UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Revision to Transmission Vegetation Management Reliability Standard	**))**	**Docket No. RM12-4-000**

COMMENTS OF THE
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Pursuant to the Federal Energy Regulatory Commission's ("FERC" or "Commission") Notice Inviting Comments on Report ("Notice Inviting Comments") issued on April 23, 2012, in the above-referenced proceeding, the North American Electric Reliability Corporation ("NERC") hereby submits comments in response to the report prepared by the Pacific Northwest National Laboratory ("PNNL") on "Applicability of the 'Gallet Equation' to the Vegetation Clearances of NERC Reliability Standard FAC-003-2" ("PNNL Report.").[1]

I. EXECUTIVE SUMMARY

Where the Commission solicits the technical expertise of outside consultants, such expertise would best be utilized within the framework of the existing NERC standard development process. While NERC does not dispute that it is appropriate for Commission Staff to seek technical assistance from outside experts, the standards development process would be more effective and efficient if such work were made available before a proposed standard has been approved by the ballot body and the NERC Board of Trustees.

A detailed response to the technical issues raised in the PNNL Report is included herein as **Attachment A**. In sum, the PNNL Report (a) improperly juxtaposes data included in the

[1] On May 4, 2012, the Commission released a Statement of Work in the above-referenced proceeding regarding the commissioning of the PNNL Report ("Statement of Work").

FAC-003-2 Reliability Standard; (b) disregards NERC's justification regarding the selection of transient overvoltage calculations; (c) fails to consider joint probability of independent events when analyzing flashover probability; and (d) disagrees with the choice of gap factor for vegetation without providing any empirical evidence, scientific reasoning, or expert consensus on what an appropriate gap factor should be.

NERC looks forward to the Notice of Proposed Rulemaking being issued in this docket where the merits of the entire proposed FAC-003-2 Reliability Standard can be evaluated and discussed.

II. NOTICES AND COMMUNICATIONS

Notices and communications with respect to this filing may be addressed to the following:[2]

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III. ATTACHMENTS

Attachment A NERC Technical Comments on PNNL Report

[2] Persons to be included on FERC's service list are indicated with an asterisk. NERC requests waiver of 18 C.F.R. § 385.203(b)(2011) to permit the inclusion of more than two people on the service list.

IV. BACKGROUND

On December 21, 2011, NERC submitted proposed Reliability Standard FAC-003-2—Transmission Vegetation Management to the Commission for approval ("Petition").[3] NERC also submitted an amendment on April 24, 2012. The proposed FAC-003-2 standard addresses the important goal of managing vegetation to maintain a reliable electric transmission system. At about the same time NERC was filing proposed FAC-003-2, the PNNL Report was commissioned by the Commission's Office of Electric Reliability "for the purpose of obtaining an independent analysis of certain technical questions raised by the Minimum Vegetation Clearance Distances as proposed in the North American Electric Reliability Corporation's Reliability Standard FAC-003-2 (Transmission Vegetation Management)."[4]

The PNNL Report concludes that the NERC filing "contains inconsistent assumptions about the value of the line overvoltage, and unsupported assumptions about the strength of an air gap between a line and some vegetation."[5] As discussed below, NERC disputes this claim.

V. NERC'S TECHNICAL COMMENTS ON THE PNNL REPORT

The conclusions in the PNNL report are predicated on assertions that in many cases, seem to be based on an incomplete understanding of the work undertaken by the Vegetation Management Standard Drafting Team ("VMSDT"). A complete response to the technical questions raised in the PNNL Report is included herein as **Attachment A**.[6]

In sum, the PNNL Report (a) improperly juxtaposes data included in the FAC-003-2 Reliability Standard; (b) disregards NERC's justification regarding the selection of transient

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[3] Exhibit I to the Petition, Transmission Vegetation Management – FAC-003-2 Technical Reference Document is herein referenced as "Technical Reference Document."

[4] Notice Inviting Comments at p. 1.

[5] PNNL Report at p. 19.

[6] On page 4, PNNL points out an error in NERC's assertion that the Gallet equation was used to design the first 500 kV and 765 kV lines in North America. NERC acknowledges this statement was made in error.

overvoltage calculations; (c) fails to consider joint probability of independent events when analyzing flashover probability; and (d) disagrees with the choice of gap factor for vegetation without providing any empirical evidence, scientific reasoning or expert consensus on what an appropriate gap factor should be.

The PNNL Report incorrectly disregards NERC's justification regarding the selection of Transient Overvoltage ("TOV") values used in developing FAC-003-2. The PNNL Report (at p. 19) states that overvoltages used in FAC-003-2 have not been calculated consistently; however, the methodology used is explained in the Technical Reference Document, and the inconsistency identified by the PNNL Report is actually a misunderstanding of: (i) the intended uses of each of the two separate tables from which PNNL draws its data, and (ii) the use of the term "maximum system voltage" as opposed to the "nominal system voltage." The PNNL Report (at p. 19) states that overvoltage is a result of line switching; however, the VMSDT explained in its Technical Reference Document (at p. 24) that switching was explicitly *not* being considered, as the standard is not intended to address overvoltages precipitated by switching.

The PNNL report also fails to consider the joint probability of independent events when analyzing flashover probability. Further, the Report incorrectly raises issues regarding the gap factor and offers no empirical evidence, scientific reasoning, or expert consensus on appropriate gap factors for vegetation.

For these reasons, as explained in further detail in **Attachment A**, NERC respectfully submits that the PNNL Report is technically flawed and deficient in its analysis of the mathematics and documentation of the technical justification behind the application of the Gallet equation.[7]

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[7] As NERC explained in its Petition (at p. 5-6), FERC provided guidance in Order No. 693 relative to the use of IEEE Standard 516-2003, therefore the proposed FAC-003-2 Reliability Standard no longer utilizes the IEEE

VI. THE COMMISSION MUST GIVE DUE WEIGHT TO NERC'S TECHNICAL EXPERTISE

Reliability Standards must be based on sound technical and engineering criteria, and where possible, draw on lessons learned from within the electric industry. The importance of technical expertise in the development of such standards has been acknowledged by the Commission.[8]

Section 215(d)(2) of the FPA mandates that the Commission give *due weight* to NERC's technical expertise with respect to the content of a proposed standard or modification to a Reliability Standard.[9] The concept of *due weight* is not defined in Section 215 and has not been explicitly defined by the Commission. In Order No. 693, the Commission noted that it would defer to the "technical expertise of NERC with respect to the content of a Reliability Standard."[10] However, the Commission has also stated that:

> while we respect the role of NERC as the ERO in developing and enforcing Reliability Standards, our task in reviewing proposed Reliability Standards is to ensure that they satisfy the statutory criteria for approval and provide for reliable operation of the Bulk-Power System. Thus, while the statute provides that the Commission shall give due weight to the technical expertise of the ERO with respect to the content of a proposed Reliability Standard or modification,

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clearance provisions. The standard requires minimum clearance distances derived from the Gallet Equation. There were four potential methods considered for use in the standard to derive flash-over distances for various voltages and altitudes. The Gallet method was selected in part because Gallet method information to support the development of the standard was readily available in an industry recognized reference. *See also* Petition at Exhibit I, Appendix 1.

8 *See e.g.*, *Rules Concerning Certification of the Electric Reliability Organization; and Procedures for the Establishment, Approval, and Enforcement of Electric Reliability Standards*, Order No. 672, FERC Stats. & Regs. ¶ 31,204 at PP 175-77, *order on reh'g*, Order No. 672-A, FERC Stats. & Regs. ¶ 31,212 (2006).

9 16 U.S.C. § 824o(d)(2).

10 *Mandatory Reliability Standards for the Bulk-Power System*, FERC Stats. & Regs. ¶ 31,242 at P 8 (2007) ("Order No. 693"), *reh'g denied*, 120 FERC ¶ 61,053 (2007) ("Order No. 693-A").

'we will not hesitate to remand a proposed Standard if we are convinced that it is not adequate to protect reliability.'[11]

As the Commission's former General Counsel and Chief of Staff has noted, "each time the Commission orders a standard modified under Section 215(d)(5), it has essentially chosen not to defer to the NERC's determination that the standard was acceptable as written."[12] While NERC does not dispute that it is appropriate for Commission Staff to seek technical assistance from outside experts, NERC's expertise and its role with respect to developing Reliability Standards must be afforded *due weight*.

A. Background: Historical Perspective on the Development of the "Due Weight" Standard of Deference

The legislative history of Section 215 of the FPA demonstrates that Congress rejected a Commission-centered regulatory model in favor of the industry-centered self-regulatory model that is in place today. During U.S. Senate consideration of an energy bill during 2002, the Senate debated two different approaches to reliability legislation. Senator Tom Daschle's approach ("Daschle Bill") contained reliability language that would have given the authority to develop Reliability Standards to FERC. Senator Craig Thomas proposed, instead, the approach that had been supported by both the Secretary of Energy Advisory Board's Task Force on Electric System Reliability ("DOE Task Force")[13] and the Clinton Administration to establish a

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[11] *North American Electric Reliability Corp.*, 132 FERC ¶ 61,218 at P 52 (2010)(citing Order No, 672, FERC Stats. & Regs, ¶ 31,204 at P 329.).

[12] John S. Moot, *When Should the FERC Defer to the NERC?* 31 Energy L. J. 317, 317 (2010).

[13] In response to the 1996 outages on the Western grid, the Secretary of Energy formed The Secretary of Energy Advisory Board's Task Force on Electric System Reliability to advise the Secretary on needed institutional reforms to improve electric system reliability. On September 29, 1998, the DOE Task Force issued a report recommending legislation that would allow for mandatory reliability standards. The Task Force recommended that a self-regulatory organization develop reliability standards rather than FERC, and that FERC have no authority to directly modify such standards:

> The FERC would have regulatory oversight to ensure compliance with and ultimately resolve disputes over any [self-regulatory organization] mandatory reliability standards. The [self-regulatory organization] would produce mandatory standards applicable to all participants in the domestic and international bulk-power

"participant-run, FERC-overseen electric reliability organization."[14] The Thomas Amendment was the basis for what eventually became Section 215 of the FPA. As Senator Thomas noted:

> This is very technical work that will require a very large commitment of resources. Unfortunately, FERC does not have either the technical capability or the manpower to take on such a significant new responsibility. FERC's expertise is ratemaking, not in technical standard setting.
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> Another key problem with [S. 517] is that it does not recognize regional differences in electrical systems due to the geography, the market design, the economics, and the operational factors. Many fear that FERC does not have the sensitivity to the regional differences that are so critically important . . . .
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> ….
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> Regional differences are best taken into account by those who are closest to the problem and those who understand what needs to be done, and that, unfortunately, is not FERC[15]

Congress recognized the experience and technical expertise of NERC, the industry, the States', and foreign jurisdictions' in drafting Reliability Standards and assigned them that responsibility.

B. "Due Weight" is Equivalent to Substantial Deference

In interpreting the FPA and other agency-related statutes, the courts have concluded that Congress's use of the term "due weight" equates to "substantial deference." For example, in *City of Oconto Falls v. FERC*,[16] the D.C. Circuit concluded that the provision in Section 10(j) of the FPA requiring the Commission to give "due weight" to the findings of expert state agencies on fisheries protection matters requires the Commission to accord "substantial deference" to those agencies.[17] Similarly, in *Northwest Research Information Center v. Northwest Power*

> system. The FERC would either confirm [self-regulatory organization] mandatory standards or deny them and refer them back to the [organization] with comments requesting revision and resubmittal of the standards.

Maintaining Reliability in a Competitive U.S. Electricity Industry: Final Report of the Task Force on Electric System Reliability, U.S. Department of Energy, p. 67 (September 29, 1998), available here: http://www.nerc.com/docs/docs/pubs/esrfinal.pdf.

[14] 148 Cong. Rec., S1873 (March 14, 2002).

[15] 148 Cong. Rec. 3217-18 (2002).

[16] 204 F.3d 1154 (D.C. Cir. 2000).

[17] *Id.* at 1160.

Planning Council,[18] the Ninth Circuit examined language in the Northwest Power Act requiring the Northwest Power Planning Council to give "due weight" to the findings of expert fish and wildlife agencies and found that this language required the Council to accord a "high degree of deference" to those expert agencies.[19]

An analysis of the language of Section 215(d)(2) also demonstrates that Congress intended "due weight" to equate to "deference." This is apparent from the fact that, while Section 215(d)(2) requires the Commission to accord "due weight" to NERC's technical expertise in developing Reliability Standards, it states that the Commission "shall not defer" with respect to whether a standard affects competition.[20] Hence, the statute draws a distinction between the requirement to accord "due weight" to NERC's technical findings, and the requirement that it "shall not defer" to NERC's findings concerning competition. In light of the legislative history discussed above, it is clear that Congress intended the Commission to accord substantial deference to NERC's technical expertise in developing Reliability Standards.

C. NERC's Technical Expertise

NERC assembled a team of seventeen industry experts with over five hundred years of collective experience across the following electric transmission system functions, design, operations, maintenance, and vegetation control.[21] This team researched the current body of knowledge to determine an approach other than IEEE 516-2003 to establish appropriate distances within which vegetation must be kept clear. NERC believes that the FAC-003-2 Reliability Standard represents a logical, reasoned approach to managing vegetation.

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[18] 35 F.3d 1371 (9th Cir. 1994).

[19] *Id.* at 1388.

[20] 16 U.S.C. § 824o(d)(2).

[21] *See* Petition at Exhibit H, Standard Drafting Team Roster for NERC Standards Development Project 2007-07, Vegetation Management.

However, as a learning organization, NERC is committed to continuous improvement. While NERC does not see any alternative suggestions offered within the PNNL Report, to the extent the Commission (or the laboratory it commissioned to provide a technical review of FAC-003-2) has suggestions for improvement of the standard, NERC is interested in this feedback, and encourages the Commission and Commission staff to explore ways that such information can be provided to NERC through the formal steps of the standards development process.

VII. COMMISSION ANALYSIS OF TECHNICAL QUESTIONS SHOULD OCCUR DURING THE STANDARD DEVELOPMENT PROCESS

The Commission contracted for an estimated start day for the PNNL Report analyzing technical questions with respect to the FAC-003-2 Reliability Standard one day prior to NERC's filing of the proposed Reliability Standard.[22] PNNL worked on this report for six calendar weeks[23] and Commission Staff allowed thirty days for comment in the Notice Inviting Comments. The Commission also issued a data request on May 4, 2012, requesting additional information in order to better understand NERC's petition.

NERC respectfully submits that the Commission's technical expertise should be utilized within the NERC Reliability Standard development process, rather than applied in a post-hoc manner. Rather than commissioning a report analyzing the FAC-003-2 Reliability Standard after it was developed, it would have been beneficial and more efficient for the Commission and its experts, both internal and external, to present any technical concerns within the existing framework of the Commission-approved process.

A. Commission Staff's Active Participation in the Standards Development Process is Consistent with the Mission of the Office of Electric Reliability

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22 *See* Scope of Work at Section 7.0.

23 *See* Scope of Work at Section 8.0.

The Office of Electric Reliability ("OER") was created by the Commission on September 20, 2007, to focus on the development and implementation of mandatory and enforceable Reliability Standards.[24] NERC respectfully submits that OER should actively and formally participate in the development of Reliability Standards and that such a role is consistent with and fulfills the purpose of the formation of OER and specifically, the Division of Reliability Standards.

Commission Staff currently attend Standard Drafting Team meetings and can and should participate freely in the standard development process, including offering their written comments for consideration. Indeed, 18 C.F.R § 375.303 (2011) provides that Commission Staff upon request or otherwise, can "issue staff position papers to further the Electric Reliability Organization and Regional Entity reliability standard development process." The Commission's website for the Office of Electric Reliability, Division of Reliability Standards states that it:

> Participate[s] in the ERO's standards development process to inform the Commission of potential issues and problems associated with the developing standards. ***Provide[s] input to the process to help improve the quality of the standards <u>before they are submitted to the Commission for approval</u>.***[25]

However, the reality is that Commission Staff rarely participate in the standard development process on the record. Commission Staff are hesitant to provide any input in writing, even with an appropriate disclaimer, and have refused invitations to participate as panelists on NERC technical conferences on Reliability Standards. An open and participatory dialogue between Commission Staff and NERC Staff and NERC Standard Drafting Teams is an essential element to the effective and efficient development of Reliability Standards.

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[24] *See Delegations to the Office of Electric Reliability*, Order No. 701, 121 FERC ¶ 61,066 (2007).

[25] *See* http://www.ferc.gov/about/offices/oer/oer-dors.asp (emphasis added).

B. Commission Staff's Active Participation in the Standard Development Process is Consistent with NERC's Principles

NERC is committed to an open and fair standards development process consistent with its American National Standards Institute accreditation. Section 304 of the NERC Rules of Procedure provides that the standards process will be consistent with the following essential principles:

- 1. **Openness —** Participation shall be open to all Persons who are directly and materially affected by the reliability of the North American Bulk Power System. There shall be no undue financial barriers to participation. Participation shall not be conditional upon membership in NERC or any other organization, and shall not be unreasonably restricted on the basis of technical qualifications or other such requirements.

- 2. **Transparency —** The process shall be transparent to the public.

- 3. **Consensus-building —**The process shall build and document consensus for each Reliability Standard, both with regard to the need and justification for the Reliability Standard and the content of the Reliability Standard.

- 4. **Fair Balance of Interests —** The process shall fairly balance interests of all stakeholders and shall not be dominated by any single interest category.

- 5. **Due Process** — Development of Reliability Standards shall provide reasonable notice and opportunity for any Person with a direct and material interest to express views on a proposed Reliability Standard and the basis for those views, and to have that position considered in the development of the Reliability Standards.

- 6. **Timeliness —** Development of Reliability Standards shall be timely and responsive to new and changing priorities for reliability of the Bulk Power System.

Consistent with these principles, NERC encourages the Commission and its Staff to participate openly and transparently within the standards development process to the extent that it is able to do so.

The NERC Board of Trustees recently recommended that NERC management "develop a strategy for improving communication and awareness of effective reliability risk controls which increases input and alignment with state, federal, and provincial authorities."[26] Specifically, one of the recommendations is to "[e]ncourage regulatory authorities to permit staff to submit **written comments** to the drafting team during informal and formal comment periods."[27]

The Commission should permit its Staff to participate and provide written comments to Standard Drafting Teams early in the process. NERC does not dispute that it is appropriate for Commission Staff to seek technical assistance from outside experts. NERC believes, however, that the standards development process would be more effective and efficient if such work were made available to the standards development process before a proposed standard has been approved by the ballot body and the NERC Board of Trustees.

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[26] *See* Recommendations of the Standards Process Input Group at p. 10, available here: http://www.nerc.com/docs/bot/agenda_items/9-Standards%20Process%20Input%20Group%20-%2004%2024%2012%20ver%208%20FINAL-CLEAN%20(3).pdf.

[27] *Id*. (emphasis added).

VIII. CONCLUSION

For the foregoing reasons, NERC respectfully submits that the PNNL Report contains certain errors and inaccurate information. Further, NERC submits that the Commission's technical expertise should be utilized within the NERC Reliability Standard development process.

Respectfully submitted,

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Dated: May 23, 2012

ATTACHMENT A

Technical Comments of the North American Electric Reliability Corporation on the PNNL Report on the Applicability of the Gallet Equation to the Vegetation Clearances of NERC Reliability Standard FAC-003-2

I. Overview

The North American Electric Reliability Corporation ("NERC") submits the following technical comments in response to the report prepared by the Pacific Northwest National Laboratory ("PNNL") on "Applicability of the 'Gallet Equation' to the Vegetation Clearances of NERC Reliability Standard FAC-003-2" ("PNNL Report"). The PNNL Report's conclusions are predicated on assertions that seem in many cases to be based on an incomplete understanding of the work undertaken by NERC. The PNNL Report incorrectly applies assumptions used to determine the minimum vegetation clearance distances specified in FAC-003-2.

In sum, the PNNL Report (a) improperly juxtaposes data included in the FAC-003-2 Reliability Standard; (b) disregards NERC's justification regarding the selection of transient overvoltage values; (c) fails to consider joint probability of independent events when analyzing flashover probability; and (d) disagrees with the choice of gap factor for vegetation without providing any empirical evidence, scientific reasoning or expert consensus on what an appropriate gap factor should be.

The majority of the technical comments provided herein are devoted to reviewing the Technical Reference document associated with FAC-003-2 and more carefully explaining the rationales within to ensure a better understanding of the FAC-003-2 standard.

II. Background

The Federal Energy Regulatory Commission ("FERC" or the "Commission"), in Order No. 693, indicated the IEEE Standard 516-2003, upon which the previous Reliability Standard was based, was "intended for use as a guide by highly-trained maintenance personnel to carry out live-line work using specialized tools under controlled environments and operating conditions, not for those conditions necessary to safely carry out vegetation management practices."[1] Further, the Commission stated, "use of IEEE clearance provision as a basis for minimum clearance prior to the next tree trimming as a Requirement in vegetation management is not appropriate for safety and

[1] *Mandatory Reliability Standards for the Bulk-Power System*, FERC Stats. & Regs. ¶ 31,242 at P 731 (2007) ("Order No. 693"), *reh'g denied*, 120 FERC ¶ 61,053 (2007) ("Order No. 693-A").

reliability reasons," and directed NERC to develop a Reliability Standard that defines the minimum clearance distances needed to avoid sustained vegetation-related outages.[2]

On December 21, 2011, as amended on April 24, 2012, NERC submitted proposed Reliability Standard FAC-003-2—Transmission Vegetation Management to the Commission for approval.

III. The PNNL Report Improperly Juxtaposes Data Included in the FAC-003-2 Reliability Standard

In Table ES-I, the PNNL Report (at page v) juxtaposes two tables of data– the comparative "sparkover" distance from page 34 of the Guidelines and Technical Basis section of NERC's FAC-003-2 Reliability Standard, and the "MVCD" table (Minimum Vegetation Clearance Distance) from NERC's FAC-003-2 Technical Reference document that is incorporated by reference into the Requirements of FAC-003-2. PNNL then uses this newly created table to highlight what are referred to as "inconsistencies" within the NERC filing. While this may be an interesting comparison of data, these two sets of data were developed with completely different purposes in mind, and so the presence of PNNL's newly created table for any analysis is misleading.

The first set of values are those provided by the NERC Vegetation Management Standard Drafting Team ("VMSDT") to demonstrate relative consistency between the values published in IEEE-516-2003 and values derived though the use of the Gallet Equation **when using similar assumptions as those used in IEEE-516-2003.** These values were included as part of a larger table within the standard that compared these values with those from IEEE 516-2003. As demonstrated in that document, this indicates that the Gallet method yields a more conservative approach (that is, greater air insulation separation distances) when comparing the same personnel safety factors associated with performing "live work."

The second set of values are those identified by the VMSDT and approved by the industry at large as being appropriate distances to maintain for clearances in Vegetation Management. These values were calculated using the Gallet equations, with a set of assumptions determined by the VMSDT to be consistent with the purposes of the standard. Accordingly, they have been included within the FAC-003-2 Reliability Standard.

PNNL acknowledges that the two sets of values are different, and asserts that the reason for their difference is the different assumptions used in their determination. NERC agrees with PNNL's assertion – different assumptions **were** used in the calculation of the two sets of values.

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2 Order No. 693 at P 731.

The PNNL Report further suggests that the only contextual difference between the two sets of values from each other is their names ("sparkover" versus "MVCD").[3] This is incorrect. As discussed above (and as FERC acknowledged in Order No. 693),[4] these values have been intentionally developed for two entirely different purposes. The first set of values uses assumptions associated with protecting personnel during "live-work" maintenance. The second set of values use assumptions based on a goal of "preventing the risk of those vegetation-related outages that could lead to Cascading."

IV. The PNNL Report Incorrectly Disregards NERC's Justification Regarding the Selection of Transient Overvoltage Values

The PNNL Report raises questions related to the Transient Overvoltage ("TOV") values used in developing FAC-003-2. These values are intended to account for "surge" voltages that may occur on the line due to lightning, switching of the line, surges associated with switching of other nearby or connected lines propagating through the network, and induced voltage surges caused by other parallel lines within the Right-of-Way. This vegetation management standard is designed to protect in-service lines (not lines being switched); therefore the VMSDT chose appropriate TOVs for in-service lines that account for indirect surges (i.e., switching of other lines, or induced voltage via coupling). The full rationale for the team's choice of TOVs is detailed in the Technical Reference Document. From page 41:

> In general, the worst case transient overvoltages occurring on a transmission line are caused by energizing or re-energizing the line with the latter being the extreme case if trapped charge is present. The intent of FAC-003 is to keep a transmission line that is *in service* from becoming de-energized (i.e. tripped out) due to sparkover from the line conductor to nearby vegetation. Thus, the worst case scenarios that are typically analyzed for insulation coordination purposes (e.g. line energization and re-energization) can be ignored. For the purposes of FAC-003-2, the worst case transient overvoltage then becomes the maximum value that can occur with the line energized. Determining a realistic value of transient overvoltage for this situation is difficult because the maximum transient overvoltage factors listed in the literature are based on a switching operation of the line in question. In other words, these maximum overvoltage values are based on the assumption that the subject line is being energized, re-energized or de-energized. These operations, by their very nature, will create the largest transient overvoltages. Typical values

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3 *See* PNNL Report at p. v. ("In essence, the Table says that for a distance that is to be called Sparkover, a certain set of assumptions will be made. For a distance that is to be named MVCD, a different set of assumptions will be applied.").

4 *See* Order No. 693 at P 731 ("The Commission declines to endorse the use of IEEE 516 as the only minimum clearance because it is intended for use as a guide by highly-trained maintenance personnel to carry out live-line work using specialized tools under controlled environments and operating conditions, not for those conditions necessary to safely carry out vegetation management practices.").

> of transient overvoltages of in-service lines, as such, are not readily available in the literature because the resulting level of overvoltage is negligible compared with the maximum (e.g. re-energizing a transmission line with trapped charge). A conservative value for the maximum transient overvoltage that can occur anywhere along the length of an in-service ac line is approximately 2.0 p.u. This value is a conservative estimate of the transient overvoltage that is created at the point of application (e.g. a substation) by switching a capacitor bank without a pre-insertion device (e.g. closing resistors). At voltage levels where capacitor banks are not very common (e.g. 362 kV), the maximum transient overvoltage of an "in-service" ac line are created by fault initiation on adjacent ac lines and shunt reactor bank switching. These transient voltages are usually 1.5 p.u. or less. It is well known that these theoretical transient overvoltages will not be experienced at locations remote from the bus at which they were created; however, in order to be conservative, it will be assumed that all nearby ac lines are subjected to this same level of overvoltage. Thus, a maximum transient overvoltage factor of 2.0 p.u. for 302 kV and below and 1.4 p.u. for ac transmission lines 362 kV and above is used to compute the required clearance distances for vegetation management purposes.
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> The overvoltage characteristics of dc transmission lines vary somewhat from their ac counterparts. The referenced empirically derived transient overvoltage factor used to calculate the minimum clearance distances from dc transmission lines to vegetation for the purpose of FAC-003-2 will be 1.8 p.u.

The PNNL Report alleges in its Executive Summary that there are "inconsistencies" within the NERC filing, and provides a table derived from assembling two different tables from two different NERC documents.

The higher TOV factors used in the table on page 31 of the FAC-003-2 standard are the TOV values historically used by the industry as defaults when implementing IEEE-516. IEEE-516 is intended to limit the possibility of a flashover occurring at a work site if a transient overvoltage were to pass through the work site when workers are present. This is not consistent with the stated purpose of the FAC-003-2 standard. While both FAC-003-02 and IEEE 516 set distance values to limit the possibility of flashover, the two standards have different applications and thus, the application of different TOV levels is appropriate.

The following table compares the IEEE-516-2003 Minimum Air Insulation Distances ("MAID") and the Gallet clearance distances using consistent TOV values in both equations. Unlike the table included with FAC-003-2, this table provides a set of MAID-like values that have been calculated using TOVs consistent with the assumptions made by the VMSDT regarding Vegetation Management. To the extent an entity believes its personnel would be exposed to similar TOVs, the Gallet values are actually more conservative than those that would be calculated based on IEEE-516-2003 MAID.

Comparison of spark-over distances computed using Gallet vs. IEEE-516-2003 MAID equations

Nom System Voltage (kV)	Max System Voltage (kV)	Over-voltage Factor (TOV)	Distance Gallet @ Alt. 3000 feet	IEEE-516-2003 MAID @ Alt. 3000 feet	Additional distance afforded by MVCD beyond MAID
765	800	1.4	8.89 ft	7.76 ft	1.13 ft (13.56 in)
500	550	1.4	5.66 ft	4.49 ft	1.17 ft (14.04 in)
345	362	1.4	3.53 ft	2.93 ft	0.60 ft (7.20 in)
230	242	2.0	3.36 ft	2.80 ft	0.56 ft (6.72 in)
115	121	2.0	1.61 ft	1.40 ft	0.21 ft (2.52 in)

In summary, the Gallet values are **larger** than the IEEE MAID values when using consistent TOV levels.

V. The PNNL Report Fails to Consider the Joint Probability of Independent Events when Analyzing Flashover Probability

In section 2.3.1, the PNNL Report discusses the probability of flashover. NERC concurs with PNNL Report's estimation of the probability as roughly 0.13% (or approximately 10^{-3}), given a drop in voltage to 85% of the "Critical Flashover Voltage (CFO)." This value represents the probability of a flashover, assuming the specified CFO is achieved or exceeded (as shown in PNNL's figure 2, the "Peak Voltage").

However, this is not the only system event being considered when attempting to model the probability of a vegetation flashover. The probability of achieving a maximum switching overvoltage ("Peak Voltage") in excess of the CFO must also be considered. This is shown on page 40 in equation 6 of the Technical Reference Document, and is specified there as roughly 0.135% (also approximately 10^{-3}).

In other words, the conditional probability of flashover **given** that the 85% CFO has been exceeded is approximately 10^{-3}. However, the probability of the CFO being exceeded is **also** 10^{-3}. As these can be treated as two independent events, the probability is statistically "joint" (the probability of exceeding the CFO **and** the probability of a flashover given the exceeding of the CFO are independent events). Accordingly, the two probabilities are to be multiplied, yielding a probability on the order of magnitude of approximately 10^{-6}.

For a more specific accounting of the number, the probability of an event (as defined in a standard normal table) being in excess of the mean plus three standard deviations is approximately 0.13%. Multiplying this value by itself (once for each independent event) results in a value of 0.000169% (technically 1.69 X 10^{-6}), or approximately a 1 in 591,716 chance of occurrence.

A. The use of Multiple Gaps to Address Vegetation Threats is Irrelevant and Impractical

PNNL on page 11 raises an issue related to "multiple gaps" that could exist and the associated impact on the probability of flashover.[5]

However, by their nature, vegetation threats are typically isolated events along the line. Vegetation does not grow uniformly, and there will always be vegetation at various distances from the conductor. The FAC-003 standard is designed to keep the closest vegetation well outside the MVCD. As such, the use of "multiple gaps" to address vegetation threats is an interesting theoretical approach based on an assumption of multiple uniform gaps, but it is not relevant or practical when considering the non-uniform vegetation growth being addressed by this standard.

VI. Gap Factor

The PNNL Report also incorrectly raises issues regarding the Gap Factor in several areas of the Report. The Gap Factor is a value determined through empirical means, and is used to represent the difference in voltage-withstand capability between a given object and a reference case (a rod-plane gap). PNNL asserts on page 13:

> "There is no basis for asserting that a *tree* has a gap factor of 1.3 (or any other number) and therefore has a *stronger* withstand capability than a rod-plane gap." (emphasis in original).

A. The PNNL Report offers no empirical evidence, scientific reasoning, or expert consensus on appropriate Gap Factors for vegetation.

The VMSDT relied on the widely regarded *Insulation Coordination for Power Systems*, by Andrew Hileman, to develop this assertion, based on the table below:

[5] The PNNL Report states: "there is a one-third chance of flashover with 20 gaps in parallel." *See also* Figure 3, Withstand Probability for Multiple Gaps.

ATTACHMENT A

Table 3 Typical Value of Gap Factors k_g for Phase-Ground Insulations

Gap Configuration	Range of k_g	Typical value of k_g
Rod-plane	1.00	1.00
Rod-rod (vertical)	1.25 – 1.35	1.30
Rod-rod (horizontal)	1.25 – 1.45	1.35
Conductor-lateral structure	1.25 – 1.40	1.30
Conductor-lower rod	1.40 – 1.60	1.50

It is worth noting that the gap factors for many shapes that could approximate vegetation are even higher than the 1.3 used in FAC-003-2, with ranges that include values as high as 1.6. Hileman notes that in regards to the substation environment (which includes many objects, conducting and non-conducting, with varying shapes and configurations): "Practically, the lowest gap factor in the substation is 1.3, which normally is conservative."[6]

PNNL makes the following statement on page 16:

> "Rod-plane testing is used in tower design because the rod-plane gap has a lower value of CFO than any other configuration of metal."

The VMSDT relied on this fact when developing FAC-003-2. Additionally, the VMSDT did not rely on any specific properties inherent in trees; rather, the VMSDT conservatively assumed that vegetation had the same properties as metal. The VMSDT elected to use the "typical" value for "conductor to lateral structure." Unlike the other examples given, which specify a "typical" value that is equivalent to the midpoint of the range, this value (1.3) is within the conservative third of the range (1.25 – 1.4). This is also consistent with Hileman's statement referenced above.

PNNL continues (at p. 16) with the following:

> "It has been found experimentally that tower window configurations require a higher voltage to flash over than the rod-plane of the same gap. **That is to say, the gap factors are greater than unity.** However, there is no reason to suppose that a gap factor of less than unity could not exist in the case of vegetation encroachment." (emphasis added).

[6] Andrew Hileman, *Insulation Coordination for Power System*, Marcel Dekker, New York, NY 1999 at 167.

The PNNL Report offers no empirical evidence, scientific reasoning, or expert consensus on appropriate gap factors for vegetation. More importantly, there is no justification for the suggestion that the gap factors for vegetation could be less than unity. This assertion appears to be based purely on speculation. The VMSDT relied on the scientific body of available knowledge and the opinions of experts (applied conservatively) currently working in industry to use the gap factor of 1.3 – the specified typical value for "conductor to lateral structure."

VII. Additional Comments

NERC has the following additional technical comments regarding the PNNL Report:

- On page 5, the PNNL Report states:

  > It is shown in an Appendix of this IEEE Guide [Std 516 – 2009] that the phase-phase voltage following reclosing a tripped line can exceed 4 times the normal line voltage. However, the line-ground overvoltage is lower, and is typically held to be no more than a factor of 2. (internal citation omitted).

  In order to ensure a clear understanding of the assumptions made, the VMSDT wishes to correct this statement. The value for the phase-to-phase voltage following reclosing a tripped line should be reported at approximately **2.3** (4/ ¯ 2.3) times the normal **phase-to-phase** voltage, not 4 times the normal line voltage.

  Regardless, whether the correct value is 4 or 2.3 is irrelevant, as the PNNL Report is describing a scenario (a reclosing of an already faulted line) for which the standard was never intended to be applicable.

  Also, the statement above that "the line-ground overvoltage is lower, and is typically held to be no more than a factor of 2," could be correct in some cases, but will be incorrect in many other cases. In reality, the maximum line-ground overvoltage range could be different for various system voltage levels. In general the range is about 1.2 to about 3 times the normal line to ground voltage. The values depend on switching operation (closing versus reclosing, single versus three phase switching), system topology, source strength, line length, line geometry and conductor type, series and / or shunt line compensation, single vs. double circuit, types of overvoltage mitigation (such as breaker resistors, surge arresters at the line terminals and /or along the line, switching control), etc.

- The PNNL Report also questions (at p. 6) the use of the Gallet "wet" equations. The Report states:

> "for an air-gap the withstand is the same whether or not it is raining. The presence of rain affects only the performance of insulator strings (see the Red Book, 'Effects of Rain,' page 550)." (internal citation omitted).

PNNL continues within a footnote (fn. 9):

> "It is observed a few pages earlier [in the Red Book] that the flashover voltage for a given path in air is increased for an increase in air density or humidity. That statement makes it hard to understand why the 'wet' description is used in the NERC Table."

As has been discussed extensively, when developing the FAC-003-2 standard, the VMSDT considered the IEEE paper "General Expression for Positive Switching Impulse Strength Valid Up to Extra Long Air Gaps" (in which the Gallet equations are documented). In this paper, the following language is included:

"…artificial rain reduces the sparkover voltage by an extra 5% to 7% , the electrode geometry being affected by the water droplets."

The VMSDT chose to accept this assertion as valid (in opposition to the assertion contained in the Red Book) based on its own experiences. This is reflected in the Technical Reference Document on page 39, in which a k_w value of 1.037 is proposed to be used (the product of the phase arrangement for outside phase (1.08) and wet conditions (0.96)). This produces more conservative distances than would have otherwise been developed had an assumption been made that there was no difference between "wet" and "dry" conditions.

- PNNL expresses concern (at p. 6) that the reader is given "no rule (for TOVs) in this part of Exhibit for any of the thousands of miles of line in the U.S. at 345kV." The PNNL Report seems to be asserting that there is a "gap" in coverage, such that it is supposedly unclear which TOV should apply given the specified voltage (345kV). NERC wishes to clarify this point; **all** of the voltages listed in this table are specified in terms of "maximum system voltage." This is the voltage that was used in determining the clearance distances listed, and as such, it was specified in the Technical Reference Document when describing the calculation of the associated values. For clarity in application and enforcement, the FAC-003-2 standard includes the both the "nominal voltages" (69, 88, 115, 138, 161, 230, 287, 345, 500, and 765) and the respective Maximum System Voltages (72, 100, 121, 145, 169, 242, 302, 362, 550, and 800). The 345kV calculations are addressed on the third line of Table 1 in the Technical Reference document and likewise in Table 2 of the Standard.

- PNNL cites the Transmission Line Reference Book (EPRI Red Book), and references its compiled tabulation of EHV line characteristics for 345kV, 500kV and 765kV voltages. This tabulation was compiled from surveys based on a diverse sampling of in-service and proposed line designs. PNNL then uses this data to imply support for the statement "there is no reason to suppose that a tree could safely be allowed so much closer to a line (less than 6 ft) than a tower." However, care must be taken when making an interpretation of the tabular data, as the original survey participants may have answered the questions in a general context involving multiple structure designs. The final structure design parameters provided in the Red Book include the CFO gap plus other factors (such as insulator geometry, personnel safety and extreme lightning events). Accordingly, they should not be considered the final word with regard to Vegetation Management, as those distances were established to address a number of other issues. FAC-003-2 is not intended to mandate the parameters for all future line designs; it is focused solely on the distances necessary to mitigate the risk of vegetation related outages.

VIII. Summary and Conclusions

The PNNL Report's conclusions are predicated on assertions which in many cases are based on an incomplete understanding of the work undertaken by NERC. The Report:

- Improperly juxtaposes data from two separate tables;
- Misunderstands the use of the term "maximum system voltage" as opposed to the "nominal system voltage;"
- Disregards the justification regarding the selection of transient overvoltage values and fails to acknowledge that the FAC-003-2 Reliability Standard is not intended to address overvoltage precipitated by line switching;
- Disagrees with the choice of gap factor for vegetation without providing any empirical evidence, scientific reasoning or expert consensus on the what an appropriate gap factor should be; and
- Fails to consider joint probability of independent events when analyzing flashover probability.

While reasonable experts can differ, the PNNL Report has not offered reasoned or supported alternative suggestions for addressing the concerns it raises. Further, the PNNL Report fails to acknowledge or understand the details provided in the Technical

Reference Document or the FAC-003-2 Reliability Standard. NERC agrees that there are times when empirical research and "field testing" is required prior to development of a standard. However, NERC believes the FAC-003-2 Standard represents an overall improvement to the reliability of the electric transmission system. Given the conservatism included in the VMSDT's assumptions, such testing in this case would be unlikely to produce any data that would significantly change the tables in FAC-003-2. This is demonstrated by the comparison of the Gallet values against the IEEE-516-2003 MAID values when using similar TOVs, provided earlier in this document. To the extent any such studies are performed, NERC stands ready to incorporate the lessons learned into future standards. However, at this time, NERC believes the FAC-003-2 standard represents the most reasonable approach to vegetation management using the best information currently available.

For these reasons, NERC asks that the Commission continue to afford "due weight" to the ERO and the work performed to develop the FAC-003-2 solution. NERC is committed to maintaining the reliability of the Bulk Power System in North America, and NERC appreciates any constructive feedback or suggestions that FERC's technical staff or contractors care to provide.