NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

March 3, 2015

VIA ELECTRONIC FILING

Ms. Katie Mitchell
Chief Clerk
New Brunswick Energy and Utilities Board
P.O. Box 5001
15 Market Square, Suite 1400
Saint John, NB
E2L 4Y9

RE: *North American Electric Reliability Corporation*

Dear Ms. Mitchell:

The North American Electric Reliability Corporation ("NERC") hereby submits Notice of Filing of the North American Electric Reliability Corporation of Proposed Reliability Standard TPL-007-1 Transmission System Planned Performance for Geomagnetic Disturbance Events. NERC requests, to the extent necessary, a waiver of any applicable filing requirements with respect to this filing.

Please contact the undersigned if you have any questions.

Respectfully submitted,

/s/ Holly A. Hawkins

Holly A. Hawkins
Associate General Counsel for the North American Electric Reliability Corporation

Enclosure

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BEFORE THE
MINISTRY OF ENERGY
OF THE PROVINCE OF NEW BRUNSWICK

NORTH AMERICAN ELECTRIC	**)**
RELIABILITY CORPORATION	**)**

NOTICE OF FILING OF THE NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION OF PROPOSED RELIABILITY STANDARD TPL-007-1 TRANSMISSION SYSTEM PLANNED PERFORMANCE FOR GEOMAGNETIC DISTURBANCE EVENTS

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NOTICE OF FILING OF THE NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION OF PROPOSED RELIABILITY STANDARD TPL-007-1 TRANSMISSION SYSTEM PLANNED PERFORMANCE FOR GEOMAGNETIC DISTURBANCE EVENTS

The North American Electric Reliability Corporation ("NERC") hereby submits proposed Reliability Standard TPL-007-1 – Transmission System Planned Performance for Geomagnetic Disturbance Events and the accompanying definition of "Geomagnetic Disturbance Vulnerability Assessment or GMD Vulnerability Assessment" ("Definition"). NERC submits the proposed Reliability Standard in response to the Federal Energy Regulatory Commission's ("FERC") directive in Order No. 779 to develop a Reliability Standard that requires owners and operators of the Bulk-Power System to conduct initial and on-going vulnerability assessments of the potential impact of benchmark geomagnetic disturbance events on the Bulk-Power System equipment and the Bulk-Power System as a whole.[1]

Proposed Reliability Standard TPL-007-1 (**Exhibit A**) and the Definition are just, reasonable, not unduly discriminatory or preferential, and in the public interest.[2] NERC also provides notice of: (i) the associated implementation plan (**Exhibit B**) for the proposed

[1] Order No. 779, *Reliability Standards for Geomagnetic Disturbances*, 143 FERC ¶ 61,147 ("Order No. 779").

[2] Unless otherwise designated, all capitalized terms shall have the meaning set forth in the *Glossary of Terms Used in NERC Reliability Standards*, *available at* http://www.nerc.com/files/Glossary_of_Terms.pdf.

Reliability Standard; and (ii) the associated Violation Risk Factors ("VRFs") and Violation Severity Levels ("VSLs") (**Exhibits A and G**). The NERC Board of Trustees adopted proposed Reliability Standard TPL-007-1 on December 17, 2014.

This filing presents the technical basis and purpose of proposed Reliability Standard TPL-007-1, a demonstration that the proposed Reliability Standard meets the Reliability Standards criteria (**Exhibit C**), and a summary of the development history (**Exhibit I**).

I. EXECUTIVE SUMMARY

Geomagnetic disturbances ("GMDs") occur during solar storms when the sun ejects charged particles directed toward the earth, and the magnetic field associated with these charged particles interacts with the earth's magnetic field. This interaction could cause geomagnetically-induced currents (also known as "GICs") to flow in an electric power system through transmission lines and grounded transformer windings. GMDs can be of varying intensity, and their impact on an electric power system is dependent on a number of factors, including where the geomagnetic storm is located, the magnitude and direction of the geomagnetic fields, the geomagnetic latitude of the electric power system, the local geology (i.e., electrical conductivity of the ground), and the characteristics of the electric power system.

During a GMD event, GIC flow in transformers can substantially increase absorption of reactive power and create harmonics, resulting in a risk of voltage instability or voltage collapse. In some cases, GIC flow in power transformers can cause increased transformer hot-spot heating, which can lead to equipment loss of life or damage. The science regarding the impacts of GMDs on electric power systems is still evolving, and much remains to be learned about the unique threat GMDs pose to the reliability of the Bulk-Power System. However, as FERC noted in Order No. 779, "while there is an ongoing debate as to how a severe GMD event will most likely impact the Bulk-Power System, there is a general consensus that GMD events can cause wide-

spread blackouts due to voltage instability and subsequent voltage collapse, thus disrupting the reliable operation of the Bulk-Power System."[3]

Proposed Reliability Standard TPL-007-1, together with Reliability Standard EOP-010-1, addresses the unique risks posed by a high-impact, low-frequency GMD event on the reliable operation of the Bulk-Power System and is responsive to FERC's concerns articulated in Order No. 779. As FERC established in Order No. 779, the proposed Reliability Standard "should include Requirements whose goal is to prevent instability, uncontrolled separation, or cascading failures of the Bulk-Power system when confronted with a benchmark GMD event."[4] The proposed standard is responsive to this directive by requiring owners and operators of the Bulk-Power System to conduct initial and on-going assessments of the potential impact of a defined GMD event (referred to herein as the "Benchmark GMD Event") on Bulk-Power System equipment and the Bulk-Power System as a whole. The Benchmark GMD Event used to develop the proposed standard[5] is based on a 1-in-100 year frequency of occurrence, and is supported by rigorous technical analysis of modern measurement data and publicly-available models. The proposed Benchmark GMD Event sets a high benchmark for reliability, as it represents the most severe GMD event expected in a 100-year period as determined by a statistical analysis of recorded geomagnetic data. Additionally, the proposed standard specifies parameters for assessments that will identify impacts from this Benchmark GMD Event and requires corrective action to protect against instability, uncontrolled separation, and cascading failures of the Bulk-Power System.

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[3] Order No. 779 at P 24 (internal citation omitted).

[4] Order No. 779 at P 84.

[5] *See* Order No. 779 at P 54 ("The Second Stage GMD Reliability Standard must identify what severity GMD events (*i.e.,* benchmark GMD events) that responsible entities will have to assess for potential impacts on the Bulk-Power System.")

The proposed Reliability Standard represents a significant milestone in NERC's ongoing efforts to understand and address the unique reliability risks that high-impact, low-frequency GMD events pose to the Bulk-Power System. The assessments and other actions required by the proposed standard complement the Operating Plans, Processes, and Procedures required in the EOP-010-1 Reliability Standard to address GMD impacts to the Bulk-Power System. Additionally, implementation of the proposed Reliability Standard will provide opportunities to further mature the tools, models, and techniques for assessing potential impacts of GMDs. Proposed Reliability Standard TPL-007-1 is just, reasonable, not unduly discriminatory or preferential, and in the public interest.

II. NOTICES AND COMMUNICATIONS

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

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III. BACKGROUND

In Order No. 779, FERC directed NERC to develop a set of Reliability Standards to address GMDs in two stages. In the first stage, NERC developed Reliability Standard EOP-010-1, requiring owners and operators of the Bulk-Power System to develop and implement

operational procedures to mitigate the effects of GMDs consistent with the reliable operation of the Bulk-Power System. FERC approved Reliability Standard EOP-010-1 in Order No. 797.[6] In the second stage, FERC directed NERC to develop one or more proposed Reliability Standards that require owners and operators of the Bulk-Power System to conduct initial and on-going vulnerability assessments of the potential impact of benchmark GMD events on Bulk-Power System equipment and the Bulk-Power System as a whole.[7] This second stage is addressed in proposed Reliability Standard TPL-007-1.

The following background information is provided below: (a) an explanation of the NERC Reliability Standards development process and (b) the history of Project 2013-03, Geomagnetic Disturbance Mitigation.

A. NERC Reliability Standards Development Process

The proposed Reliability Standard was developed in an open and fair manner and in accordance with the Reliability Standard development process. NERC develops Reliability Standards in accordance with Section 300 (Reliability Standards Development) of its Rules of Procedure and the NERC Standard Processes Manual.[8] NERC's proposed rules provide for reasonable notice and opportunity for public comment, due process, openness, and a balance of interests in developing Reliability Standards and thus addresses certain of the criteria for approving Reliability Standards. The development process is open to any person or entity with a legitimate interest in the reliability of the Bulk-Power System. NERC considers the comments of all stakeholders, and a vote of stakeholders and the NERC Board of Trustees is required to

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[6] Order No. 797, *Reliability Standard for Geomagnetic Disturbance Operations*, 147 FERC ¶ 61,209, *reh'g denied*, Order No. 797-A, 149 FERC ¶ 61,027 (2014) ("Order No. 797").

[7] Order No. 779 at PP 2, 67.

[8] The NERC Rules of Procedure are available at http://www.nerc.com/AboutNERC/Pages/Rules-of-Procedure.aspx. The NERC Standard Processes Manual is available at http://www.nerc.com/comm/SC/Documents/Appendix_3A_StandardsProcessesManual.pdf.

approve a Reliability Standard before the Reliability Standard is submitted to the applicable governmental authorities.

B. History of Project 2013-03, Geomagnetic Disturbance Mitigation

In June 2010, NERC identified that GMDs posed a serious threat to the reliable operation of the Bulk-Power System and that addressing this issue required significant staff and industry attention. Since that time, NERC has spent a substantial amount of time and effort working with experts across the North American power industry, U.S. and Canadian government agencies, transformer manufacturers, and other vendors to develop a scientifically sound understanding of the potential risks GMDs may pose to reliability.

In early 2011, a NERC-sponsored GMD Task Force was formed to "develop a technical white paper describing the evaluation of scenarios of potential GMD impacts, identifying key bulk power system parameters under those scenario conditions, and evaluating potential reliability implications of these incidents."[9] The GMD Task Force issued an interim report evaluating the effects of GMDs on the Bulk-Power System in February 2012.[10] Using an open process involving leading experts from industry, government and private researchers, and equipment and software vendors, the GMD Task Force has continued to support the development of tools and methods for assessing and mitigating GMD impacts.

In October 2012, FERC issued a Notice of Proposed Rulemaking ("NOPR") proposing to direct that NERC submit proposed Reliability Standards that address the risks posed by GMDs to

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[9] NERC, Board of Trustees Minutes, Exhibit J, at 1 (Nov. 4, 2010), *available at* http://www.nerc.com/docs/docs/bot/BOT-1110m-open-complete.pdf.

[10] North American Electric Reliability Corp., *2012 Special Reliability Assessment Interim Report: Effects of Geomagnetic Disturbances on the Bulk Power System* (February 2012) ("2012 NERC Interim GMD Report"), *available at* http://www.nerc.com/files/2012GMD.pdf.

the reliable operation of the Bulk-Power System.[11] The NOPR stated that GMD vulnerabilities are not adequately addressed in the existing Reliability Standards, and that this therefore constitutes a reliability gap — because GMD events can cause the Bulk-Power System to collapse suddenly and can potentially damage equipment on the Bulk-Power System.[12]

In May 2013, FERC issued Order No. 779 directing NERC to develop proposed Reliability Standards addressing GMD events in two stages, as explained above. In June 2014, FERC issued Order No. 797, approving the first stage GMD Reliability Standard EOP-010-1. Reliability Standard EOP-010-1 mitigates the effects of GMDs on the Bulk-Power System by requiring applicable entities to implement Operating Plans and Operating Procedures or Processes. This filing addresses the second stage GMD Reliability Standard.

Proposed Reliability Standard TPL-007-1 is based on sound research and industry-leading engineering approaches. The standard drafting team that developed the proposed standard includes engineers, planners, and operators that are at the forefront of the industry's GMD activities, including an experienced representative from Canada, as well as a leading space weather researcher from NASA.[13] Several members of the standard drafting team are also leaders of the NERC GMD Task Force. Through the NERC GMD Task Force, the standard drafting team has worked collaboratively with scientific and technical organizations, equipment manufacturers, software vendors, and colleagues throughout the industry to develop state-of-the-art guidelines, modeling approaches, and technical resources that underpin the proposed Reliability Standard.

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[11] *Reliability Standards for Geomagnetic Disturbances*, Notice of Proposed Rulemaking, 77 Fed. Reg. 64,935 (Oct. 24, 2012), 141 FERC ¶ 61,045 (2012) ("NOPR").

[12] *Id.* at P 4.

[13] The standard drafting team roster for Project 2013-03, Geomagnetic Disturbance Mitigation is attached as **Exhibit J** to this filing.

IV. JUSTIFICATION

As discussed in detail in **Exhibit C**, proposed Reliability Standard TPL-007-1—Transmission System Planned Performance for Geomagnetic Disturbance Events addresses the Reliability Standards criteria and is just, reasonable, not unduly discriminatory or preferential, and in the public interest. As described more fully herein and in **Exhibit C**, the proposed Reliability Standard contains significant reliability benefits for the Bulk-Power System and addresses the directives and concerns identified by FERC in Order No. 779.

The purpose of proposed Reliability Standard TPL-007-1 is to establish requirements for planned Transmission system performance during GMD events. The provisions of the proposed standard raise the level of preparedness among applicable entities by requiring these entities to plan for the reliable operation of the Bulk-Power System during the Benchmark GMD Event - a severe, 1-in-100 year GMD event.

The proposed standard includes the proposed definition of GMD Vulnerability Assessment. GMD Vulnerability Assessments provide the framework for evaluating potential impacts of the Benchmark GMD Event on Bulk-Power System equipment and the Bulk-Power System as a whole. Using a planning approach, the proposed Reliability Standard includes requirements for coordinating responsibilities among applicable entities, developing and maintaining models, establishing performance criteria and assessing performance, exchanging relevant information necessary to coordinate the actions of applicable entities, and developing Corrective Action Plans to address performance deficiencies.

This section of the filing addresses: (i) the description of the proposed Definition; (ii) the applicability of proposed Reliability Standard TPL-007-1; (iii) the description and technical basis for the Benchmark GMD Event; (iv) the description and technical basis for thermal impact

assessments for power transformers; (v) the description of the proposed Requirements; and (vi) the description of the proposed implementation plan. This section also provides a brief summary of how proposed Reliability Standard TPL-007-1 addresses FERC's directives from Order No. 779 and concludes with a discussion of the enforceability of the proposed standard.

A. Proposed Definition of "Geomagnetic Disturbance Vulnerability Assessment or "GMD Vulnerability Assessment"

The following Definition is proposed for inclusion in the *Glossary of Terms Used in NERC Reliability Standards*:

> **Geomagnetic Disturbance Vulnerability Assessment or GMD Vulnerability Assessment**: Documented evaluation of potential susceptibility to voltage collapse, Cascading, or localized damage of equipment due to geomagnetic disturbances.

The GMD Vulnerability Assessment is an integral part of the proposed Reliability Standard and provides the framework for evaluating potential impacts of the Benchmark GMD Event on Bulk-Power System equipment and the Bulk-Power System as a whole.[14] It also provides the means to allow for the identification of "facilities most at-risk from severe geomagnetic disturbance" in accordance with Order No. 779.[15]

Figure 1 below provides a graphical depiction of the GMD Vulnerability Assessment process. A summary description follows.

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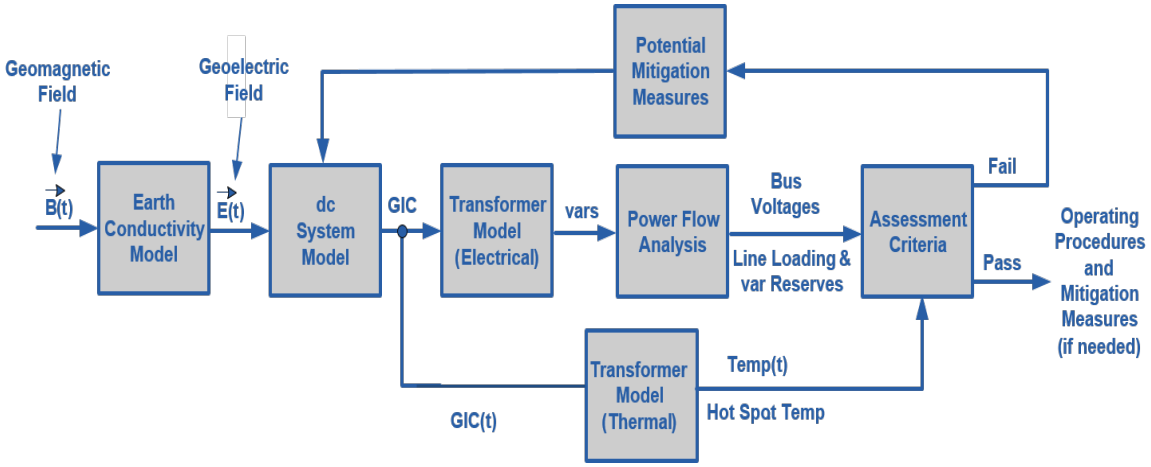
[14] *See* Order No. 779 at P 67. *See also* Order No. 779 at P 24 ("[T]here is a general consensus that GMD events can cause wide-spread blackouts due to voltage instability and subsequent voltage collapse, thus disrupting the reliable operation of the Bulk-Power System.")

[15] Order No. 779 at P 51.

Figure 1. GMD Vulnerability Assessment Process



In the GMD Vulnerability Assessment process outlined in the diagram above, the transmission system GIC flows are calculated by applicable Transmission Planners and Planning Coordinators for the Benchmark GMD Event using GIC system models. These models represent the direct current (dc) characteristics of the transmission system, including applicable power transformers, transmission lines, GIC reduction or blocking devices, and reactive power compensation devices.[16] The GIC flow information at each applicable power transformer is used with power transformer electrical models to determine the maximum reactive power losses; the maximum reactive power losses are applied to the power flow analysis required by the GMD Vulnerability Assessment. Additionally, using transformer thermal models and GIC flow information at each applicable power transformer, Transmission Owners and Generator Owners conduct transformer thermal impact assessments to determine the additional hot-spot heating that could be caused by the Benchmark GMD Event. Results of the power flow analysis and transformer thermal impact assessments are evaluated according to assessment criteria. When

[16] NERC GMD Task Force, Application Guide for Computing Geomagnetically-Induced Current in the Bulk-Power System at 18-25 (December 2013), *available at* http://www.nerc.com/comm/PC/Geomagnetic%20Disturbance%20Task%20Force%20GMDTF%202013/GIC%20Application%20Guide%202013_approved.pdf. ("GIC Application Guide")

mitigation measures are determined to be necessary, steps in the GMD Vulnerability Assessment process are repeated to recalculate GIC flows and reevaluate transmission system performance. The Geomagnetic Disturbance Planning Guide, developed by the NERC GMD Task Force in 2013, provides detailed technical guidance to support GMD-specific studies that are used in the GMD Vulnerability Assessment process.[17]

As described more fully below, proposed Reliability Standard TPL-007-1 contains requirements to develop the models, studies, and assessments necessary to build a picture of overall GMD vulnerability and identify where mitigation measures may be necessary.

B. Applicability of Proposed Reliability Standard TPL-007-1 – Transmission System Planned Performance for Geomagnetic Disturbance Events

Proposed Reliability Standard TPL-007-1 is applicable to: (1) Planning Coordinators with a planning area that includes a power transformer(s) with a high side, wye-grounded winding with terminal voltage greater than 200 kV; (2) Transmission Planners with a planning area that includes a power transformer(s) with a high side, wye-grounded winding with terminal voltage greater than 200 kV; (3) Transmission Owners that own a Facility or Facilities that include a power transformer(s) with a high side, wye-grounded winding with terminal voltage greater than 200 kV; and (4) Generator Owners that own a Facility or Facilities that include a power transformer(s) with a high side, wye-grounded winding with terminal voltage greater than 200 kV.[18]

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[17] NERC GMD Task Force, *Geomagnetic Disturbance Planning Guide* (Dec. 2013), *available at* http://www.nerc.com/comm/PC/Geomagnetic%20Disturbance%20Task%20Force%20GMDTF%202013/GMD%20Planning%20Guide_approved.pdf ("GMD Planning Guide").

[18] A power transformer with a "high side wye-grounded winding" refers to a power transformer with windings on the high voltage side that are connected in a wye configuration and have a grounded neutral connection.

The applicability section of proposed Reliability Standard TPL-007-1 is consistent with Order No. No. 779 and Order No. 797. As FERC noted in Order No. 779, "[b]ecause many Bulk-Power System transformers are grounded, the GIC appears as electrical current to the Bulk-Power System and flows through the ground connection and conductors, such as transformers and transmission lines."[19] The applicability of proposed Reliability Standard TPL-007-1 recognizes the technical considerations of the impact of a GMD event on the Bulk-Power System.

Proposed Reliability Standard TPL-007-1 complements the stage one GMD Reliability Standard, EOP-010-1, which is applicable to Reliability Coordinators and those Transmission Operators with a Transmission Operator Area that includes a power transformer with a high side wye-grounded winding with terminal voltage greater than 200 kV. EOP-010-1 requires these entities to implement Operating Plans and Operating Procedures or Processes to mitigate the effects of GMDs on the Bulk-Power System.

The standard drafting team determined that a voltage threshold of greater than 200 kV for proposed Reliability Standard TPL-007-1 is appropriate because the effect of GICs in networks less than 200 kV would have a negligible impact on the reliability of the interconnected transmission system. This finding is supported by operating experience and the preponderance of peer-reviewed studies on GMD effects[20] and is consistent with the scope and purpose of both the proposed Reliability Standard and the EOP-010-1 Reliability Standard.

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[19] Order No. 779 at P 6 (citing 2012 NERC Interim GMD Report at ii).

[20] *See* Notice of Filing of the North American Electric Reliability Corporation of Proposed Reliability Standard EOP-010-1, submitted on November 26, 2013 at Exhibit D.

C. The Benchmark GMD Event

Proposed Reliability Standard TPL-007-1 requires applicable entities to conduct initial and on-going assessments of the potential impact of the Benchmark GMD Event on Bulk-Power System equipment and the Bulk-Power System as a whole. The purpose of the Benchmark GMD Event is to provide a defined event for assessing system performance during a low probability, high magnitude GMD event as required by the proposed TPL-007-1 Reliability Standard. The Benchmark GMD Event defines the geoelectric field values used to compute GIC flows that are needed to conduct a GMD Vulnerability Assessment. As FERC noted in Order No. 779, the Benchmark GMD Event must be technically justified to "define the scope of the Second Stage GMD Reliability Standards (i.e., responsible entities should not be required to assess GMD events more severe than the benchmark GMD events)."[21] The proposed Benchmark GMD Event is technically supported by modern measurement data and publicly-available models. Further, the proposed Benchmark GMD Event sets a high benchmark for reliability, as it represents the most severe GMD event expected in a 100-year period as determined by a statistical analysis of recorded geomagnetic data.

As discussed below, the proposed Benchmark GMD Event is described in terms that can be directly applied to the performance of GMD Vulnerability Assessments required by proposed Reliability Standard TPL-007-1. Further, the proposed Benchmark GMD Event supports the assessment of known GMD-related vulnerabilities with the potential to impact the reliable operation of the Bulk-Power System, such increased reactive power consumption in power transformers, loss of reactive power sources, and increased transformer hot-spot heating. The Benchmark Geomagnetic Disturbance Event Description white paper included as **Exhibit D**

[21] Order No. 779 at P 2.

provides additional description of the parameters of the Benchmark GMD Event, explains the technical details that led to the selection of these parameters, and demonstrates how they should be applied to obtain entity-specific values.

Thus, the proposed Benchmark GMD Event addresses FERC's directive to specify what severity GMD event an entity must assess for potential impacts on the Bulk-Power System and defines the scope for proposed Reliability Standard TPL-007-1.

1. The Proposed Benchmark GMD Event Sets a High Benchmark for Reliability

The proposed Benchmark GMD Event sets a high benchmark for reliability, as it represents the most severe GMD event expected in a 100-year period as determined by a statistical analysis of recorded geomagnetic data. The Benchmark GMD Event used to develop the proposed standard is based on a 1-in-100 year frequency of occurrence, which is a conservative planning criterion for electric power systems.[22] A 1-in-100 year occurrence rate addresses risks from a GMD event on the order of the March 1989 GMD event, which has caused known impacts to the Bulk-Power System, and reasonably protects against impacts from more extreme GMD events.

The March 1989 GMD event, which impacted the North American Bulk-Power System by causing a blackout in Quebec,[23] is considered to be a 1-in-50 year GMD event and one of the strongest for which detailed and accurate records are available.[24] The Carrington Event of 1859 was stronger than the March 1989 GMD event, but limited information is available to accurately

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[22] For additional information, *see* Benchmark Geomagnetic Disturbance Event Description (**Exhibit D**) at 5 and Appendix I.

[23] For more information about the March 1989 GMD event, *see* 2012 NERC Interim GMD Report at i.

[24] *See* Jeffrey J. Love, *Credible Occurrence Probabilities for Extreme Geophysical Events: Earthquakes, Volcanic Eruptions, Magnetic Storms*, GEOPHYSICAL RES. LETTERS (May 2012) (hereinafter "Love (2012)").

describe this event.[25] A Carrington-type event is considered to be a 1-in-150 year GMD event, but uncertainty in the occurrence rate is even greater than that for the March 1989 GMD event.[26] Thus, the selection of a 1-in-100 year occurrence rate for the Benchmark GMD Event provides a high level of assurance that the Bulk-Power System is planned for reliable operations during a severe GMD event.

The Benchmark GMD Event is technically-supported by the use of modern measurement data and statistical techniques. The Benchmark GMD Event expands on work conducted by the NERC GMD Task Force in which 1-in-100 year geoelectric field amplitudes were calculated from a well-known source of dense high-resolution geomagnetic data commonly used in space weather research.[27] This approach was adapted to develop the Benchmark GMD Event which supports, through the GMD Vulnerability Assessments required by proposed Reliability Standard TPL-007-1, the identification of GMD impacts with the potential to cause "instability, uncontrolled separation, or cascading failures of the Bulk-Power System."[28] Additional extreme value analysis was performed to determine that the geoelectric field associated with the proposed Benchmark GMD Event exceeds the 95% confidence bound, which indicates that the likelihood of a GMD event exceeding the proposed benchmark during a 100-year period is low.

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[25] This is the largest recorded GMD event, named after the British astronomer Richard Carrington.

[26] *See id.*

[27] A. Pulkkinen et al., *Generation of 100-year Geomagnetically Induced Current Scenarios*, SPACE WEATHER (2012); *see also* 2012 NERC Interim GMD Report at 20-23.

[28] FERC indicated in Order No 779 that the proposed Reliability Standard should include "Requirements whose goal is to prevent instability, uncontrolled separation, or cascading failures of the Bulk-Power System when confronted with a benchmark GMD event." Order No. 779 at P. 84. Appendix I to the Benchmark Geomagnetic Disturbance Event Description white paper (**Exhibit D**) describes how the Benchmark GMD Event was developed to support assessment of these impacts.

2. The Benchmark GMD Event Can be Directly Applied to the Performance of GMD Vulnerability Assessments

The proposed Benchmark GMD Event is described by parameters that are usable by applicable entities in conducting their GMD Vulnerability Assessments. While there are a variety of measurements and indices that can be used to describe GMD conditions,[29] assessment of GMD effects on an electric power system requires the calculation of GICs that result from the geoelectric fields produced by the earth's varying magnetic field during a GMD event. The geoelectric field produced during a GMD event is dependent upon the geomagnetic latitude and earth conductivity where the electric power system is located and is the direct physical parameter leading to the creation of GICs, as described in technical references.[30] Consequently, the proposed Benchmark GMD Event is described in terms of the geoelectric field (V/km) for use by applicable entities in conducting GMD Vulnerability Assessments.

Although the Benchmark GMD Event is described in proposed Reliability Standard TPL-007-1 as a single event, it includes several components within its framework for assessing GMD vulnerabilities. The Benchmark GMD Event includes technically-justified scaling factors to enable applicable entities to tailor the geoelectric field to their specific location for conducting GMD Vulnerability Assessments. This accounts for differences in the intensity of a GMD event due to geographical considerations, such as geomagnetic latitude and local earth conductivity.[31] The geomagnetic latitude scaling factor is based on modern global scientific observations for

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[29] These include the A index, K index, and G scales that are used by space weather monitoring and forecasting organizations to describe geomagnetic storm severity and the disturbance storm time (Dst) index measuring the amplitude of the main phase disturbance for a magnetic storm. Many of these indices were originally designed for scientific or research purposes.

[30] *See generally* GIC Application Guide.

[31] *See* Benchmark Geomagnetic Disturbance Event Description (**Exhibit D**).

major storms since late 1980s.[32] Scaling factors for earth conductivity take into account that the induced geoelectric field depends on local earth conductivity, and that different parts of the continent have different earth conductivity and deep earth structure. The Benchmark GMD Event includes default scaling factors for earth conductivity based on publicly-available earth models. These technically-justified scaling factors allow the applicable entities of proposed Reliability Standard TPL-007-1 to perform GMD Vulnerability Assessments according to entity-specific criteria.[33]

3. The Proposed Benchmark GMD Event Includes the Necessary Parameters to Support Assessment of Known GMD Related Vulnerabilities

The Benchmark GMD Event also includes the parameters necessary to support assessment of various known GMD-related vulnerabilities that have the potential to impact the reliable operation of the Bulk-Power System. GMD events have the potential to produce electric power system impacts, such as increased reactive power consumption in power transformers, loss of reactive power sources, and increased transformer hot-spot heating. For the purpose of conducting GMD Vulnerability Assessments, some impacts, such as reactive power losses, should be considered as having a nearly-instantaneous effect on an electric power system. Other impacts, like increased transformer hot spot heating, affect an electric power system over longer periods of time during a GMD event, and thus should not be assumed to occur instantaneously. To address these considerations, the proposed Benchmark GMD Event includes both: (i) a peak

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[32] The studied storms reveal that the propagation of auroral boundaries stops at about 50 degrees of geomagnetic latitude. This is a repeating feature of the geospace system under strong solar driving conditions and scaling over the band between 40-60 degrees of geomagnetic latitude. *See* C. Ngwira and A. Pulkinnen et al., *Extended Study of Extreme Geoelectric Field Event Scenarios for Geomagnetically Induced Current Applications*, 11 SPACE WEATHER 121 (2013)).

[33] In Order No. 779, FERC recognized the need for tailored assessments based on "geographic location and geology" and stated the expectation that "vulnerability assessments would be based on uniform criteria (e.g., geographic location and geology) but the values for such criteria would be entity-specific." Order No. 779 at P 70.

geoelectric field magnitude for assessing near-instantaneous voltage impacts, as discussed previously; and (ii) a waveshape for calculating a GIC time-series that is used in assessing thermal impacts in power transformers, as discussed in more detail below.

An analysis of the high resolution magnetometer data from several GMD events, as shown in the Benchmark Geomagnetic Disturbance Event Description white paper **(Exhibit D)**, indicates that the March 1989 GMD event provides a conservative worst-case waveshape for conducting transformer thermal impact assessments. Consequently, the Benchmark GMD Event waveshape is based on magnetometer data of the March 1989 GMD event recorded by the Ottawa geomagnetic observatory.[34] To conduct a transformer thermal assessment, an applicable Transmission Owner or Generator Owner uses GIC flows based on the March 1989 GMD event waveshape, magnified to the statistically-derived 1-in-100 year geoelectric field strength. Thus, the Benchmark GMD Event provides a 1-in-100 year benchmark for assessing GMD impacts to Bulk-Power System equipment.

4. Additional Benchmark GMD Event Considerations in the Standards Development Process

Past reports and ongoing scientific research reflect varying perspectives on the potential severity of GMD events. As FERC recognized in Order No. 779, there is no consensus on benchmark GMD events for assessing the vulnerability of the Bulk-Power System.[35] Accordingly, the proposed Benchmark GMD Event was evaluated throughout the development of the proposed standard, resulting in a benchmark supported by rigorous technical analysis of modern measurement data and publicly-available models. The use of modern measurement data

[34] In the Benchmark Geomagnetic Disturbance Event Description white paper (**Exhibit D**), an analysis of available GMD events with 10-second magnetic data was conducted to determine that the March 1989 GMD event represented the most conservative selection. *See id.* at 15-16.

and statistical techniques provides for a state-of-the-art Benchmark GMD Event for use in GMD Vulnerability Assessments required by proposed Reliability Standard TPL-007-1.

As discussed above, the proposed Benchmark GMD Event is more intense than the March 1989 GMD event to appropriately address the risks of a high-impact, low frequency GMD event.[36] The standard drafting team also examined other historical GMD events in developing the proposed Benchmark GMD Event, some of which are described below.

Geomagnetic Storm of 1921

Some reports examining the effects of GMD events on the power system suggested that the geomagnetic storm of 1921 is a 1-in-100-year event. These reports described the potential impacts a GMD event of this magnitude could have on the grid.[37] After much consideration, the standard drafting team determined, that with limited direct observations of the magnetic fields, it was not possible to include the 1921 event in a rigorous determination of the 1-in-100-year Benchmark GMD Event characteristics. Without this data, it was also not possible to perform a more-detailed analysis of the impacts of the 1921 event on the modern electric power system.[38]

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35 *See* Order No. 779 at P 71 ("[T]here is currently no consensus on benchmark GMD events, and the Commission does not identify specific benchmark GMD events for NERC to adopt. Instead, this issue should be considered in the NERC standards development process so that any benchmark GMD events proposed by NERC have a strong technical basis.").

36 Some estimate the March 1989 GMD Event is a 1-in-50 year event. *See* Love (2012), *supra* n. 38. The Benchmark GMD Event magnifies the March 1989 GMD event waveshape to the statistically-derived 1-in-100 year geoelectric field strength to provide a 1-in-100 year intensity.

37 *See* Oak Ridge National Laboratory, *FERC EMP-GIC Metatech Report Meta-R-319* at 3-22 (January 2010), *available at* http://web.ornl.gov/sci/ees/etsd/pes/pubs/ferc_Meta-R-319.pdf ("Meta R-319"); *see also* National Research Council of the National Academies, *Severe Space Weather Events – Understanding Societal and Economic Impacts, a Workshop Report* at 3, 77 (2008)*, available at* http://www.nap.edu/catalog/12507/severe-space-weather-events--understanding-societal-and-economic-impacts.

38 The 2011 JASON Summer Study sponsored by U.S. Department of Homeland Security reported that the authors were "not convinced that the worst-case scenario [of Meta-R-319] is plausible." *See* JASON, *Impacts of Severe Space Weather on the Electric Grid*, *JSR-11-320* at 2 (2011).

Carrington Event of 1859

Another extreme GMD event that has been considered by some researchers as a basis for risk assessment is the Carrington Event of 1859. Like the 1921 GMD event, high-quality geomagnetic field data are not available that would allow direct determination of the geoelectric fields experienced during the Carrington Event. Research is being conducted to examine the capability for complex dynamic space weather prediction models to determine the geoelectric fields produced by Carrington-like space weather conditions.[39] However, at present, these efforts are a basic research endeavor aimed at assessing performance of the dynamic space weather prediction models. Furthermore, the occurrence rate of a Carrington-type GMD event is uncertain, but it is estimated to be a 1-in-150 year event, as discussed previously.[40]

July 2012 Coronal Mass Ejection

Some researchers have examined, through simulations, the potential geomagnetic effects of a powerful coronal mass ejection observed by NASA spacecraft in July 2012.[41] Since the July 2012 coronal mass ejection did not impact the earth, research analyses require relying on space science models for estimating its geomagnetic impact. Due to the complex nature of the space weather phenomena and relatively immature state of modern space science models, dynamic model-based assessments contain inherent uncertainties that are not always well known. While events such as the July 2012 coronal mass ejection provide a valuable research opportunity for the space weather community to improve its space weather prediction modeling capabilities, the

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39 C. Ngwira et al., *Modeling Extreme "Carrington-type" Space Weather Events Using Three-dimensional Global MHD Simulations*, 119 J. OF GEOPHYSICAL RES.: SPACE PHYSICS 4456 (2014)).

40 *See* Love (2012), *supra* n. 24.

41 *See* C. Ngwira et al., *Simulation of the 23 July 2012 Extreme Space Weather Event: What if This Extremely Rare CME was Earth Directed?*, 11 SPACE WEATHER 671 at 677 (2013) (concluding that "had the 23 July CME hit Earth, there is a possibility that it could have produced comparable or slightly larger geomagnetically induced electric fields to those produced by previously observed Earth directed events such as the March 1989 storm or the Halloween 2003 storms."); *see also* D.N. Baker et al*., A Major Solar Eruptive Event in July 2012: Defining Extreme Space Weather Scenarios*, 11 SPACE WEATHER 585 (2013).

standard drafting team determined that observed geomagnetic data is more appropriate for direct application to the Benchmark GMD Event description and the proposed Reliability Standard.

Given the varying nature and degree of scientific uncertainty in the events described above, the proposed Reliability Standard and accompanying Benchmark GMD Event incorporate rigorous technical analysis that is representative of the complex nature of space weather phenomena, and therefore reflects a balanced and practical approach in the proposed TPL-007-1 Reliability Standard.

D. Transformer Thermal Impact Assessment

Large power transformers connected to the high voltage and extra high voltage Transmission systems can experience both increased winding and structural hot spot heating as a result of GIC flow during GMD events. Proposed Reliability Standard TPL-007-1 requires owners of such transformers to conduct thermal analyses of their transformers to determine if the transformers would be able to withstand the thermal effects associated with the Benchmark GMD Event. The Transformer Thermal Impact Assessment White Paper (**Exhibit E)** discusses methods that can be employed to conduct such analyses, including example calculations.

Transformers are exempt from the thermal impact assessment requirement included in the proposed standard if the maximum effective GIC in the transformer is less than 75 A per phase during the Benchmark GMD Event as determined by an analysis of the system.[42] Based on available power transformer measurement data and as described in the Screening Criterion for Transformer Thermal Impact Assessment white paper (**Exhibit F)**, transformers with an

[42] *See* Screening Criterion for Transformer Thermal Impact Assessment (**Exhibit F**) for technical justification of the thermal impact screening criterion. The 75 A per phase threshold is based on the Benchmark GMD Event waveshape and resulting GIC time series in order to identify those applicable transformers that may experience excessive hot spot heating during the Benchmark GMD Event. The criterion should not be interpreted as a continuous value of 75 A per phase effective GIC.

effective GIC of less than 75 A per phase during the Benchmark GMD Event are unlikely to exceed known temperature limits established by technical organizations. To provide an added measure of conservatism, the 75 A per phase threshold, although derived from measurements of single-phase units, is applicable to transformers with all core types (e.g., three-limb, three-phase).

E. Requirements in Proposed Reliability Standard TPL-007-1 – Transmission System Planned Performance for Geomagnetic Disturbance Events

The purpose of proposed Reliability Standard TPL-007-1 is to establish requirements for Transmission system planned performance during GMD events. The proposed Reliability Standard consists of seven Requirements, Table 1 – Steady State Planning Events, and Attachment 1 – Calculating Geoelectric Fields for the Benchmark GMD Event. Table 1 sets forth requirements for System steady state performance. Attachment 1 explains how to calculate geoelectric fields to establish the Benchmark GMD Event.

Proposed Requirement R1 requires Planning Coordinators, in conjunction with Transmission Planner(s), to identify the responsibilities of the Planning Coordinator and Transmission Planner(s) in the Planning Coordinator's planning area for maintaining models and performing the study or studies needed to complete GMD Vulnerability Assessment(s). Proposed Requirements R2, R3, R4, R5, and R7 therefore refer to the "responsible entity, as determined by Requirement R1," when identifying which applicable Planning Coordinators or Transmission Planners are responsible for maintaining models and performing the necessary study or studies.

Proposed Requirement R2 is intended to ensure that the responsible entities maintain models for performing the studies needed to complete GMD Vulnerability Assessment(s) required by proposed Requirement R4. Proposed Requirement R3 requires the responsible

entities to have criteria for acceptable System steady state voltage performance during a Benchmark GMD Event.

Proposed Requirement R4 requires the responsible entities to complete a GMD Vulnerability Assessment of the Near-Term Transmission Planning Horizon once every 60 calendar months.

Proposed Requirement R5 requires the responsible entities to provide GIC flow information to Transmission Owners and Generator Owners that own a Bulk Electric System (BES) power transformer in the planning area. This information is necessary for applicable Transmission Owners and Generator Owners to conduct the thermal impact assessments required by proposed Requirement R6. Proposed Requirement R6 requires applicable Transmission Owners and Generator Owners to conduct thermal impact assessments where the maximum effective GIC value provided in proposed Requirement R5, Part 5.1 is 75 A per phase or greater.

Proposed Requirement R7 requires the responsible entities to develop a Corrective Action Plan when its GMD Vulnerability Assessment indicates that its System does not meet the performance requirements of Table 1 – Steady State Planning Events. The Corrective Action Plan must address how the performance requirements will be met, must list the specific deficiencies and associated actions that are necessary to achieve performance, and must set forth a timetable for completion.

Collectively, the proposed Requirements, Table 1, and Attachment 1 address FERC's directives in Order No. 779 and are intended to establish requirements for Transmission system planned performance during GMD events. Provided below is a justification of the proposed Reliability Standard on a requirement-by-requirement basis.

Proposed Requirements

R1. Each Planning Coordinator, in conjunction with its Transmission Planner(s), shall identify the individual and joint responsibilities of the Planning Coordinator and Transmission Planner(s) in the Planning Coordinator's planning area for maintaining models and performing the study or studies needed to complete GMD Vulnerability Assessment(s).

Proposed Requirement R1 requires applicable Planning Coordinators, in conjunction with Transmission Planner(s), to identify the responsibilities of the Planning Coordinator and Transmission Planner(s) in the Planning Coordinator's planning area for maintaining models and performing the study or studies needed to complete GMD Vulnerability Assessment(s). This determination sets forth the roles and responsibilities for applicable Planning Coordinators and Transmission Planners for Requirements R2 through R5 and R7 of proposed Reliability Standard TPL-007-1 and is designed to allow for differences in regional organizations and to provide flexibility. No requirement in the standard is intended to prohibit a collaborative approach where roles and responsibilities are determined by a planning organization made up of one or more Planning Coordinator(s). Proposed Requirement R1 ensures that the responsibilities within a planning area are clearly articulated and understood, particularly where there are joint responsibilities.

R2. Each responsible entity, as determined in Requirement R1, shall maintain System models and GIC System models of the responsible entity's planning area for performing the study or studies needed to complete GMD Vulnerability Assessment(s).

Proposed Requirement R2 builds upon Requirement R1, and it is intended to ensure that the responsible entities maintain System models and GIC System models for performing the studies needed to complete GMD Vulnerability Assessment(s) as required in proposed

Requirement R4. A GMD Vulnerability Assessment requires a GIC System model to calculate GIC flow, which is then used to determine transformer Reactive Power absorption and transformer thermal response.

The GIC System model includes all power transformer(s) in the planning area with a high side, wye-grounded winding with terminal voltage greater than 200 kV. Technical guidance for developing the GIC System model is provided in the GIC Application Guide.

The System model specified in proposed Requirement R2 is used in conducting steady state power flow analysis that accounts for the Reactive Power absorption of power transformer(s) due to GIC in the System. Steady state power flow analysis is required by the GMD Vulnerability Assessment, as specified in proposed Requirement R4.

R3. Each responsible entity, as determined in Requirement R1, shall have criteria for acceptable System steady state voltage performance for its System during the benchmark GMD event described in Attachment 1.

Proposed Requirement R3 specifies that the responsible entity shall establish the System steady state voltage performance criteria for use in the GMD Vulnerability Assessment. Steady state voltage limits are an example of System steady state performance criteria. Proposed Requirement R3 provides flexibility for development of more sophisticated methods of determining voltage stability.

R4. Each responsible entity, as determined in Requirement R1, shall complete a GMD Vulnerability Assessment of the Near-Term Transmission Planning Horizon once every 60 calendar months. This GMD Vulnerability Assessment shall use a study or studies based on models identified in Requirement R2, document assumptions, and document summarized results of the steady state analysis.

4.1. The study or studies shall include the following conditions:

4.1.1. System On-Peak Load for at least one year within the Near-Term Transmission Planning Horizon; and

4.1.2. System Off-Peak Load for at least one year within the Near-Term Transmission Planning Horizon.

4.2. The study or studies shall be conducted based on the benchmark GMD event described in Attachment 1 to determine whether the System meets the performance requirements in Table 1.

4.3. The GMD Vulnerability Assessment shall be provided within 90 calendar days of completion to the responsible entity's Reliability Coordinator, adjacent Planning Coordinators, adjacent Transmission Planners, and to any functional entity that submits a written request and has a reliability-related need.

4.3.1. If a recipient of the GMD Vulnerability Assessment provides documented comments on the results, the responsible entity shall provide a documented response to that recipient within 90 calendar days of receipt of those comments.

Proposed Requirement R4 requires the responsible entities (as determined in Requirement R1) to complete a GMD Vulnerability Assessment of the Near-Term Transmission Planning Horizon once every 60 calendar months. The "Near Term Transmission Planning Horizon" is defined in the *Glossary of Terms Used in NERC Reliability Standards* as "The transmission planning period that covers Year One through five."[43] Requirement R4 Part 4.1 specifies that studies must be conducted for both On-Peak Load and Off-Peak Load conditions in order to account for a range of System Reactive Power resources in the assessment. Table 1 – Steady State Planning Events establishes uniform performance criteria and assessment details. Because some devices that are susceptible to harmonic impacts may affect System steady state

[43] "Year One" is defined in the *Glossary of Terms Used in NERC Reliability Standards* as "The first twelve month period that a Planning Coordinator or a Transmission Planner is responsible for assessing. For an assessment started in a given calendar year, Year One includes the forecasted peak Load period for one of the following two calendar years. For example, if a Planning Assessment was started in 2011, then Year One includes the forecasted peak Load period for either 2012 or 2013."

performance, Table 1 requires responsible entities to remove such devices from the analysis when assessing System performance. Proposed Requirement R4 establishes consistent parameters for the responsible entities to conduct initial and on-going GMD Vulnerability Assessments that meet the directives in Order No. 779.[44]

R5. Each responsible entity, as determined in Requirement R1, shall provide GIC flow information to be used for the transformer thermal impact assessment specified in Requirement R6 to each Transmission Owner and Generator Owner that owns an applicable Bulk Electric System (BES) power transformer in the planning area. The GIC flow information shall include:

5.1. The maximum effective GIC value for the worst case geoelectric field orientation for the benchmark GMD event described in Attachment 1. This value shall be provided to the Transmission Owner or Generator Owner that owns each applicable BES power transformer in the planning area.

5.2. The effective GIC time series, GIC(t), calculated using the benchmark GMD event described in Attachment 1 in response to a written request from the Transmission Owner or Generator Owner that owns an applicable BES power transformer in the planning area. GIC(t) shall be provided within 90 calendar days of receipt of the written request and after determination of the maximum effective GIC value in Part 5.1.

Proposed Requirement R5 is intended to ensure that Transmission Owners and Generator Owners can access GIC flow information in order to perform the transformer thermal impact assessment required in proposed Requirement R6. GIC information should be provided in accordance with proposed Requirement R5 as part of the GMD Vulnerability Assessment process since, by definition, the GMD Vulnerability Assessment includes documented evaluation of susceptibility to localized equipment damage due to GMD. The GIC flow information specified in Part 5.1 and Part 5.2 of proposed Requirement R5 support various methods for

[44] Order No. 779 directed that "[e]ach responsible entity under the Second Stage GMD Reliability Standards would then be required to assess its vulnerability to the benchmark GMD events consistent with the five assessment parameters identified in the NOPR and adopted in this Final Rule." Order No. 779 at P. 67.

performing transformer thermal impact assessments. These methods are described in the Transformer Thermal Impact Assessment White Paper, included as **Exhibit E** to this filing.

R6. Each Transmission Owner and Generator Owner shall conduct a thermal impact assessment for its solely and jointly owned applicable BES power transformers where the maximum effective GIC value provided in Requirement R5, Part 5.1, is 75 A per phase or greater. The thermal impact assessment shall:

- **6.1. Be based on the effective GIC flow information provided in Requirement R5;**
- **6.2. Document assumptions used in the analysis;**
- **6.3. Describe suggested actions and supporting analysis to mitigate the impact of GICs, if any; and**
- **6.4. Be performed and provided to the responsible entities, as determined in Requirement R1, within 24 calendar months of receiving GIC flow information specified in Requirement R5, Part 5.1.**

Proposed Requirement R6 requires Transmission Owners and Generator Owners to conduct thermal impact assessments for their solely and jointly-owned power transformers with a high side, wye-grounded winding with terminal voltage greater than 200 kV where the maximum effective GIC value for the worst case geoelectric field orientation for the Benchmark GMD Event described in Attachment 1 is 75 A per phase or greater. Transformers are exempt from the thermal impact assessment requirement if the maximum effective GIC in the transformer is less than 75 A per phase during the Benchmark GMD Event as determined by an analysis of the system. Based on available power transformer measurement data, transformers with an effective GIC of less than 75 A per phase during the Benchmark GMD Event are unlikely to exceed known temperature limits established by technical organizations. Additional information is available in the Screening Criterion for Transformer Thermal Impact Assessment white paper, included as **Exhibit F** to this filing.

Thermal impact assessments are provided to the responsible entity, as determined in proposed Requirement R1, so that identified issues can be included in the GMD Vulnerability Assessment (Requirement R4) and the Corrective Action Plan (Requirement R7) as necessary.

Thermal impact assessments of non-BES transformers are not required because those transformers do not pose a risk of Bulk-Power System instability, uncontrolled separation, or Cascading.

R7. Each responsible entity, as determined in Requirement R1, that concludes, through the GMD Vulnerability Assessment conducted in Requirement R4, that their System does not meet the performance requirements of Table 1 shall develop a Corrective Action Plan addressing how the performance requirements will be met. The Corrective Action Plan shall:

7.1. List System deficiencies and the associated actions needed to achieve required System performance. Examples of such actions include:
• Installation, modification, retirement, or removal of Transmission and generation Facilities and any associated equipment.
• Installation, modification, or removal of Protection Systems or Special Protection Systems.
• Use of Operating Procedures, specifying how long they will be needed as part of the Corrective Action Plan.
• Use of Demand-Side Management, new technologies, or other initiatives.

7.2. Be reviewed in subsequent GMD Vulnerability Assessments until it is determined that the System meets the performance requirements contained in Table 1.

7.3. Be provided within 90 calendar days of completion to the responsible entity's Reliability Coordinator, adjacent Planning Coordinator(s), adjacent Transmission Planner(s), functional entities referenced in the Corrective Action Plan, and any functional entity that submits a written request and has a reliability-related need.

7.3.1. If a recipient of the Corrective Action Plan provides documented comments on the results, the responsible entity shall provide a documented response to that recipient within 90 calendar days of receipt of those comments.

When a responsible entity's GMD Vulnerability Assessment does not meet the performance requirements of Table 1 – Steady State Planning Events, proposed Requirement R7 mandates that it must develop a Corrective Action Plan addressing how the performance requirements of Table 1 will be met. A "Corrective Action Plan" is defined in the *Glossary of Terms Used in NERC Reliability Standards* as "[a] list of actions and an associated timetable for implementation to remedy a specific problem." The Corrective Action Plan must list the System

deficiencies and associated actions needed to achieve performance as set forth in Section 7.1 of proposed Requirement R7. To ensure accountability, the responsible entities must review these deficiencies in subsequent GMD Vulnerability Assessments until such time that the System meets the performance requirements of Table 1. Proposed Requirement R7 is technology-neutral and provides flexibility for the responsible entities to select appropriate mitigation strategies, subject to the vulnerabilities identified in the assessments and as supported by technical guidance. These mitigating strategies may include installation of hardware (e.g., GIC blocking or monitoring devices), equipment upgrades, training, or enhanced Operating Procedures.[45] With this range of potential mitigation strategies, it is appropriate to provide flexibility to the responsible entities with respect to establishing timetables for completion.

The Corrective Action Plan must be provided within 90 calendar days of completion to the responsible entity's Reliability Coordinator, adjacent Planning Coordinator(s), adjacent Transmission Planner(s), functional entities referenced in the Corrective Action Plan, and any functional entity that submits a written request and has a reliability-related need. This provision ensures that there is coordination and communication among the functional entities. The provision of information in proposed Requirement R7 Part 7.3 shall be subject to the legal and regulatory obligations for the disclosure of confidential and/or sensitive information.

For the reasons described above, the proposed Reliability Standard is just and reasonable and is designed to protect against instability, uncontrolled separation, or cascading failures of the Bulk-Power System as a result of a Benchmark GMD Event through the performance of initial and on-going GMD Vulnerability Assessments.

[45] Mitigating measures and approaches, including geomagnetically-induced current reduction devices, monitoring, and system reconfiguration, are discussed in Chapters 9 and 10 of the 2012 NERC Interim GMD Report and Chapter 5 of the GMD Planning Guide (Dec. 2013).

F. Implementation of Proposed Reliability Standard TPL-007-1

The implementation plan for proposed Reliability Standard TPL-007-1, included as **Exhibit B** to this filing, provides a multi-phased approach to implementation over a five-year period as follows:

- Requirement R1, pertaining to establishing responsibilities among applicable Planning Coordinators and Transmission Planners, shall become effective on the first day of the first calendar quarter that is **six months** after regulatory approval.[46]
- Requirement R2, requiring the maintenance of System models and GIC System models for performing the study or studies needed to complete GMD Vulnerability Assessments, shall become effective on the first day of the first calendar quarter that is **18 months** after regulatory approval.
- Requirement R5, which requires the responsible Planning Coordinators and Transmission Planners to provide GIC flow information to applicable Transmission Owners and Generator Owners for the transformer thermal impact assessments specified in Requirement R6, shall become effective on the first day of the first calendar quarter that is **24 months** after regulatory approval.
- Requirement R6, which requires applicable Transmission Owners and Generator Owners to conduct thermal impact assessments and provide the results to the responsible Planning Coordinators or Transmission Planners, shall become

[46] "Regulatory approval" refers specifically to the date that the standard is approved by an applicable governmental authority or as otherwise provided for in a jurisdiction where approval by an applicable governmental authority is required for a standard to go into effect. The implementation plan also provides effective dates where approval by an applicable governmental authority is not required for a standard to go into effect.

effective on the first day of the first calendar quarter that is **48 months** after regulatory approval.

- Requirements R3, R4, and R7, which address establishing criteria for acceptable System steady state voltage performance during the Benchmark GMD Event, performing GMD Vulnerability Assessments, and developing Corrective Action Plans to address identified vulnerabilities, respectively, shall become effective on the first day of the first calendar quarter that is **60 months** after regulatory approval.

The proposed implementation plan provides for the proper sequencing of system and equipment assessments performed by various applicable entities to build an overall assessment of GMD vulnerability. In accordance with Order No. 779, the proposed implementation plan provides an appropriate time period for applicable entities to obtain tools, models, and data required for GMD Vulnerability Assessments.[47] In many cases, applicable entities will be developing GIC system models needed for proposed Requirement R2 and obtaining transformer thermal models needed for proposed Requirement R6 for the first time. The proposed implementation plan allows sufficient time for the necessary analysis and coordination. The proposed implementation plan also provides the necessary time for the development of viable Corrective Action Plans to address identified vulnerabilities. These Corrective Action Plans may require entities to develop, perform, or validate new or modified studies, assessments, or procedures to meet the requirements of the proposed standard. Further, some mitigation measures may have significant budget, siting, or construction planning requirements. Therefore,

[47] Order No. 779 at P 68 ("When developing the Second Stage GMD Reliability Standards implementation schedule, NERC should consider the availability of validated tools, models, and data necessary to comply with the Requirements.").

the five-year phased implementation plan reflects an appropriate and realistic timeframe for compliance with proposed Reliability Standard TPL-007-1.

G. FERC Directives and Issues Addressed

As explained in **Exhibit H**, the proposed Reliability Standard addresses all of FERC's directives in Order No. 779 with respect to Stage 2 of the GMD Reliability Standards. In addition, the proposed Reliability Standard addresses a number of concerns and issues identified for consideration by FERC.

Provided below is an explanation of how the proposed Reliability Standard addresses each FERC directive or how it addresses a concern or issue identified by FERC in Order No. 779.

1. Benchmark GMD Event and Timing: Order No. 779, Paragraph 2

In Order No. 779, FERC directed NERC to "submit, within 18 months of the effective date of this Final Rule, one or more Reliability Standards that require owners and operators of the Bulk-Power System to conduct initial and on-going vulnerability assessments of the potential impact of benchmark GMD events on Bulk-Power System equipment and the Bulk-Power System as a whole."[48] FERC also stated that the proposed Reliability Standard must "identify 'benchmark GMD events' that specify what severity GMD events a responsible entity must assess for potential impacts on the Bulk-Power System."[49]

Proposed Reliability Standard TPL-007-1 requires initial and on-going vulnerability assessments of the impact of a Benchmark GMD Event, as described herein. The severity of GMD events is specified in the Benchmark GMD Event, which is set forth in Attachment 1. The

[48] Order No. 779 at P 2.

[49] *Id.*

benchmark provides a defined event for assessing system performance as required by the proposed Reliability Standard. It also defines the geoelectric field values used to compute GIC flows for a GMD Vulnerability Assessment.

Order No. 779 became effective on July 22, 2013. The instant filing is being submitted within 18 months, in compliance with FERC's directive.[50]

2. Costs and Benefits: Order No. 779, Paragraph 28

In Order No. 779, FERC stated that it "expect[ed] NERC and industry [to] consider the costs and benefits of particular mitigation measures as NERC develops the technically-justified Second Stage GMD Reliability Standards."[51] While not a directive, NERC solicited comments on mitigation costs from stakeholders during formal comment periods in order to address FERC's concerns related to consideration of costs.

The standard drafting team chose a planning standard approach to meet the directives for the second stage GMD Reliability Standard, which allows applicable entities flexibility to select mitigation measures based on a variety of considerations, including costs. Like other existing planning standards, proposed Reliability Standard TPL-007-1 does not prescribe specific mitigation measures or strategies. When mitigation is necessary to meet the performance requirements specified in the standard, applicable entities can evaluate options using criteria which could include cost considerations.

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[50] Order No. 779 at P 18.

[51] Order No. 779 at P 28.

3. Identification of Facilities and Wide-Area Assessment: Order No. 779, Paragraph 51

In Order No. 779, FERC directed NERC to "'identify facilities most at-risk from severe geomagnetic disturbance' and 'conduct wide-area geomagnetic disturbance vulnerability assessment' as well as give special attention to those Bulk-Power System facilities that provide service to critical and priority loads."[52]

When fully implemented, proposed Reliability Standard TPL-007-1 will enable wide-area assessment of GMD impact. Through the standard development process, industry has provided projections on the time required for obtaining validated tools, models, and data necessary for conducting GMD Vulnerability Assessments. The five-year phased implementation plan has been tailored accordingly and reflects a realistic timeline for the performance of GMD Vulnerability Assessments.

Corrective Action Plans required by proposed Reliability Standard TPL-007-1 provide the means to address risk to all applicable facilities from a Benchmark GMD Event, not only those determined to be most at-risk in wide-area assessments. Additionally, the proposed Reliability Standard enhances NERC's ability to further assess the reliability risks that GMDs pose to the Bulk-Power System through the reliability assessment functions described in Section 800 of the NERC Rules of Procedure. Once the proposed standard is fully implemented, NERC and the Regional Entities will be better able to assess further the potential impacts of GMD events on the Bulk-Power System as a whole.

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[52] Order No. 779 at P 51 (internal citation omitted).

4. Assessment Parameters: Order No. 779, Paragraph 67

In Order No. 779, FERC stated that each responsible entity under the Second Stage GMD Reliability Standards would "be required to assess its vulnerability to the benchmark GMD events consistent with the five assessment parameters identified in the NOPR and adopted in this Final Rule."[53] The proposed Reliability Standard requires applicable entities to perform assessments that will identify the impacts from the Benchmark GMD Event on the interconnected transmission system. The five assessment parameters are addressed as follows:

a) Parameter No. 1: The Reliability Standards should contain uniform evaluation criteria for owners and operators to follow when conducting their assessments.

Evaluation criteria are uniformly established in proposed Requirement R4, Table 1 – Steady State Planning Events, and Attachment 1 – Calculating Geoelectric Fields for the Benchmark GMD Event. Proposed Requirement R4 specifies system conditions. Table 1 establishes uniform performance criteria. Attachment 1 describes the procedure for calculating the Benchmark GMD Event for use in the GMD Vulnerability Assessment.

b) Parameter No. 2: The assessments should, through studies and simulations, evaluate the primary and secondary effects of GICs on Bulk-Power System transformers, including the effects of GICs originating from and passing to other regions.

Proposed Requirements R4 and R6 address assessments of the effects of GICs on applicable transformers. Proposed Requirement R4 specifies that the responsible Planning Coordinators or Transmission Planners (as determined in Requirement R1) must conduct GMD Vulnerability Assessments that include steady state analysis to ensure transformer reactive losses

[53] Order No. 779 at P 67 (internal citation omitted).

from the Benchmark GMD Event do not produce voltage collapse, Cascading, and uncontrolled islanding. Proposed Requirement R6 specifies that applicable Transmission Owners and Generator Owners must conduct thermal impact assessments of applicable power transformers. Proposed Requirement R4 Part R4.3 provides for information-sharing so that the effects of GICs in other planning areas are factored into GMD Vulnerability Assessments. Specifically, proposed Requirement R4 Part 4.3 specifies that GMD Vulnerability Assessments must be provided to the responsible entity's Reliability Coordinator, adjacent Planning Coordinators, adjacent Transmission Planners, and to any functional entity that submits a written request and has a reliability related need.

c) Parameter No. 3: The assessments should evaluate the effects of GICs on other Bulk-Power System equipment, system operations, and system stability, including the anticipated loss of critical or vulnerable devices or elements resulting from GIC-related issues.

In addition to assessing heating and reactive power effects in transformers, proposed Requirements R4 and Table 1 – Steady State Planning Events address assessments of the effects of GICs on other Bulk-Power System equipment, system operations, and system stability, including the loss of devices due to GIC impacts. The study or studies conducted by the applicable Planning Coordinators and Transmission Planners in complying with Requirement R4 must evaluate the performance of the System during a Benchmark GMD Event to prevent voltage collapse, Cascading, and uncontrolled islanding. Devices that Planning Coordinators and Transmission Planners anticipate may be susceptible to harmonic impacts as a result of GIC are to be removed from the System in the analysis, since these devices may affect System performance. Thus, the GMD Vulnerability Assessment includes the effects caused by GIC on the reliable operation of the Bulk-Power System.

d) Parameter No. 4: In conjunction with assessments by owners and operators of their own Bulk-Power System components, wide-area or Regional assessments of GIC impacts should be performed. A severe GMD event can cause simultaneous stresses at multiple locations on the Bulk-Power System, potentially resulting in a multiple-outage event. In predicting GIC flows, it is necessary to take into consideration the network topology as an integrated whole (i.e., on a wide-area basis).

Proposed Reliability Standard TPL-007-1 accounts for wide-area impacts by requiring information exchange and involving appropriate entities. Proposed Requirement R4 and Requirement R7 specify that GMD Vulnerability Assessments and Corrective Action Plans must be provided to Reliability Coordinators, adjacent Planning Coordinators and Transmission Planners, and the functional entities specifically referenced in the plans. Reliability Coordinators work together to maintain real-time reliable operations in the wide area. The information in GMD Vulnerability Assessments and Corrective Action Plans from entities in the Reliability Coordinator area will support this function. Planning Coordinators integrate plans within their areas and coordinate plans with adjacent Planning Coordinators as described in the NERC Functional Model.[54]

e) Parameter No. 5: The assessments should be periodically updated, taking into account new facilities, modifications to existing facilities, and new information, including new research on GMDs, to determine whether there are resulting changes in GMD impacts that require modifications to Bulk-Power System mitigation schemes.

Proposed Reliability Standard TPL-007-1 requires GMD Vulnerability Assessments to be periodically updated, not to exceed every 60 calendar months from the preceding GMD

[54] NERC, *Reliability Functional Model Technical Document* v. 5 (Dec. 2009) at 10-11, *available at* http://www.nerc.com/pa/Stand/Functional%20Model%20Archive%201/FM_Technical_Document_V5_2009Dec1.pdf.

Vulnerability Assessment. The periodicity was established with consideration to the high-impact, low-frequency nature of the Benchmark GMD Event.

5. Improvements in Scientific Understanding of GMDs: Order No. 779, Paragraph 68

In Order No. 779, FERC stated that NERC should consider "developing Reliability Standards that can incorporate improvements in the scientific understanding of GMDs."[55] NERC considered and addressed FERC's concerns.

The Requirements in proposed Reliability Standard TPL-007-1 are performance-based, which allows applicable entities to use state of the art tools and methods to accomplish the specified reliability objectives. The standard does not contain prescriptive requirements for applicable entities to use specific tools, models, or procedures which would limit the applicability of improvements in scientific understanding. Furthermore, the use of modern magnetometer data and statistical methods in determining the Benchmark GMD Event supports reevaluation as additional magnetometer data are collected during future solar cycles.

6. Plans to Protect Against Instability, Uncontrolled Separation, or Cascading Failures of the Bulk-Power System: Order No. 779, Paragraph 79

In Order No. 779, FERC directed NERC to submit for approval one or more Reliability Standards that, in the event potential impacts from a benchmark GMD event are identified:

> [R]equire owners and operators of the Bulk-Power System to develop and implement a plan to protect against instability, uncontrolled separation, or cascading failures of the Bulk-Power System, caused by damage to critical or vulnerable Bulk-Power

[55] Order No. 779 at P 68.

System equipment, or otherwise, as a result of a benchmark GMD event.[56]

This directive is addressed by proposed Requirement R7 of proposed Reliability Standard TPL-007-1. An entity must develop a Corrective Action Plan in the event its System fails to meet specified performance criteria. Proposed Requirement 7 Part 7.1 lists acceptable actions, which are not limited to considering Operating Procedures or enhanced training.

7. Performance of Vulnerability Assessments and Developing Plans to Mitigate Identified Vulnerabilities: Order No. 779, Paragraph 82

In Order No. 779, FERC stated, "As with the First Stage GMD Reliability Standards, the responsible entities should perform vulnerability assessments of their own systems and develop the plans for mitigating any identified vulnerabilities."[57] As discussed above, the proposed standard requires applicable entities to conduct assessments on their systems and develop plans to mitigate identified vulnerabilities. In proposed Requirement R1, applicable Planning Coordinators and Transmission Planners identify responsibilities for maintaining models and performing studies needed for GMD Vulnerability Assessments, as specified in Requirement R4. In proposed Requirement R6, applicable Transmission Owners and Generator Owners are required to conduct thermal impact assessments of applicable BES power transformers and, if necessary, specify mitigating actions. Proposed Requirement R7 requires the responsible Planning Coordinator or Transmission Planner (as determined in Requirement R1) to develop a Corrective Action Plan in the event that it concludes, through the GMD Vulnerability Assessment, that its system does not meet performance requirements.

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[56] Order No. 779 at P 79.

[57] Order No. 779 at P 82.

8. Strict Liability: Order No. 779, Paragraph 84

FERC noted in Order No. 779 that the second stage Reliability Standards "should not impose 'strict liability' on responsible entities for failure to ensure the reliable operation of the Bulk-Power System in the face of a GMD event of unforeseen severity, as some commenters fear."[58] In accordance with Order No. 779, proposed Reliability Standard TPL-007-1 establishes requirements for evaluating and mitigating the impacts of a Benchmark GMD Event on the reliable operation of the Bulk-Power System, but does not impose strict liability on responsible entities for failure to ensure reliable operation during a GMD event of unforeseen severity. Instead, the proposed Reliability Standard is designed to ensure the reliable operation of the Bulk-Power System in response to the identified Benchmark GMD Event. The identification of a robust and technically-justified Benchmark GMD Event in the Reliability Standard addresses the concern that responsible entities might otherwise be required to prevent instability, uncontrolled separation, or cascading failures of the Bulk-Power System when confronted with GMD events of unforeseen severity.

9. Automatic Blocking Measures: Order No. 779, Paragraph 85

In Order No. 779, FERC stated that it would not require the use of automatic blocking measures in the second stage GMD Reliability Standards. FERC stated, "given that some responsible entities have or may choose automatic blocking measures, the NERC standards

[58] Order No. 779 at P 84.

development process should consider how to verify that selected blocking measures are effective and consistent with the reliable operation of the Bulk-Power System."[59]

The GMD Vulnerability Assessment process considers all mitigation measures in modeling, assessment, and mitigation requirements. Proposed Requirement R2 specifies that the responsible entity (i.e. the Planning Coordinator or Transmission Planner(s), as determined in Requirement R1) shall maintain system models for performing GMD Vulnerability Assessments, which will include automatic blocking measures that are part of the system as described in the technical guidance.[60] The responsible entity must perform studies based on these models, as required in proposed Requirement R4, to verify effectiveness and the reliable operation of the Bulk-Power System. When an applicable Transmission Owner or Generator Owner (R6) or responsible Planning Coordinator or Transmission Planner (R7) identifies a need for mitigation actions such as blocking measures, proposed Requirements R6 and R7 specify that information must be shared with planning entities. A planning entity is in the best position to identify whether selected mitigation actions are effective to address the GMD impacts identified in the GMD Vulnerability Assessment and are consistent with the reliable operation of its System. In this way, the standards development process has addressed evaluation of automatic blocking measure effectiveness on the reliable operation of the Bulk-Power System.

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10. Reliability Goals: Order No. 779, Paragraph 86

In Order No. 779, FERC stated that "the NERC standards development process should consider how the reliability goals of the proposed Reliability Standards can be achieved by a

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[59] Order No. 779 at P 85.

[60] *See generally* GIC Application Guide.

combination of automatic measures including, for example, some combination of blocking, improved "withstand" capability, instituting specification requirements for new equipment, inventory management, and isolating certain equipment that is not cost effective to retrofit."[61]

This suggestion is addressed by proposed Requirement R7 of proposed Reliability Standard TPL-007-1. When a responsible Planning Coordinator or Transmission Planner concludes through the GMD Vulnerability Assessment that its System does not meet performance requirements, it is required to develop a Corrective Action Plan. The plan must list deficiencies and the associated actions needed to achieve required performance. Proposed Requirement R7 provides examples of such actions, including installation or modification of equipment, use of Operating Procedures, and other actions specified in the Requirement.

11. Implementation Plan: Order No. 779, Paragraph 91

In Order No. 779, FERC specified a number of considerations for NERC in developing an implementation plan for the second stage GMD Reliability Standard. FERC stated:

> As stated in the NOPR, in a proposed implementation plan, we expect that NERC will consider a multi-phased approach that requires owners and operators of the Bulk-Power System to prioritize implementation so that components considered vital to the reliable operation of the Bulk-Power System are protected first. We also expect, as discussed above, that the implementation plan will take into account the availability of validated tools, models, and data that are necessary for responsible entities to perform the required GMD vulnerability assessments.[62]

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61 Order No. 779 at P 86.

62 Order No. 779 at P 91.

NERC's implementation for proposed Reliability Standard TPL-007-1 is included as **Exhibit B** to this filing. As described above, the proposed implementation plan provides a multi-phased approach to implementation over a five-year period.

Phased implementation will provide the necessary time for applicable entities to develop the required models and for proper sequencing of system and equipment assessments performed by various applicable entities to build an overall assessment of GMD vulnerability. The proposed implementation plan takes into account the availability of validated tools, models, and data that are necessary to perform GMD Vulnerability Assessments.

Additionally, phased implementation will provide the necessary time for the development of viable Corrective Action Plans, which may require entities to develop, perform, or validate new or modified studies, assessments, and procedures to meet the TPL-007-1 requirements. Some mitigation measures may have significant budgeting, siting, or construction planning requirements.

GMD Vulnerability Assessment results are necessary to identify components that are vital to reliable operation during a benchmark GMD event. Therefore, a phased implementation approach will provide an appropriate time period for applicable entities to develop Corrective Action Plans that address identified impacts in a prioritized manner.

H. Enforceability of Proposed Reliability Standard TPL-007-1

The proposed Reliability Standard includes Violation Risk Factors ("VRFs") and Violation Severity Levels ("VSLs"). The VSLs provide guidance on the way that NERC will enforce the Requirements of the proposed Reliability Standard. The VRFs are one of several elements used to determine an appropriate sanction when the associated Requirement is violated. The VRFs assess the impact to reliability of violating a specific Requirement. The VRFs and

VSLs for the proposed Reliability Standards comport with NERC and FERC guidelines related to their assignment. For a detailed review of the VRFs, the VSLs, and the analysis of how the VRFs and VSLs were determined using these guidelines, please see **Exhibit G**.

The proposed Reliability Standard also include Measures that support each Requirement by clearly identifying what is required and how the Requirement will be enforced. These Measures help ensure that the Requirements will be enforced in a clear, consistent, and non-preferential manner and without prejudice to any party.

Respectfully submitted,

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(Available on the NERC Website at

http://www.nerc.com/FilingsOrders/ca/Canadian%20Filings%20and%20Orders%20DL/TPL-007-1_exhibits.pdf)

Exhibit C -- Reliability Standards Criteria

Reliability Standards Criteria

The discussion below identifies these factors and explains how the proposed Reliability Standard has met or exceeded the criteria.

1. Proposed Reliability Standards must be designed to achieve a specified reliability goal and must contain a technically sound means to achieve that goal.

Proposed Reliability Standard TPL-007-1 addresses the unique risks posed by a high-impact, low-frequency GMD event on the reliable operation of the Bulk-Power System and is responsive to FERC's concerns articulated in Order No. 779. The proposed standard requires applicable entities to conduct initial and on-going assessments of the potential impact of a benchmark GMD event on Bulk-Power System equipment and the Bulk-Power System as a whole and requires corrective action to protect against instability, uncontrolled separation, and cascading failures of the Bulk-Power System. The benchmark GMD event used to develop the proposed standard is based on a 1-in-100 year frequency of occurrence, and is supported by rigorous technical analysis of modern measurement data and publicly-available models. Additional information regarding the benchmark GMD event is attached as **Exhibit D** to this filing.

Using a planning approach, the proposed Reliability Standard includes requirements for coordinating responsibilities among applicable entities, developing and maintaining models, establishing performance criteria and assessing performance, exchanging relevant information

necessary to coordinate the actions of applicable entities, and developing Corrective Action Plans to address performance deficiencies.

2. Proposed Reliability Standards must be applicable only to users, owners and operators of the bulk power system, and must be clear and unambiguous as to what is required and who is required to comply.

The proposed Reliability Standard is clear and unambiguous as to what is required and who is required to comply. The proposed Reliability Standard is applicable to: (1) Planning Coordinators with a planning area that includes a power transformer(s) with a high side, wye-grounded winding with terminal voltage greater than 200 kV; (2) Transmission Planners with a planning area that includes a power transformer(s) with a high side, wye-grounded winding with terminal voltage greater than 200 kV; (3) Transmission Owners that own a Facility or Facilities that include a power transformer(s) with a high side, wye-grounded winding with terminal voltage greater than 200 kV; and (4) Generator Owners that own a Facility or Facilities that include a power transformer(s) with a high side, wye-grounded winding with terminal voltage greater than 200 kV. [63] The proposed Reliability Standard clearly articulates the actions that such entities must take to comply with the standard.

[63] A power transformer with a "high side wye-grounded winding" refers to a power transformer with windings on the high voltage side that are connected in a wye configuration and have a grounded neutral connection.

3. A proposed Reliability Standard must include clear and understandable consequences and a range of penalties (monetary and/or non-monetary) for a violation.

The Violation Risk Factors ("VRFs") and Violation Severity Levels ("VSLs") for the proposed Reliability Standard comport with NERC and FERC guidelines related to their assignment. The assignment of the severity level for each VSL is consistent with the corresponding requirement and the VSLs should ensure uniformity and consistency in the determination of penalties. The VSLs do not use any ambiguous terminology, thereby supporting uniformity and consistency in the determination of similar penalties for similar violations. For these reasons, the proposed Reliability Standard includes clear and understandable consequences in accordance with Order No. 672.

4. A proposed Reliability Standard must identify clear and objective criterion or measure for compliance, so that it can be enforced in a consistent and non preferential manner.

The proposed Reliability Standard contains Measures that support each Requirement by clearly identifying what is required and how the Requirement will be enforced. These measures help provide clarity regarding how the Requirements will be enforced and help ensure that the Requirements will be enforced in a clear, consistent, and non-preferential manner and without prejudice to any party.

5. Proposed Reliability Standards should achieve a reliability goal effectively and efficiently — but do not necessarily have to reflect "best practices" without regard to implementation cost or historical regional infrastructure design.

The proposed Reliability Standard achieves its reliability goals effectively and efficiently. The proposed Reliability Standard clearly enumerates the responsibilities of applicable entities with respect to conducting initial and on-going assessments of the potential impact of a benchmark GMD event on Bulk-Power System equipment and the Bulk-Power System as a whole and provides entities the flexibility to select appropriate mitigation strategies to address identified vulnerabilities.

6. Proposed Reliability Standards cannot be "lowest common denominator," i.e., cannot reflect a compromise that does not adequately protect Bulk-Power System reliability. Proposed Reliability Standards can consider costs to implement for smaller entities, but not at consequences of less than excellence in operating system reliability.

The proposed Reliability Standard does not reflect a "lowest common denominator" approach. To the contrary, the proposed Reliability Standard contains significant reliability benefits for the Bulk-Power System and addresses directives and concerns identified by FERC in Order No. 779. The provisions of the proposed standard raise the level of preparedness by requiring applicable entities to plan for the reliable operation of the Bulk-Power System during a severe, 1-in-100 year GMD event. The proposed Reliability Standard and accompanying benchmark GMD event incorporate rigorous technical analysis that is representative of the complex nature of space weather phenomena and reflects a balanced and practical approach. Further, the proposed standard provides flexibility for entities to select appropriate mitigation

strategies, subject to the vulnerabilities identified in the assessments and as supported by technical guidance.

7. Proposed Reliability Standards must be designed to apply throughout North America to the maximum extent achievable with a single Reliability Standard while not favoring one geographic area or regional model. It should take into account regional variations in the organization and corporate structures of transmission owners and operators, variations in generation fuel type and ownership patterns, and regional variations in market design if these affect the proposed Reliability Standard.

The proposed Reliability Standard applies consistently throughout North America and does not favor one geographic area or regional model.

8. Proposed Reliability Standards should cause no undue negative effect on competition or restriction of the grid beyond any restriction necessary for reliability.

Proposed Reliability Standard TPL-007-1 has no undue negative effect on competition and does not unreasonably restrict the available transmission capacity or limit the use of the Bulk-Power System in a preferential manner. The proposed standard requires the same performance by each of the applicable entities. The information sharing required by the proposed standard is necessary for reliability and can be accomplished without presenting any market or competition-related concerns.

9. The implementation time for the proposed Reliability Standard is reasonable.

The proposed effective date for proposed Reliability Standard TPL-007-1 and the proposed Definition of "Geomagnetic Disturbance Vulnerability Assessment" (or "GMD Vulnerability Assessment") is just and reasonable and appropriately balances the urgency in the need to implement the standard against the reasonableness of the time allowed for those who

must comply to develop necessary procedures, software, facilities, staffing or other relevant capability. NERC proposes a multi-phase implementation plan over five years to allow applicable entities adequate time to ensure compliance with the Requirements. The proposed implementation plan is attached as **Exhibit B** to this filing.

10. The Reliability Standard was developed in an open and fair manner and in accordance with the Reliability Standard development process.

The proposed Reliability Standard was developed in accordance with NERC's ANSI-accredited processes for developing and approving Reliability Standards. **Exhibit I** includes a summary of the Reliability Standard development proceedings, and details the processes followed to develop the proposed Reliability Standard.

These processes included, among other things, multiple comment periods, pre-ballot review periods, and balloting periods. Additionally, all meetings of the standard drafting team were properly noticed and open to the public. The initial and recirculation ballots both achieved a quorum and exceeded the required ballot pool approval levels.

11. NERC must explain any balancing of vital public interests in the development of proposed Reliability Standards.

NERC has identified no competing public interests regarding the request for approval of this proposed Reliability Standard. No comments were received that indicated the proposed Reliability Standard conflicts with other vital public interests.

12. Proposed Reliability Standards must consider any other appropriate factors.

No other negative factors relevant to whether the proposed Reliability Standard is just and reasonable were identified.