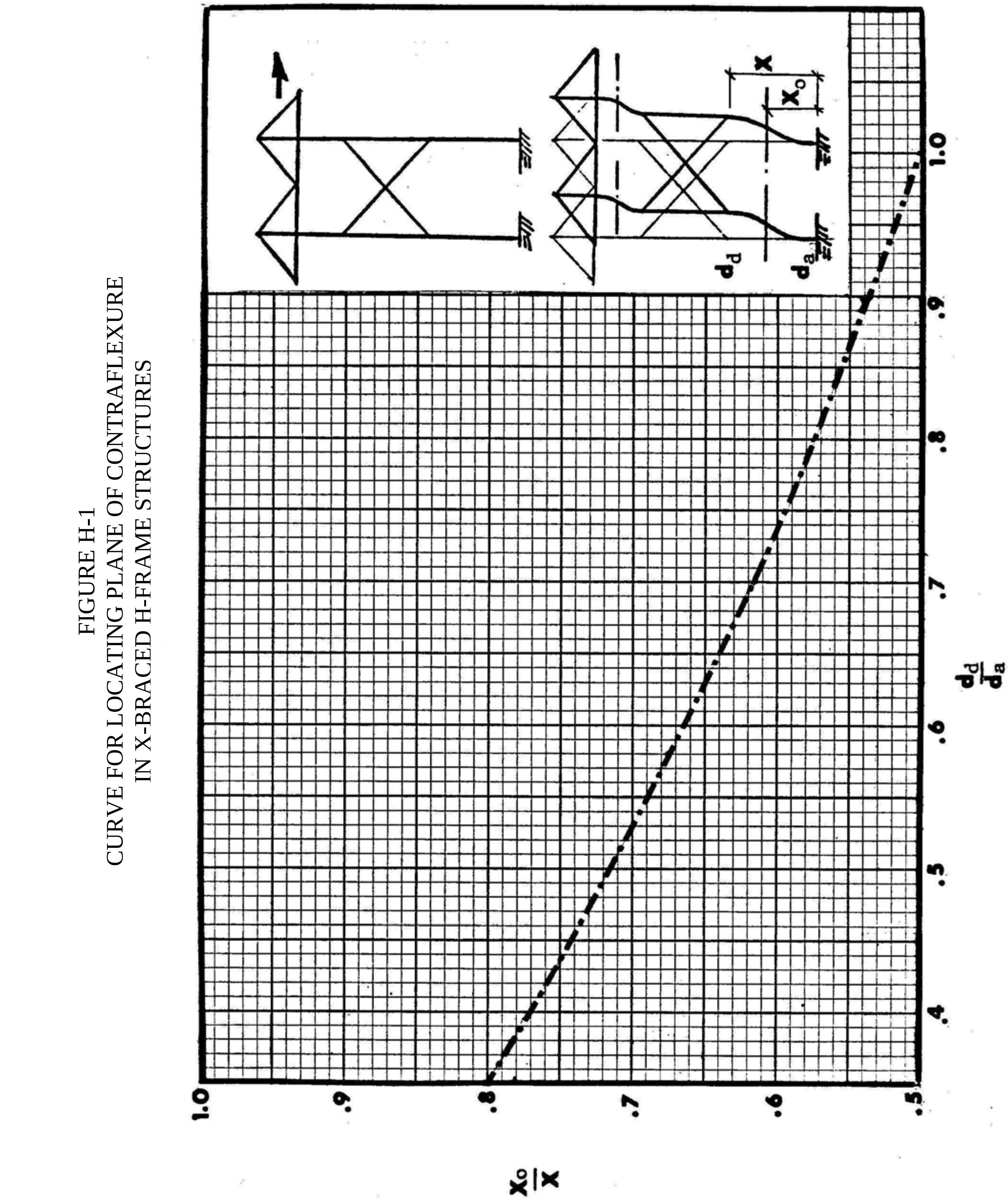


TABLE H-2
STRENGTHS FOR MACHINE BOLTS
DOUBLE ARMING BOLTS, DOUBLE END BOLTS
(Conforming to ANSI C135.1)

Machine Bolt Diameter (in.)	Tension Stress Area (in.^{2})	Min. Tensile Strength (lbs.)
1/2"	0.142	7,800
5/8"	0.226	12, 400
3/4"	0.334	18,350
7/8"	0.462	25,400
1"	0.606	33,500

TABLE H-3
STRENGTHS OF ASTM A325
HEAT TREATED, HIGH STRENGTH BOLTS

Machine Bolt Diameter (in.)	Tensile Stress Area (sq. in.)	Minimum Tensile Strength (lbs.)	Minimum Yield Strength (lbs.)
1/2	0.142	17,500	13,050
5/8	0.226	27,100	20,800
3/4	0.334	40,100	30,700
7/8	0.462	55,450	42,500
1	0.606	72,700	55,570

TABLE H-4
STRENGTH OF GUY STRANDS

Strand Size	Description	Minimum Breaking Strength (lbs)
3/8 in.	H.S.	10,800
7 No. 9 AWG	A.C.S	12,600
3/8 in.	E.H.S	14,400
7/16 in.	H.S.	14,500
7 No. 8 AWG	A.C.S	15,930
7 No. 7 AWG	A.C.S	19,060
7/16 in.	E.H.S	20,080

H.S.= high strength, E.H.S. = extra high strength, A.C.S.= aluminum clad steel

APPENDIX I
RI AND TVI

INSULATOR AND HARDWARE RIV PERFORMANCE VALUES

The values below give recommended maximum RIV levels for insulators plus hardware assemblies for various voltages. The RIV values are measured using the procedure outlined in NEMA publication 107, *Methods of Measuring Radio Noise* – 1964.

TABLE I-1
RIV LEVELS

kV_{LL}	RIV Level in Microvolts at 1000 kH_{Z*}
34.5	100
46	200
69	200
115	200
138	200
161	500
230	500

Note:
The values in Table I-1 are from Figure 3 of "Transmission System Radio Influence"-IEEE Committee Report – Power Apparatus and System, August 1965. (This publication is the major work on the subject.)

SOME POSSIBLE SOURCES OF RI OR TVI ON TRANSMISSION LINES

1. Poor contact between metal parts of suspension insulators; an insufficient vertical span or an uplift condition can cause this.
2. Poor contact between clamps and clamp support brackets on clamp-top insulators;
3. Loose conductor clamps;
4. Loose hardware which can result from wood shrinkage, structure vibration or wind movement;
5. Loose crossarm braces or bolts;
6. Loose insulator mounting brackets;
7. Loose staples, bonding wire or ground wire;
8. Staples, bonding wire or ground wire too near ungrounded hardware;
9. Bond or ground wire clamped against wood under washer;
10. Unbonded guy wires too close to each other or to pole hardware;
11. Slack guy wire causing poor contact at pole attachments or at anchor eye;
12. Metal-to-metal clearance insufficient on pole hardware;
13. "Trash" on conductors (bits of wire, metal kite strings, tree limb, etc.).

FORMULAE FOR CALCULATING SURFACE GRADIENTS OF CONDUCTORS

Excessively high conductor surface gradients can result in radio noise, television interference, and corona. The equations below can be used to check the surface gradient. They are approximate but yield reasonably accurate results. They assume phase conductors that are far apart compared to their diameter.

Equation for Single Conductor per Phase**:**

$$g = \frac{kV_{LL}}{\sqrt{3}\ r\ \ell n\ \frac{D}{r}} \qquad \text{Eq. I-1}$$

where:

kV_{LL} = line-to-line voltage, kV
r = conductor radius, cm.
D = geometric mean distance (GMD) of the phase conductors, cm.
g = conductor surface gradient, kV/cm

Equation for Two Conductor Bundle per Phase**:**

$$g = \frac{kV_{LL}(1 + 2\ r/s)}{2\sqrt{3}\ r\ \ell n\ \frac{D}{\sqrt{rs}}} \qquad \text{Eq. I-2}$$

where:

All the symbols are the same as those above with the addition that:

s = the separation between subconductors, cm.

Application of Formulae**:**

It is recommended that transmission line designs that have unusually close phase spacing have the conductor surface gradient checked. A maximum conductor gradient of 16 kV/cm should be used.

<u>Example</u>

Determine the conductor gradient for a 230 kV line with (1) a 556.5 kcmil (dove) ACSR conductor and (2) a 1272 kcmil (pheasant) conductor. GMD for TH-230 is 24.57 feet or 784.90 cm.

556.5 kcmil conductor:

$$r = \frac{.927}{2}(2.54) = 1.18$$

$$g = \frac{230\ (1.05)}{\sqrt{3}\ (1.18) 1n \frac{748.90}{1.18}}$$

g = 18.3 kV/cm.

The 556.5 kcmil conductor should not be used for 230 kV lines.

1272 kcmil Conductor (1 Conductor):

$$r = \frac{1.382}{2}(2.54) = 1.755$$

$$g = -\ g = \frac{230\ (1.05)}{\sqrt{3}\ (1.755) 1n \frac{748.90}{1.755}}$$

g = 13.12 kV/cm.

TABLE I-2
SURFACE GRADIENT FOR TYPICAL DESIGNS

16 kV/cm recommended to minimize radio noise

				TP-3 GMD	**TP-3 GMD**	**TS-1 GMD**	**TU-1AA GMD**	**TH-230 GMD**
			(feet)	2.53	2.53	3.00	3.59	24.57
			(cm)	77.15	77.15	91.33	109.35	748.85
Conductor	**Diameter**	**Radius (inches)**	**Radius (cm)**	**Gradient (kV/cm) 34.5**	**Gradient (kV/cm) 46**	**Gradient (kV/cm) 69**	**Gradient (kV/cm) 161**	**Gradient (kV/cm) 230**
RAVEN	0.398	0.199	0.505	8.23	10.97	15.92	35.91	37.78
QUAIL	0.447	0.224	0.568	7.50	10.00	14.50	32.68	34.19
PIGEON	0.502	0.251	0.638	6.84	9.12	13.22	29.76	30.94
PENGUIN	0.563	0.282	0.715	6.25	8.33	12.06	27.14	28.04
WAXWING	0.609	0.305	0.773	5.88	7.83	11.33	25.49	26.22
PARTRIDGE	0.642	0.321	0.815	5.64	7.52	10.87	24.44	25.06
MERLIN	0.684	0.342	0.869	5.37	7.16	10.34	23.24	23.75
LINNET	0.721	0.361	0.916	5.15	6.87	9.93	22.29	22.70
ORIOLE	0.741	0.371	0.941	5.04	6.72	9.72	21.81	22.18
CHICKADEE	0.743	0.372	0.944	5.03	6.71	9.69	21.76	22.13
IBIS	0.783	0.392	0.994	4.83	6.44	9.31	20.88	21.17
LARK	0.806	0.403	1.024	4.73	6.30	9.10	20.41	20.65
PELICAN	0.814	0.407	1.034	4.69	6.25	9.03	20.25	20.48
FLICKER	0.846	0.423	1.074	4.55	6.07	8.76	19.65	19.82
HAWK	0.858	0.429	1.090	4.51	6.01	8.67	19.44	19.59
HEN	0.883	0.442	1.121	4.41	5.88	8.48	19.00	19.12
OSPREY	0.879	0.440	1.116	4.42	5.90	8.51	19.07	19.19
PARAKEET	0.914	0.457	1.161	4.29	5.72	8.25	18.50	18.57
DOVE	0.927	0.464	1.177	4.25	5.66	8.17	18.30	18.35
EAGLE	0.953	0.477	1.210	4.16	5.55	7.99	17.91	17.92
KINGBIRD	0.94	0.470	1.194	4.20	5.60	8.08	18.10	18.13
ROOK	0.977	0.489	1.241	4.08	5.44	7.84	17.56	17.55
GROSBEAK	0.99	0.495	1.257	4.04	5.39	7.76	17.38	17.36
EGRET	1.019	0.510	1.294	3.95	5.27	7.59	17.00	16.94

TABLE I-2 (Continued)
SURFACE GRADIENT FOR TYPICAL DESIGNS

16 kV/cm recommended to minimize radio noise

Conductor	Diameter	Radius (inches)	Radius (cm)	TP-3 GMD	TP-3 GMD	TS-1 GMD	TU-1AA GMD	TH-230 GMD
			(feet)	2.53	2.53	3.00	3.59	24.57
			(cm)	77.15	77.15	91.33	109.35	748.85
				Gradient (kV/cm) 34.5	Gradient (kV/cm) 46	Gradient (kV/cm) 69	Gradient (kV/cm) 161	Gradient (kV/cm) 230
CUCKOO	1.092	0.546	1.387	3.75	5.00	7.20	16.11	15.98
DRAKE	1.108	0.554	1.407	3.71	4.95	7.12	15.93	15.79
MALLARD	1.14	0.570	1.448	3.63	4.84	6.97	15.59	15.41
TERN	1.063	0.532	1.350	3.83	5.11	7.35	16.45	16.35
CONDOR	1.093	0.547	1.388	3.75	5.00	7.20	16.10	15.97
RAIL	1.165	0.583	1.480	3.57	4.77	6.86	15.33	15.13
CARDINAL	1.196	0.598	1.519	3.51	4.67	6.72	15.03	14.80
BUNTING	1.302	0.651	1.654	3.29	4.39	6.31	14.08	13.79
GRACKLE	1.338	0.669	1.699	3.23	4.30	6.18	13.79	13.48
BITTERN	1.345	0.673	1.708	3.21	4.28	6.15	13.74	13.42
PHEASANT	1.382	0.691	1.755	3.15	4.20	6.03	13.46	13.12
LAPWING	1.502	0.751	1.908	2.96	3.95	5.67	12.64	12.24
FALCON	1.545	0.773	1.962	2.90	3.87	5.55	12.37	11.95
CHUKAR	1.602	0.801	2.035	2.83	3.77	5.40	12.04	11.60
BLUEBIRD	1.762	0.881	2.238	2.64	3.52	5.04	11.21	10.72

APPENDIX J

INSULATOR SWING TABLES

TABLE J-1
INSULATOR SWING VALUES FOR STANDARD TANGENT STRUCTURES
(Porcelain Insulators with Ball Hook and Suspension Clamp
per Drawing TM-1A. Insulator String Lengths per TABLE C-3)

Sturcture and Voltage	Number of Insulators	Insulator Swing Angle In Degrees (no wind clearance, note 1)	Insulator Swing Angle In Degrees (moderate wind clearance, note 2)	Insulator Swing Angle In Degrees (high wind clearance, note 3)
34.5 kV				
TS-1, TS-1X	3	40.2	69.8	82.0
TS-1L, TS-1LX	3	40.8	69.8	82.0
TS-2, TS-2X	3	40.2	70.5	82.3
TSD-1, TSD-1X,	3	25.3	52.3	68.0
TSD-2, TSD-2X	3	25.3	52.9	68.0
TS-9	3	67.9	92.9	108.6
TSS-1, TSS-2	3	40.8	72.5	89.5
TSS-1L	3	40.8	70.1	89.1
TSS-9	3	77.0	101.9	115.1
TSZ-1, TSZ-2	3	52.6	77.1	90.5
TH-1, TH-1G	3	41.3	72.9	89.8
TH-9, TH-9G	3	77.0	101.9	115.1
46 kV				
TS-1, TS-1X	3	40.2	64.5	82.0
TS-1L, TS-1LX	3	40.8	64.5	82.0
TS-2, TS-2X	3	40.2	65.0	82.3
TSD-1, TSD-1X	3	25.3	47.7	68.0
TSD-2, TSD-2X	3	25.3	48.0	68.0
TS-9	3	67.9	86.9	108.6
TSS-1, TSS-2	3	40.8	64.9	89.5
TSS-1L	3	40.8	64.9	89.5
TSS-9	3	77.0	97.2	115.1
TSZ-1, TSZ-2	3	52.6	72.3	90.5
TH-1, TH-1G	3	41.3	67.8	89.8
TH-9, TH-9G	3	77.0	97.2	115.1
69 kV				
TS-1, TS-1X	4	20.0	38.5	74.0
TS-1L, TS-1LX	4	33.5	53.5	74.0
TS-2, TS-2X	4	20.0	38.5	74.2
TSD-1, TSD-1X	4	17.8	38.5	62.8
TSD-2, TSD-2X	4	17.8	38.5	62.8
TS-9	4	45.8	71.7	93.2
TSS-1, TSS-2	4	25.9	45.8	85.4
TSS-1L	4	35.1	60.9	85.4
TSS-9	4	45.8	79.2	106.6

TABLE J-1 (Continued)
INSULATOR SWING VALUES FOR STANDARD TANGENT STRUCTURES
(Porcelain Insulators with Ball Hook and Suspension Clamp
per Drawing TM-1A. Insulator String Lengths per TABLE C-3)

Sturcture and Voltage	**Number of Insulators**	**Insulator Swing Angle In Degrees (no wind clearance)**	**Insulator Swing Angle In Degrees (moderate wind clearance)**	**Insulator Swing Angle In Degrees (high wind clearance)**
69 kV (continued)				
TSZ-1, TSZ-2	4	41.7	61.2	81.4
TH-1, TH-1G	4	35.6	61.2	85.6
TH-1B, TH-1BG	4	66.5	86.2	106.6
TH-1A,	4	35.6	61.2	85.6
TH-1AA, TH-1AAX	4	27.2	56.1	81.3
TS-115	4	33.7	60.0.	84.6
115 Kv				
TS-115	7	26.9	54.2	80.2
TH-1A	7	28.3	58.7	80.8
TH-1AA,TH-1AAX	7	22.1	55.5	78.1
TH-10 SERIES	7	22.1	55.5	78.1
138 kV				
TH-10 SERIES	8	19.9	54.5	77.2
161 kV				
TH-10 SERIES	10	16.4	50.5	77.7
230 kV				
TH-230	12	16.5	47.8	74.8
TH-230	13	15.2	43.9	76.0

Notes:

1. Conditions at which insulator swing no wind clearances are to be maintained follow (See Chapter 7 of this bulletin):
   - Wind: Assume no wind.
   - Temperature: Assume a temperature of 60°F.
2. Conditions at which insulator swing moderate wind clearances are to be maintained follow (See Chapter 7 of this bulletin):
   - Wind: Assume a wind of at least 6 psf blowing. A wind pressure values of no higher than 9 psf (60 mph) should be used for the moderate wind clearance design
   - Temperature: A temperature of no more than 32°F should be used for tangent and small angle structures where the insulator string is suspended from a crossarm. A lower temperature value should be used where such a temperature can be reasonably expected to occur in conjunction with the wind value assumed.
3. Conditions at which insulator swing high wind clearances are to be maintained follow (See Chapter 7 of this bulletin):
   - Wind: The minimum assumed wind value should be at least the 10-year mean recurrence interval. More wind may be assumed if deemed appropriate.
   - Temperature: The temperature assumed should be that temperature at which the wind is expected to occur. The conductor should be assumed to be at initial tension conditions.

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APPENDIX K
SYMBOLS AND ABBREVIATIONS

A	=	Cross sectional area	ft^2, in^2
A	=	Separation between points of insulator string for two phases	ft^2
A	=	Allowable separation at midspan	ft
A_U	=	Designated ultimate anchor capacity	lbs
B	=	Vertical separation at supports	ft
C	=	Clearance between a supply conductor and an object or ground. May be specified as C_1 $C_2,$ $C_3,$ etc.	in
C	=	Circumference of pole. Depending on the location, the circumference may be indicated as C_A, C_B C_C .	ft, in
D_e	=	Embedment depth	ft
D_v	=	Vertical separation between conductors	ft
E_C	=	Experience factor for horizontal separation requirements	
E	=	Experience factor for horizontal separation requirements. It is generally recommended that E be greater then 1.25.	
E	=	Modulus of elasticity of wood	psi
EI&W	=	Extreme Ice and Concurrent Wind	
F	=	Wind pressure on a cylindrical surface	psf
F_b	=	Designated ultimate bending stress for either the pole or the crossarm	psi
F_c	=	Experience factor to be used in horizontal separation requirements (Fc = 1.15 for light loading district, 1.2 for medium loading district, and 1.25 for heavy loading district).	
F_s	=	Designated ultimate skin friction of soil	psf
G, G_N	=	Calculated force in the guy, considering guy lead	lbs
G_U	=	Rated breaking strength of guy.	lbs
H	=	Horizontal separation between the phase conductors at the structure.	ft
HS	=	Horizontal span. For any structure the HS = $(L_1 + L_2)/2$ and is the horizontal distance between the midspan points of adjacent spans. The horizontal span times the wind force per foot on the conductor (p_c) will yield the total horizontal force per conductor on the structure.	ft
HS_N	=	For an H-frame structure, $HS_A,$ $HS_B,$ etc., are the horizontal spans limited by pole strength at locations on the pole.	ft
HS_R	=	Horizontal span limited by bearing	ft

APPENDIX K
SYMBOLS AND ABBREVIATIONS

HSx	=	Horizontal span as limited by crossbrace strength Of an H-frame structure	ft
I	=	Moment of inertia of a structural member	in^4
L	=	Span length or the horizontal distance from one structure to an adjacent structure. L_1, L_2, L_3, etc., are designations for difference spans.	ft
L_{avg}	=	Average span length	ft
L_{max}	=	Maximum span length	ft
LF	=	Load Factor	
LL	=	Loop length of conductor when vibrating	ft
M	=	Major axis of Lissagous ellipses	ft
M_a	=	Moment capacity of crossarms	ft.-lbs
M_g	=	Moment capacity of a pole at groundline	ft.-lbs
M_N	=	Moment capacity at the indicated location.	ft-lbs
M_{bh}	=	Moment capacity at the indicated location.	ft-lbs
M_{wp}	=	Moment due to wind on the pole.	ft-lbs
P	=	Horizontal force.	lbs
P_C	=	Force due to wind on conductors (plus ice, if any)	lbs
P_g	=	Force due to wind on OHGW (plus ice, if any)	lbs
P_t	=	Force due to wind on conductors and OHGW (plus ice)	lbs
P_{cr}	=	Critical buckling load for a member in compression	lbs
P-δ	=	P-delta moment, additional moment due to deflection	ft-lbs
R	=	Rise of a davit arm	ft
R	=	Total transverse load due to wind on the conductors and OHGW and wire tension load for conductors and OHGW	lbs
R_g	=	Total transverse load due to wind on the OHGW (P_g) and wire tension load for OHGW (T_g)	lbs
RS	=	Ruling Span	ft
S	=	Section modulus of a structural member equal I/c	in^3

APPENDIX K
SYMBOLS AND ABBREVIATIONS

S	=	Sag of conductor	ft
Se	=	Soil constant	
S_f	=	Final Sag of a bare conductor at condition specified	ft
Si	=	Sag of an iced conductor	ft
S_ℓ	=	Sag of the lower bare conductor	ft
$S_{i\ell}$	=	Sag of an iced lower conductor	ft
S_{RS}	=	Sag at midspan for a span equal to the ruling span	ft
S_u	=	Sag of an upper conductor	ft
S_{iu}	=	Sag of an iced upper conductor	ft
SP	=	Diagonal distance between phase conductors at structure	ft
T	=	Resultant tension at support	lbs
T_c	=	Average conductor tension	lbs
T_g	=	Average OHGW tension	lbs
T_h	=	Horizontal component of tension	lbs
T_{avg}	=	Average conductor tension in a span, ($T_{avg}=\frac{T_h+T}{2}$)	lbs
V	=	Wind velocity	miles/hr
V	=	Vertical separation between phase conductors at a structure	ft
VS	=	Vertical span, the horizontal distance between the maximum sag points of two adjacent spans. The vertical span times the weight of the loaded conductor per foot (W_c) will yield the vertical force per conductor.	ft
W	=	Weight	lbs
W	=	Right-of-way width	ft
W_c	=	Weight of conductors (plus ice, if any)	lbs
W_g	=	Weight of OHGW (plus ice, if any)	lbs
W_p	=	Weight of pole	lbs
Wi	=	Weight of insulators	lbs
V	=	Wind velocity	miles/hr
V	=	Vertical separation between phase conductors at a structure	ft

APPENDIX K
SYMBOLS AND ABBREVIATIONS

a	=	Length as indicated	ft
a	=	Insulator swing clearance for normal condition	in
b	=	Distance between two poles for an H-frame	ft
b	=	Bolt hole diameter; width of a section	in
b	=	Insulator swing clearance for 6 psf wind condition	in
c	=	Insulator swing clearance for high wind condition	in
c	=	Distance from the neutral axis to the extreme fiber	in
d_c	=	Diameter of conductor	in
d_g	=	Diameter of overhead ground wire	in
d_g	=	Diameter at the groundline of a pole	in
d_n	=	Diameter of a pole. Depending on the location the diameter may be indicated as da, db, dc, dd, , etc.	in
d_t	=	Diameter at the top of a pole	in
f	=	Frequency of conductor vibration	Hz
f_b	=	Computed bending stress	psi
a	=	Length as indicated	ft
a	=	Insulator swing clearance for normal condition	in
b	=	Distance between two poles for an H-frame	ft
b	=	Bolt hole diameter; width of a section	in
b	=	Insulator swing clearance for 6 psf wind condition	in
c	=	Insulator swing clearance for high wind condition	in
c	=	Distance from the neutral axis to the extreme fiber.	in
d_c	=	Diameter of conductor	in
d_g	=	Diameter of overhead ground wire	in
d_g	=	Diameter at the groundline of a pole.	in

APPENDIX K
SYMBOLS AND ABBREVIATIONS

d_n	=	Diameter of a pole. Depending on the location the diameter may be indicated as da, db, dc, dd, , etc.	in
d_t	=	Diameter at the top of a pole	in
f	=	Frequency of conductor vibration	Hz
f_b	=	Computed bending stress	psi
f_s	=	Computed skin friction of soil	psf
g	=	Acceleration due to gravity 9.81 (32.2)	ft/sec^2
g	=	Conductor surface gradient	
h_n	=	Length, may be indicated as h1, h2, h3, or ha, hb hc, etc.	ft.
kVL-G	=	Line to ground voltage	kV
kVL-L	=	Line to line voltage	kV
ℓ	=	Unbraced length used in buckling calculations	ft.
ℓ_i	=	Insulator string length	in. ft.
m_c	=	Mass per unit length of the conductor	lbm/ft.
m_g	=	Mass for unit length of the overhead ground wire	lbs./ft.
p_c	=	Horizontal force per unit length due to wind on the conductors (plus ice, if any)	lbs/ft.
p_g	=	Horizontal force per unit length due to wind on the overhead ground wire (plus ice, if any)	lbs/ft
p_t	=	Total horizontal force per unit length due to wind on the conductors and overhead ground wire	lbs/ft
q_a	=	Calculated allowable soil bearing capacity	psf
q_u	=	Calculated ultimate soil bearing capacity.	psf
r	=	Radius of gyration. a property of a cross section equal to $\sqrt{I / A}$.	lbs/ft
r	=	Radius of conductor	in.
r_c	=	Resultant load per unit length on conductor including ice and wind and K factor	lbs/ft

APPENDIX K
SYMBOLS AND ABBREVIATIONS

s	=	Maximum moment arm for a crossarm	ft.
w_c	=	Weight per unit length of the conductors (plus ice, if any)	lbs/ft.
w_g	=	Weight per unit length of the overhead ground wire (plus ice, if any)	lbs/ft.
x_n, y_n, z_n	=	Length. May be indicated as x_0, x_1, z_0, x_1, etc.	ft.

APPENDIX L
SELECTED SI-METRIC CONVERSIONS

AREA

To Convert From	To	Multiply by
circular mil (cmil)	square meter (m^2)	5.067075 E – 10
square centimeter (cm^2)	square meter (m^2)	*1.000 E – 04
square foot (ft^2)	square meter (m^2)	*9.290304 E – 02
square inch (in^2)	square meter (m^2)	*6.451600 E – 04
square kilometer (km^2)	square meter (m^2)	*1.000 E + 06
square mile (mi^2)	square meter (m^2)	2.589988 E + 06

FORCE

To Convert From	To	Multiply by
kilogram force (kgf)	newton (N)	*9.806650
Kip	newton (N)	4.448222 E + 03
pound force (lbf)	newton (N)	4.448222

FORCE PER LENGTH

To Convert From	To	Multiply by
kilogram force per meter (kgf/m)	newton per meter (N/m)	*9.806650
pound per foot (lb/ft)	newton per meter (N/m)	1.459390 E + 01

DENSITY

To Convert From	To	Multiply by
pound per cubic inch (lb/in^3)	kilogram per cubic meter (kg/m^3)	2.767990 E + 04
pound per cubic foot (lb/ft^3)	kilogram per cubic meter (kg/m^3)	1.601846 E + 01

LENGTH

To Convert From	To	Multiply by
foot (ft)	meter (m)	3.048 E – 01
inch (in)	meter (m)	*2.540 E – 02
kilometer (km)	meter (m)	*1.000 E + 03
mile (mi)	meter (m)	*1.609344 E + 03

*Exact Conversion.

SELECTED SI-METRIC CONVERSIONS (Continued)

LINEAR DENSITY

To Convert From	To	Multiply by
pound per foot (lb/ft)	kilogram per meter (kg/m)	1.488164
pound per inch (lb/in)	kilogram per meter (kg/m)	1.785797 E + 01

LOAD CONCENTRATION

To Convert From	To	Multiply by
pound per square inch (lb/in^2)	kilogram per square meter (kg/m^2)	7.03069 E + 02
pound per square foot (lb/ft^2)	kilogram per square meter (kg/m^2)	4.882428
ton per square foot (ton/ft^2)	kilogram per square meter (kg/m^2)	9.071847 E + 02

MASS

To Convert From	To	Multiply by
pound (avoirdupois) (lb)	kilogram (kg)	4.535924 E - 01

PRESSURE

To Convert From	To	Multiply by
kip per square inch (kip/in^2)	pascal (Pa)	6.894757 E + 06
kip per square foot (kip/ft^2)	pascal (Pa)	4.788026 E + 04
newton per square meter (N/m^2)	pascal (Pa)	*1.000
pound per square foot (lb/ft^2)	pascal (Pa)	4.788026 E + 04
pound per square inch (lb/in^2)	pascal (Pa)	6.894757 E + 03

BENDING MOMENT

To Convert From	To	Multiply by
kilogram force meter (kgf-m)	newton meter (N-m)	*9.806650
kip-foot (kip-ft)	newton meter (N-m)	1.355818
pound-foot (lb-ft)	newton meter (N-m)	1.355818

*Exact Conversion.

SELECTED SI-METRIC CONVERSIONS, (Continued)

VELOCITY

To Convert From	To	Multiply by
foot per second (ft/s)	meter per second (m/s)	*3.048 E - 01
kilometer per hour (km/h)	meter per second (m/s)	2.777778 E - 01
mile per hour (mi/h or mph)	meter per second (m/s)	4.470400 E - 01
meter per hour (m/h)	meter per second (m/s)	2.777778 E - 04

VOLUME

To Convert From	To	Multiply by
cubic foot (ft^3)	cubic meter (m^3)	2.831685 E - 02.
cubic inch (in^3)	cubic meter (m^3)	1.638706 E - 05
cubic kilometer (km^3)	cubic meter (m^3)	*1.000 E + 09
cubic millimeter (mm^3)	cubic meter (m^3)	*1.000 E - 09

TEMPERATURE

To Convert From	Degrees Fahrenheit **ºF**	Degrees Celsius **ºC**
XºC =	9/5 X + 32	--------------
XºF =	---------------	5/9(X – 32)

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