Generation Interconnection Impact Study Report

For

PJM Generation Interconnection Request Queue Position AD1-128

Modoc - Delaware 138 kV

December 2019

Preface

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the Feasibility Study, but the actual allocation will be deferred until the System Impact Study is performed.

The System Impact Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

The Interconnection Customer seeking to interconnect a wind or solar generation facility shall maintain meteorological data facilities as well as provide that meteorological data which is required per Schedule H to the Interconnection Service Agreement and Section 8 of Manual 14D.

An Interconnection Customer with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.

General

Riverstart Solar Park Energy, LLC proposes to install PJM Project #AD1- 128, a 150.0 MW (57.0 MW Capacity) solar generating facility in Randolph County, Indiana (see Figure 2). The primary point of interconnection will be a connection AEP's Modoc – Delaware 138 kV section of the College Corner – Delaware 138 kV circuit (see Figure 3).

The requested in Backfeed date is August 1, 2021.

The requested in service date is October 31, 2021.

Point of Interconnection

Point of Interconnection (Modoc – Delaware 138 kV)

To accommodate the interconnection on the Modoc – Delaware 138 kV section of the College Corner – Delaware 138 kV circuit, a new three (3) circuit breaker 138 kV switching station physically configured in a breaker and half bus arrangement but operated as a ring-bus will be constructed (see Figure 3). Installation of associated protection and control equipment, 138 kV line risers, SCADA, and 138 kV revenue metering will also be required. AEP reserves the right to specify the final acceptable configuration considering design practices, future expansion, and compliance requirements.

Cost Summary

This project will be responsible for the following costs:

Description	Total Cost	
Attachment Facilities	$	250,000
Direct Connection Network Upgrades	$	6,000,000
Non Direct Connection Network Upgrades	$	1,750,000
Allocation for New System Upgrades	$	300,000
Contribution for Previously Identified Upgrades	$	0
Total Costs	**$**	**8,300,000**

Attachment Facilities

The total preliminary cost estimate for the Attachment work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Estimated Cost
138 kV Revenue Metering	$250,000

Direct Connection Cost Estimate

The total preliminary cost estimate for the Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Interconnection Station Work and Cost:

- Construct a new three (3) circuit breaker 138 kV switching station physically configured in a breaker and half bus arrangement but operated as a ring-bus. Installation of associated protection and control equipment, 138 kV line risers, SCADA, and 138 kV revenue metering will also be required (see Figure 1).
    - **Estimated Station Cost: $6,000,000**

Non-Direct Connection Cost Estimate

The total preliminary cost estimate for the Non-Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Estimated Cost
College Corner-Delaware 138 kV T-Line Cut In	$1,000,000
Upgrade line protection and controls at the expanded Modoc 138 kV	$250,000
Upgrade line protection and controls at the Centreville 138 kV substation to coordinate with the expanded Modoc 138 kV substation.	$250,000
Upgrade line protection and controls at the Delaware 138 kV substation to coordinate with the expanded Modoc 138 kV substation.	$250,000
Total	**$1,750,000**

Interconnection Customer Requirements

It is understood that Riverstart Solar Park Energy is responsible for all costs associated with this interconnection. The cost of Riverstart Solar Park Energy's generating plant and the costs for the line connecting the generating plant to the Modoc 138 kV substation are not included in this report; these are assumed to be Riverstart Solar Park Energy's responsibility.

The Generation Interconnection Agreement does not in or by itself establish a requirement for American Electric Power to provide power for consumption at the developer's facilities. A separate agreement may be reached with the local utility that provides service in the area to ensure that infrastructure is in place to meet this demand and proper metering equipment is installed. It is the responsibility of the developer to contact the local service provider to determine if a local service agreement is required.

Requirement from the PJM Open Access Transmission Tariff:

1. An Interconnection Customer entering the New Services Queue on or after October 1, 2012 with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.

2. The Interconnection Customer may be required to install and/or pay for metering as necessary to properly track real time output of the facility as well as installing metering which shall be used for billing purposes. See Section 8 of Appendix 2 to the Interconnection Service Agreement as well as Section 4 of PJM Manual 14D for additional information.

Revenue Metering and SCADA Requirements

PJM Requirements

The Interconnection Customer will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

AEP Requirements

The Interconnection Customer will be required to comply with all AEP Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "Requirements for Connection of New Facilities or Changes to Existing Facilities Connected to the AEP Transmission System" document located at the following link:

http://www.pjm.com/~/media/planning/plan-standards/private-aep/aep-interconnection-requirements.ashx

Network Impacts

The Queue Project AD1-128 was evaluated as a 150.0 MW (Capacity 57.0 MW) injection into a tap of the Modoc – Delaware 138 kV line in the AEP area. Project AD1-128 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD1-128 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Analysis - 2021

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

None.

Light Load Analysis

Light Load Studies to be conducted during later study phases (applicable to wind, coal, nuclear, and pumped storage projects).

Multiple Facility Contingency

(Double Circuit Tower Line contingencies were studied for the full energy output. The contingencies of Line with Failed Breaker and Bus Fault will be performed for the Impact Study.)

1. (AEP - DEO&K) The 05COLLCO-08COLINV 138 kV line (from bus 243262 to bus 250001 ckt 1) loads from 95.56% to 101.09% (AC power flow) of its emergency rating (167 MVA) for the tower line contingency outage of 'DEO&K P7-1 DEO&K-AEP-DAY CIRCUIT3284&13803'. This project contributes approximately 10.56 MW to the thermal violation.

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CONTINGENCY 'DEO&K P7-1 DEO&K-AEP-DAY CIRCUIT3284&13803'
  OPEN BRANCH FROM BUS 250105 TO BUS 250116 CKT 1
  OPEN BRANCH FROM BUS 243262 TO BUS 250106 CKT 1
  OPEN BRANCH FROM BUS 253057 TO BUS 250106 CKT 1
  END
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Please refer to Appendix 2 for a table containing the generators having contribution to this flowgate.

Short Circuit

(Summary of impacted circuit breakers)

None.

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

None.

Steady-State Voltage Requirements

(Summary of the VAR requirements based upon the results of the steady-state voltage studies)

See Figure 4

Stability and Reactive Power Requirement for Low Voltage Ride Through

(Summary of the VAR requirements based upon the results of the dynamic studies)

See Figure 4

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

1. To resolve the 05COLLCO-08COLINV 138 kV line overload:

    AEP:

    1) Limiting element is ACSR ~ 397.5 ~ 30/7 ~ LARK - Conductor section 1. A Sag Study will be required on the 0.15 mile section of line to mitigate the overload. Depending on the sag study results, cost for this upgrade is expected to be between $20,000 (no remediation required just sag study) and $0.3 million (complete line reconductor/rebuild required). PJM Network Upgrade N6123.

        (A) Sag Study: 6 to 12 months.
        (B) Rebuild: The standard time required for construction differs from state to state. An approximate construction time would be 24 to 36 months after signing an interconnection agreement.

    AD1-128 is responsible for this cost.

    DEOK: The DEOK SE rating on this line is 178MVA. No upgrade required.

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

None.

Potential Congestion due to Local Energy Deliverability

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which shall study all overload conditions associated with the overloaded element(s) identified

None.

Incremental Capacity Transfer Rights (ICTRs)

Will be determined at a later study phase

Affected System Analysis & Mitigation

LGEE Impacts:

None

MISO Impacts:

MISO Impacts to be determined during later study phases (as applicable).

Duke, Progress & TVA Impacts:

None

OVEC Impacts:

None

Figure 1: (Modoc - Delaware 138 kV) Single-Line Diagram

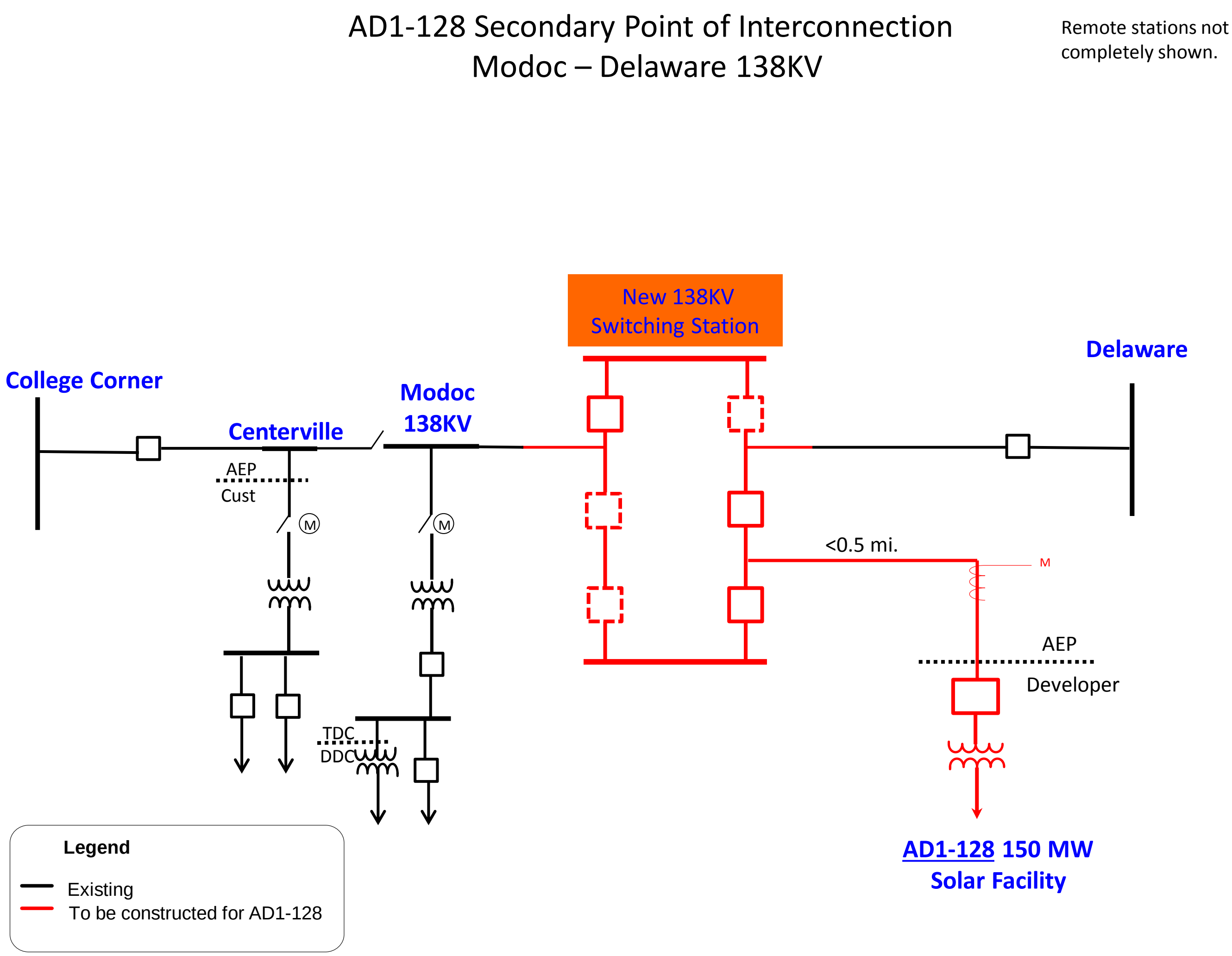

Figure 2: Point of Interconnection (Modoc – Delaware 138 kV)

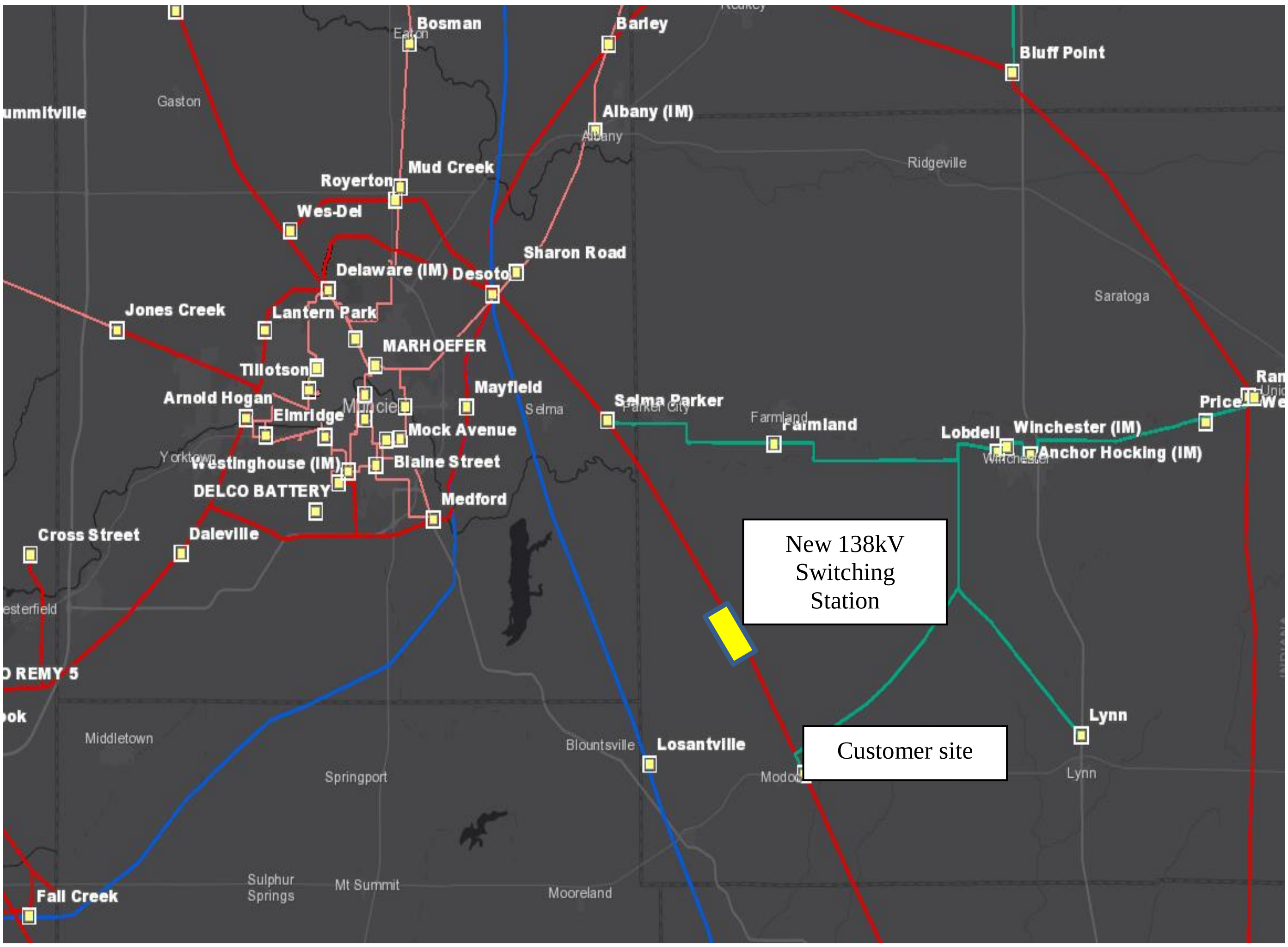

Figure 3: Appendices

The following appendices contain additional information about each flowgate presented in the body of the report. For each appendix, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. All New Service Queue Requests, through the end of the Queue under study, that are contributors to a flowgate will be listed in the Appendices. Please note that there may be contributors that are subsequently queued after the queue under study that are not listed in the Appendices. Although this information is not used "as is" for cost allocation purposes, it can be used to gage the impact of other projects/generators.

It should be noted the project/generator MW contributions presented in the body of the report and appendices sections are full contributions, whereas the loading percentages reported in the body of the report, take into consideration the commercial probability of each project as well as the ramping impact of "Adder" contributions.

Appendix 2

(AEP - DEO&K) The 05COLLCO-08COLINV 138 kV line (from bus 243262 to bus 250001 ckt 1) loads from 95.56% to 101.09% (AC power flow) of its emergency rating (167 MVA) for the tower line contingency outage of 'DEO&K P7-1 DEO&K-AEP-DAY CIRCUIT3284&13803'. This project contributes approximately 10.56 MW to the thermal violation.

CONTINGENCY 'DEO&K P7-1 DEO&K-AEP-DAY CIRCUIT3284&13803'
 OPEN BRANCH FROM BUS 250105 TO BUS 250116 CKT 1
 OPEN BRANCH FROM BUS 243262 TO BUS 250106 CKT 1
 OPEN BRANCH FROM BUS 253057 TO BUS 250106 CKT 1
 END

Bus Number	*Bus Name*	*Full Contribution*
247288	*05RICHG1*	*0.73*
247289	*05RICHG2*	*0.73*
243415	*05WWVSTA*	*2.21*
932841	*AC2-111 C*	*4.95*
932842	*AC2-111 E*	*8.08*
934961	*AD1-128 C O1*	*4.01*
934962	*AD1-128 E O1*	*6.55*
LTF	*BLUEG*	*0.02*
LTF	*CALDERWOOD*	*< 0.01*
LTF	*CARR*	*0.02*
LTF	*CATAWBA*	*0.01*
LTF	*CBM-S1*	*0.13*
LTF	*CBM-W1*	*3.15*
LTF	*CBM-W2*	*3.61*
LTF	*CHEOAH*	*< 0.01*
LTF	*CHILHOWEE*	*< 0.01*

LTF	*CIN*	*0.78*
LTF	*CLIFTY*	*0.97*
LTF	*G-007*	*0.06*
LTF	*HAMLET*	*0.04*
LTF	*IPL*	*0.8*
LTF	*MEC*	*1.33*
LTF	*MECS*	*0.85*
LTF	*O-066*	*0.38*
LTF	*RENSSELAER*	*0.01*
LTF	*SANTEETLA*	*< 0.01*
LTF	*TRIMBLE*	*< 0.01*
LTF	*WEC*	*0.23*

Figure 4: Dynamic Simulation Analysis

Executive Summary

Generator Interconnection Request AD1-128 is for a 150 MW Maximum Facility Output (MFO) solar powered generating facility with a Point of Interconnection (POI) at a tap of the Modoc – Delaware 138 kV circuit in the AEP system, Randolph County, Indiana.

This report describes a dynamic simulation analysis of AD1-128 as part of the overall system impact study.

The load flow scenario for the analysis was based on the RTEP 2021 peak load case, modified to include applicable queue projects. AD1-128 has been dispatched online at maximum power output, with 1.0 p.u. voltage at the generator bus.

AD1-128 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. Steady-state condition and 58 contingencies were studied, each with a 10 second simulation time period. Studied faults included:

a) Steady-state operation (20 second);
b) Three-phase faults with normal clearing time for an intact network and during planned mainetanance outages;
c) Single-phase faults with stuck breaker;
d) Single phase faults with delayed (Zone 2) clearing at remote due to primary relay failure;
e) Single phase bus faults;
f) Single-phase faults with loss of multi-circuit tower line.

No relevant high-speed reclosing (HSR) contingencies were identified for this study.

For all simulations, the queue project under study along with the rest of the PJM system were required to maintain synchronism and with all states returning to an acceptable new condition following the disturbance.

For all of the fault contingencies tested on the 2021 peak load case:

a) AD1-128 was able to ride through the faults (except for faults where protective action trips a generator(s)),
b) Post-contingency oscillations were positively damped with a damping margin of at least 3% for interarea modes and 4% for local modes.
c) Following fault clearing, all bus voltages recovered to a minimum of 0.7 per unit after 2.5 seconds (except where protective action isolates that bus).
d) No transmission element tripped, other than those either directly connected or designed to trip as a consequence of that fault.

For some contingencies it was found that the post fault response of AD1-128 resulted in reactive output and terminal voltage temporarily ramping to below the final setpoint before settling into the new steady state. This is a result of the inverter overcompensating during low voltage ride through, then ramping reactive output down after the fault is cleared. Once the fault is cleared and the voltage dips below the setpoint due to reactive power ramping down, the power plant controller resumes control of the plant. This response can be tuned by changing model parameters.

No mitigations were found to be required.