March 2025

THE NARRAGANSETT ELECTRIC COMPANY

Woonsocket Substation – Nasonville Substation 115 kV Transmission Line

Rhode Island Energy Facility Siting Board

Siting Report

Prepared for:
The Narragansett Electric Company
280 Melrose Street
Providence, RI 02907

BSC Project No. 0101159.00

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PREPARED FOR:

THE NARRAGANSETT ELECTRIC COMPANY
280 MELROSE STREET
PROVIDENCE, RI 02907

FOR SUBMITTAL TO:

STATE OF RHODE ISLAND ENERGY FACILITY SITING BOARD
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ACRONYMS AND ABBREVIATIONS

ACGIH	American Conference of Governmental and Industrial Hygienists
ACI	American Concrete Institute
ACSR	Aluminum Conductor Steel-Reinforced cable
ACSS	Aluminum Conductor Steel-Supported cable
Act	Energy Facility Siting Act (the "Act")
ANSI	American National Standards Institute
AOI	Area Of Interest (Soil Mapping)
APE	Area of Potential Effects (Cultural resources assessment)
ASCE	American Society of Civil Engineers
ASF	Areas Subject to Flooding
ASSF	Areas Subject to Storm Flowage
BMP	Best Management Practices
BSC	BSC Group, Inc.
CFR	Code of Federal Regulations
Company	The Narragansett Electric Company
dB	Decibels
DC	Double Circuit
EFSB	Energy Facility Siting Board
EFSB Rules	EFSB's "Rules of Practice and Procedure" effective November 8, 2018"
EG-303	TNEC's ROW Access, Maintenance and Construction Best Management Practices for New England
EG-802	TNEC's Environmental Guidance EP-8; Air Emissions Management
EMF	Electric and Magnetic Fields
ESA	Endangered Species Act
Exponent	Exponent, Inc.
FEMA	Federal Emergency Management Agency
GA	RI Groundwater Classification – waters known or presumed to be suitable for drinking water use without treatment and located outside of the three priority areas described under GAA.
GAA	RI Groundwater Classification – waters known or presumed to be suitable for drinking water use without treatment, and located within a major stratified drift aquifer, wellhead protection area or groundwater dependent area.
GB	RI Groundwater Classification – groundwater which may not be suitable for drinking water use without treatment due to known or presumed degradation.
GC	RI Groundwater Classification – groundwater classified GC is or may be unsuitable for drinking water use due to certain waste disposal practices.
Hz	Hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEEE	Institute of Electrical and Electronic Engineers
IpaC	Information for Planning and Conservation
ISO-NE	Independent System Operator – New England
kV	kilovolt
kV/M	kilovolts per meter
mG	milliGauss
NEEWS	New England East-West Solutions
NESC	National Electrical Safety Code
NHESP	Natural Heritage Endangered Species Program
NLEB	Northern Long-Eared Bat
NRCS	Natural Resource Conservation Service

NRHP	National Register of Historic Places
OPGW	Optic Fiber Ground Wire
PAL	Public Archaeology Laboratory
PBO	Programmatic Biological Opinion
PPL	Pennsylvania Power and Light
Project	Rebuild of the S171N/T172N Lines Transmission Lines in North Smithfield, RI.
Report	Siting Report
RI	Rhode Island
RIDEM	Rhode Island Department of Environmental Management
RIDOT	Rhode Island Department of Transportation
RIGIS	Rhode Island Geographic Information System
R.I.G.L	Rhode Island General Laws
RIHPHC	Rhode Island Historic Preservation and Heritage Commission
ROW	Right-of-Way
Rules	Rhode Island Fresh Water Wetlands Act and Rules
SC	Single Circuit
SESC	Soil Erosion and Sediment Control
SHPO	State Historic Preservation Office
SHWTD	Seasonal High Water Table Depth
TMDL	Total Maximum Daily Load
TNEC	The Narragansett Electric Company
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife
USGS	United States Geological Survey
V	Volt
V/m	volts per meter

1 EXECUTIVE SUMMARY

1.1 Project Description

This Siting Report (the "Report") has been prepared in accordance with Rule 1.6 of the Rhode Island Energy Facility Siting Board ("EFSB") Rules of Practice and Procedure to support a License for The Narragansett Electric Company's ("TNEC" or the "Company") **Woonsocket Substation – Nasonville Substation 115 kV Transmission Line Project** (the "Project"). The Project is the construction of a new 115 kilovolt ("kV") transmission line (the "U-170 Line") between the Woonsocket Substation in North Smithfield and the Nasonville Substation in Burrillville, the expansion of the Woonsocket Substation in North Smithfield, and the rebuild of the existing B23 115 kV transmission line ("B23 Line") between the Nasonville Substation and West Farnum Substation (~4.7 miles long). The Project will use the existing right-of-way ("ROW") occupied by the B23 Line. Please refer to Project Overview Map (Figure 1-1), for details of the Project ROW.[1]

1.2 Project Team

This Report has been prepared by TNEC employees and consultants retained by TNEC. The description of the affected natural and social environments, and impact analyses were prepared by BSC Group, Inc. ("BSC"). Other consultants contributing to the Report include Public Archaeology Laboratory ("PAL") for cultural resources; Exponent, Inc. for analysis of health effects of electric and magnetic fields ("EMF"); and Robinson & Cole LLP for legal counsel. Sargent & Lundy is responsible for Project engineering and design.

1.3 Project Need

The Project is needed to address violations of the distribution planning criteria that were identified in the 2022 Northwest Rhode Island Study ("NWRI Study") performed by the Company's Distribution Planning. Specifically, the Project will address potential system overload risks and system reliability at the Nasonville Substation by the construction of the new U-170Line. The additional transmission line and the substation improvements are designed to: prevent overloads in the event of an outage; bring the system into conformance with distribution planning criteria; and improve overall system reliability and resilience.

1.4 Project Alternatives

The following alternatives were considered to address the issues raised in the NWRI Study:

1) The construction of a second 34.5 kV Tap Line from Iron Mine Substation to Nasonville Substation (rejected as it would involve the use of two different supply voltages, which could cause significant load sharing imbalance, and because portions of the route were within heavily wooded areas, presenting hazards to the lines).

[1] The Company applied for and received approval to construct the first phase of the line per EFSB Docket SB 2024-03 located between the Woonsocket Substation and the West Farnum Substation. In that filing and in Company's 2025 Master Construction Plan, the new transmission line identification ("ID") was U-181 Line. The line ID was changed to U-170 after ISO - NE confirmed that the U-181 Line ID was being used in New Hampshire.

2) The construction of a new 115 kV transmission line from the West Farnum Substation to Nasonville Substation which includes expansion of the West Farnum Substation (rejected due to complications with expanding the 115 kV ring bus at West Farnum Substation).

3) The construction of a new underground 115 kV transmission line from the Woonsocket Substation to Nasonville Substation, following streets and/or newly acquired easements, and includes the expansion of the Woonsocket Substation (rejected due to logistical constraints in obtaining new easement rights, high project costs, and practical constraints associated with the difficulty in repairing faults in underground cables, and the disruption this causes when roadways need to be dug-up).

4) The proposed Project (and preferred alternative) is the construction of the overhead U-170 Line from the Woonsocket Substation to Nasonville Substation, within the existing B23 Line ROW, and includes the expansion of the Woonsocket Substation.

The rebuild of the B23 Line is required to fit a second transmission line in the ROW. Although the B23 Line has not reached its end of life, the B23 Line is an older line that would have been up for replacement in the next decade.

As summarized in Section 4 of this Report, the proposed Project was selected because it provides the most cost-effective solution with lowest environmental impacts. Rebuilding the B23 Line on double circuit structures with the U-170 Line does not provide the operational challenges of installing a second lower voltage line and is the most cost effective and least environmentally impactful approach of the other alternatives.

1.5 Project Impacts

Consistent with other transmission line projects, the Project impacts will be limited because the work is within the existing transmission line ROW, associated off-ROW access roads, and Company-owned substation parcels (collectively, the "Project Area"). The Project Area crosses areas of mixed forest, deciduous forest, softwood forest, and medium density residential land use. Limited permanent impacts will occur as a result of tree removals. Temporary impacts will occur as a result of the use of construction matting for access and work pads within sensitive resource areas.

The Project will have limited impacts within wetland resource areas (including wetlands, streams, riverfront area, and floodplain), within potential habitat for the federally listed species Northern Long Eared Bat ("NLEB") and tricolored bat, and within mapped habitat for five (5) state-listed rare plant species. These impacts are described in greater detail in Section 7 of the Report and the proposed mitigation of the impacts is described in Section 8 of the Report.

Historic resources are located within proximity of the Project, and a determination on possible impacts is pending.

1.6 Project Mitigation

Throughout construction, Best Management Practices (BMPs) will be employed to avoid, minimize, and mitigate for all Project impacts. Measures will include:

Mitigation for environmental impacts – construction limited to existing ROW; restoration of all disturbed areas (including loaming and seeding with appropriate native seed mix, where required); removal of all construction debris, materials and equipment once construction is complete; restoration

of pre-existing grades and drainage patterns where practicable; restoration of existing stone walls, fences, or other features where appropriate.

Mitigation for wetland impacts – use of construction matting to protect wetland soils and vegetation; use of sediment and erosion controls to protect water quality; selecting access routes and work pad orientations that minimize wetland impacts; monitoring throughout construction by an environmental monitor.

Mitigation for rare species impacts – Project verified by USFWS and received a "no effect" determination for federally-listed endangered species; state listed rare plants will be fenced and avoided, in accordance with RIDEM advise.

Mitigation for social resource impacts – construction limited to existing ROW; construction to conform with all local, state and federal air quality and noise level requirements; dust suppression measures.

1.7 Compliance with EFSB Requirements

This Report is being submitted to satisfy the applicable requirements of Rhode Island General Laws ("R.I.G.L.") 42-98-1 et seq., the Energy Facility Siting Act (the "Act"), in compliance with Section 4 of the Energy Facility Siting Act, which states that: "*No person shall site, construct, or alter a major energy facility within the state without first obtaining a license from the siting board pursuant to this chapter.*" Under the Act, transmission lines with a design rating of greater than or equal to 69 kV are classified as major energy facilities. The Report filing requirements and associated procedures for a major generating facility are established in the EFSB's "Rules of Practice and Procedure" effective November 8, 2018 (the "EFSB Rules").

1.8 Arrangement of the Report

This Report has been prepared in support of an application to the EFSB for construction of jurisdictional facilities and for submission with other state and local applications required for the Project. The Report has been prepared in accordance with the EFSB Rules to provide information on the potential impacts of the electric transmission system improvements proposed by TNEC. The Purpose and Need for the Project is detailed in *Section 2* of this Report. *Section 3* provides a detailed description of each of the components of the Project; discusses construction practices; and includes ROW maintenance practices, safety and public health considerations, Public Outreach, estimated costs for the Project, and the anticipated Project schedule. An analysis of the alternatives to the Project, together with reasons for the rejection of these alternatives, is presented in *Section 4* of this Report. Detailed descriptions of the characteristics of the natural and social environment within and immediately surrounding the Project location are included in *Sections 5* and *6*, respectively. *Section 7* of this Report summarizes the potential impacts of the Project on the natural and social environments. *Section 8* summarizes proposed mitigation measures intended to offset or eliminate the potential impacts associated with the Project. *Section 9* lists the federal, state, and local governmental agencies which may exercise licensing authority and from which TNEC may be required to obtain approvals prior to constructing the Project. The Figures section contains supporting mapping and figures. The Appendices of this Report contain supporting reports and project guidance documents, as applicable.

1.9 Conclusion

The proposed Woonsocket Substation – Nasonville Substation 115 kV Transmission Line Project will address existing violations of the distribution planning criteria and will improve overall electrical

system reliability and resilience. The Project is comprised of three components: the construction of the new U-170 Line; the rebuild of the existing B23 Line; and the expansion of the Woonsocket Substation. As summarized in this Report, the Project is needed and cost justified, and the design and construction practices will minimize the impacts on the natural and social environment.

2 PROJECT PURPOSE AND NEED

2.1 New U-170 Line

The new U-170 Line addresses violations of the distribution planning criteria identified by the NWRI Study performed by the Company's Distribution Planning. The NWRI Study identified the Nasonville Substation as a reliability issue, as it is sourced from a single transmission line that terminates at the substation. Currently, the loss of either the B23 Line or the single Nasonville transformer results in over 17 MVA of unserved load at peak. The loss would impact about 4,670 of the Company's customers, including about 440 commercial customers. Additionally, this condition would impact the supply to the Pascoag Utility District, which serves approximately 5,000 customers.[2]

Although the Pascoag Utility District has the benefit of the Pascoag energy storage project that was completed in 2022 after the NWRI Study was completed, the Pascoag energy storage project does not alter the conclusions of the NWRI Study because the energy storage project is a customer owned facility that is not under contract with the Company to provide contingency support during outages.

The Company experienced the reliability issue on August 22, 2022 when lightning triggered a B23 Line outage and Nasonville Substation 13.8 kV bus failure. This outage resulted in a concerted effort to minimize customer hours interrupted during the installation of the mobile switchgear to restore all Nasonville Substation feeders to their normal configuration. To minimize the interruption, feeder ties at the Woonsocket Substation and Riverside Substation were utilized to pick up as much load as possible. Existing distributed energy resources and existing and roll-on diesel generation were used to support the multi-day restoration effort. Additionally, some large customers volunteered to curtail their load. During this abnormal configuration, there were several loading and voltage concerns in the area that would not have been sustainable through higher loading conditions.

The new U-170 Line will be sourced by creating a new transmission line from the Woonsocket Substation. The new 115 kV line will be located in a new 2 breaker bay, requiring a footprint expansion of the Woonsocket Substation. The new U-170 Line will be installed on the same double-circuit structures for the majority of the Project route, with a short (~930-ft) section outside of the West Farnum Substation being supported on separate structures. This configuration could not occur with the existing wood structures.

Construction of the new U-170 Line and the rebuild of the B23 will provide the transmission line reliability that is missing from the current configuration.

2.2 B23 Line Rebuild

The B23 Line was originally constructed in 1982. Since 2021, there have been six operations on the B23 Line, five of which have been permanent outages affecting nearly 5,000 customers momentarily and nearly 14,000 customers permanently. The line is primarily wood monopole structures, several of which are from the original construction date, and currently utilizes 336 ACSR Linnet as the conductor. Seventy-five percent of the wood structures are over 33 years old and 22% of the structures are over 43 years old. The typical lifespan of a wood pole is 40-50 years, and as such, nearly 75% of the existing

[2] The Town of Burrillville Zoning Board approved the expansion of the Nasonville Substation (CASE 2023-25) on December 12, 2023. The Nasonville Substation will benefit from this project, but the Project is not required for the expansion because the new substation could run two taps off of the B23 Line. However, such a setup would not address the reliability issue that is being addressed by the installation of the U-170 Line.

B23 Line is approaching that end-of-life timeframe within the next decade. Inspections of B23 Line in 2023 revealed 24 defects including pole top rot, pole top cracking, woodpecker holes, loose guy wires, flashed and scaling insulators, and missing Pal nuts. Due to the existing age and condition of the B23 assets, TNEC expects that the Line would require rebuilding within the next decade once the majority of the existing structures were 40 years or older. Maintaining this line and making repairs as needed was rejected because the existing B23 Structures cannot support the new U-170 Line in its current configuration and there is insufficient space to run a separate 115 kV transmission line within the narrower portions of the ROW.

The B23 Line has original 336 ACSR conductor which is 43 years old with an expected life of 65 years. Based on this, replacing both the aging conductor and structures at the same time will limit disruption to the surrounding area as well as optimize the constructability and costs by reducing the need to mobilize crews multiple times. The B23 Line's failing structures drive the asset condition need for its rebuild. Additionally, due to ROW width constraints, constructing the U-170 Line is only feasible if it is double-circuited with the B23 Line. The current B23 Line's wood structures were not designed to bear the load of multiple circuits. Replacing both the failing structures and aging conductor at the same time will limit the disruption to the surrounding area and optimize the constructability and costs.

2.3 Woonsocket Substation Expansion

The existing 115 kV yard at the Woonsocket Substation will be expanded to the north to accommodate a new 115 kV bay which is needed to accommodate the new U-170 Line. Based on conversations with Mark Carruolo, North Smithfield Director of Planning, additional Town review and/or approvals are not required for the expansion of the Woonsocket Substation.

3 PROJECT DESCRIPTION AND PROPOSED ACTION

3.1 Introduction

This section of the Report summarizes: the scope of the Project, the proposed facilities, TNEC's construction practices, estimated Project costs, and the anticipated Project schedule.

3.1.1 U-170 Line Construction & B23 Line Rebuild

The Project involves the construction of the new U-170 Line from Woonsocket Substation to Nasonville Substation, which will require the rebuild of the existing B23 Line (~4.7 miles long) into a double circuit configuration with the U-170 line between the Nasonville Substation and West Farnum Substation (except for a short ~930-ft long stretch outside of the West Farnum Substation, which will be supported on separate structures). The existing B23 Line is a single 115 kV circuit, supported on wood poles. The B23 Line will be rebuilt (in its existing location) on 115 kV double-circuit steel monopoles. The circuit for the new U-170 Line will be installed on the same double-circuit monopoles. The existing 13.8 kV distribution line that's currently underbuilt with the B23 Line between Structures 1 and 18 will be relocated to the south side of the ROW. Each transmission line will use 1113 kcmil 54/19 ACSS ("Finch") conductor and an OPGW wire of SFPOC/SFSJ-J-5288 0.567" OPGW. The new U-170 Line will connect the Nasonville and Woonsocket Substations. Two (2) new poles will be installed at the Woonsocket Substation to support the U-170 Line connection to the substation.

The existing B23 Line is located in two ROWs that connect in North Smithfield. The first portion of the ROW, approximately 4.1 miles, extends west from the West Farnum Substation and is approximately 300 feet wide. *See Figure 7-3.* The second portion of the ROW, approximately 0.6 miles, is located in North Smithfield and Burrillville between the Nasonville Substation and Structure 18 is presently 50 feet wide, which is narrower than typical for a 115 kV Line. *See Figure 7-2.* The narrowness was considered in the design by using a double circuit compact design with braced posts that do not decrease the distance to the edge of ROW. The easement rights to the narrower ROW allow for a maximum width of 75 feet when there are two lines present in the ROW. The relocated 13.8 kV distribution line will be the second line in the ROW. For reference purposes, attached as **Appendix E** is a copy of one of the easements from the narrower ROW.

In order to provide adequate line clearances, and avoid outage risks from falling tree branches, 52,657 sf / 1.21 acres of tree removals are required along the narrower B23 Line ROW to achieve the allowed 75-foot width. Additional tree clearing is proposed within a new easement to be acquired from the solar facility to accommodate the relocated distribution line interconnection with the existing solar facility located on Oxford Road in North Smithfield.

3.2 Construction and Maintenance Practices

3.2.1 Transmission Line Construction Sequence

The Project will be constructed using conventional overhead electric transmission line method and techniques. TNEC and its consultants conducted detailed constructability field reviews to determine access and workspace requirements and to evaluate measures to avoid or minimize environmental impacts.

The transmission lines will be constructed in a progression of activities that typically proceed in the sequence and with the equipment described in Table 3-1 (below).

TABLE 3-1: TYPICAL CONSTRUCTION EQUIPMENT

CONSTRUCTION PHASE	TYPICAL EQUIPMENT REQUIRED	
ROW Mowing & Tree removals	• Grapple trucks • Track-mounted mowers • Chippers • Brush hogs, skidders • Bucket trucks	• Chain saws • Low-bed trailers, flatbed trucks • Pickup trucks
Soil Erosion/Sediment Controls	• Stake body trucks • Pickup and other small trucks	• Small excavators • Trencher
Access Roads Improvement and Maintenance	• Dump trucks • Bulldozers • Excavators • Backhoes • Front end loaders • Graders	• Pick-up trucks • Low-bed trailers • Stake body trucks
Removal, Disposal and Replacement of Existing Transmission Line Components	• Cranes • Flatbed trucks • Pullers with take-up reels • Excavators	• Backhoes • Trucks with welding equipment • Dump trucks • Storage containers
Conductor and Shield Wire Installation	• Bucket trucks • Puller-tensioners • Conductor reel stands	• Cranes • Flatbed trucks • Pickup trucks • Tracked carriers or skidders
Restoration of the ROW	• Pickup and other small trucks • Excavators • Backhoes • Bulldozers	• Dump trucks • Tractor-mounted York rakes • Straw blowers

3.2.1.1 ROW Mowing & Tree Removals in Advance of Construction

Vegetation mowing may be required to provide safe work sites for personnel within the ROW. Tree removals are expected for the Project. Prior to vegetation removal and mowing, the boundaries of wetlands will be clearly marked to prevent unauthorized encroachment of equipment into wetland areas. Appropriate forestry techniques will be implemented within wetlands to minimize ground disturbance. Other sensitive resources will be flagged and enclosed with protective fencing prior to removal of vegetation on the ROW. Existing access routes along the ROW will be used by the vegetation removal personnel and equipment to the extent practicable, and road improvements will be kept to a minimum during this phase of the work. The use of temporary swamp mats will be required to gain access to and across wetlands, to minimize wetland disturbance, and to provide a stable platform for safe equipment operation.

Generally, shrubs will be cut close to the ground, leaving the stumps and roots in place to reduce soil disturbance and erosion. If grading is required for access road improvements or at structure sites, stumps will be removed and disposed of off-site. Small trees and shrubs within the ROW will be mowed as necessary with the intent of preserving roots and low-growing vegetation to the extent practical. Brush, limbs, and cleared trees will be chipped or removed from the site.

3.2.1.2 Installation of Soil Erosion and Sediment Controls

Following vegetation removal activities, TNEC will install appropriate soil erosion and sediment control devices, such as straw wattles/bales, siltation fencing, and/or chip bales in accordance with approved plans and permit requirements. The soil erosion and sediment control program for the Project will follow the procedures identified in the *Rhode Island Soil Erosion and Sediment Control Handbook*, the *Rhode Island Stormwater Design and Installation Standards Manual*, the Rhode Island Department of Environmental Management's ("RIDEM") manual of best management practices ("BMP")*: Wetland BMP Manual: Techniques for Avoidance and Mitigation,* and TNEC's *ROW Access, Maintenance and Construction BMPs* (EG-303).

The installation of these erosion and sediment control devices will be supervised by TNEC's environmental monitor. During construction, these devices will be periodically inspected and monitored by the environmental monitor, and the environmental monitor's findings will be reported regularly to TNEC's Construction Supervisor. The soil erosion and sediment controls will be installed between the work area and environmentally sensitive areas (such as wetlands, streams, and drainage courses), and roads and adjacent property when work activities will disturb soils and potentially cause soil erosion and sedimentation. The devices will function to mitigate construction-related soil erosion and sedimentation and will also serve as a physical boundary to delineate resource areas and to contain construction activities within approved areas.

Where feasible, staging areas and equipment storage will be situated outside of watershed protection areas, wetlands, and other environmentally sensitive areas. Equipment refueling (except for large, fixed equipment) will occur outside of environmentally sensitive areas (such as waterways and wetlands). If extenuating circumstances arise requiring refueling within or in close proximity to sensitive areas, secondary containment devices and other spill prevention BMPs, such absorbent pads, will be used during refueling.

In resource areas temporarily disturbed by construction, swamp mats, soil erosion and sediment controls, and other measures will be installed as appropriate in accordance with BMPs. Herbaceous vegetation in disturbed areas will be restored using a native wetland or conservation seed mix. Enhancements proposed as mitigation for important wildlife features lost as a result of construction activities may include seeding, planting native shrub species, leaving snags, and placing woody debris and slash or stone piles to create wildlife cover. At the end of construction, swamp mats will be removed and cleaned prior to being moved to another location or off-site.

3.2.1.3 Access Road and Work Pad Maintenance

Access roads are required along the ROW to construct, inspect, and maintain the existing and proposed transmission line facilities. Typical access roads are 16 feet wide with a travel lane of approximately 12 feet to accommodate the vehicles and equipment needed for the Project.

TNEC is planning to use the existing network of access roads on the ROW to the greatest extent practicable. Access road improvements will be limited to minor repairs (filling of ruts and potholes). Stabilized construction entrances may need to be refreshed where the ROW crosses public roadways.

Access across wetlands and streams, where upland access is not available, will be accomplished by the placement of temporary swamp mats. Such temporary swamp mat access roads will be removed following completion of construction and areas will be restored to re-establish pre-existing topography and hydrology. Swamp mats or similar matting may also be used to cross land in active agricultural use or in other environmentally sensitive areas.

Any access road improvements and/or maintenance will be carried out in compliance with the conditions and approvals of the appropriate federal and state regulatory agencies. Exposed soils on access roads will be wetted and stabilized as necessary to suppress dust generation during construction. Crushed stone aprons/tracking pads will be used at all access road entrances to public roadways to clean the tires of construction vehicles and minimize the migration of soil off site.

Upland work pads will be constructed at structure locations by grading or adding gravel or crushed stone to provide a level work surface for construction equipment and crews. Once construction is complete, the work pads in uplands will remain in place, and will be stabilized with topsoil and mulched to allow vegetation to re-establish. In wetlands, these work pads will be constructed with temporary swamp mats and will be removed after the completion of construction activities.

3.2.1.4 Removal and Relocation of Existing Distribution Line Components

In order to accommodate the new double circuit structures for the B23 and U-170 Lines, the existing underbuilt distribution line currently located between Structures 1 and 18 on B23 Line will be removed and relocated to the edge of the ROW. The relocated distribution poles will be installed by direct embed techniques along the south side of the existing ROW. TNEC proposes to recycle as much of the material generated by construction as possible. Those components not salvaged and any debris that cannot be recycled will be removed from the ROW to an approved off-site facility. Handling of such materials will be performed in compliance with applicable laws and regulations and in accordance with TNEC's policy and procedures.

3.2.1.5 Installation of Replacement Structures

Equipment typically used during the installation of foundations and the replacement of structures includes excavating equipment such as backhoes and excavators, rock drills/augers, and concrete trucks. Suspension structures will be installed using the "Direct Embed" construction method, and deadend structures will be installed using the "Self-Supporting" construction method, also referred to as caisson foundations, described as follows in Table 3-2:

TABLE 3-2: STRUCTURE INSTALLATION METHODS

DIRECT EMBED	The installation of a direct embed structure (e.g., tangent or in-line structures) involves the excavation of a hole, the installation of the pole directly in the ground and backfilling around the pole. To address engineering design requirements and construction feasibility, direct-embedded pole structures may be encased within a corrugated metal pipe ("CMP") or metal casing. Depending on structural loading, modified stone, flowable fill, or concrete will be used to backfill around the pole and within the CMP or casing.
FOUNDATION STRUCTURE	Caissons will be constructed by drilling a vertical shaft, installing a steel reinforcing cage (tied rebar), placing a steel anchor bolt cluster, pouring concrete, and backfilling. Structures will be lifted by a crane and placed and secured onto the anchor bolts. In some locations temporary casing shaft (oversized to fit the permanent casing) and/or permanent casing within the temporary casing may be utilized.

In general, any excavated material will be placed next to the excavation. Steel culvert casings may be used to support the sides of excavations. Once the structure has been properly positioned and plumbed within the hole, the excavation will be backfilled with clean 3/4″ Minus gravel, flowable fill, or concrete to provide structural integrity. Following the backfilling operation, any remaining excavation spoils will be spread over upland areas or removed from the site.

Handheld equipment, including shovels and vibratory tampers, may be used during the backfilling of foundations and structures. Dump trucks are used to remove excavation spoils from the work site if necessary. Cranes are used to erect structures, and a bucket truck or a crane with a basket is used to lift the linemen to the aerial work zone. Tracked equipment that cannot be operated on public roadways will be transported to the work site by means of a low-bed trailer.

Dewatering may be necessary during excavations for foundations near wetland areas. At all times dewatering will be performed in compliance with the EG-303NE guidelines and BMPs. If there is adequate vegetation in upland areas to function as a filter medium, the water generally will be discharged to the vegetated land surface. Where vegetation is absent or where slope prohibits, the water will be pumped into a hay bale or silt fence settling basin located in an upland area. The pump intake will not be allowed to rest on the bottom of the excavation throughout dewatering. The basin and all accumulated sediment will be removed following dewatering operations and the area will be seeded and mulched.

3.2.1.6 Installation of Conductor

The new conductors will be installed using stringing blocks and tensioning equipment. The tensioning equipment is used to pull the conductors through the stringing blocks to achieve the desired sag and tension condition. During the stringing operation, temporary guard structures or boom trucks will be placed at road and highway crossings and at crossings of existing utility lines to ensure the public safety and the continued operation of other utility equipment. To minimize any additional disturbance to soil and vegetation, existing access roads will be used to the fullest extent possible in the placement of pulling and tensioning equipment.

The equipment that will typically be used during the conductor installation operation includes puller-tensioners and conductor reel stands that will be located at the stringing sites. Bucket trucks and platform cranes will be used at non-wetland locations to mount stringing blocks on the structures. To avoid setting temporary poles as guard structures in environmentally sensitive areas, the booms of small cranes and bucket trucks will be used as guard structures in such areas during the stringing operation to prevent the conductors from falling across roads or other utility lines. Pickup trucks will be used to transport work crews and small materials to work sites.

Construction of temporary wire stringing and pulling sites will be required (i) to provide a level workspace for equipment and personnel and (ii) to establish remote wire stringing set-up sites at angle points in the transmission line and at dead-end structures.

A “red-tag” outage sequence will be employed during construction of the new line components. The new line will be constructed in place of the existing line, while only the existing single 48F OPGW is operational until a new fiber path has been constructed. Then, the remaining poles and fiber will be removed, allowing for energization of the new circuit. Poles will be offset from the existing centerline at the angles to allow for safe clearances between energized circuits and setting of pole bases/foundations during construction. The B23 Line conductor will be installed first, and the new U-170 Line conductor will be installed on the opposite side of the double circuit structures.

3.2.1.7 Removal and Disposal of Existing Transmission Line Components

TNEC proposes to recycle as much of the material generated by construction as possible. Those components not salvaged and any debris that cannot be recycled will be removed from the ROW to an approved off-site facility. Handling of such materials will be performed in compliance with applicable laws and regulations and in accordance with TNEC's policy and procedures.

3.2.1.8 Restoration of the ROW

Restoration efforts, including removal of construction debris, final grading, stabilization of disturbed soil, and installation of permanent sediment control devices (water bars/diversion channels/rock fords), will be completed following construction. All disturbed areas around structures and other graded locations will be seeded with an appropriate conservation seed mixture and/or mulched to stabilize the soil in accordance with applicable regulations. Temporary sediment control devices will be removed following the stabilization of disturbed areas. Existing walls and fences will be restored if necessary. Regulated environmental resource areas that are temporarily disturbed by construction will be restored to pre-construction conditions to the extent practicable, in accordance with applicable permit conditions.

3.2.2 Construction Traffic and Mitigation

Construction-related traffic will occur over the duration of construction. The Project may cause intermittent and temporary additional traffic during the construction period. Construction equipment typically will access the ROW from public roadways crossing the ROW in various locations along the route. Because each of the construction tasks will occur at different times and locations over the course of the construction, traffic will be intermittent at these entry roadways. Traffic will consist of vehicles ranging from pick-up trucks to heavy construction equipment.

TNEC's contractors will coordinate closely with the Rhode Island Department of Transportation ("RIDOT") to develop acceptable traffic management plans for work within state highways. TNEC will coordinate with local authorities in the Town of North Smithfield for work on local streets and roads. At locations where construction equipment must be staged in a public way, the contractors will follow a pre-approved work zone traffic control plan with appropriate police details.

3.2.3 Project Construction Work Hours

Proposed construction work hours for the Project will be between 7:00 a.m. and 7:00 p.m. Monday through Friday (when daylight permits), and, when necessary, between 7:00 a.m. and 7:00 p.m. on weekends. Some limited construction may have to occur outside of standard work hours when needed to complete certain activities. For example, once started, some work tasks such as installing reels of conductor must be continued through to completion and may go beyond normal work hours.

In addition, the nature of transmission line construction requires line outages for certain procedures such as transmission line connections, equipment cutovers, or stringing under or over other transmission lines. Availability of these outages, which is dictated by the Independent System Operator - New England ("ISO-NE") based on regional system load and weather conditions, can be very limited. Such scheduled outages will have no effect on electric service to local customers. Work will be completed under red-tag/green-tag outage constraints, in which one circuit will remain energized while work is taking place on the other (unenergized) line. Work requiring scheduled outages and crossings of certain transportation and utility corridors may need to be performed on a limited basis outside of normal work hours, including on Sundays and holidays.

Prior to and during construction, TNEC will notify landowners, abutting property owners, municipal officials, the Towns' Department of Public Works and Police and Fire Chiefs of the details of planned construction including the normal work hours and any extended work hours.

3.2.4 Environmental Compliance Monitoring

Throughout the construction process, TNEC will retain the services of an environmental monitor. The primary responsibility of the monitor will be to oversee construction activities including the installation and maintenance of soil erosion and sediment controls and other BMPs to ensure compliance with all federal, state and local permit commitments. Prior to the start of construction, all Project personnel will be trained on Project environmental requirements and permit conditions, including environmental, rare species, stormwater management, and cultural resources. Refresher training will be held as new crew members join the Project workforce and as otherwise necessary. TNEC will conduct regular construction progress meetings to reinforce the contractor's awareness of these issues. Pre-construction "look-ahead meetings" will take place in the field with appropriate Project personnel. The environmental monitor will attend these meetings to provide feedback on environmental requirements and compliance to construction personnel.

During the construction process, the environmental monitor will verify and report on compliance with all federal, state, and local permit requirements and TNEC's policies and procedures. At regular intervals and during periods of prolonged precipitation, the environmental monitor will inspect the environmental controls to determine whether they are functioning properly.

In addition to retaining the services of an environmental monitor, TNEC will require the construction contractor to designate an individual to be responsible for the daily inspection and maintenance of environmental controls. This person will also be responsible for providing direction to the other members of the construction crew regarding matters such as wetland access, appropriate work methods, driving safety, and good housekeeping practices along the ROW.

3.3 Safety and Public Health Considerations

TNEC will design, build, and maintain the Project so that the health and safety of the public are protected. This will be accomplished through adherence to all applicable regulations, and industry standards and guidelines established for the protection of the public. Specifically, the Project will be designed, built, and maintained in accordance with the National Electric Safety Code ("NESC"). The facilities will be designed in accordance with sound engineering practices using established design codes and guides published by, among others, the Institute of Electrical and Electronic Engineers ("IEEE"), the American Society of Civil Engineers ("ASCE"), the American Concrete Institute ("ACI"), and the American National Standards Institute ("ANSI"). The practices that TNEC will use to protect the public during construction include, but are not limited to, establishing traffic control plans for construction traffic on busy streets to maintain safe driving conditions; restricting public access to potentially hazardous work areas; use of temporary guard structures at road and electric line crossings to prevent accidental contact with conductors during installation; noise and dust control management; and coordination with the Town of North Smithfield and RIDOT during construction.

A report discussing the current status of the health research relevant to exposure to EMF was prepared by Exponent and is attached as **Appendix A**.

3.4 Public Outreach

The Company believes in, and has committed to, a fully open, transparent, and regular two-way dialogue with project stakeholders throughout the life of its projects. The Company has already undertaken efforts in this regard and will continue its comprehensive stakeholder outreach campaign to educate and inform neighborhood residents, municipal officials, and businesses about the full scope of work to be undertaken to support this Project. Pre-construction outreach activity has included notifications to abutters and conversations with Project stakeholders regarding a variety of topics including grants of access, environmental matting needs, proposed structure locations, vegetation management, etc. We have also hosted Community Information Sessions in Burrillville and North Smithfield for the public to attend and ask questions of our project team. The Company remains committed to maintaining those conversations throughout the Project.

Public outreach will also include, but is not necessarily limited to:

- Meetings with municipalities and relevant governmental organizations with interest in the Project scope;
- Community outreach (e.g., door-to-door);
- Regular project communications (direct mail);
- A Project hotline and email;
- Fact sheets, door hangers, FAQs, timelines, etc; and
- Advertising project milestones and impacts, as needed.

The team will continue to maintain a high level of outreach to discuss the Project, receive comments, and answer questions throughout the permitting and construction phases.

3.4.1 State and Local Meetings

The Project team has met, and will continue to meet as needed, with governmental bodies with interest in, or impacted by, the Project scope. In advance of the filing, the Project team met with Town representatives of Burrillville and North Smithfield, Rhode Island to outline the Project need, benefits and high-level details around the Project route, local impacts, and tentative Project schedule. In addition, the Project team has briefed RIDOT and other relevant state agencies. The Project team will continue to meet regularly with governmental stakeholders throughout the Project schedule to ensure a timely flow of information and provide opportunities for input.

3.4.2 Project Hotline

A local phone number (401-400-5800) has been established for project-related Stakeholder inquiries. The Hotline number will be listed in all Project outreach materials, including fact sheets, mailings, and signage at community events. A Project representative will staff the hotline and the Company pledges to respond within two businesses days to all inquiries – most often on the same business day whenever practical.

3.4.3 Abutter Communications

The Company representatives expect to meet individually with Project abutters who have questions specific to their properties throughout the life of the Project. In addition, the Project team will be sending letters via U.S. Mail to keep them abreast of Project developments throughout the Project duration.

3.4.4 Door-to-Door Outreach

The Company will engage in a door-to-door outreach campaign, canvassing residents and businesses adjacent to Project activities. The purpose of this outreach is to provide information and answers to questions. If a resident is not available, a Company representative will leave Project-related information at the door. A similar effort will be undertaken with affected businesses and facilities along the Project route.

3.4.5 Construction Communication Plan

Building off the existing outreach and communications plan, the Company will develop a comprehensive construction communication plan to update residents, businesses, fire, police, emergency personnel, and municipal officials on work schedules, work locations, and construction activities. In addition to the Project hotline, and email, this plan will include, as needed, work area signage, construction notifications, and direct contact with Project abutters.

The Company's Project representatives will be responsible for coordinating outreach during construction and serving as a single point of contact for the public. Project information also will be communicated through various town and businesses websites as permitted.

3.4.6 Advertising

The Company will, in addition to the efforts outlined in the sections above, advertise/post important Project information to augment and support these communications efforts. For this project, advertising will be placed in community newspapers and other publications, when necessary, to ensure maximum visibility in the communities.

3.4.7 Project Materials

The Company will also produce Project materials – fact sheets, frequently asked questions and other background materials for dissemination to affected Project abutters and elected officials.

3.5 Estimated Project Costs

TNEC has prepared conceptual level estimates[3] based on 2020 costs for the Project, which are described in **TABLE 3-3**. These estimates reflect the double circuit structures being installed under the B23 Line Rebuild, which is planned to be in service first. The U-170 Transmission Line Construction costs reflect the installation of an additional conductor on the double circuit structures already in place for the B23 Line Rebuild.

TABLE 3-3: ESTIMATED PROJECT COSTS

PROJECT COMPONENTS	ESTIMATED COST ($M)
Transmission Line Rebuild B23	$24M +/- 20%
Transmission Line Construction U-170	$11M +/- 20%
Woonsocket Substation Expansion	$6M +/- 20%
Project Total	$41M +/- 20%
Note: Distribution Line Relocation Costs (not included in total)	$1.375M +/- 20%

[3] These are capital costs for the project and do not include the removal of the existing assets.

3.6 Project Schedule

TNEC has developed a preliminary schedule based on time estimates for planning and engineering, permitting and licensing, and construction (Table 3-4). The Project is expected to be completed and in-service by the fall of 2026.

TABLE 3-4: PROJECT SCHEDULE

ACTIVITY	ESTIMATED START DATE	ESTIMATED COMPLETION DATE
Planning and Engineering	Q4 2024	Q4 2024
Permitting and Licensing	Q4 2024	Q4 2025
Construction	Q4 2025	Q4 2026
Facilities In-Service	Q4 2026	
Final Restoration	Q1 2027	

Note: The Permitting and Licensing estimated completion date, and the Construction estimated start dates are based on an expedited review. The actual construction start time will not occur until all Permitting and Licensing is completed.

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4 PROJECT ALTERNATIVES

4.1 Introduction – U-170 Line Construction

The Company considered several alternatives to the construction of the U-170 Line to address the need for the new transmission line to the Nasonville Substation. The alternatives include the preferred alternative, which is the construction of the new 115 kV transmission line between Woonsocket Substation and the Nasonville Substation, as well as other construction alternatives.

Selecting a preferred design option involves evaluating a suite of comparable and feasible project alternatives, analyzing the alternative routes and configurations, general ranking of alternatives and identification of initial recommendations in the selection of a preferred solution. TNEC's overriding goal has been to select the lowest cost alternative that best meets the identified need, with a minimum impact on the natural and social environment.

Section 4.1.1 describes the no-action alternative, Section 4.1.2 describes building a new 34.5 kV circuit from Iron Mine Hill Substation alternative, Section 4.1.3 describes a new overhead transmission line from West Farnum Substation to the Nasonville Substation alternative, Section 4.1.4 describes a new underground transmission line from Woonsocket Substation to Nasonville Substation alternative, and Section 4.1.5 describes the Project (Preferred Alternative).

4.1.1 No-Action Alternative

The no-action alternative will leave the Nasonville Substation in its current condition where an outage at the substation or on the B23 Line will result in an unacceptable level of unserved load which may result in system overloads . Because of this, the no-action alternative was rejected because it is not acceptable from either an operational or reliability perspective.

4.1.2 New 34.5 kV Tap Line to Nasonville Alternative

The Company considered constructing a new 34.5 kV circuit from the Iron Mine Hill Substation and adding 34.5 kV/13.8 kV transformation at the Nasonville Substation. The Iron Mine Hill Substation is just south of the West Farnum Substation and was built to serve a large solar site. There are operational concerns using two different supply voltages at the Nasonville Substation. The 115 kV supply has a lower source impedance than the 34.5 kV source, so transferring load between feeders originating from separate buses supplied by different voltage lines may cause significant load sharing imbalance that may trip breakers or reclosers when the tie connection is made.

There were two routes identified for the 34.5 kV supply line. One preliminary route for the 34.5 kV supply line into Nasonville was in both transmission line ROWs and on public streets. There were reliability concerns with this route because the overbuilt 34.5 kV lines would be in heavily wooded areas that are more susceptible to faults. Another preliminary route was in the existing transmission ROW double circuited with the B23 Line. While double circuiting a 34.5kV supply line with a 115kV transmission line is technically possible, it is generally avoided due to maintenance and outage conflicts. This route is similar to the route for the new 115 kV line from Woonsocket in the preferred plan.

The total cost of this alternative was $55.067 million. Ultimately, this alternative was not pursued due to the operational concerns from using two different supply voltages, the reliability concerns with the public street route option, and the maintenance and outage conflicts with the transmission line ROW route option.New 115 kV Line from West Farnum Substation to Nasonville Tap, co-located within the B23 ROW Alternative.

4.1.3 New 115 kV Line from West Farnum Substation to Nasonville Tap, co-located within the B23 ROW

Similar to the proposed Project, the Company considered constructing the new 115 kV line from the West Farnum Substation to the Nasonville Substation. This alternative would share the same route as the proposed Project and would eliminate the need for the Phase I portion between Woonsocket Substation and West Farnum Substation. This alternative would require expanding the existing ring bus configuration at the West Farnum Substation and converting it to a three bay configuration by adding a new bay in the center of the substation existing layout; however, there is insufficient space in the current substation layout to accommodate this expansion. Both existing 345/115kV transformers would need to be relocated to make space for a new bay and line terminal. The resulting layout would be condensed, complex, atypical, and undesirable. Working clearances and appropriate space for future equipment maintenance and replacement will be restricted. This layout could make it such that aged or failed equipment could not be removed and replaced without de-energizing and disassembling adjacent portions of the substation. There also may not be sufficient space to route the new transmission line overhead into the substation and an underground installation may be required, further driving up cost and complexity.

In addition, one of the two transformers is 42 years old and would require replacement rather than a simple relocation. Constructability and outage restraints could require both transformers be completely replaced to minimize outage time as extended outages may impact reliability in the area. Complex projects like this are challenging to build and increase risk design or construction related mis-operations or safety events.

This alternative was estimated to cost $62.724 million and was deemed too expensive, complex, and impractical; therefore, it was ruled out.

4.1.4 New Underground 115kV Line from Woonsocket Substation to Nasonville Tap Alternative

TNEC examined potential underground alternatives to the proposed Project. Similar to the analysis in Section 4.2.3, an underground alternative would operate similar to the preferred alternative by bringing a new 115 kV supply line to the Nasonville Substation. The ROW in use by the existing transmission line does not allow for underground construction, so the routing of the underground line would have to go through streets or newly acquired easements.

Underground lines also present system and operational disadvantages versus an overhead transmission line. When an overhead transmission line experiences an outage, it can be repaired typically within 24 to 48 hours. In the case of a failure of an underground transmission cable, repair times can be in the range of two weeks to a month or more. Additionally, many faults on overhead lines are temporary in nature. Often it is possible to re-energize an overhead line after a temporary fault and return the line to service with only a brief interruption. Faults on underground transmission cables are almost never temporary, and the cable must remain out of service until the problem is diagnosed and repairs can be completed.

This alternative was estimated to cost $98.638 million. Due to the substantially higher costs, as well as the operational disadvantages discussed above, a potential underground alternative was not considered further.

4.1.5 New 115 kV Line from Woonsocket Substation to Nasonville Tap, co-located within the B23 ROW (Preferred Alternative)

The proposed Project will see the new U-170 Line routed along the same ROW as the B23 Line, which is in need of rebuilding due to the existing aged wooden structures. Due to ROW limitations associated with the existing width of TNEC's easements, as part of this re-build TNEC will upgrade the existing B23 single-circuit structures to double-circuit structures, accommodating the new U-170 Line within the existing B23 Line ROW. While the conversion from a single circuit to a double circuit line will necessitate some additional clearing within the limits of the ROW (and associated tree removals), this solution will have fewer environmental and abutter impacts, and lower Project costs, than the alternative of attempting to add the new U-170 line on single circuit structures in new or expanded ROW or underground.

The preferred alternative was estimated to cost $57.377 million. This option is the only alternative that addresses the need to bring an additional service to the Nasonville Substation while limiting the impact on the natural and social environment. For these reasons, TNEC concluded that the proposed Project is the preferred alternative to meet the identified need.

4.2 Cost Comparison of Alternatives

The costs provided in Table 4-1, below, reflect the alternatives analysis developed by the Company in April 2020. The only exception is the transmission line component of the New Underground 115 kV Line alternative, which utilizes a cost per mile based off of 2025 numbers.

TABLE 4-1: COST COMPARISON OF ALTERNATIVES

ALTERNATIVE	COMPONENT	COST ($M)	TOTAL ($M)
New 34.5kV Tap Line to Nasonville	Iron Mine Hill Sub (T)	$ 10.662	$ 55.067
	Iron Mine Hill Sub (D)	$ 7.721	
	34.5 kV Line	$ 24.614	
	Nasonville Sub (D)	$ 11.800	
	Nasonville D-Line	$ 0.270	
New 115kV Line from West Farnum to Nasonville & Rebuild B23	West Farnum Sub (T)	$ 24.000	$ 62.724
	T-Line	$ 22.614	
	Nasonville Sub (T)	$ 2.640	
	Nasonville Sub (D)	$ 13.200	
	Nasonville D-Line	$ 0.270	
New Underground 115kV Line from Woonsocket to Nasonville	Woonsocket Sub (T)	$ 5.937	$ 98.638
	T-Line	$ 76.591	
	Nasonville Sub (T)	$ 2.640	
	Nasonville Sub (D)	$ 13.200	
	Nasonville D-Line	$ 0.270	
New 115 kV Line from Woonsocket Substation to Nasonville & Rebuild B23 (Preferred Alternative)	Woonsocket Sub (T)	$ 5.937	$ 57.377
	T-Line	$ 35.330	
	Nasonville Sub (T)	$ 2.640	
	Nasonville Sub (D)	$ 13.200	
	Nasonville D-Line	$ 0.270	

4.3 Introduction – B23 Line Reconstruction

Alternatives to the reconstruction of the B23 Line are limited. A no-build alternative is not feasible because it would not address the reliability issue and would prohibit the addition of the additional U-170 line. Building a new overhead line in a different location would address the need for a new transmission line but acquiring new property rights and clearing new land would have significantly greater costs and impacts on the natural and social environment, so this alternative was rejected. For the same reasons referenced above in Section 4.1.4, building a new underground line was also rejected. Maintaining this line and making repairs as needed was rejected because the existing B23 Structures cannot support the new U-170 Line in its current configuration, and the structures and existing conductor are nearing the end of their lifespan.

4.4 Conclusion

After reviewing the alternatives, the Company selected the Project as the preferred alternative because it addressed the identified need at the lowest cost while also minimizing the impact on the natural and social environment. All other alternatives for the Project would either present operational challenges or be significantly more expensive than the Project. Similarly, alternate overhead and underground routes for the new transmission line would result in greater costs and greater impacts on the natural and social environment.

5 DESCRIPTION OF AFFECTED NATURAL ENVIRONMENT

This section of the Report describes the existing natural environment that may be affected by the Project, both within and surrounding the Project ROW. As required by the EFSB Rules, a detailed description of environmental characteristics within and immediately surrounding the Project is provided below. This section describes the specific natural features that were evaluated using published resource information, the Rhode Island Geographic System ("RIGIS") database, various state and local agency databases, and field investigations of the Project ROW.

The Project involves work activities on existing 115 kV transmission lines with an established and maintained ROW, therefore the Project is anticipated to have only negligible impacts on the geology, surficial geology, air quality, population trends, and employment and labor force. For this reason, these environmental characteristics are not included in the below assessment.

5.1 Study Area

A Study Area was established to assess the existing environment both within and immediately adjacent to the existing ROW. This Study Area consists of a 5,000-foot-wide corridor, measured 2,500 feet on either side of the centerline of the ROW. The boundaries of this corridor were determined to allow for a detailed desktop analysis of existing conditions within and adjacent to the Project ROW (Figure 5-1).

5.2 Soils

Detailed information concerning the physical properties, classification, agricultural suitability, and erodibility of soils in the vicinity of the Study Area were obtained from the Natural Resource Conservation Service (NRCS, 2019). In addition to the named series, map units include specific phase information that describes the texture and stoniness of the soil surface and the slope class. Table 5-1 (below), lists the characteristics of the soil phases (lower taxonomic units than series) found within the Study Area. Tables 5-2 and 5-3 provide a key to the drainage class codes, and hydrologic soil group ("HSG") / seasonal high water table depth ("SHWTD") codes, respectively. Study Area hydric soil status is depicted on Figure 5-2.

TABLE 5-1: CHARACTERISTICS OF SOIL PHASES WITHIN THE STUDY AREA

T SYMBOL	MAP UNIT NAME	HSG	FARMLAND CLASS*	K FACTOR	ACRES IN AOI	% OF AOI
CeC	Canton and Charlton fine sandy loams, 3-15% slopes, very rocky	B			1,383.70	18.5%
HkC	Hinckley loamy sand, 8-15% slopes	A	SI		616.6	8.2%
Rf	Ridgebury, Leicester, and Whitman soils, 0-8% slopes, extremely stony	D			615.7	8.2%
CaD	Canton-Charlton-Rock outcrop complex, 15-35% slopes, very stony	B			542.8	7.2%
HkD	Hinckley loamy sand, 15-25% slopes	A			485.4	6.5%
FeA	Freetown muck, 0-1% slopes	B/D			302.9	4.0%
MmB	Merrimac fine sandy loam, 3-8% slopes	A	Prime	0.28	286.7	3.8%
ChC	Canton and Charlton fine sandy loams, 8-15% slopes, very stony	B			271.9	3.6%
W	Water				270.4	3.6%
Pg	Pits, gravel				247	3.3%
ChB	Canton and Charlton fine sandy loams, 0-8% slopes, very stony	B			211.2	2.8%
Wa	Walpole sandy loam, 0-3% slopes	B/D	SI		193.4	2.6%

T SYMBOL	MAP UNIT NAME	HSG	FARMLAND CLASS*	K FACTOR	ACRES IN AOI	% OF AOI
ChD	Canton and Charlton very stony fine sandy loams, 15-25% slopes	B			162.5	2.2%
CdB	Canton and Charlton fine sandy loams, 3-8% slopes	B	Prime	0.24	156.5	2.1%
Sb	Scarboro mucky fine sandy loam, 0-3% slopes	A/D			139.3	1.9%
WgB	Windsor loamy sand, 3-8% slopes	A	SI		136	1.8%
WgA	Windsor loamy sand, 0-3% slopes	A	SI		133.8	1.8%
UD	Udorthents-Urban land complex	A		0.28	131.9	1.8%
WhA	Woodbridge fine sandy loam, 0-3% slopes	C/D	Prime	0.28	108.8	1.5%
AfB	Agawam fine sandy loam, 3-8% slopes	B	Prime	0.37	92.4	1.2%
SwA	Swansea muck, 0-1% slopes	B/D			90.8	1.2%
MU	Merrimac-Urban land complex, 0-8% slopes	A		0.28	76.8	1.0%
HkA	Hinckley loamy sand, 0-3% slopes	A	SI		76.3	1.0%
MmA	Merrimac fine sandy loam, 0-3% slopes	A	Prime	0.28	74.4	1.0%
PbB	Paxton fine sandy loam, 0-8% slopes, very stony	C			63.7	0.8%
WoB	Woodbridge fine sandy loam, 0-8% slopes, very stony	C/D			52.3	0.7%
Ss	Sudbury sandy loam	B	Prime		48.6	0.6%
SuB	Sutton fine sandy loam, 0-8% slopes, very stony	B/D			48.2	0.6%
Nt	Ninigret fine sandy loam, 0-3% slopes	C	Prime	0.32	45.2	0.6%
CdC	Canton and Charlton fine sandy loams, 8-15% slopes	B	SI	0.24	45	0.6%
CB	Canton-Urban land complex	B			42.2	0.6%
WhB	Woodbridge fine sandy loam, 3-8% slopes	C/D	Prime	0.28	40.2	0.5%
Du	Dumps				40	0.5%
CC	Canton-Urban land complex, very rocky	B			37.5	0.5%
SvB	Sutton fine sandy loam, 0-8% slopes, extremely stony	B/D			36.7	0.5%
Ru	Rippowam fine sandy loam	B/D	SI	0.24	32.1	0.4%
PaB	Paxton fine sandy loam, 3-8% slopes	C	Prime	0.28	31.5	0.4%
PaA	Paxton fine sandy loam, 0-3% slopes	C	Prime	0.28	18	0.2%
StB	Sutton fine sandy loam, 3-8% slopes	B/D	Prime	0.24	16.1	0.2%
CkC	Canton and Charlton fine sandy loams, 3-15% slopes, extremely stony	B			14.2	0.2%
Dc	Deerfield loamy fine sand, 0-3% slopes	A	SI	0.2	12.6	0.2%
PD	Paxton-Urban land complex, 3-15% slopes	C		0.28	11.2	0.1%
Pk	Pits, quarries				9.4	0.1%
AfA	Agawam fine sandy loam, 0-3% slopes	B	Prime	0.37	9.1	0.1%
Pp	Pootatuck fine sandy loam	B	Prime**	0.24	6.4	0.1%
CaC	Canton-Charlton-Rock outcrop complex, 3-15% slopes	B			5.8	0.1%
Ur	Urban land				4.6	0.1%
Re	Ridgebury fine sandy loam, 0-3% slopes	D	SI		3.7	0.0%
CdA	Canton and Charlton fine sandy loams, 0-3% slopes	B	Prime		3.1	0.0%
WcB	Wapping very stony silt loam, 0-8% slopes	C		0.43	2.7	0.0%
StA	Sutton fine sandy loam, 0-3% slopes	B/D	Prime	0.24	2.4	0.0%
PbC	Paxton fine sandy loam, 8-15% slopes, very stony	C			1.9	0.0%
	Totals for Area of Interest				**7,491.40**	**100.0%**

** Farmland soils: **Prime** – Prime farmland wherever found; **SI** – Farmland of Statewide Importance.*
*** Prime farmland soil, if protected from flooding.*

Source: nesoil.com and Web Soil Survey.

TABLE 5-2: DRAINAGE CLASS CODES

CODE	DRAINAGE CLASS
ED	Excessively Drained
SWED	Somewhat Excessively Drained
WD	Well Drained
MWD	Moderately Well Drained
PD	Poorly Drained (hydric)
VPD	Very Poorly Drained (hydric)
SUBAQUIC	Permanently Submerged Soil (hydric)

TABLE 5-3: HYDROLOGIC SOIL GROUP & SEASONAL HIGH WATER TABLE DEPTH

FIELD ID	DESCRIPTION
A, > 6 feet.	HSG A soils having low runoff potential, with seasonal high-water table greater than 6 feet.
B, > 6 feet.	HSG B soils having moderate runoff potential, with SHWT greater than 6 feet.
B, 1.5 feet.	HSG B soils having moderate runoff potential, with SHWT of 1.5 feet (one unit has 2.0 feet water).
B, > 6 feet., Bedrock	Soil complexes with map units consisting of HSG B (Canton and Charlton) and a bedrock component (CeC). This category includes soil units that are moderately shallow to rock that are not mapped separately, and where field investigation is needed to determine HSG.
C, 1.5 feet.	HSG C soils having high runoff potential, with SHWT of 1.5 feet. Most of these have restrictive layer in subsoil (densic). The SHWT ranges from 1.4 to 1.9 for this class.
D, 0 feet., HYDRIC	Soils that have SHWT at soil surface and are hydric soils.
D, 1.5 feet	Soils that have a SHWT within 1.5 feet and are in HSG D (these are typically moderately well drained soils with densic contact).
Variable	Variable rating is assigned where the HSG and/or SHWT is listed as variable or not rated.
Water	All subaquatic soils and mapped water bodies

5.2.1 Soil Series

The soil series detailed in the following subsections were identified as making up 5% or more of the Study Area. The following classifications are as published online (nesoil.com).

Canton and Charlton fine sandy loam (18.5% of the Study Area): This is a very deep, strongly sloping, well drained soil on the sides of upland hills and ridges near outwash plains and terraces. Areas are irregular in shape and range from 6 to 150 acres in size. Stones 10 to 24 inches in diameter cover 1 to 15 percent of the land surface. In some map units the stones are in clusters and the rest of these map units do not have stones.

Hinkley loamy sand (13.7% of the Study Area): This is a very deep, undulating, excessively drained soil in broad areas on glacial outwash plains, terraces, and kames. Areas are irregular in shape and range from 6 to 100 acres.

Canton-Charlton-Rock outcrop complex (7.2% of the Study Area): Strongly sloping and highly erodible soil, and areas of exposed bedrock on hills and ridges where the relief is affected by the underlying bedrock.

5.2.2 Prime Farmland Soils & Farmland of Statewide Importance

Prime farmland, as defined by the United States Department of Agriculture ("USDA") (USDA Soil Survey Staff, n.d.), is the land that is best suited to producing food, feed, forage, fiber, and oilseed crops. It has the soil quality, growing season, and moisture supply needed to economically produce a sustained yield of crops when it is treated and managed using acceptable farming methods. Urbanized land and water are exempt from consideration as prime farmland.

Farmland of statewide importance is land that is designated by the Rhode Island Department of Administration Division of Planning to be of statewide importance for the production of food, feed, fiber, storage, and oilseed crops. Generally, farmlands of statewide importance include those lands that do not meet the requirements to be considered prime farmland, but that economically produce high crop yields when treated and managed with modern farming methods. Some may produce as high a yield as prime farmland if conditions are favorable.

To extend the additional protection of state regulation to prime farmland, the state of Rhode Island has expanded its definition of farmland of stateside importance to include all prime farmland areas. Therefore, in Rhode Island all USDA-designated prime farmland soils are also farmland of statewide importance.

Prime farmland soils and farmlands of statewide importance (within the Study Area), are identified in Table 5-1. The Project ROW crosses fifteen (15) areas of prime farmland, and nine (9) areas of farmland of statewide importance, including areas of fine sand loams, silt loam and sandy loam.

5.2.3 Erosive Soils

The erodibility of soils is dependent upon the slope of the land and the texture of the soil. Soils are given an erodibility factor ("K"), which is a measure of the susceptibility of the soil to erosion by water. Soils having the highest K values are the most erodible. K values in Rhode Island range from 0.10 to 0.64 and vary throughout the depth of the soil profile with changes in soil texture. K values aid in determining locations where soil erosion and sediment controls may be necessary. Very poorly drained soils and certain floodplain soils usually occupy areas with little or no slope. Therefore, these soils are not subject to erosion under normal conditions and are not given an erodibility factor. Soil map units described as strongly sloping or rolling may include areas with slopes greater than eight percent. Soil map units with assigned K values (within the project study area), are listed in Table 5-1.

5.3 Surface Water

The Study Area is drained by waterways in the Blackstone River Watershed. The major surface water resources and classifications within the Study Area are listed in Table 5-4. Only one (1) of these resources – Tarkiln Brook – is crossed by the Project ROW. Waters of the State of Rhode Island (meaning all surface water and groundwater of the State) are assigned a Use Classification which is defined by the most sensitive uses which it is intended to protect. Waters are classified according to specific physical, chemical, and biological criteria which establish parameters of minimum water quality necessary to support the water Use Classification. The water quality classification of the major surface waters within the Study Area are identified in the descriptions of the water courses that follow.

TABLE 5-4: MAJOR SURFACE WATER RESOURCES WITHIN THE STUDY AREA

WATER BODY NAME	WATER QUALITY STANDARD	FISHERY DESIGNATION	IMPAIRMENT CATEGORY	WATER BODY CROSSED BY PROJECT
Branch River	B	Unassigned	5	No
Cherry Brook	B	Unassigned	5	No
Rankin Brook	B	Unassigned	2	No
Tarkiln Brook	B	Unassigned	4A	Yes
Trout Brook	B	Unassigned	3	No

Source: RIDEM Environmental Resource Map:
https://ridemgis.maps.arcgis.com/apps/webappviewer/index.html?id=87e104c8adb449eb9f905e5f18020de5

Most of the surface water within the Study Area is a Class B water. These waters are designated for primary and secondary contact recreational activities and for fish and wildlife habitat. They shall be suitable for compatible industrial processes and cooling, hydropower, aquacultural uses, navigation, and irrigation and other agricultural uses. Tarkiln Brook does not have an assigned water quality standard / use category.

Pursuant to the requirements of Section 305(b) of the Federal Clean Water Act, water bodies that don't support their designated uses in whole or in part are considered impaired and scheduled for restoration. The causes of impairment are those pollutants or other stressors that contribute to the actual chemical contaminants, physical parameters, and biological parameters. Sources of impairment are not determined until a total maximum daily load ("TMDL") assessment is conducted on a water body. Two (2) of the surface waters within the Study Area- Branch River and Cherry Brook- have been assigned an impairment category 5, meaning the waters are impaired or threatened for one or more uses.

5.4 Groundwater Resources

The RIDEM classifies all the state's groundwater resources and establishes groundwater quality standards for each class. The four classes are designated GAA, GA, GB, and GC. Groundwater classified as GAA and GA is to be protected to maintain drinking water quality, whereas groundwater classified as GB and GC is known or presumed to be unsuitable for drinking water use without treatment. The presence and availability of groundwater resources is a direct function of geologic deposits in the vicinity of the Project.

Groundwater resources within the Study Area are depicted on Figure 5-4. Groundwater resources in the study area are predominantly protected to maintain drinking water quality (~54% of the study area classified as GA and ~45% of the study area classified as GAA), while ~1% is classified as GB.

5.5 Vegetation

The Study Area contains a variety of vegetative covers typical of Southern New England as shown in Table 5-5 below. These include urban/suburban built land (67.5% of the study area), oak forest (29% of the study area), forested swamp (9.1% of the study area), ruderal forest (6.4% of the study area), and ruderal grassland/shrubland (6.2% of the study area). This section of the report focuses on upland communities. Wetland communities are discussed in 5.6 of this report. The Project occurs within existing ROWs maintained by TNEC as low-growth vegetative communities that are typical along overhead transmission line facilities.

TABLE 5-5: VEGETATIVE COMMUNITIES WITHIN THE STUDY AREA

SYSTEM	DEVELOPED LAND	COMMUNITY	ACRES	% OF STUDY AREA
Upland System	Developed Land	Urban/Suburban Built	2243.7	67.5
Upland System	Open Mineral Soil Wetlands	Oak Forest	965.5	29.0
Palustrine System	Fresh Water	Forested Swamp	302.7	9.1
Upland System	Plantation & Ruderal Forest	Ruderal Forest	212.9	6.4
Upland System	Agricultural	Ruderal Grassland/Shrubland	206.5	6.2
Upland System	Open Uplands (Grassland and Shrubland)	Urban/Recreational Grasses	61.3	1.8
Upland System	Deciduous Woodlands & Forests	Tree Plantation	57.8	1.7
Palustrine System	Forested Wetlands (Mineral and Peat Soils)	Shrub Swamp	55.0	1.7
Upland System	Developed Land	Hayfields/Pasture	51.4	1.5
Palustrine System	Open Mineral Soil Wetlands	Emergent Marsh	48.1	1.4
Upland System	Agricultural	Cropland	42.8	1.3
Upland System	Developed Land	Hayfields/Pasture	40.7	1.2
Palustrine System	Developed Land	Fresh Water	28.5	0.9
Upland System	Agricultural	Hayfields/Pasture	10.6	0.3
Upland System	Mixed Deciduous / Coniferous Forests	Urban/Suburban Built	8.3	0.2
Upland System	Plantation & Ruderal Forest	Extractive Industry	4.8	0.1

5.5.1 Vegetative Communities Typical of the Study Area

5.5.1.1 Oak/Heath Forest

Deciduous forest on well-drained, acidic soils. This community type is relatively common outside of the ROW (within the wider 5,000 feet study area), where trees are not regularly managed. Black oak and/or scarlet oak (*Quercus velutina, Q. coccinea*) are generally dominant, but in less common instances chestnut oak (*Q. prinus*) or white oak (*Q. alba*) are the dominant trees. Common associates include white oak (*Q. alba*), black birch (*Betula lenta*), black gum (*Nyssa sylvatica*), red maple (*Acer rubrum*) and sassafras (*Sassafras albidum*). Pitch pine (*Pinus rigida*) and white pine (*Pinus strobus*) may be present in small amounts. American chestnut (*Castanea dentata*) was a common associate prior to the chestnut blight; saplings are still found in the understory. Total percent canopy cover can range from 60 to 100% (woodland to forest). The shrub layer is ericaceous with characteristic species including black huckleberry (*Gaylussacia b*accata), mountain laurel (*Kalmia latifolia*), and lowbush blueberries (*Vaccinium pallidum and V. angustifolium*). Plants in the ground layer include early sedge (*Carex pensylvanica*), wild sarsaparilla (*Aralia nudicaulis*), and wintergreen (*Gaultheria procumbens*). Oak forests occupy approx. 29% of the Study Area.

5.5.1.2 Ruderal Forest

Ruderal forest is found in eastern temperate North America, and shows evidence of former and heavy human disturbance, such as through plowing, grading, skidding, etc., followed by plantings, but has been

allowed to succeed more-or-less spontaneously. The tree layer is dominated (>80% cover) by "weedy" or generalist native tree species, or exotic invasive tree species. This community is common both within the ROW, and in the urban/suburban areas of the wider study area. Typical species include Eastern red cedar (*Juniperus virginiana*), white pine (*Pinus strobus*), red maple (*Acer rubrum*), *Amelanchier* spp., gray birch (*Betula populifolia*), hawthorn (*Crataegus* spp.), and quaking aspen (*Populus tremuloides*). The understory often contains invasive shrub species, including a variety of honeysuckles (*Lonicera japonica, Lonicera morrowii, Lonicera tatarica, Lonicera x bella*), European buckthorn (*Rhamnus cathartica*), and others. Ruderal Forests occupy approx. 6.4% of the study area.

5.5.2 Vegetative Communities Typical within the ROW

5.5.2.1 Deciduous forest on well-drained, Old Field Community

Vegetation within the cleared portions of the ROW is typically representative of an old field successional community. Old field communities are established through the process of natural succession from cleared land to mature forest. Within the cleared ROW, periodic vegetation management has favored the establishment and persistence of grasses and herbs. Over time, pioneer woody plant species including gray birch, black cherry, sumac (*Rhus* sp.) and eastern red cedar (*Juniperus virginiana*) have become established. Within the cleared portions of the ROW, vegetation varies considerably. On dry hilltops, little bluestem (*Schizachyrium scoparium*), round-head bushclover (*Lespedeza capitata*), staghorn sumac (*Rhus typhina*) and eastern red cedar are common. On the mid-slope, greenbrier and blackberry (*Rubus* sp.) form dense, impenetrable thickets. Numerous herbs including goldenrod (*Solidago* sp.), aster (*Aster* sp.), pokeweed (*Phytolacca americana*), and mullein (*Verbascum thapsus*) are also common.

5.5.2.2 Ruderal Grassland/Shrubland Community

Ruderal grasslands and shrublands encompass sites in the northern and central regions of the eastern United States that have been cleared and plowed (for farming or development) and then abandoned and are now are dominated by weedy or generalist native and exotic forbs, grasses, ferns, and shrubs. They are also a common community type within ROWs, where vegetation management removes the tree canopy and re-sets successional communities periodically to herbaceous/scrub-shrub layers. The ROW has been managed to selectively remove trees, so they do not interfere with the operation of the existing transmission lines. Low shrub lands dominate portions of the ROW where succession of old field has occurred and where ROW management has resulted in tree sapling removal. Sweet fern (*Comptonia peregrina*), bayberry (*Myrica pensylvanica*), and northern arrowwood (*Viburnum recognitum*) are shrub species that are commonly found within the ROW.

Forest vegetation abuts the area of managed ROW in many places along the corridor. This forested edge contains species of trees, and the ROW contains saplings that require more sunlight, such as black cherry (*Prunus serotina*), grey birch (*Betula populifolia*) and eastern red cedar (*Juniperus virginiana*). Mature forest containing northern red oak (*Quercus rubra*) and red maple (*Acer rubrum*) are also present along the corridor, and saplings of these species are occasionally found in the ROW. Ruderal grassland/shrub type communities occupy approx. 6.2% of the study area.

5.6 Wetlands

Wetlands are resources which have ecological functions and societal values. Wetlands are characterized by three criteria: (i) the presence of undrained hydric soil, (ii) a prevalence (>50 percent) of hydrophytic vegetation, and (iii) wetland hydrology, where soils are saturated near the surface or flooded by shallow water during at least a portion of the growing season.

Federal and State-regulated freshwater wetlands and/or streams were identified and delineated within the Project ROW during the summer of 2023. Field methodology for the delineation of State-regulated resource areas within the ROW was based upon vegetative composition, presence of hydric soils, and evidence of wetland hydrology. The study methods included both on-site field investigations and off-site analysis to determine the wetland and watercourse resource areas on the Project ROWs. Wetlands outside the ROW within the Study Area were identified based on a desktop review of RIGIS wetlands data (RIGIS 2019). Figure 5-3 depicts wetland resources within the Study Area, based on the results of this desktop analysis.

In total, 283 waterbodies (including 45 freshwater emergent wetlands, 157 freshwater forested/shrub wetlands, and 81 freshwater ponds), were mapped within the Study Area, as well as 52 perennial streams, 63 marsh/swamp areas, and 26 connector streams. Of these wetlands and waterways, field investigations identified 19 wetlands and eight (8) streams within the Project ROW.

The Rhode Island Fresh Water Wetlands Act and Rules ("Rules"), apply to the following jurisdictional areas: **freshwater wetlands**, **buffer zones**, **floodplains**, **areas subject to storm flowage**, **areas subject to flooding**, and contiguous areas that extend outward **two hundred feet (200') from the edge of a river or stream**, **two hundred feet (200') from the edge of a drinking water supply reservoir**, and **one hundred feet (100') from the edge of all other freshwater wetlands**, except as otherwise provided for in R.I. Gen. Laws § 2-1-22(k) for farmers conducting normal farming and ranching activities.

In accordance with the provisions of the Rules, state-regulated freshwater wetlands are areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Freshwater wetlands include (but are not limited to) **marshes, swamps, bogs, emergent and submergent plant communities, rivers, streams, ponds, and vernal pools**. These freshwater wetland types are defined as follows:

Marshes are areas within standing or running water which, during the growing season, support one or more of the following plant groups: hydrophytic reeds (*Phragmites*), grasses (*Gramineae*), mannagrasses (*Glyceria*), cutgrasses (*Leersia*), pickerelweeds (*Pontederiaceae*), sedges (*Cyperaceae*), rushes (*Juncaceae*), cattails (*Typha*), water plantains (*Alismataceae*), burreeds (*Sparganiaceae*), pondweeds (*Zosteraceae*), frog's bits (*Hydrocharitaceae*), arums (*Araceae*), duckweeds (*Lemnaceae*), water lilies (*Nymphaeaceae*), water-milfoils (*Haloragaceae*), water-starworts (*Callitrichaceae*), bladderworts (*Utricularia*), pipeworts (*Eriocaulon*), sweet gale (*Myrica gale*), and buttonbush (*Cephalanthus occidentalis*).

Swamps are areas where groundwater is near or at the surface for a significant portion of the growing season, where runoff water collects frequently, and/or where the vegetational community is made up significantly of one or more of the following plant species: red maple (*Acer rubrum*), elm (*Ulmus americana*), black spruce (*Picea mariana*), white cedar (*Chamaecyparis thyoides*), ashes (*Fraxinus*), poison sumac (*Rhus vernix*), larch (*Larix laricina*), spice bush (*Lindera benzoin*), alders (*Alnus*), skunk cabbage (*Symplocarpus foetidus*), hellebore (*Veratrum viride*), hemlock (*Tsuga canadensis*), sphagnums (*Sphagnum*), azaleas (*Rhododendron*), black alder (*Ilex verticillata*), coast pepperbush (*Clethra alnifolia*), marsh marigold (*Caltha palustris*), blueberries (*Vaccinium*), buttonbush (*Cephalanthus occidentalis*), willow (*Salicaceae*), water willow (*Decodon verticillatus*), tupelo (*Nyssa sylvatica*), laurels (*Kalmia*), swamp white oak (*Quercus bicolor*), or species indicative of marsh. For purposes of this definition, "significant part of the growing season" means that period of the growing season when water is present long enough to support a plant community of predominantly hydrophytic vegetation.

Bogs are areas where standing or slowly running water is near the surface during a growing season, and/or where the surface is covered by 50% or more with *Sphagnum* moss, and/or where the vegetational

community is made up of one or more of the following plant groups: blueberries and cranberries (*Vaccinium*), leatherleaf (*Chamaedaphne calyculata*), pitcher plant (*Sarracenia purpurea*), sundews (*Drosera*), orchids (*Orchidaceae*), white cedar (*Chamaecyparis thyoides*), red maple (*Acer rubrum*), black spruce (*Picea mariana*), bog aster (*Aster nemoralis*), larch (*Larix laricina*), bog rosemary (*Andromeda glaucophylla*), azaleas (*Rhododendron*), laurels (*Kalmia*), sedges (*Carex*), and bog cotton (*Eriophorum*).

An **emergent plant community** is a freshwater wetland characterized by erect, rooted, herbaceous hydrophytic vegetation that is present for most of the growing season in most years, and that may be persistent or non-persistent in nature.

A **submergent plant community** is a freshwater wetland characterized by plants that grow principally below the surface of the water for most of the growing season. Submergent plants are either attached to the substrate or float freely in the water.

Streams are any flowing body of water or watercourse [other than a river] that flows long enough each year to develop and maintain a channel and that may carry groundwater discharge or surface runoff. Such watercourses may not have flowing water during extended dry periods but may contain isolated pools or standing water. **Rivers** are a type of stream which is designated as perennial by the United States Department of Interior Geologic Survey on 7.5-minute series topographic maps.

Ponds are areas where open standing or slowly moving water shall be present for at least six (6) months a year. They may be natural or manmade. **Vernal Pools** are a type of ephemeral pond which dries out periodically. They are defined as depressional wetland basins that typically go dry in most years and may contain inlets or outlets, typically of intermittent flow. Vernal pools range in both size and depth depending upon landscape position and parent materials. Vernal pools usually support one (1) or more of the following obligate indicator species: wood frog (*Lithobates sylvaticus*), spotted salamander (*Ambystoma maculatum*), marbled salamander (*Ambystoma opacum*), and fairy shrimp (*Eubranchipus* spp.) and typically precludes sustainable populations of predatory fish.

The Rules also regulate activities in and around streams and open water bodies which include **Buffers**, **Floodplains**, **Areas Subject to Storm Flowage ("ASSF")**, and **Areas Subject to Flooding ("ASF")**. **Buffers** or **buffer zones** are areas of undeveloped vegetated land adjacent to a freshwater wetland. The width of buffer zones varies between river regions, based on conservation priority and level of development/urbanization.

A **floodplain** is the land area adjacent to a river or stream or other body of flowing water which is, on the average, likely to be covered with flood waters resulting from a one hundred (100) year frequency storm. A "one hundred (100) year frequency storm" is one that is to be expected to be equaled or exceeded once in one hundred (100) years; or may be said to have a one percent (1%) probability of being equaled or exceeded in any given year. **ASF** are areas that include, but are not limited to, low-lying areas that collect, hold or meter out storm and flood waters from any of the following: rivers, streams, intermittent streams, or areas subject to storm flowage. **ASSF** means areas that include drainage swales and channels that lead into, out of, pass through or connect other freshwater wetlands or coastal wetlands, and that carry flows resulting from storm events, but may remain relatively dry at other times.

5.6.1 River / Perennial Stream

A river is typically a named body of water designated as a perennial stream by United States Geological Survey ("USGS") (a blue line stream on a USGS topographic map). A perennial stream maintains flow year-round. There are three (3) river / perennial stream crossings within the Project ROW, associated with Cherry Brook and its unnamed tributaries.

5.6.2 Floodplain

A floodplain is the land area adjacent to a river, stream or other body of flowing water which is, on average, likely to be covered with flood waters resulting from a 100-year frequency storm event as mapped by Federal Emergency Management Agency ("FEMA") (RIGIS 2017). There are 25 areas of 100-year floodplain located within the Study Area, covering Zones A, AE and Regulated Floodway. Based on FEMA flood mapping (FIRMettes 44007C0157G [eff. 3/2/09] and 44007C0156G [eff. 3/2/09]), the majority of the Project ROW is located within floodplain, with an elevation range of approx. 228 – 229 feet.

5.6.3 Area Subject to Storm Flowage

Area Subject to Storm Flowage ("ASSFs") are channel areas which carry storm, surface, groundwater discharge, or drainage waters out of, into, and/or connect freshwater wetlands or coastal wetlands. ASSFs are recognized by evidence of scouring and/or other marked changes in vegetative density and/or composition. There are no mapped ASSFs within the Study Area.

5.6.4 Special Aquatic Site – Vernal Pools

A vernal pool is a type of special aquatic site that is generally defined as a contained basin that generally lacks a permanent above-ground outlet. It fills with water between late fall and spring from rising groundwater, or with the meltwater and runoff of winter and spring snow and rain (RIDEM 2016). Many vernal pools are regulated by the RIDEM as special aquatic sites. A special aquatic site is defined in the RIDEM Freshwater Wetlands Rules and Regulations as a body of open standing water, either natural or artificial, which does not meet the definition of pond, but which is capable of supporting and providing habitat for aquatic life forms, as documented by the: 1) presence of standing water during most years, as documented on site or by aerial photographs; and 2) presence of habitat features necessary to support aquatic life forms of obligate wildlife species, or the presence of evidence of, or use by aquatic life forms of obligate wildlife species (excluding biting flies).

Most vernal pools contain water for a few months in the spring and early summer and are dry by mid-summer. Because they lack a permanent water source and dry periodically, vernal pools lack a permanent fish population. Vernal pools provide breeding habitat for species, particularly amphibians, which depend upon pool drying and the absence of fish for breeding success and survival (obligate vernal pool species). Some wetlands and water bodies may provide breeding habitat for amphibians but lack the specific criteria to meet the definition of a vernal pool (e.g., provide habitat to facultative vernal pool species only, or contain evidence of breeding obligate vernal pool species occurring together with fish populations); these wetlands and water bodies have been designated as "amphibian breeding habitats."

No impacts to vernal pools will occur because of Project activities.

5.7 Wildlife

As previously described, the Study Area includes a variety of aquatic and terrestrial habitats. The wildlife assemblages present within the Study Area vary according to habitat characteristics. A list of amphibians, reptiles, birds, and mammals expected to occur within a given habitat are provided in Table 5-6. It should be noted that individual species may not occur in any one particular area but may be found throughout the general Study Area. This information is based on geographical distribution and habitat preferences as described in *New England Wildlife: Habitat, Natural History and Distribution* (DeGraaf and Yamasaki 2001).

5.7.1 Fisheries

There are no Designated Trout Waters or cold-water fisheries within the Study Area.

TABLE 5-6: EXPECTED WILDLIFE SPECIES WITHIN THE STUDY AREA

	TERRESTRIAL HABITATS				AQUATIC HABITATS					
	OAK / PINE FOREST	WHITE PINE / NORTHERN RED OAK / RED MAPLE FOREST	OLD FIELD COMMUNITY †	UPLAND LOW SHRUBLAND COMMUNITY†	POND	SHALLOW MARSH†	SHRUB SWAMP	FORESTED WETLAND†	RIVER	STREAM†
Amphibians/Reptiles										
American Bullfrog					X	X	X		X	X
American Toad	X	X	X	X	X	X	X	X		
Black Rat Snake	X	X	X	X				X		
Blanding's Turtle			X	X						
Blue-spotted Salamander	X	X			X	X	X	X		
Common Garter Snake	X	X	X	X	X	X	X	X		X
Common Musk Turtle			X		X	X	X		X	X
Common Snapping Turtle	X	X	X	X	X	X	X		X	X
Eastern Box Turtle	X	X	X	X		X	X	X		
Eastern Hognose Snake	X	X	X	X		X		X		
Eastern Milk Snake	X	X	X	X				X		
Eastern Smooth Green Snake	X	X	X	X		X	X	X		
Eastern Worm Snake	X	X	X	X						
Four-toed Salamander	X	X				X	X	X		X
Fowler's Toad	X	X	X	X	X	X	X	X		
Green Frog					X	X	X	X	X	X
Gray Treefrog	X	X			X	X	X	X		
Marbled Salamander	X	X			X		X	X		
Northern Black Racer	X	X	X	X		X	X	X		
Northern Brown Snake	X	X	X	X		X	X	X		
Northern Dusky Salamander	X	X						X		X
Northern Redback Salamander	X	X				X		X		
Northern Redbelly Snake	X	X	X	X			X	X		

	TERRESTRIAL HABITATS				AQUATIC HABITATS					
	OAK / PINE FOREST	WHITE PINE / NORTHERN RED OAK / RED MAPLE FOREST	OLD FIELD COMMUNITY †	UPLAND LOW SHRUBLAND COMMUNITY†	POND	SHALLOW MARSH†	SHRUB SWAMP	FORESTED WETLAND†	RIVER	STREAM†
Northern Ringneck Snake	X	X						X		
Northern Spring Peeper	X	X			X	X	X	X		
Northern Two-lined Salamander	X	X						X		X
Northern Water Snake					X	X	X		X	X
Painted Turtle			X	X						
Pickerel Frog					X	X		X		X
Red-spotted Newt	X	X			X	X	X	X		X
Ribbon Snake	X	X			X	X	X	X		X
Spotted Salamander	X	X			X	X	X	X		
Spotted Turtle	X	X	X	X	X	X	X	X		
Wood Frog	X	X				X	X	X		
Wood Turtle	X	X	X	X	X	X	X	X	X	X
Birds										
American Black Duck					X	X	X	X	X	X
Acadian Flycatcher	X	X						X		
American Crow	X	X	X	X				X		
American Goldfinch	X	X	X	X		X	X	X		
American Kestrel	X	X	X	X		X		X		
American Redstart	X	X						X		
American Robin*	X	X	X				X	X		
American Tree Sparrow	X	X	X	X		X	X	X		
American Woodcock	X	X	X	X			X	X		
Baltimore Oriole	X	X	X				X	X		
Bank Swallow	X	X	X	X	X	X		X	X	X
Barn Owl										
Barn Swallow	X	X	X	X	X	X		X	X	X
Barred Owl	X	X	X	X				X		

	TERRESTRIAL HABITATS				AQUATIC HABITATS					
	OAK / PINE FOREST	WHITE PINE / NORTHERN RED OAK / RED MAPLE FOREST	OLD FIELD COMMUNITY †	UPLAND LOW SHRUBLAND COMMUNITY†	POND	SHALLOW MARSH†	SHRUB SWAMP	FORESTED WETLAND†	RIVER	STREAM†
Belted Kingfisher					X				X	X
Black & White Warbler	X	X						X		
Black-billed Cuckoo			X	X				X		
Black-capped Chickadee	X	X	X	X			X	X		
Black-throated Green Warbler	X	X						X		
Blue-gray Gnatcatcher	X	X	X	X			X	X		
Blue-headed Vireo	X	X						X		
Blue Jay	X	X	X					X		
Blue-winged Warbler	X	X	X	X			X	X		
Bobolink						X				
Broad-winged Hawk	X	X						X		
Brown Creeper	X	X						X		
Brown Thrasher	X	X	X	X				X		
Brown-headed Cowbird	X	X	X	X		X		X		
Bufflehead									X	X
Canada Goose					X	X			X	X
Canada Warbler	X	X					X	X		
Carolina Wren	X	X	X	X				X		
Cedar Waxwing	X	X	X	X			X	X		
Chestnut-sided Warbler			X	X			X	X		
Chimney Swift			X	X						
Chipping Sparrow	X	X						X		
Common Nighthawk	X	X	X	X				X		
Common Grackle	X	X				X	X	X		
Common Merganser	X	X			X			X	X	X
Common Redpoll	X	X	X	X		X	X			

	TERRESTRIAL HABITATS				AQUATIC HABITATS					
	OAK / PINE FOREST	WHITE PINE / NORTHERN RED OAK / RED MAPLE FOREST	OLD FIELD COMMUNITY †	UPLAND LOW SHRUBLAND COMMUNITY†	POND	SHALLOW MARSH†	SHRUB SWAMP	FORESTED WETLAND†	RIVER	STREAM†
Common Yellowthroat	X	X	X	X	X	X	X	X		
Cooper's Hawk	X	X	X	X				X		
Dark-eyed Junco	X	X	X	X				X		
Downy Woodpecker	X	X	X					X		
Eastern Bluebird	X	X	X	X			X	X		
Eastern Kingbird	X	X	X	X		X	X	X	X	
Eastern Meadowlark					X					
Eastern Phoebe	X	X	X				X	X		
Eastern Screech Owl	X	X	X	X		X		X		
Eastern Towhee	X	X	X	X				X		
Eastern Wood-Pewee	X	X	X				X	X		
European Starling	X	X	X					X		
Evening Grosbeak	X	X						X		
Field Sparrow	X	X	X	X				X		
Fish Crow					X	X			X	X
Fox Sparrow	X	X	X	X				X		
Grasshopper Sparrow										
Golden-crowned Kinglet	X	X					X	X		
Golden-winged Warbler	X	X	X	X				X		
Gray Catbird	X	X	X	X			X	X		
Great Black-backed Gull										
Great Blue Heron	X	X			X	X	X	X	X	X
Great Crested Flycatcher	X	X	X					X		
Great Horned Owl	X	X	X	X		X	X	X		
Green Heron	X	X			X	X	X	X	X	X
Hairy Woodpecker	X	X						X		
Hermit Thrush	X	X	X	X			X	X		

	TERRESTRIAL HABITATS				AQUATIC HABITATS					
	OAK / PINE FOREST	WHITE PINE / NORTHERN RED OAK / RED MAPLE FOREST	OLD FIELD COMMUNITY †	UPLAND LOW SHRUBLAND COMMUNITY†	POND	SHALLOW MARSH†	SHRUB SWAMP	FORESTED WETLAND†	RIVER	STREAM†
Herring Gull									X	
Hoary Redpoll			X	X		X	X	X		
Hooded Merganser	X	X			X			X	X	X
Hooded Warbler	X	X	X	X			X	X		
Horned Lark										
House Wren	X	X	X	X			X	X		
House Finch	X	X								
House Sparrow										
Indigo Bunting	X	X	X	X				X		
Killdeer										
Lapland Longspur										
Least Bittern						X				
Least Flycatcher	X	X						X		
Louisiana Waterthrush	X	X						X		X
Mallard					X	X	X		X	X
Mourning Dove	X	X	X	X				X		
Mute Swan					X	X	X		X	X
Nashville Warbler	X	X					X	X		
Northern Bobwhite	X	X	X	X						
Northern Cardinal	X	X	X	X			X	X		
Northern Flicker	X	X	X					X		
Northern Goshawk	X	X	X	X				X		
Northern Mockingbird	X	X	X	X			X	X		
Northern Rough-winged Swallow	X	X	X	X	X	X		X		X
Northern Saw-whet Owl	X	X						X		
Northern Shrike	X	X	X	X		X		X		
Northern Waterthrush	X	X					X	X		

	TERRESTRIAL HABITATS				AQUATIC HABITATS					
	OAK / PINE FOREST	WHITE PINE / NORTHERN RED OAK / RED MAPLE FOREST	OLD FIELD COMMUNITY †	UPLAND LOW SHRUBLAND COMMUNITY†	POND	SHALLOW MARSH†	SHRUB SWAMP	FORESTED WETLAND†	RIVER	STREAM†
Orchard Oriole	X	X						X		
Ovenbird	X	X						X		
Pine Grosbeak	X	X						X		
Pine Siskin	X	X	X	X			X	X		
Pine Warbler	X	X								
Prairie Warbler	X	X	X	X						
Purple Finch	X	X	X	X				X		
Purple Martin			X	X	X	X		X		
Red-bellied Woodpecker	X	X						X	X	X
Red-breasted Nuthatch	X	X								
Red-eyed Vireo	X	X						X		
Red-shouldered Hawk	X	X					X	X		
Red-tailed Hawk	X	X	X	X			X	X		
Ring-necked Pheasant			X	X			X			
Rose-breasted Grosbeak	X	X	X	X			X	X		
Red-winged Blackbird					X	X		X		
Rock Dove							X			
Rough-legged Hawk			X	X		X				
Ruby-crowned Kinglet	X	X								
Ruby-throated Hummingbird	X	X	X	X				X		
Ruffed Grouse	X	X	X	X				X		
Rusty Blackbird								X		
Savannah Sparrow						X				
Scarlet Tanager	X	X						X		
Sharp-shinned Hawk	X	X						X	X	
Snow Bunting						X				
Solitary Sandpiper						X	X			

	TERRESTRIAL HABITATS				AQUATIC HABITATS					
	OAK / PINE FOREST	WHITE PINE / NORTHERN RED OAK / RED MAPLE FOREST	OLD FIELD COMMUNITY †	UPLAND LOW SHRUBLAND COMMUNITY†	POND	SHALLOW MARSH†	SHRUB SWAMP	FORESTED WETLAND†	RIVER	STREAM†
Song Sparrow	X	X	X	X		X	X	X		
Sora Rail					X	X				
Spotted Sandpiper					X		X		X	X
Swamp Sparrow					X	X	X	X		
Tree Swallow	X	X	X	X	X	X	X	X	X	X
Tufted Titmouse	X	X	X				X	X		
Turkey Vulture	X	X	X		X		X	X		
Veery	X	X						X		
Virginia Rail						X				
Warbling Vireo	X	X	X							
Whip-poor-will	X	X	X	X				X		
White-breasted Nuthatch	X	X	X					X		
White-eyed Vireo	X	X	X	X			X	X		
White-throated Sparrow	X	X	X	X				X		
Wild Turkey	X	X	X	X				X		
Willow Flycatcher	X	X	X	X				X		
Wilson's (Common) Snipe			X			X	X			
Winter Wren	X	X					X	X		
Wood Duck	X	X			X	X	X	X	X	X
Wood Thrush	X	X						X		
Worm-eating Warbler	X	X								
Yellow-bellied Sapsucker	X	X						X		
Yellow-billed Cuckoo	X	X	X	X			X	X		
Yellow-throated Vireo	X	X						X		
Yellow Warbler	X	X	X	X			X	X		
Mammals										

	TERRESTRIAL HABITATS				AQUATIC HABITATS					
	OAK / PINE FOREST	WHITE PINE / NORTHERN RED OAK / RED MAPLE FOREST	OLD FIELD COMMUNITY †	UPLAND LOW SHRUBLAND COMMUNITY†	POND	SHALLOW MARSH†	SHRUB SWAMP	FORESTED WETLAND†	RIVER	STREAM†
Beaver	X	X			X	X	X	X	X	X
Big Brown Bat	X	X	X	X	X	X	X	X	X	X
Black Bear	X	X	X	X	X	X	X	X	X	X
Bobcat	X	X	X	X			X	X		
Coyote	X	X	X	X		X	X	X		X
Deer Mouse	X	X	X	X				X		
Eastern Chipmunk	X	X	X	X				X		
Eastern Cottontail	X	X	X	X		X	X	X		X
Eastern Mole	X	X	X	X				X		
Eastern Pipistrelle	X	X	X	X	X	X	X	X	X	X
Ermine	X	X	X	X		X	X	X		X
Fisher	X	X	X	X				X		
Gray Fox	X	X	X	X		X	X	X		X
Gray Squirrel	X	X						X		X
Hairy-tailed Mole	X	X	X	X				X		
Hoary Bat	X	X	X	X	X	X	X	X	X	X
House Mouse			X	X						
Little Brown Myotis	X	X	X	X	X	X	X	X	X	X
Long-tailed Weasel	X	X	X	X		X	X	X		X
Meadow Jumping Mouse	X	X	X	X		X	X	X		X
Meadow Vole	X	X	X	X		X	X	X		X
Masked Shrew	X	X	X	X		X	X	X		X
Mink	X	X			X	X	X	X	X	X
Muskrat					X	X	X		X	X
New England Cottontail	X	X	X	X		X	X	X		X
Northern Flying Squirrel	X	X								
Northern Myotis	X	X	X	X	X	X	X	X	X	X

	TERRESTRIAL HABITATS				AQUATIC HABITATS					
	OAK / PINE FOREST	WHITE PINE / NORTHERN RED OAK / RED MAPLE FOREST	OLD FIELD COMMUNITY †	UPLAND LOW SHRUBLAND COMMUNITY†	POND	SHALLOW MARSH†	SHRUB SWAMP	FORESTED WETLAND†	RIVER	STREAM†
Northern Short-tailed Shrew	X	X	X	X		X	X	X		X
Norway Rat			X	X						
Porcupine	X	X	X	X				X		
Raccoon	X	X	X	X		X	X	X		X
Red Bat	X	X	X	X	X	X	X	X	X	X
Southern Flying Squirrel	X	X						X		
Red Fox	X	X	X	X		X	X	X		X
Red Squirrel	X	X						X		
River Otter	X	X			X	X	X	X	X	X
Silver-haired Bat	X	X	X	X	X	X	X	X	X	X
Smoky Shrew	X	X					X	X		X
Snowshoe Hare	X	X	X	X		X		X		
Southern Bog Lemming	X	X	X	X		X		X		X
Southern Red-backed Vole	X	X	X	X				X		X
Star-nosed Mole					X	X	X	X	X	X
Striped Skunk	X	X	X	X		X	X	X		X
Virginia Opossum	X	X	X	X		X	X	X		X
Water Shrew	X	X			X	X	X	X	X	X
White-footed mouse	X	X	X	X			X	X		X
White-tailed Deer	X	X	X	X		X	X	X		X
Woodchuck	X	X	X	X				X		
Woodland Vole	X	X	X	X			X	X		

Legend: X = Expected Source: DeGraaf and Yamasaki 2001. † Habitat type crossed by Project RO

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5.7.2 Rare and Endangered Species

Correspondence regarding Federal and Rhode Island state-listed species is included in **Appendix B**, **Agency Correspondence.**

5.7.2.1 Federal-Listed Species

To assess the potential for state or federally-listed, endangered, threatened, and/or special concern plant and/or animal species along the Project route, BSC reviewed the RIDEM 2023 Natural Heritage datalayers, solicited database information from RIDEM, and followed the U.S. Fish and Wildlife Service ("USFWS") Endangered Species Consultation Procedure available on their website.

As a result of the USFWS Endangered Species Consultation Procedure, it was determined that the federally listed for Northern Long-Eared Bat ("NLEB") (*Myotis septentrionalis*) may be present within the Project area. However, no known hibernaculum, maternity roost trees, or potential roost trees are located within the Project area. In accordance with 4(d) Rule for Non-Federal activities, a permit is not required for the Project. No federally designated Critical Habitat occurs in the Project ROW. Species descriptions and habitat requirements for NLEB are described below.

5.7.2.1.1 Northern Long-eared Bat

The NLEB is a medium-sized bat in the Family Vespertilionidae with distinguishing long ears. Their body lengths range from 3.0 to 3.7 inches with a wingspan of 9.0 to 10 inches. Fur color ranges from medium to dark brown on the back and tawny to pale-brown on the underside. The NLEB has both a winter and summer habitat. During winter, these bats hibernate in natural caves and abandoned mines (known as hibernacula) which have high humidity, constant temperatures, and no air currents (Natural Heritage Endangered Species Program ("NHESP"), 2019). NLEB will share caves and mines with other wildlife species, but hibernate singly or in small groups within deep crevices or cracks of the caves and mines. Rhode Island does not have any natural caves or abandoned mines so most bats that spend the summer in Rhode Island must leave the state and travel elsewhere to hibernate (RIDEM/Fish and Wildlife, n.d.). During the summer, NLEB prefer forests where the bats roost in colonies or singly in cavities of both live and dead trees, as well as underneath tree bark. Females give birth to a single pup each season. The estimated maximum lifespan of the NLEB is up to 18.5 years. NLEB feed at dusk and eat a variety of insects such as flies, leafhoppers, caddisflies, beetles, and moths. The greatest threat to the NLEB is white-nose syndrome, which is spreading from the Northeast to the Midwest and Southeast United States. The NLEB is federally listed as a threatened species under the Endangered Species Act ("ESA") (U.S. Fish & Wildlife, 2015).

In accordance with the final 4(d) Rule for the NLEB, a verification letter for the Project was submitted to the US Fish & Wildlife Service on October 18, 2024. Based upon the IPaC ("Information for Planning and Conservation") submission, a "no effect" determination was made for NLEB. The verification letter from US Fish & Wildlife Service verifies that the Programmatic Biological Opinion ("PBO") satisfies and concludes responsibilities for the Action under ESA Section 7(a)(2) with respect to NLEB.

5.7.2.2 State-Listed Species

Based on correspondence with the RIDEM, BSC Group completed field surveys in summer and fall of 2024 for state-listed plant species previously identified in proximity to the Project ROW. BSC confirmed the presence of five (5) state listed plant species within the Project area: *Lygodium palmatum*, *Aureolaria pedicularia*, *Agalinis tenuifolia, Penstemon digitalis, and Gentiana clausa*. These state-listed plant populations will be fenced and avoided during the construction of the Project.

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6 DESCRIPTION OF AFFECTED SOCIAL ENVIRONMENT

Per the EFSB Rules, this section provides a detailed description of all environmental characteristics of the proposed site including the physical and social environment on and off site.

6.1 Land Use

This section describes existing and future land use within the Study Area. The scope of this discussion will address those features which might be affected by the Project. Land use within the Study Area is predominantly mixed forest (27%), followed by deciduous forest (25%), softwood forest (13%), and medium density residential (9%). Other land uses which occupy more than 1% of the study area include power lines, transitional areas, mines, softwood forest, pasture, wetland/water, roads, developed recreation and cropland.

6.1.1 Open Space and Recreation

Open space (characterized by brushland/areas of reforestation, hardwood and softwood forest, recreation land, transitional areas, vacant land, water, and wetlands) is the dominant land use within the study area, comprising ~73% of the study area. Of this, most of the open space is classified as undeveloped forest land. Recreational areas within the study area include Slatersville Reservoir (a swimming and fishing lake), Audubon Fort Wildlife Refuge, and Mattity and Cedar Swamps (park and gardens).

6.1.2 Residential

Residential development is the second-most dominant land use type within the Study Area (13% when high and medium density residential are combined). Of the 1029 acres dedicated to residential development within the Study Area, approximately 5.5 acres are classified as High density (<0.125 acre lots), 110 acres as Medium-High density (0.125 – 0.25 acre lots), 700 acres as Medium density (0.25 – 1 acre lots), 150 acres as Medium-Low density (1 – 2 acre lots), and 64 acres as low density (>2 acre lots).

Residential neighborhoods are located throughout the Study Area, but are particularly dominant in the north and east portions of the Study Area associated with Woonsocket and Manville, RI.

6.1.3 Commercial Business

Commercial business within the Project Study Area are characterized by commercial and industrial mixed development. Commercial development within the Study Area is predominantly located in the northeast of the Study Area, along Route 146A. This includes buildings associated with grocery stores, restaurants, gyms, and beauty salons.

6.1.4 Institutions

Institutional land use identified as churches, municipal buildings (e.g., Schools, fire stations), and hospitals exists within the Study Area. This includes the North Smithfield Police Department (to the northeast of the study area), a childcare center, and a church.

6.1.5 Agricultural

Agricultural land use within the Study Area includes 94 acres of pasture (agricultural land not suitable for tillage), and 104 acres of tillable cropland.

6.1.6 Future Land Use

A zoning analysis was completed to assess future land use in the Study Area. Typically, towns and cities manage future growth through zoning regulations. According to the Town of North Smithfield Comprehensive Plan (2019), the majority of the Study Area in North Smithfield is Zoned for Rural Estate Agriculture or Open Space, with smaller areas to the northeast of the Project area zoned for Residential - Urban Use. There is no specific mention upgrades the electric transmission or distribution system in the Town Comprehensive Plan. However, the plan does mention the need for embracing renewable energy and supporting renewable energy projects.

6.2 Visual Resources

The Project is within an existing maintained ROW. Although the Project will require a height increase for structures, the height increase does not represent a substantial change in the apparent height of the transmission line facilities. On average, the steel structures replacing the wood structures will be taller than current conditions due to the switch from the horizontal alignment to the vertical alignment (existing height range is 52 – 81 feet., and the proposed range is 51 – 111 feet.). The range of change in structure heights is -1 to +30-feet. Although structures will be slightly taller, the difference in appearance when viewed from the ground will be negligible.

Although not required for construction and operation of the B23 and S171 Transmission Lines, the Project will also involve widening of the B23 Line ROW between the Nasonville Substation and the 328/341 ROW, with the removal of 42,700 sf/~ 1 acre of trees. Please refer to the visual simulations included in **Appendix C** for renderings of the ROW with the new double circuit structures and cleared ROW.

6.3 Noise

Environmental sound levels are quantified using a variety of parameters and metrics. This section introduces general concepts and terminology related to acoustics and environmental noise.

Sound energy is physically characterized by amplitude and frequency. Sound amplitude is measured in decibels (“dB”) as the logarithmic ratio of a sound pressure to a reference sound pressure which corresponds to the typical threshold of human hearing. Generally, the average listener considers a 1.0 dB change in a constant broadband noise “imperceptible” and a 3.0 dB change “just barely perceptible.” Similarly, a 5.0 dB change is generally considered “clearly noticeable”, and a 10 dB change is generally considered a doubling (or halving) of the apparent loudness. Frequency is measured in hertz (“Hz”), which is the number of cycles per second. The typical human ear can hear frequencies ranging from approximately 20 Hz to 20,000 Hz. Typically, the human ear is most sensitive to sounds in the middle frequencies (1,000 Hz to 8,000 Hz) and is less sensitive to sounds in the low and high frequencies. As such, the A-weighted scale was developed to simulate the frequency response of the human ear to sounds at typical environmental levels. The A-weighted scale emphasizes sounds in the middle frequencies and de-emphasizes sounds in the low and high frequencies. Any sound level to which the A-weighted scale has been applied is expressed in A- weighted dB, dBA. For reference, the A-weighted sound pressure levels associated with some common noise sources are shown in Table 6-1 below:

TABLE 6-1: TYPICAL SOUND PRESSURE LEVELS FOR COMMON NOISE SOURCES

SOUND (DBA)	SUBJECTIVE EVALUATION	ENVIRONMENT	
		OUTDOOR	INDOOR
140	Deafening	Jet aircraft takeoff at 75 feet	
130	Threshold of pain	Jet aircraft takeoff at 300 feet	
120	Threshold of feeling	Elevated train	Rock band concert
110	Extremely loud	Jet flyover at 1,000 feet	Inside propeller plane
100	Very loud	Motorcycle at 25 feet, auto horn at 10	
90	Very loud	Propeller plane flyover at 1,000 feet, noisy urban street	Full symphony or band, food blender, noisy factory
80	Moderately loud	Diesel truck (40 mph) at 50 feet	Inside auto at high speed, garbage disposal, dishwasher
70	Loud	B-757 cabin during flight	Close conversation, vacuum cleaner, electric typewriter
60	Moderate	Air-conditioner condenser at 15 feet, near highway traffic	General office
50	Quiet		Private office
40	Quiet	Farm field with light breeze, birdcalls, soft stereo music in residence	Bedroom, average residence (without television & stereo)
30	Very quiet	Quiet residential neighborhood	
20	Very quiet	Rustling leaves	Quiet theater, whisper
10	Just audible		Human breathing
0	Threshold of hearing		

Source: Adapted from Architectural Acoustics, M. David Egan 1988 and Architectural Graphic Standards, Ramsey and Sleeper 1994, as referenced in the Environmental Noise Assessment prepared for the Southern Rhode Island Transmission Project by Black & Veatch Corporation.

Within North Smithfield, the Study Area encompasses the Route 146 and Route 104 corridors but is predominantly within quiet forest areas. Ambient sound levels are influenced by diverse factors such as vehicular traffic, commercial and industrial activities, and outdoor activities typical of both rural and developed environments. Noise receptors include residences, hospitals and designated recreational areas.

6.4 Cultural and Historic Resources

This section presents the findings of a cultural resources due diligence review conducted by TNEC's cultural resource consultant, PAL, in July 2024. The purpose of this review was to identify historic architectural properties, archaeological sites, and other cultural resources within the vicinity of the Project, and to make recommendations regarding consultation with the Rhode Island Historic Preservation and Heritage Commission ("RIHPHC"), or additional cultural resource investigations. Properties were identified through a search of the RIHPHC's archaeological, National Register of Historic Places ("NRHP") and architectural survey files, and consultation with interested stakeholders during previous projects.

The study areas established for the purposes of the identification effort were broadly defined to provide information about the types of resources located within the vicinity of the Project. For archaeological resources, the study area encompassed 0.5 mile on either side of the Project centerline for a total width of one mile. For historic architectural properties, the study area was established at 0.25 mile on either side of the Project centerline. The area of potential effects ("APE") for archaeological sites is defined as any areas of ground disturbances that may occur as a result of implementing planned improvements, including the

relocation or replacement of existing structures, access roads, and staging areas. The APE for historic architectural properties includes the construction area and areas adjacent to the ROW where visual impacts may occur.

Several aboveground historic resources were identified within ¼ mile of the Study Area, including the Todd Farm National Register District. The Todd Farm National Register District is located at 670 Farnum Pike south of the Project. The farmhouse was constructed in 1740 with later additions. The farm includes several outbuildings including a sawmill (RIHPHC site files). Twenty-three archaeological resources (including 16 pre-contact and 7 post-contact), 4 historic cemeteries, and 1 discarded headstone were identified within ½ mile of the Study Area. The pre-contact sites consist of artifact clusters and lithic tool manufacturing and resource processing areas, and the Second Battle of Nipsachuck Battlefield (the Battle of Mattity Swamp). The post-contact sites consist of a quarry, cider mill, road, and farmstead dating from the nineteenth and twentieth centuries.

6.5 Transportation

The Study Area is served by a limited network of state and local roads and highways. The major north/south route in the area is Route 104 (which the Line crosses between Structures 1A and 1B), and the major east/west route is Route 146 (which the Line crosses between Structures 10 and 11).

6.6 Electric and Magnetic Fields

EMF is a term used to describe electric and magnetic fields that are created by the voltage (electric field) and the current (magnetic field) on electric conductors. The Company like all North American electric utilities, supplies electricity at a frequency of 60 Hertz ("Hz"); therefore, the electric utility system and the equipment and conductors connected to it produce 60-Hz (power-frequency) EMF. These fields can be either measured using instruments or calculated using models.

Power-frequency EMFs are present wherever electricity is used. This includes utility transmission lines, distribution lines, and substations. It also includes electrical wiring in homes, offices, and schools. Appliances and machinery that use electricity will also generate electric and magnetic fields.

Electric fields exist whenever voltages are present on transmission conductors and are not directly dependent on the magnitude of current flow. The magnitude of the electric field from a transmission line is primarily a function of the configuration and operating voltage of the line and decreases with the distance from the source. The electric field may be shielded (i.e., the strength may be reduced) by any grounded conducting object, such as trees, fences, walls, buildings, and most common structures. The strength of an electric field is measured in volts per meter ("V/m") or kilovolts per meter ("kV/m"), where 1 kV = 1,000 volts ("V").

Magnetic fields are present whenever current flows in a conductor and are not directly dependent on the voltage present on the conductor. The magnetic field strength from a transmission line is a function of both the current flow on the conductor and the configuration of the transmission line. The strength of magnetic fields also decreases with distance from the source. Since the flow of electric current (expressed in units of Amperes), or load on a transmission line varies based on the need for electric power in the region, the magnetic field associated with electric transmission lines also varies throughout the day and with seasonal changes in electric demand. Unlike electric fields, however, most common materials have little shielding effect on magnetic fields.

Magnetic fields are measured as magnetic flux density in units called Gauss ("G"). For the low levels normally encountered during daily activities, the field strength is expressed in a much smaller unit, the milliGauss ("mG"), which is one thousandth of a Gauss.

Table 6-2 lists common household devices and typical magnetic field levels measured at the distances indicated from the source.

TABLE 6-2: COMMON SOURCES OF MAGNETIC FIELDS

SOURCES*	DISTANCE FROM SOURCE	
	6 INCHES (mG)	24 INCHES (mG)
Microwave Ovens	100-300	1-30
Dishwashers	10-100	2-7
Refrigerators	Ambient - 40	Ambient – 10
Fluorescent Lights	20-100	Ambient – 8
Copy Machines	4-200	1-13
Drills	100-200	3-6
Power Saws	50-1,000	1-40

Note: * Different makes and models of appliances, tools, or fixtures will produce different levels of magnetic fields. Source: (adapted from National Institute of Environmental Health Sciences, 2002)

The federal government has implemented no regulations or guidelines for EMF from transmission lines or electric utility infrastructure. In addition, the state of Rhode Island has no requirements for EMF.

Since there are no federal or Rhode Island guidelines, EMF levels from the Project were assessed using standards and guidelines developed by two international health and scientific organizations that have evaluated the relevant research related to EMF. The guidance levels, referred to as reference levels recommended by the International Committee on Electromagnetic Safety ("ICES"), a committee of the Institute of Electrical and Electronics Engineers, and the International Commission on Non-Ionizing Radiation Protection ("ICNIRP") are summarized in Table 6-3. It is important to note that these reference values are not exposure limits per se because exposure to higher EMF levels comply with the standards if the underlying basic restrictions on fields in the human-body are not exceeded. It is important to note that these reference values are not exposure limits per se because exposure to higher EMF levels comply with the standards if the underlying basic restrictions on fields in the human-body are not exceeded.

TABLE 6-3: REFERENCE LEVELS FOR WHOLE BODY EXPOSURE TO 60-HZ EMF

ORGANIZATION	MAGNETIC FIELD	ELECTRIC FIELD
International Commission on Non-Ionizing Radiation Protection ("ICNIRP") (general public, continuous exposure)	2,000 mG	4.2 kV/m
International Committee on Electromagnetic Safety ("ICES")	9,040 mG	10 kV/m[a] 5.0 kV/m

[a] This is an exception for persons within transmission line ROWs.

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7 IMPACT ANALYSIS

This section presents an analysis of the potential impacts of the Project on the existing natural and social environments within the Study Area. As with any construction project, potential adverse impacts can be associated with the construction, operation, or maintenance of an electric transmission line. These impacts will be minimized to the greatest extent feasible through thoughtful design and construction, operation and maintenance practices.

Potential impacts to the natural and social environments associated with the Project can be categorized based on construction-related (temporary) impacts and operational-related (permanent) impacts. Examples of potential temporary construction-related impacts include traffic impacts, temporary use of areas to stage construction equipment and supplies, and short-term construction noise associated with the operation of heavy equipment.

The Project will be constructed in a manner that minimizes adverse environmental impacts. A monitoring program will be conducted by TNEC to verify that the Project is constructed in compliance with all required licenses and permits and all applicable federal, state, and local laws and regulations. Design and construction mitigation measures will be implemented so that construction-related environmental impacts are minimized. Utilizing the B23 structures to support the proposed S-171 Transmission line will substantially reduce impacts since all construction work will be consolidated into a multi-phase project.

7.1 Summary of Environmental Effects and Mitigation

The Project will occur within the existing ROW, thereby minimizing adverse environmental impacts. No long-term impacts to soil, bedrock, vegetation, surface water, groundwater, wetland resources or air quality will occur. Any potential sedimentation impacts, and other short-term construction impacts to wetlands and surface waters, will be mitigated through the use of soil erosion and sediment control BMPs and equipment access mats (construction mats) to protect wetland soils, vegetation root stock, and streams. There will be no impacts to State Listed threatened or endangered species, since the identified (plant) species will be fenced off and protected. Minor, temporary disturbances of wildlife may result from equipment travel and construction crews working in the Project corridor. Any wildlife displacement will be negligible and temporary, and no permanent alteration of the existing habitat is proposed. As part of the Project, an environmental monitor will be part of the Project team to ensure compliance with all applicable regulatory programs and permit conditions, and to oversee the proper installation and maintenance of the soil erosion and sediment control BMPs.

7.2 Summary of Social Effects and Mitigation

The Project involves the reconstruction of an existing transmission line (with the addition of a new circuit), within an existing ROW. No long-term impacts to residential, commercial, or industrial land uses will occur as a result of the Project. Any construction noise impacts are expected to be brief and localized. Minimal visual impacts will result from the Project (associated with the slight increase in height of transmission line structures). The Project will improve the reliability of the electric supply and as such will have a positive effect for the area. Traffic controls plans will be employed as necessary, and as required at the ROW access points off local and state roads. The Project will not adversely impact the social and economic conditions in the Project area.

7.3 Soils

Construction activities which expose unprotected soils have the potential to increase soil erosion and sedimentation rates. Soil compaction and decreased infiltration rates may result from equipment operations. Standard construction techniques and BMPs will be employed to minimize any short- or long-term impacts due to construction activity. These include the installation of straw bales, siltation fencing, water bars, diversion channels, the use of dust control measures, and the re-establishment of vegetation post-construction. Sediment and erosion control devices will be inspected by TNEC's environmental monitor frequently during construction and repaired or replaced if necessary. The Applicant will develop and implement a Soil Erosion and Sediment Control Plan ("SESC" Plan), which will detail BMPs and inspection protocols.

Highly erodible soils are present within the Study Area. On all slopes greater than eight percent, which are above sensitive areas, impacted soils will be stabilized with straw or chipped brush mulch to prevent the migration of sediments.

Soil erosion and sediment control measures will be selected to minimize the potential for soil erosion and sedimentation in areas where soil is impacted. TNEC will adhere to its ROW Access, Maintenance, and Construction BMPs (EG-303).

Temporary soil erosion controls listed below may be placed in the following types of areas, in accordance with site-specific field determinations.

- Across or along portions of cleared ROW, at intervals dictated by slope, soil erodibility, amount of vegetative cover remaining, and down-slope environmental resources.
- On all slopes greater than eight percent, which are above sensitive areas, impacted soils will be stabilized with straw or chipped brush mulch to prevent the migration of sediments.
- Along access ways within the transmission line ROW.
- Across areas of impacted soils on slopes leading to streams and wetlands.
- Around portions of construction work sites that must unavoidably be located in wetlands.

The temporary soil erosion controls will be maintained, as necessary, throughout the period of active construction until restoration has been deemed successful, as determined by standard criteria for storm water pollution control/prevention and soil erosion control. In addition to silt fence or straw bales, temporary soil erosion controls may include the use of mulch, jute netting (or equivalent), soil erosion control blankets, reseeding to establish a temporary vegetative cover, temporary or permanent diversion berms (if warranted), and/or other equivalent structural or vegetative measures. After the completion of construction activities in any area, permanent stabilization measures (e.g., seeding and/or mulching) will be performed as necessary.

To minimize soil disturbance during tree removal activities, trees will be cut at stump, and root balls will be left intact except for areas that will require grading and/or structure installation.

During periodic post-construction inspections, TNEC will determine the appropriate time frame for removing these temporary soil erosion controls. This determination will be made based on the effectiveness of restoration measures, such as percent re-vegetative cover achieved, in accordance with applicable permit and certificate requirements.

7.4 Surface Water Resources

Any impact of the Project upon surface waters will be minor and temporary. Rivers and streams within the Project ROW are spanned by existing transmission lines. Tree removals are proposed in the vicinity of two (2) watercourses along the ROW. However, the existing shrub and emergent understory will remain in place at these locations to provide soil stabilization and vegetative cover. Construction activities temporarily increase risks for soil erosion and sedimentation that may temporarily degrade existing water quality; however, appropriate BMPs will be implemented and maintained to effectively control sediment. In addition, construction equipment will not cross the stream along the construction corridor without the use of temporary swamp mat bridges. Emphasis has been placed on using existing gravel roadways within the Project ROW and seeking access points that avoid crossing wetlands and surface waters to the extent possible.

There are several surface water features within the Study Area. Temporary swamp mats will be used to access structure locations within or adjacent to surface water features as conditions warrant. Access to most structure locations adjacent to these watercourses will be provided without impacting the channels either by using alternate upland access on the Project ROW or by spanning the areas using temporary swamp mats during construction. Sedimentation and turbidity within these watercourses will be minimized through the implementation of BMPs prior to construction activities.

Potential impacts to surface waters if sediment transport is not controlled include temporary increased turbidity and sedimentation (locally and downstream) and subsequent alterations of benthic substrates, decreases in primary production and dissolved oxygen concentrations, releases of toxic substances and/or nutrients from sediments, and destruction of benthic invertebrates. Soil erosion and sediment controls are intended to effectively minimize the potential for this situation to occur. The implementation and maintenance of stringent soil erosion and sediment control BMPs will limit the levels of Project related sedimentation and will minimize adverse impacts to surface waters.

7.4.1 Water Quality

The primary potential impact to water quality from any construction project is the increase in turbidity of surface waters in the vicinity of construction resulting from soil erosion and sedimentation from the impacted site. A second potential impact is the spillage of petroleum, hydraulic fluid, or other products near waterways. Impacts to previously undisturbed areas on the ROW will be minimized using existing access roads. Further, equipment (with exceptions for equipment that is not readily mobile) will not be refueled or maintained near wetlands or surface water resources. The contractors will respond to an inadvertent release or spill of soil or other hazardous materials in accordance with Rhode Island State and TNEC requirements. Pre-construction environmental training of contractors will reinforce this obligation. TNEC has company procedures to minimize risks and provide procedural requirements to be followed in the event of an inadvertent release. Therefore, it is anticipated that any adverse impacts to water resources resulting from construction of the Project will be negligible.

7.4.2 Hydrology

Some minor, temporary impacts to surface drainage can be expected during construction on the transmission lines. These impacts will be associated with access road and work pad improvements. TNEC will employ soil erosion and sediment controls prior to the initiation of soil disturbing activities to protect adjacent surface waters where necessary. Following construction, temporarily disturbed areas will be restored to pre-construction conditions to the extent practicable. Features that will permanently remain on the Project ROW (such as improved access roads), will be stabilized.

The hydrology of surface waters will not be significantly affected during or after construction since temporary wooden mat bridges will be constructed across stream channels to allow for the staging of equipment without disturbing the stream or its channel substrate.

7.4.3 Floodplain

Project activities located within Floodplain will include tree removals, the replacement of structures, construction of temporary access roads, and construction matting. No other impacts are proposed within Floodplain. The existing vegetated understory will be left intact in floodplain areas to the maximum extent practicable.

7.5 Groundwater Resources

Impacts to groundwater resources as a result of construction activity on the transmission line facilities will be negligible. Equipment used for construction will be properly inspected, maintained, and operated to reduce the chances of spilled petroleum products. Refueling equipment will be required to carry spill containment and prevention devices (i.e., absorbent pads, clean up rags, five-gallon containers, and absorbent material) and fueling of equipment will occur in upland areas where practicable. In addition, maintenance equipment and replacement parts for construction equipment will be on hand to repair failures and stop a spill in the event of equipment malfunction. Following construction, the normal operation and maintenance of the transmission line facilities will have no impact on groundwater resources.

7.6 Vegetation

TNEC's vegetation management program maintains safe operation and access to transmission line facilities and promotes the growth of vegetative communities along ROWs that are compatible with transmission line operation and in accordance with federal and state standards. TNEC has conducted vegetation management within its ROWs as a matter of good utility practice since the late 1980s. TNEC's vegetation management program is designed to allow the safe operation of transmission lines by preventing the growth of incompatible vegetation that may interfere with the transmission facilities or access along its ROW. As a result, the vegetation within the maintained portions of the TNEC ROW typically consists of low-growing shrubs, herbaceous species, and other low-growing species. Portions of the ROW that are not proximate to an existing line may support taller vegetation, if it will not conflict with the construction or operation of the lines.

Where ROW widening is required to provide adequate clearances for the new double-circuit B23/U-170 Line, tree removals will be conducted to minimize disturbance. Only trees within 25-ft of the current ROW edge or that present a hazard to the reconstructed line will be removed. Additionally wherever the understory can be maintained without impacting the safe operation of the transmission line, to provide vegetative cover and wildlife habitat.

To stabilize impacted sites after the work on the transmission facilities, TNEC will seed and mulch impacted areas with appropriate grass-type mixes and straw mulch. Vegetative species compatible with the use of the ROW for transmission line purposes are expected to regenerate naturally. TNEC will promote the re-growth of desirable species by implementing vegetative maintenance practices to control tall-growing trees and undesirable invasive species that conflict with line clearances, thereby enabling native plants to dominate. Where tree removals or tree trimming (on or off-ROW) are required for the Project, efforts will be made to retain understory vegetation. Where trees are removed, root systems will be left intact and trees cut at base to protect soil stability.

7.7 Wetlands

Construction of the Project will result in temporary and permanent impacts to wetland resources. Table 7-1 summarizes the potential impacts of the Project on wetlands, based on preliminary design data.

TABLE 7-1: POTENTIAL IMPACTS ON WETLANDS & WATERCOURSES

IMPACTS	APPROXIMATE IMPACT AREA
TEMPORARY - Swamp Mats for Access and Work Pads	196,757 sf/ 4.52 ac
PERMANENT – Tree removals / vegetation conversion	5,960-sf
PERMANENT – Fill for structures requiring caisson foundations	360-sf

All temporary matting used for access and work pads in wetlands and over watercourses will be removed after the completion of the Project.

7.8 Wildlife

Minor, temporary disturbances of wildlife may result from equipment travel and construction activities within the Project corridor. During construction, temporary displacement of wildlife may occur due to disturbance associated with ROW mowing and the operation of construction equipment. Wildlife currently utilizing the forested edge of the cleared ROW may be affected by the construction of the Project.

Larger, more mobile species, such as eastern white-tailed deer or red fox, will leave the construction area. Individuals of some bird species will also be temporarily displaced. Depending on the time of year of these operations, this displacement could impact breeding and nesting activities. Smaller and less mobile animals such as small mammals, reptiles, and amphibians may be affected during vegetation mowing and the transmission line construction. The species impacted during the reconductoring of the transmission line are expected to be limited in number. Effects will be localized to the immediate area of construction around structure locations and along existing access roads. However, this is anticipated to be a temporary effect as it is expected that existing wildlife use patterns will resume, and population sizes will recover, once work activities are completed.

Long-term impacts to wildlife will not occur as a result of tree removals along the edge of the existing ROW, since loss of habitat and disturbance of wildlife will be limited. Overall, the generally small extent of ROW widening will have a negligible impact on available forested wildlife habitats, and no long-term impacts to wildlife are expected to result from the Project.

7.9 Social and Economic

Based on the proposed location of the Project, the greatest potential for social impact is the interaction of construction and future maintenance activities on current and future land uses abutting the Project ROW.

7.9.1 Social Impacts

The Project will not adversely impact the overall social and economic condition of the Project area. The Project does not require, nor will it lead, to long-term residential or business disruption. Temporary construction impacts, primarily related to construction traffic and equipment operation, are expected to be minor. As described in Section 3.0, the proposed work will be located entirely within an existing cleared transmission line.

7.10 Land Use

The following section addresses the compatibility of the Project with various land uses along the proposed route. Because the Project will occupy areas dedicated to use for electrical facilities, it will not displace any existing residential uses, nor will it affect any future development proposals that meet local zoning requirements. Short-term land use impacts may occur during the construction phase of the Project. Impacts associated with the construction phase of the Project will be temporary, and most present land uses within the existing ROW could resume following construction.

The construction of the Project in the ROW will be consistent with the established land use and therefore, will not present long-term land use impacts. Generally, existing land uses within and adjacent to the Project ROW will be allowed to continue following construction. The encroachment, installation or construction of buildings, pools or other non-transmission related facilities is not allowed with the transmission line easement.

7.10.1 Residential

Several residential areas are in proximity to the Project ROW. No tree clearing or widening of the ROW is required for the Project. The existing vegetative visual buffers will continue to provide visual screening of the facilities from residences.

7.10.2 Agriculture

The Project will not impact agricultural land use within the ROW or wider Study Area.

7.10.3 Institutions

The Project is not anticipated to impact the institutions located within the Study Area.

7.10.4 Recreation

No existing recreational uses or trails will be displaced in the long-term by the Project. Impacts to existing parks and recreational areas from the construction of the Project will be minimal and short-term. Since the Project is located within existing maintained ROW, potential long-term impacts will be avoided.

7.11 Visual Resources

The Project involves replacing conductors and upgrades to existing structures, which will involve a slight increase in structure heights (with ranges of -1 to +30 feet). The structures will be replaced along the same alignment and in roughly the same location. No significant impacts to visual resources are anticipated because of the Project. Please refer to the visual simulations provided in **Appendix C** for renderings of the ROW after the installation of the double circuit structures and proposed tree removals.

7.12 Cultural and Historic Resources

Section 106 of the National Historic Preservation Act of 1966 requires federal agencies to review federally funded or permitted projects for their potential impacts to historic and cultural resources. Potential resources addressed under this review include known and unknown properties that are listed or are determined eligible for listing on the NRHP. Once a review has been initiated, the agency, in consultation with the RIHPHC, office of the State Historic Preservation Officer (“SHPO”) and appropriate Tribal authorities, must identify historic properties, assess whether effects to the properties will be adverse, and then work to minimize, resolve, or mitigate those adverse effects.

Eligibility for inclusion on the NRHP is based on four criteria, at least one of which must be met (36 Code of Federal Regulations ("CFR") Part 60). In order to be eligible, cultural resources must:

- be "associated with events that have made a significant contribution to the broad patterns of our history,"
- be "associated with the lives of persons significant in our past,"
- "embody the distinctive characteristics of a type, period, or method of construction, or … represent a master, or … possess high artistic values, or … represent a significant and distinguishable entity whose components may lack individual distinction," or
- "have yielded, or may be likely to yield, information important in prehistory or history[.]"

In addition to meeting at least one of these four criteria, an eligible property must retain integrity in its location, design, setting, materials, workmanship, feeling, and/or association. Resources can include both above-ground/architectural resources and archaeological sites; NRHP criteria and standards of integrity are applied to both types of resources. In Rhode Island, the state review process follows that of Section 106 and is conducted by the SHPO at the RIHPHC pursuant to the Antiquities Act of Rhode Island as per R.I.G.L. 42-45 et seq.

TNEC's cultural resource consultant, PAL, previously conducted archaeological survey along portions of the ROW for the New England East-West Solution Transmission ("NEEWS") between 2008 and 2012 and as part of the B23 Line Asset Condition Refurbishment project in 2019 and 2020. PAL assessed areas of moderate and high archaeological sensitivity along the ROW and secured RIHPHC Archaeological Permit No. 24-09 to perform a Phase I archaeological survey of archaeologically sensitive areas. PAL commenced the Phase I archaeological survey fieldwork in August 2024 and completed the survey in December 2024. PAL and TNEC will continue to consult with the RIHPHC and the Narragansett Indian, the Mashpee Wampanoag Tribe, and Wampanoag Tribe of Gay Head (Aquinnah) Tribal Historic Preservation Offices to avoid, minimize, or mitigate any effects to archaeological resources and traditional cultural properties, and to develop and implement an archaeological avoidance and protection plan, if needed. PAL plans to submit a report on the Phase I archaeological survey to the RIHPHC and the above-referenced Native American Tribes in the 1st quarter of 2025. A response from the RIHPHC is anticipated in early 2025.

PAL completed an historic architectural effects assessment and effects assessment in August 2024 and submitted a report to RIHPHC on December 18, 2024, recommending that the Project will not affect historic architectural properties (36 CFR Part 800.4[d][1]). A response from the RIHPHC is anticipated in 1st quarter of 2025.

7.13 Noise

Noise impacts are expected to be negligible. Temporary, minor construction noise may be generated by the Project that will occur predominantly during normal daytime working hours. Proper mufflers will be required to control noise levels generated by construction equipment.

7.14 Transportation

The construction-related traffic increase will be small relative to total traffic volume on public roads in the area. In addition, it will be intermittent and temporary, and construction related traffic will cease once the Project is completed. These limited periods of traffic are not expected to result in any additional congestion or a change in operating conditions on any of the roadways along the ROW. TNEC will coordinate closely with RIDOT to develop acceptable traffic management plans for work within state highway ROWs. At all locations where access to the ROW intersects a public way, the contractor will follow a pre-approved work

zone traffic control plan. Although traffic entering and exiting the ROW at these locations is expected to be small, vehicles entering and exiting the site will do so safely and with minimal disruption to traffic along the public way. Following construction, traffic activity will be minimal and will occur only when the ROW or transmission lines require maintenance. As a result, the construction and operation of the transmission line will have minimal impact on the traffic of the surrounding area roadways. No long-term impacts to traffic flow or roadways are expected.

7.15 Safety and Public Health

Trespassing on the ROW will be discouraged using existing gates and/or barriers at entrances from public roads.

7.16 Electric and Magnetic Fields

At the request of RIE, Exponent, Inc. ("Exponent") assessed levels of 60-Hertz electric fields and magnetic fields associated with existing and proposed transmission lines connecting the Nasonville Substation and the West Farnum Substation. This analysis relied on geometry, material data, usage conditions, specifications, and various other types of information provided by the client.

The Project route is represented by two cross sections. The first cross section (Figure 7-1) represents ~1.26 miles of the Project route where the existing B23 Line is the only transmission line within the ROW. RIE proposes to expand this existing ROW 25-ft to the south to accommodate the post-construction double circuit structures. The second cross section (Figure 7-1) represents the remaining ~3.35 miles of Project route, where the Project lines will share the ROW with two existing 345-kV lines, which will not be modified by the Project.

All EMF calculations are reported along a transect perpendicular to the transmission line's centerline and reported at a height of 1 meter (3.28 feet) above ground in accordance with IEEE Standard 644-2019 ("IEEE, 2019"). EMF levels are reported as the root mean square of the sum of the squares of three orthogonal field components. EMF levels during operation at annual average and annual peak loading of the existing and proposed line configurations (before and after the Project), were calculated to be very similar at the ROW edges of both route segments. The levels of EMF on the second segment are higher because of the existing 345-kV lines that are not part of the Project. At peak line loadings, which may apply for only a few hours or days of the year, the calculated magnetic field levels of the existing lines and the proposed rebuilt and new lines will be slightly increased. The minimal effect of the Project on EMF levels was achieved principally by optimizing the phasing of the rebuilt and new lines to minimize magnetic fields at the edges of the ROW. Calculated EMF levels at all locations on the ROW and beyond are far below the guidelines of international scientific and health agencies for electric fields (4.2 kV/m) and magnetic fields (2,000 mG).

Figure 7-1 below shows the proposed route of the Project, as well as the location of representative cross sections where EMF were modeled. The Project route is represented by two cross sections. The first cross section (XS-01) represents approximately 1.26 miles of the Project route where existing Line B23 is the only transmission line within ROW. RIE proposes to expand the existing ROW of this portion of route to the south by an additional 25 feet, already owned by RIE, to accommodate the post-construction double circuit structure. The second cross section represents the remaining approximately 3.35 miles of Project route where the Project lines will share the ROW with two existing 345-kV lines which will not be modified by the Project.

FIGURE 7-1: PROPOSED PROJECT ROUTE SECTIONS CONTAINING REPRESENTATIVE CROSS SECTIONS XS-01 AND XS-02

FIGURE 7-2: CROSS SECTION XS-01: 1-B23 TO 18-B23

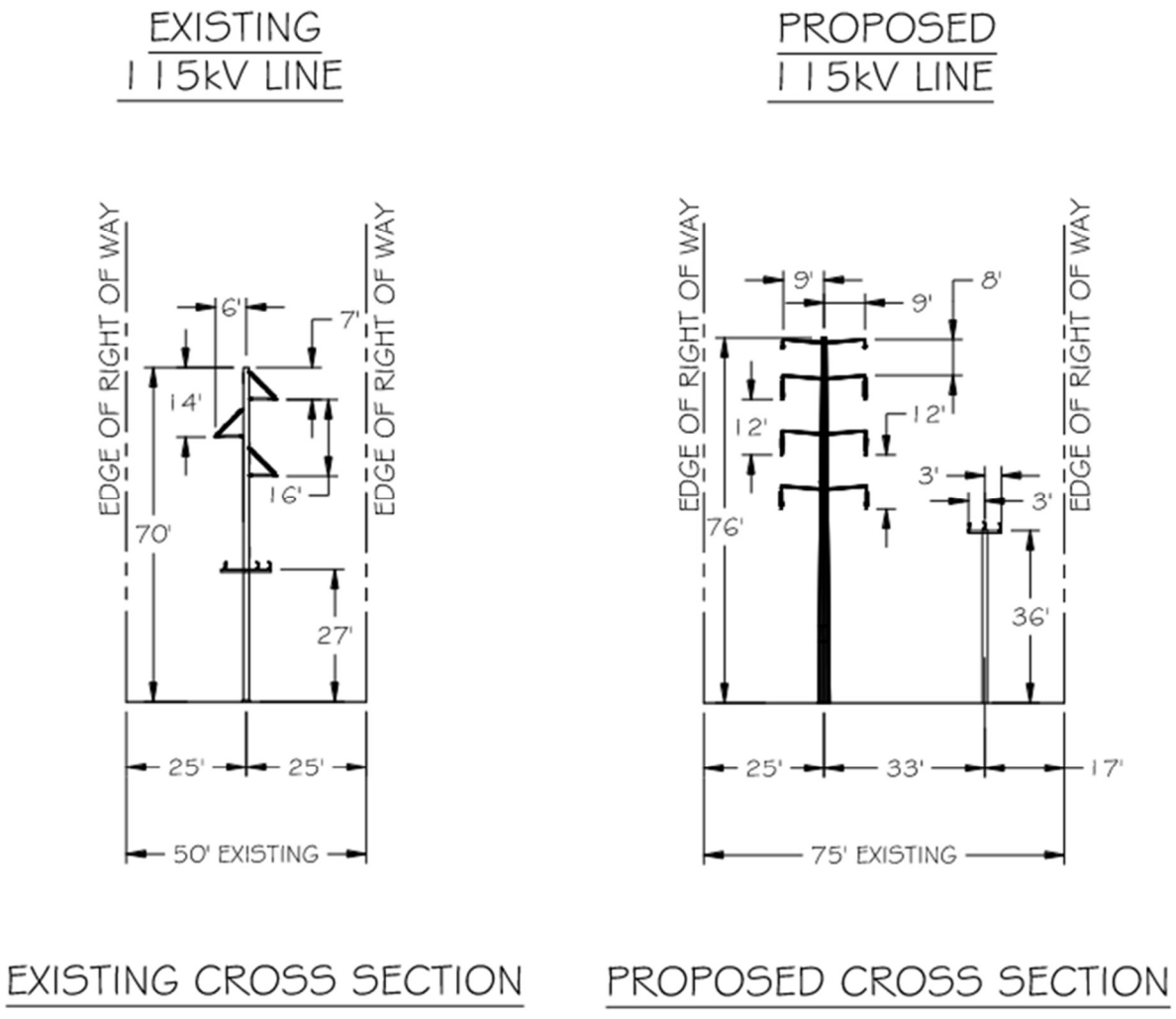
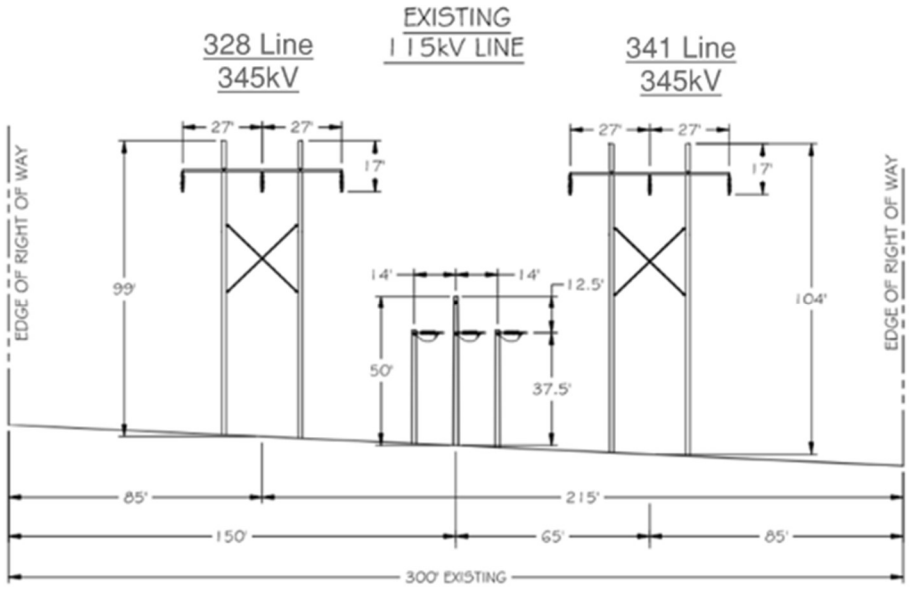
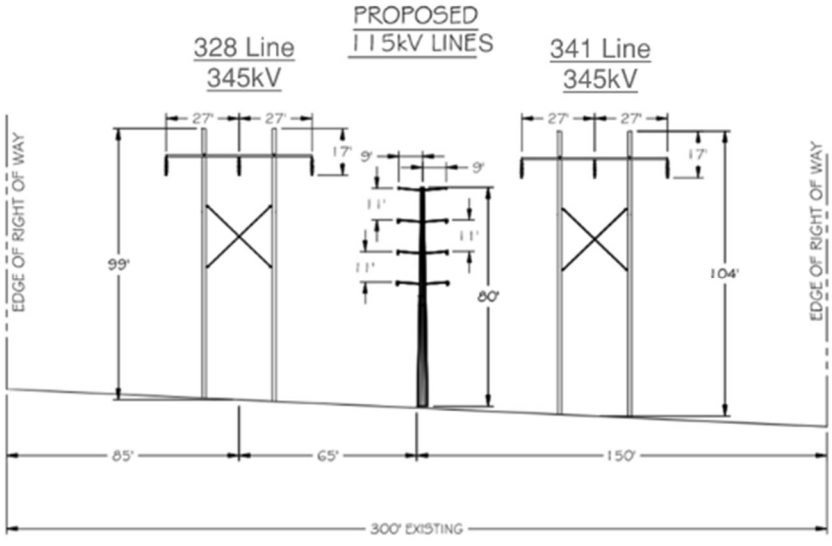


FIGURE 7-3: CROSS SECTION XS-02: 18-B23 TO 64-B23



EXISTING CROSS SECTION



PROPOSED CROSS SECTION

7.16.1 Magnetic Fields

Magnetic field levels were calculated for two loading scenarios: expected annual average and annual peak loading for both existing and rebuilt configurations. The calculated magnetic-field levels for the existing and proposed Project configurations are far below the ICNIRP Reference Level of 2,000 mG and the ICES Exposure Reference Level of 9,040 mG for the general public across the ROW for the entire Project route.

Calculated magnetic-field levels for average and peak loading conditions are presented below in

Table 7-2 and Table 7-3. Along XS-01, the cleared ROW will be 25' wider than the existing cleared ROW. Where the Project lines do not share ROW with any existing lines, the maximum magnetic-field levels at average loading within the ROW was 5.8 mG. Where the Project lines share ROW with two existing 345-kV lines, maximum magnetic-field levels at (average loading) for the proposed configuration was calculated on the ROW to be significantly higher (93 mG) than for the existing lines, but decreased to 23 mG or lower at the edges of the ROW. Along the north-eastern ROW edge (nearest Line U-170) and immediately after construction, the magnetic-field levels were calculated to be 15 mG or less (average and peak loading), decreasing by as much as 6 mG as a result of the Project. At the south-western ROW edge (nearest Line B23), the magnetic-field levels were calculated to generally remain similar to existing levels. Magnetic-field levels at the post-construction ROW edge were calculated to increase from existing levels by no more than 0.4 mG immediately after construction and 0.8 mG at 5 years post-construction (average loading).

The maximum calculated magnetic field level at either ROW edge at average loading conditions was 22 mG. At peak loading, magnetic field levels increase slightly by no more than 9 mG. The maximum magnetic-field level at either ROW edge for peak loading conditions was calculated to be 40 mG immediately after construction, decreasing to a maximum of 33 mG at 5 years post-construction.

Magnetic field levels also decrease quickly with distance and at 100 feet from the ROW edges, calculated magnetic-field levels were 4.8 mG or less for existing and proposed conditions along the entire Project route at average loading. Magnetic field levels at the ROW edges along the entire Project route for all configurations were calculated to be within 2% or less of the ICNIRP or ICES limits.

TABLE 7-2: MAGNETIC-FIELD LEVELS (MG) AT AVERAGE LOADING*

SEGMENT	CONFIGURATION	–ROW EDGE	+ROW EDGE	PROPOSED +ROW EDGE
XS-01±	Existing	2.9	3.2	1.9
	Proposed	2.2	4.1	2.3
	Proposed + 5 years	2.7	4.9	2.7
XS-02	Existing	9.9	23	N/A
	Proposed	8.2	22	N/A
	Proposed + 5 years	9.0	22	N/A

*Values shown as "--" are not applicable to that particular cross section.

± Current cleared easement equals a distance of 50'. Proposed tree clearing to 25' wider than existing cleared ROW.

TABLE 7-3: MAGNETIC-FIELD LEVELS (MG) AT PEAK LOADING*

SEGMENT	CONFIGURATION	–ROW EDGE	+ROW EDGE	PROPOSED +ROW EDGE
XS-01±	Existing	7.0	7.7	4.5
	Proposed	3.7	5.7	2.9
	Proposed + 5 years	4.0	7.0	3.7
XS-02	Existing	21	31	N/A
	Proposed	15	40	N/A
	Proposed + 5 years	18	33	N/A

*Values shown as "--" are not applicable to that particular cross section.

± Current cleared easement equals a distance of 50'. Proposed tree clearing to 25' wider than existing cleared ROW.

7.16.2 Electric Fields

Both the pre-Project (existing) and post-Project (rebuilt) modeled electric field values for the two cross sections (XS-1 and XS-2) at the ROW edges are below health-based guidelines of 4.2 kV/m for all modeled cases. Electric field levels were calculated to remain similar to existing levels as a result of the Project (see Table 7-44, below).

Where the Project lines do not share ROW with any existing lines, maximum electric-field levels within the ROW were 0.6 kV/m. Where the Project lines share ROW with two existing 345-kV lines, existing maximum electric-field levels were calculated within the ROW to be significantly higher (2.8 kV/m) than without the existing 345-kV lines, but decreased by as much as 0.5 kV/m as a result of the Project. At the north-eastern ROW edge (nearest Line U-170), electric field levels were calculated to remain the same or increase by no more than 0.2 kV/m for any Project configuration. At the south-western ROW edge (nearest Line B23), the electric-field levels were calculated to decrease from 0.5 kV/m at the existing ROW edge to 0.1 kV/m at the post-construction ROW edge. The maximum calculated electric field level at either ROW edge along the entire Project route for all Project configurations was 1 kV/m.

TABLE 7-4: ELECTRIC-FIELD LEVELS (KV/M) *

SEGMENT	CONFIGURATION	–ROW EDGE	+ROW EDGE	PROPOSED +ROW EDGE
XS-01±	Existing	0.3	0.5	0.2
	Proposed	0.5	0.5	0.1
	Proposed + 5 years	0.5	0.5	0.1
XS-02	Existing	0.9	1.0	N/A
	Proposed	0.9	1.0	N/A
	Proposed + 5 years	0.9	1.0	N/A

*Values shown as "--" are not applicable to that particular cross section.

± Current cleared easement equals a distance of 50'. Proposed tree clearing to 25' wider than existing cleared ROW.

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8 MITIGATION MEASURES

The Project is not anticipated to have any long-term impact to the natural or social environment of the Study Area. Mitigation measures for this Project will be used to reduce the impact of the work on the natural and social environment. The Project consists of the installation of the new U-170 115 kV line on existing structures. As described in Chapter 6.0, there are no long-term impacts to mitigate because of the Project. Therefore, mitigation efforts are focused on the construction phase.

8.1 Construction Phase

Construction for this Project will require only minor temporary disturbances to the surrounding natural environment. Mitigation measures will be implemented during construction to effectively minimize Project impacts on the natural and social environments. These mitigation measures include the use of existing access roads and structure pads where possible to minimize disturbed areas, installation of erosion and sedimentation controls, and supervision and inspection of construction activities within resource areas by an environmental monitor. The following section details various mitigation measures which will be implemented to minimize construction related impacts.

8.1.1 Mitigation of Natural Resource Impacts

When the existing transmission lines were constructed, access roads were established within most portions of the ROW. During construction of the Project, vehicles will utilize these existing access roads where practical to minimize disturbance within the ROW. Access through wetlands to the existing structure locations will be provided using swamp mats from the existing maintained portion of the ROW. Construction access will be limited to the existing structure locations and proposed access routes, which will be bordered by erosion and sedimentation control BMPs, where needed. Following overhead reconductoring and thermal upgrade activities along the Lines, all disturbed areas will be stabilized and restored.

Vegetation management operations will largely be confined to the existing ROW. Where tree removals are required for ROW widening, the existing understory will be left in place to the greatest extent practicable and allowed to regrow with compatible species.

Vegetation mowing and tree removals adjacent to wetland areas is of particular concern due to the potential for erosion, and therefore, specific mitigation measures will be implemented to minimize this potential where needed. These measures will include the installation of straw wattle or compost mulch tube diversion berms across the slope, to intercept storm water runoff, which will be directed through straw wattle or silt fence to remove suspended sediment. These structures will be maintained until vegetative cover is reestablished. In addition, straw wattle and/or erosion control blankets will be installed across disturbed slopes adjacent to wetland areas in accordance with an erosion and sediment control plan. Excavated soils will be stockpiled and spread in approved soil areas well outside all biological wetland areas in such a manner that general drainage patterns will not be affected.

Where possible, existing vegetation will be retained at all road crossings and areas subject to public view to maintain a visual buffer to the ROW. Stream crossings will be located perpendicular to the channel to the extent possible to reduce the crossing length and reduce the potential for disturbance to the water body. Design and implementation of all stream crossing structures (i.e., temporary mat bridges) will comply with standards and specifications as outlined in the *Rhode Island Soil Erosion and Sediment Control Handbook* and TNEC's EG303. Temporary access is used where the substrate is sufficiently firm or level to support equipment without creating a disturbance to the soil substrate.

8.1.2 Erosion and Sedimentation Control

Erosion and sediment control devices will be installed along the perimeter of identified wetland resource areas prior to the onset of soil disturbance activities to ensure that soil stockpiles and other disturbed soil areas are confined and do not result in downslope sedimentation of sensitive areas. Low growing tree species, shrubs and grasses will only be mowed along access roads and at pole locations. Construction crews will be responsible for conducting daily inspections and identifying erosion controls that must be maintained or replaced as necessary. Erosion and sedimentation controls will be installed and maintained in accordance with the *Rhode Island Soil Erosion and Sediment Control Handbook* and TNEC's Environmental Guidance Policies for ROW Access, Maintenance and Construction BMPs for New England (EG-303).

8.1.3 Supervision and Monitoring

Throughout the entire construction process, TNEC will retain the services of an environmental monitor who will oversee the implementation and maintenance of BMPs and soil erosion and sediment controls on a routine basis to ensure compliance with all federal and state permit requirements and TNEC environmental guidance and policy. The environmental monitor will be a trained environmental scientist, who will be responsible for supervising construction activities relative to environmental issues. The environmental monitor will be experienced in soil erosion and sediment control management and the project's environmental resources.

During periods of prolonged precipitation, the monitor will inspect all locations to confirm environmental controls are functioning properly. In addition to retaining the services of an environmental monitor, TNEC will require the contractor to designate an individual to be responsible for the daily inspection and upkeep of environmental controls. This person will also be responsible for providing direction to the other members of the construction crew regarding matters of wetland access and appropriate work methods. Additionally, all construction personnel will be briefed on Project environmental compliance issues and obligations prior to the start of construction. Regular construction progress meetings will provide the opportunity to reinforce the contractor's awareness of these issues and make corrective actions.

8.1.4 Mitigation of Social Resource Impacts

TNEC will minimize social resource impacts during construction by incorporating several standard mitigation measures. By use of an established transmission line ROW rather than creating a new ROW, the potential for disruption due to construction activities will be limited to an area already dedicated to transmission line uses. There are two potential sources of air quality impacts associated with the Project – dust and vehicle emissions – neither of which are expected to be significant. During earth disturbing activities, the contractor will deploy dust mitigation measures as described in TNEC's EG-303. Exposed soils will be wetted and stabilized as necessary to suppress dust generation, and crushed stone aprons will be used at all access road entrances to public roadways. Consequently, fugitive dust emissions are anticipated to be low.

TNEC requires the use of ultra-low sulfur diesel fuel exclusively in its contractor's diesel-powered construction equipment. Vehicle idling is to be minimized during the construction phase of the Project, in compliance with the Rhode Island Diesel Engine Anti-Idling Program, Air Pollution Control Regulation No. 45, authorized pursuant to R.I.G.L.s § 31-16.1 and § 23-23-29. Vehicle idling for diesel and non-diesel-powered vehicles is limited to five minutes except for powering auxiliary equipment, for heating/defrosting purposes in cold weather, and for cooling purposes in hot weather. The contractor is responsible for complying with the state regulatory requirements along with the TNEC Environmental Guidance (EG-802) Vehicle Idling.

Construction generated noise will be limited to the use of mufflers on all construction equipment and by limiting construction activities to the hours specified in the local ordinances. Dust will be controlled by wetting and stabilizing access road surfaces, as necessary, and by maintaining crushed stone aprons at the intersections of access roads with paved roads and street sweeping. TNEC will minimize the potential for disturbance from the construction by notifying the Town of planned construction activities before and during construction of the line. Some short-term impacts are unavoidable, even though they have been minimized. By carrying out the reconductoring of the line in a timely fashion, TNEC will keep these impacts to a minimum. TNEC will prepare a traffic management plan for approval by the RIDOT, which will minimize impacts associated with increased construction traffic on local roadways.

8.2 Post-Construction Phase

Following the completion of construction, TNEC uses standard mitigation measures on all transmission line construction projects to minimize the impacts of projects on the natural and social environment. These measures include revegetation and stabilization of disturbed soils, ROW vegetation management practices, and vegetation screening maintenance at road crossings and in sensitive areas. Other measures are used on a site-specific basis. TNEC will implement the following standard and site-specific mitigation measures for the Project.

8.2.1 Mitigation of Natural Resource Impacts

Restoration efforts, including final grading and installation of permanent erosion control devices, and seeding of disturbed areas, will be completed following construction. Construction debris will be removed from the Project site and disposed of at an appropriate landfill. Pre-existing drainage patterns, ditches, roads, fences, and stone walls will be restored to their former condition, where appropriate. Permanent slope breakers and erosion control devices will be installed in areas where the disturbed soil has the potential to impact wetland resource areas.

Vegetation maintenance of the ROW will be accomplished with methods identical to those currently used in maintaining the existing ROW. TNEC's ROW vegetation maintenance practices encourage the growth of low-growing shrubs and other vegetation, which do not interfere with utility line safety or maintenance, but help inhibit soil erosion, and provide habitat for certain wildlife species.,

8.2.2 Mitigation of Social Resource Impacts

Where possible, TNEC will limit access to the ROW by locking permanent gates and placing barriers where access roads enter the ROW from public ways.

8.3 Conclusion

As described, the Project's mitigation measures have been designed to minimize disturbance to the natural and social resources of the project area. TNEC's project activities are expected to only cause minor temporarily disturbances in the surrounding natural and social environments during the construction of the Project. TNEC will employ mitigation measures to reduce impact, such as using existing access roads, limiting vegetation management, limiting noise and air pollution from construction vehicles, using wetland matting with minimal footprints, and restoring the ROW to the maximum extent practicable. An environmental professional will inspect construction activities within or adjacent to resource areas, and construction crew members will be briefed on environmental compliance issues and prompt maintenance of sediment and erosion controls. No long-term impacts to natural or social environment are anticipated as a result of the Project.

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9 PERMIT REQUIREMENTS

9.1 Permits and Other Regulations

Prior to the start of construction, the following local, state and federal permits must be obtained.

9.1.1 Local Permits

9.1.1.1 Soil Erosion and Sediment Control Permit

This project requires a Soil Erosion and Sediment Control (SESC) Permit per RIDEM for work in or near wetlands or watercourses, such as construction of new structures, maintenance of existing structures, and improvement of access roads. The RIDEM approved SESC plans will also be submitted to the Building Officials for Burrillville and North Smithfield for their review and approval.

9.1.1.2 Planning Board Unified Permit (Burrillville)

This project requires a special use permit under the Zoning Ordinance of the Town of Burrillville, Article VI, Section 30-216 for the expansion of a pre-existing non-conforming use. A dimensional variance is required for the structures because the structures (i) exceed the local height restriction and (ii) are taller than the existing structures. Development plan review is required for the project. All of the requested relief will be reviewed by the Planning Board as part of a unified development review.

9.1.1.3 Noise Ordinance Exemption Requests (Burillville Zoning Board of Review & North Smithfield Town Council)

This project requires exemptions from local noise ordinances in Burrillville (Section 16-35 (b)) and North Smithfield (Chapter 229-5 (B)) for the expected hours of work between 7:00 a.m. and 7:00 p.m. Monday through Friday (when daylight permits), and, when necessary, between 7:00 a.m. and 7:00 p.m. on weekends. Longer hours are required for certain necessary work that may require completion same day such as wire pulling and concrete pour. The requested exemptions will be reviewed by the Burrillville Zoning Board and North Smithfield Town Council.

9.1.2 State Permits

9.1.2.1 EFSB License

This project requires a license from the EFSB to rebuild the existing B23 Line between the Nasonville Substation and West Farnum Substation and to construct the new U-170 Line, per Rhode Island General Laws ("R.I.G.L.") Section 42-98-1 et seq.

9.1.2.2 RIDEM Freshwater Wetland Permit

This project requires a freshwater wetlands permit from RIDEM per R.I.G.L. Section 2-1-18 et seq. for the temporary and permanent alteration of freshwater wetlands in association with the construction of new structures, maintenance of existing structures, and improvement of access roads.

9.1.3 Federal Permits

9.1.3.1 Army Corps of Engineers

This project requires a USACE Section 404 Pre-Construction Notification (PCN) for work associated with temporary or permanent fill in wetlands such as wetland matting for access and workpads, tree clearing in resource area, and new structures constructed in resource area.

9.1.3.2 Historic Preservation

This project requires consultation with Rhode Island Historical Preservation & Heritage Commission ("RIHPHC") and the Tribal Historic Preservation Office per Section 106 of the National Historic Preservation Act (36 CFR 800).

10 REFERENCES

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Woonsocket Substation – Nasonville Substation
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EXPONENT, INC.'S STATUS OF RESEARCH ON EXTREMELY LOW FREQUENCY ELECTRIC AND MAGNETIC FIELDS AND HEALTH, JANUARY 2022 THROUGH APRIL 2024 DATED MARCH 19, 2025

Exponent®

Status of Research on Extremely Low Frequency Electric and Magnetic Fields and Health, January 2022 through April 2024

Status of Research on Extremely Low Frequency Electric and Magnetic Fields and Health, January 2022 through April 2024

Prepared For:

The Narragansett Electric Company
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Bowie, MD 20715

March 19, 2025

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Limitations

At the request of the Narragansett Electric Company, a subsidiary of PPL Electric Utilities, Exponent prepared a summary report on the status of research related to extremely low frequency electric- and magnetic-field exposure and health. Exponent reserves the right to supplement this report and to expand or modify opinions based on review of additional material as it becomes available, through any additional work, or review of additional work performed by others.

The scope of services performed for this report may not adequately address the needs of other users of this report beyond the permitting of the projects for which it was prepared, and any re-use of this report or its findings, conclusions, or recommendations presented herein are at the sole risk of the user. The findings, opinions and comments formulated during this assessment are based on observations and information available at the time of the report writing and are made to a reasonable degree of scientific certainty. No guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

1 Introduction

Questions about electric and magnetic fields (EMF) and health are sometimes raised during the permitting of transmission lines. Numerous national and international scientific and health agencies have reviewed the research and evaluated potential health risks of exposure to extremely low frequency (ELF) EMF, which include the frequencies stemming from the delivery of electricity at 60 Hertz (Hz) in North America (50 Hz in Europe and other countries). A weight-of-evidence review of ELF EMF and health was released in 2015 by the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), in which the Committee did not conclude that the available scientific evidence confirms a causal link between any adverse health effects (including both cancer and non-cancer health outcomes) and EMF exposure. The conclusions of the 2015 SCENIHR report are consistent with those of other agencies that have reviewed the research, most notably the comprehensive review of ELF EMF research published by the World Health Organization (WHO) in 2007, in which the WHO's Task Group critically reviewed the cumulative epidemiologic and laboratory research through 2005. SCENIHR's findings in their 2015 report were also maintained in the organization's 2024 report providing an update on the potential health effects of exposure to electromagnetic fields in the 1 Hz to 100 kHz range (SCHEER, 2024).

The Narragansett Electric Company, a subsidiary of PPL Electric Utilities, requested that Exponent, Inc. (Exponent) provide an easily-referenced guide to the current status of EMF health research that updates a report previously prepared for the Narragansett Electric Company (Exponent, 2022). Exponent (2022) systematically evaluated peer-reviewed research and reviews by scientific panels published through December 2021. This current report extends this earlier report with a systematic evaluation of peer-reviewed research and reviews by scientific panels published from January 2022 through April 2024, and describes if and how these recent results affect conclusions reached by SCENIHR in 2015, the WHO in 2007, and other reviewing agencies.

Nature of extremely low frequency electric and magnetic fields

Electricity is transmitted as current from generating sources to high-voltage transmission lines, substations, distribution lines, and then finally to our homes and workplaces for consumption. The vast majority of electricity in North America is transmitted as alternating current (AC), which changes direction 60 times per second (i.e., a frequency of 60 Hz).

Everything that is connected to our electrical system (i.e., power lines, wiring, appliances, and electronics) produces ELF EMF (*see* Figure 1). Both electric fields and magnetic fields are properties of the space near these electrical sources. Forces are experienced by objects capable of interacting with these fields; electric charges are subject to a force in an electric field created by

voltage differences, and moving charges (e.g., electric current) experience a force in a magnetic field. The strengths of both electric and magnetic fields decline rapidly with distance.

- **Electric fields** are the result of voltage applied to electrical conductors and equipment. The electric field is expressed in measurement units of volts per meter (V/m) or kilovolts per meter (kV/m); 1 kV/m is equal to 1,000 V/m. Grounded conducting objects including fences, buildings, and our own skin and muscle easily block electric fields. Therefore, certain appliances and electronics within homes and workplaces are the major source of electric fields indoors, while transmission and distribution lines are the major source of electric fields outdoors.
    - **Magnetic fields** are produced by the flow of electric currents; however, unlike electric fields, most materials do not readily block magnetic fields. The strength of a magnetic field is expressed as magnetic flux density in units of gauss (G) or milligauss (mG), where 1 G=1,000 mG.[1] The strength of the magnetic field at any point depends on characteristics of the source. In the case of power lines, magnetic-field strength is dependent on the arrangement of conductors, the amount of current flow, and distance from the conductors.

[1] Scientists also refer to magnetic flux density at these levels in units of microtesla. Magnetic flux density in units of mG can be converted to microtesla by dividing by 10 (i.e., 1 mG = 0.1 microtesla).

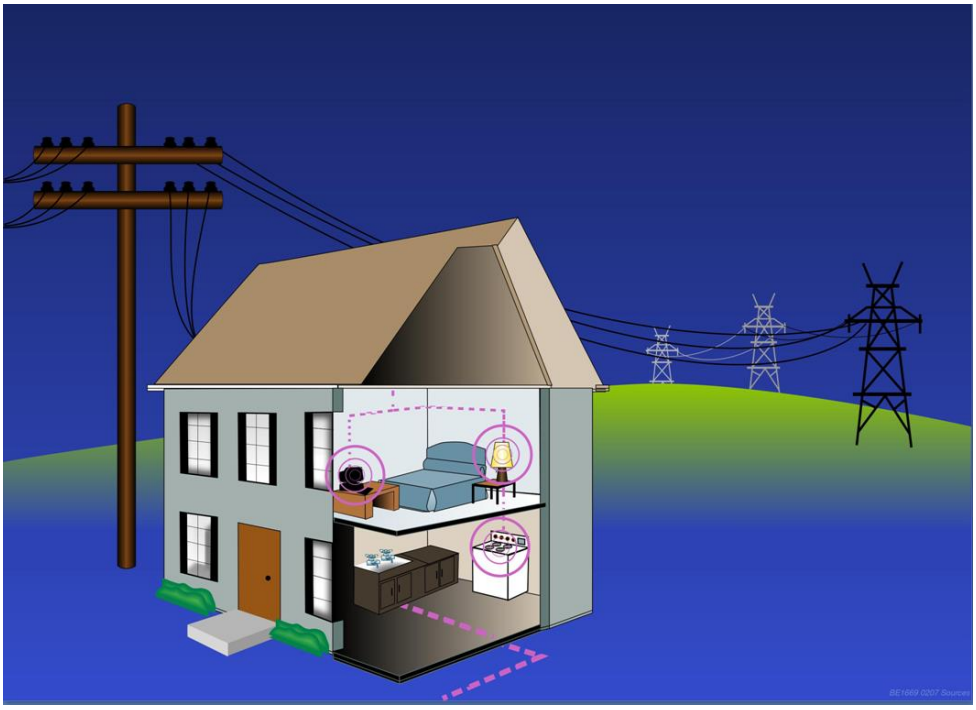

Figure 1. Numerous sources of ELF EMF in our homes (appliances, wiring, currents running on water pipes, and nearby distribution and transmission lines).

Sources and exposure

The intensity of both electric fields and magnetic fields diminishes with increasing distance from the source. Electric fields and magnetic fields from transmission lines generally decrease with distance from the conductors in proportion to the square of the distance, described as creating a bell-shaped curve of field strength around the lines.

Since electricity is such an integral part of our infrastructure and everyday life (e.g., in transportation systems and in homes and businesses), people living in modern communities are surrounded by these fields. Figure 2 describes typical EMF levels measured in residential and occupational environments, compared to levels measured on or at the edge of transmission-line rights-of-way (ROW). While EMF levels decrease with distance from the source, any home, school, or office tends to have a background EMF level as a result of the combined effect of the numerous EMF sources. In general, the background magnetic-field level in a house away from appliances is typically less than 20 mG, while levels can be hundreds of mG in close proximity to appliances. Background levels of electric fields range from 10 V/m to 20 V/m, while appliances produce levels up to several tens of V/m (WHO, 2007a).

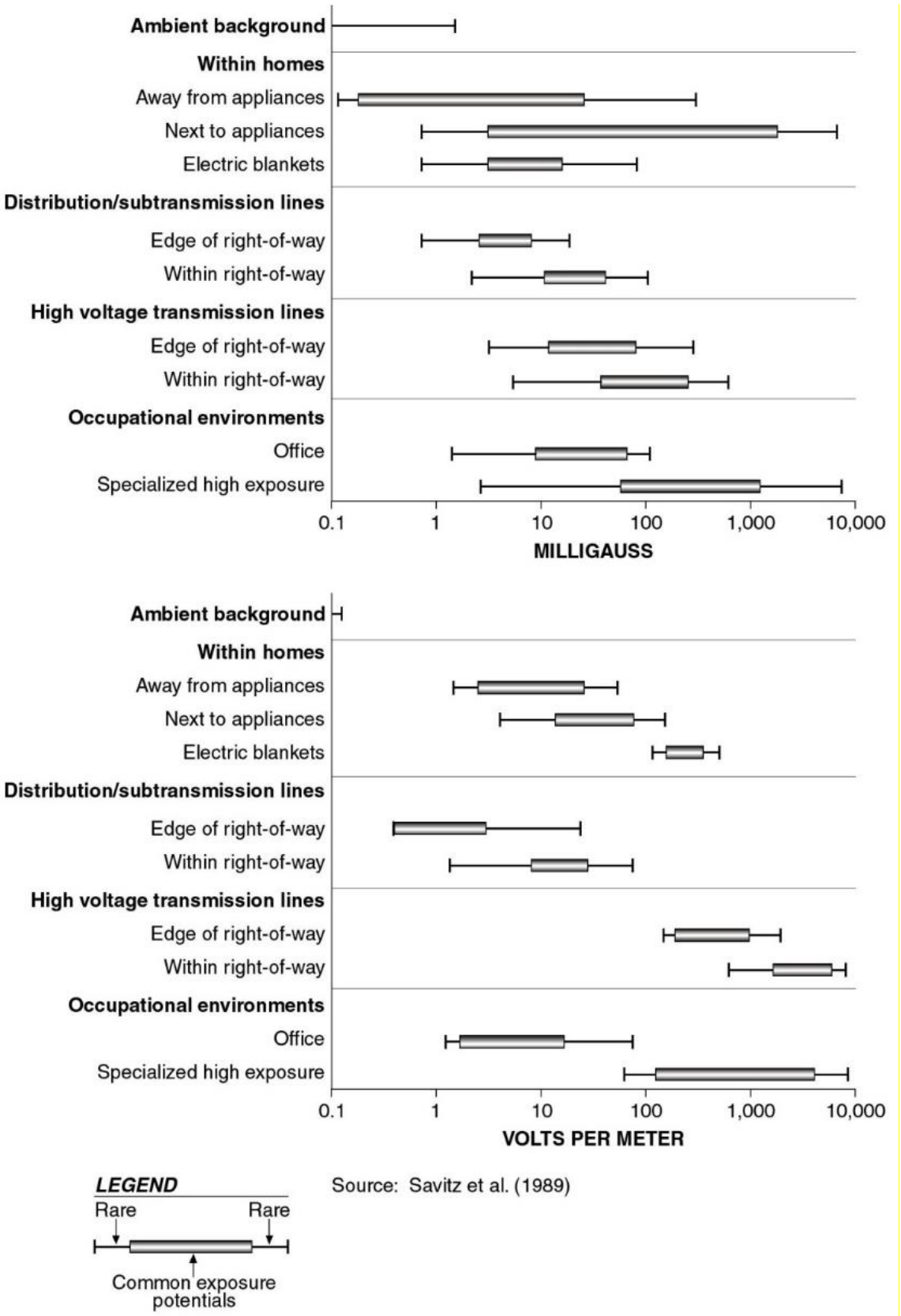

Figure 2. Electric- and magnetic-field strengths in the environment.

Experiments have yet to show which aspect of ELF EMF exposure, if any, may be relevant to biological systems. As short-term ELF EMF exposures are not known to produce adverse effects at common environmental levels and shielding by buildings blocks electric fields from outdoor power lines from entering buildings, little scientific or regulatory attention has been given to assessing public exposure to electric fields. In contrast, exposure and health research has focused on magnetic fields, particularly long-term, average personal exposure, which is the average of all exposures to the varied electrical sources encountered in the many places we live, work, eat, and shop. As expected, this exposure is difficult to approximate, and exposure assessment is a major source of uncertainty in studies of ELF EMF and health (WHO, 2007a).

Considerable research has been done to characterize the general public's exposure to magnetic fields, although some basic conclusions are available from the literature:

- *Personal magnetic-field exposure:*
    - The vast majority of persons in the United States have a time-weighted average (TWA) exposure to magnetic fields of less than 2 mG (Zaffanella and Kalton, 1998).[2]
    - In general, personal magnetic-field exposure is greatest at work and during travel (Zaffanella and Kalton, 1998).
- *Residential magnetic-field exposure:*
    - The highest magnetic-field levels are typically found directly next to appliances (Zaffanella, 1993). For example, Gauger (1985) reported the maximum ELF magnetic field at 3 centimeters from a sampling of appliances as 3,000 mG (can opener); 2,000 mG (hair dryer); 5 mG (electric oven); and 0.7 mG (refrigerator).
    - Several parameters affect the level and distribution of personal magnetic-field exposures at home: residence type, residence size, type of water line, and proximity to overhead power lines. Persons living in small homes, apartments, homes with metal piping, and homes close to three-phase electric power distribution and transmission lines tend to have higher at-home magnetic-field levels (Zaffanella and Kalton, 1998).
    - Residential magnetic-field levels are caused by currents from nearby transmission and distribution systems, pipes or other conductive paths, and electrical appliances (Zaffanella, 1993).
- *Workplace magnetic-field exposure*

[2] TWA is the average exposure to a chemical or physical agent over a specified period (e.g., an 8-hour workday or 24 hours). The average is determined by sampling the exposure of interest throughout the selected period.

- Some occupations (e.g., electric utility workers, welders, telecommunications workers) have higher exposures due to work near equipment with high magnetic-field levels (NIEHS, 2002).

- *Power line magnetic-field exposure*

  - The magnetic-field levels associated with transmission and distribution lines vary substantially depending on their configuration, amount of current flow (load), and distance from conductors, among other parameters. At distances of a few hundred feet from overhead transmission lines and during average electricity demand, the magnetic-field levels from many transmission lines are often similar to the background levels found in most homes, as illustrated in Figure 2 above, and as discussed in a National Institute of Environmental Health Sciences (NIEHS) booklet on EMF (NIEHS, 2002).

Known effects

Similar to virtually any exposure, adverse effects can be expected from exposure to very high levels of ELF EMF. In the presence of an extremely strong electric or magnetic field, stimulation of muscles and nerves is possible (ICNIRP, 2010). Additionally, strong electric fields can induce voltages and currents in nearby objects (e.g., fences, vehicles, buildings, etc.) that can, if contacted by a person under particular conditions, may lead to small shocks (i.e., micro shocks).[3] These acute effects cause no long-term damage or health consequences. Limits for the general public and workplace have been set to prevent these effects, but there are no real-life situations where these levels are exceeded on a regular basis. Standards and guidelines are discussed in more detail in Section 6.

[3] Under some conditions higher voltage transmission lines can induce voltages and currents in nearby objects (e.g., fences, vehicles, buildings, etc.). to produce secondary shocks. Depending on the size and proximity of the object, as well as the strength of the electric field, it is possible for persons to experience small shocks (i.e., micro shocks) or continuous currents. Such micro-shocks are acute effects that cause no long-term damage or health consequences. Adherence to standards for transmission lines in the National Electrical Safety Code (NESC) are designed to prevent stronger shocks or continuous currents.

2 Methods for Evaluating Scientific Research

Science follows a method of obtaining information and of reasoning to ensure that the information and conclusions are accurate and correctly describe physical and biological phenomena. Often misconceptions occur when people casually interpret their observations and experience. Therefore, scientists use systematic methods to conduct and evaluate research and assess the potential impact of a specific agent (e.g., ELF EMF) on human health. This process is designed to ensure that more weight is given to studies of better quality, and to ensure studies with a given result are not selectively chosen from available studies to advocate or suppress a preconceived idea of an adverse effect. Scientists, scientific agencies, and health organizations use these standard methods to draw conclusions about the many exposures in our environment.

Weight-of evidence reviews

The scientific process entails looking at *all* the evidence on a particular issue in a systematic and thorough manner to evaluate if the overall data present a logically coherent and consistent picture. This is often referred to as a weight-of-evidence review in which all studies are considered together, giving more weight to studies of higher quality, and using an established analytic framework to arrive at a conclusion about a possible causal relationship. Weight-of-evidence reviews typically are conducted within the larger framework of health risk assessments or evaluations of particular exposures or exposure circumstances that qualitatively and quantitatively define health risks.

Several agencies have described weight-of-evidence and health risk assessment methods, including the International Agency for Research on Cancer (IARC), which routinely evaluates substances such as drugs, chemicals, and physical agents for their ability to cause cancer; the WHO International Programme for Chemical Safety; the U.S. Environmental Protection Agency (U.S. EPA), which sets guidance for public exposures; SCENIHR for the European Union; and the U.S. National Toxicology Program (NTP) (U.S. EPA, 1993, 1996; World Health Organization (WHO), 1994; SCENIHR, 2012; NTP, 2015a).

Two steps precede a weight-of-evidence evaluation: 1) a systematic review to identify the relevant literature, and 2) an evaluation of each relevant study to determine its strengths and weaknesses. A systematic review is a method to evaluate and synthesize evidence from a large body of scientific research on a topic to reach a conclusion (NTP, 2015b). By virtue of synthesizing insights from a multitude of scientific studies, systematic reviews arrive at a conclusion that is inherently more representative than one from a single study. This comprehensive approach can significantly mitigate the risk of bias or design flaws that might compromise the validity of a conclusion drawn from a solitary study.

The following sections discuss important considerations in the evaluation of human health studies of ELF EMF in a weight-of-evidence review, including exposure considerations, study

design, methods for estimating risk, bias, and the process of causal inference. The purpose of discussing these considerations here is to provide context for the later weight-of-evidence evaluations.

Exposure considerations

Methods to describe ELF EMF exposure vary widely and each have their own strengths and limitations (Kheifets and Oksuzyan, 2008). Methods include:

- Classifying residences based on the relative capacity of nearby power lines to produce magnetic fields (i.e., wire code categories) within selected distances.
- Assessing exposure based on occupational titles.
- Calculating magnetic-field levels based on job histories (i.e., a job-exposure matrix [JEM]).
- Determining distance of residences from nearby power lines.
- Taking spot measurements of magnetic-field levels inside or outside residences.
- Taking 24-hour and 48-hour measurements of magnetic fields in a particular location in a house (e.g., a child's bedroom).
- Calculating magnetic-field levels based on known design features of nearby power lines including line loading.
- Taking personal measurements of magnetic fields for a 24-hour or 48-hour period using a dosimeter.

Magnetic-field exposure is ubiquitous, but it varies for each individual over a lifetime because the locations where people spend time change and the ELF EMF sources at those locations also change. This lack of consistency makes valid estimates of personal magnetic-field exposure challenging. Furthermore, without a biological basis to define a relevant exposure metric (average exposure or peak exposure) and a defined critical period for exposure (e.g., *in utero*, shortly before diagnosis), relevant and valid assessments of exposure are problematic. Exposure misclassification is one of the most significant concerns in studies of ELF EMF.

In general, personal measurements are the metrics valued by epidemiologists because they record exposure from all sources but the sample of exposure covers at most a few days. More studies have estimated long-term exposure at residences from transmission lines from calculations based on the line design, distance to the residence, and historical measure or estimated of current flow on the lines that allows for estimation of long-term exposure in the past. Other methods to estimate exposure are generally weaker because they may not be strong predictors of long-term exposure. ELF EMF can be estimated indirectly by assigning an estimated amount of exposure to an individual based on the distance of the residence from a transmission line. Indirect measures are not as accurate as direct measurements because they do not contain information specific to

that person or the exposure situation For instance using distance from a transmission line to estimate homeowners' ELF EMF exposure would not provide information about the current flow on the line that is the source of the magnetic field or if the line is in service. .

Types of health research studies

Research studies can be broadly classified into three groups: 1) epidemiologic observations of people; 2) experimental laboratory studies of humans and animals (*in vivo*); and 3) experimental laboratory studies of cells and tissues (*in vitro*). Epidemiologic studies investigate how disease is distributed in populations and what factors influence or determine this disease distribution (Gordis, 2000), and attempt to identify potential causes for disease while observing people as they go about their daily lives. Such studies are designed to quantify and evaluate the associations between disease and reported exposures to environmental factors.

The most common types of epidemiologic studies in the ELF EMF literature are case-control and cohort studies. In case-control studies, people with and without the disease of interest are identified and the exposures of interest are evaluated. Often, people are interviewed or their personal records (e.g., medical records or employment records) are reviewed in order to establish the exposure history for each individual. The exposure histories are then compared between the diseased and non-diseased populations to determine whether any statistically significant differences in exposure histories exist. In cohort studies, on the other hand, individuals within a defined cohort of people (e.g., all persons working at a utility company) are classified as exposed or non-exposed and followed over time for the incidence of disease. Researchers then compare disease incidence in the exposed and non-exposed groups.

Experimental studies are designed to test specific hypotheses under controlled conditions and are vital to assess cause-and-effect relationships. An example of a human experimental studies relevant to this area of research would be ones that measure the impact of magnetic-field exposure on acute biological responses in humans, such as hormone levels. These studies are conducted in laboratories under controlled conditions. *In vivo* studies of animals and *in vitro* experimental studies also are conducted under controlled conditions in laboratories. *In vivo* studies expose laboratory animals to very high levels of a chemical or physical agent to determine whether exposed animals develop cancer or other effects at higher rates than unexposed animals, while attempting to control for other factors that could possibly affect disease rates (e.g., diet, genetics). *In vitro* studies of isolated cells and tissues are important because they can help scientists understand biological mechanisms that relate to the same exposure to the whole body of humans and animals. The responses of cells and tissues outside the body, however, may not reflect the response of those same cells if maintained in a living system, so their relevance cannot be assumed. Therefore, it is both necessary and desirable to assess whether a particular agent could cause adverse health effects using both epidemiologic and experimental studies, and both approaches have been used to evaluate whether exposure to ELF EMF has any adverse effects on human health. Epidemiologic studies are valuable because they are conducted in human populations, but they are limited by their non-experimental design.

In epidemiologic studies of magnetic fields, for example, researchers cannot control the amount of individual exposure, how exposure occurs over time, the contribution of different sources, or individual behavior other than factors such as diet that may affect disease risk. In valid risk assessments of ELF EMF, epidemiologic studies are considered alongside experimental studies of laboratory animals, while studies of isolated cells and tissues are generally considered as supplementary data.

Estimating risk

Epidemiologists measure statistical associations between exposures and disease in order to estimate risk. *The calculation of risk in this way does not, by itself, establish that the exposures are the cause of disease.* This brief summary is included to provide a foundation for understanding and interpreting statistical associations in epidemiologic studies as risk estimates.

Two common types of risk estimates are absolute risk and relative risk (RR). Absolute risk, also known as incidence, is the amount of new disease that occurs in a given period. For example, the absolute risk of childhood leukemia in children 0 to 19 years of age for 2021 was 4.8 per 100,000 children (NCI, 2024). An RR evaluates whether a particular exposure or inherent quality (e.g., genetics) is associated with a disease outcome and is calculated by looking at the absolute risk in one group relative to a comparison group. For example, “Non-Hispanic White” children 0 to 19 years of age had an estimated absolute risk of childhood cancer of 4.2 per 100,000 in 2021, and “Non-Hispanic Black” children in the same age range had an estimated age-adjusted absolute risk of 3.0 per 100,000 in the same year. By dividing the absolute risk of “Non-Hispanic White” children by the absolute risk of “Non-Hispanic Black” children, we obtain an RR of 1.40. This RR estimate can be interpreted to mean that white children have a risk of childhood cancer that is 40% greater than the risk of “Non-Hispanic Black” children . This RR estimate can be interpreted to mean that white children have a risk of childhood cancer that is 40% greater than the risk of “Non-Hispanic Black” children (NCI, 2024). Additional statistical analysis is needed to evaluate whether this association is statistically significant, as defined in the following sub-section.

Traditional cohort studies provide direct estimates of RR, and usually provide reliable estimates of the risk associated with a particular exposure.

Another type of epidemiology study is the case-control study. Whereas a cohort study follows a group of exposed and unexposed people to see who develops a health outcome, case-control studies start with people who either have a disease or not and evaluate who was exposed or unexposed. Case-control studies are more common than cohort studies, because they are less costly and more time efficient. Such case control studies are less reliable because they prone to biases such as recall bias which can distort the association between an exposure and health outcome.

Thus, the association between a particular disease and exposure is measured quantitatively in an epidemiologic study as either the RR (cohort studies) or OR (case-control studies) estimate. The general interpretation of a risk estimate equal to 1.0 is that the exposure is not associated with an increased incidence of the disease. If the risk estimate is greater than 1.0, the inference is that the exposure is associated with an increased incidence of the disease. On the other hand, if the risk estimate is less than 1.0, the inference is that the exposure is associated with a reduced incidence of the disease. The magnitude of the risk estimate is often referred to as its strength (i.e., strong versus weak). Stronger associations are given more weight because they are less susceptible to the effects of bias.

Statistical significance

Statistical significance testing provides an idea of whether or not a statistical association is a chance occurrence or whether the association is likely to be observed upon repeated testing. The term statistically significant is used in epidemiologic studies to describe the tendency of the level of exposure and the occurrence of disease to be linked, with chance as an unlikely explanation. Statistically significant associations, however, are not necessarily an indication of cause-and-effect because the interpretation of statistically significant associations depends on many other factors associated with the design and conduct of the study, including how the data were collected and the number of study participants.

Confidence intervals (CI), reported along with RR and OR values, indicate a range of values for an estimate of effect that has a specified probability (e.g., 95%) of including the true estimated effect. CIs evaluate statistical significance, but do not address the role of bias, described further below. A 95% CI indicates that if the study was conducted a very large number of times, 95% of the measured estimates would be within the upper and lower confidence limits.

The CI range is also important for interpreting estimated associations, including the precision and statistical significance of the association. A very wide CI indicates great uncertainty in the value of the true risk estimate. This is usually due to a small number of observations. A narrow CI provides more certainty about the true RR estimate. If the 95% CI does not include 1.0, the probability that an association is due to chance alone is 5% or lower, and the result is considered statistically significant, as discussed above.

Meta-analysis and pooled analysis

In scientific research, the results of smaller studies may be difficult to distinguish from normal, random variation. This is especially the case for sub-group analyses where few cases are estimated to have high exposure levels (e.g., in case-control studies of childhood leukemia and TWA magnetic-field exposure greater than 3 to 4 mG). Meta-analysis is an analytic technique that combines the published results from a group of studies into one summary result. A pooled analysis, on the other hand, combines the raw, individual-level data from the original studies and analyzes the data from the studies altogether. These methods are valuable because they increase

the number of individuals in the analysis, which allows for a more robust and stable estimate of association. Meta- and pooled analyses are important tools for qualitatively synthesizing the results of a large group of studies.

The disadvantage of meta- and pooled analyses is that they can convey a false sense of consistency across studies if *only* the combined estimate of effect is considered (Rothman and Greenland, 1998). These analyses typically combine data from studies with different study populations, methods for measuring and defining exposure, and disease definitions. This is particularly true for analyses that combine data from case-control studies, which often use very different methods for the selection of cases and controls and exposure assessment (Linet et al., 2003). Therefore, meta- and pooled analyses are used not only to synthesize or combine data, but also to understand which factors cause the results of the studies to vary (i.e., publication date, study design, possibility of selection bias), and how these factors affect the associations calculated from the data of all the studies combined (Rothman and Greenland, 1998).

Meta- and pooled analyses are a valuable technique in epidemiology; however, in addition to calculating a summary RR, they should follow standard techniques (Stroup et al., 2001) and analyze the factors that contribute to any heterogeneity between the studies.

Bias in epidemiologic studies

One key reason that the results of epidemiologic studies cannot directly provide evidence for cause-and-effect is the presence of bias. Bias is defined as "*any systematic error in the design, conduct or analysis of a study that results in a mistaken estimate of an exposure's effect on the risk of disease*" (Gordis, 2000, p. 204). In other words, sources of bias are factors or research situations that can mask a true association or cause an association that does not truly exist. As a result, the extent of bias, as well as its types and sources, is one of the most important considerations in the interpretation of epidemiologic studies. Since it is not possible to fully control human populations, perfectly measure their exposures, or control for the effects of all other risk factors, bias will exist in some form in all epidemiologic studies of human health. Laboratory studies, on the other hand, more effectively manage bias because of the tight control the researchers have over most study variables.

One important source of bias occurs in epidemiologic studies when a third variable confuses the relationship between the exposure and disease of interest because of its relationship to both. Consider an example of a researcher whose study finds that people who exercise have a lower risk of diabetes compared to people who do not exercise. It is known that people who exercise more also tend to consume healthier diets and healthier diets may lower the risk of diabetes. If the researcher has not controlled for the impact of diet, it is not possible to say with certainty that the lower risk of diabetes is due to exercise and not to a healthier diet. In this example, diet is called a confounding variable.

Cause versus association and evaluating evidence regarding causal associations

Epidemiologic studies can help suggest factors that may contribute to the risk of disease, but they are not used as the sole basis for drawing inferences about cause-and-effect relationships. Since epidemiologists do not have control over the many other factors to which people in their studies are exposed, and diseases can be caused by a complex interaction of many factors, the results of epidemiologic studies must be interpreted with caution. A single epidemiologic study is rarely unequivocally supportive or non-supportive of causation; rather, a weight is assigned to the study based on the validity of its methods and all relevant studies (epidemiology, *in vivo*, and *in vitro*) must be considered together in a weight-of-evidence review to arrive at a conclusion about possible causality between an exposure and disease.

In 1964, the U.S. Surgeon General published a landmark report on smoking-related diseases (HEW, 1964). As part of this report, the Surgeon General outlined nine criteria for evaluating epidemiologic studies (along with experimental data) for causality. In a more recent edition of this report, these criteria have been reorganized into seven criteria (HHS, 2004). Table 1 provides a list and brief description of each criterion.

Table 1. Criteria for evaluating whether an association is causal (HHS, 2004)

Criteria	Description
Consistency	Repeated observation of an association between exposure and disease in multiple studies of adequate statistical power, in different populations, and at different times.
Strength of the association	The larger (stronger) the magnitude and statistical strength of an association between exposure and disease, the less likely such an effect is the result of chance or unmeasured confounding.
Specificity	The exposure is the single cause or one of a few causes of disease.
Temporality	The exposure occurs prior to the onset of disease.
Coherence, plausibility, and analogy	The association cannot violate known scientific principles and the association must be consistent with experimentally demonstrated biologic mechanisms.
Biologic gradient	The observation that the stronger or greater the exposure, the stronger or greater the effect, also known as a dose-response relationship.
Experiment	Observations that result from situations in which natural conditions imitate experimental conditions. Also stated as a change in disease outcome in response to a non-experimental change in exposure patterns in populations.

These criteria were meant to be applied to statistically significant associations observed in the

cumulative epidemiologic literature (i.e., if no statistically significant association is observed for an exposure, then the criteria are not relevant). It is important to note that these criteria were not intended to serve as a checklist, but as guide to evaluate associations for causal inference. Theoretically, it is possible for an exposure to meet all seven criteria, but still not be deemed a causal factor. Also, no one criterion can provide indisputable evidence for causation, nor can any single criterion, except for temporality, rule out causation.

In summary, the judicious consideration of these criteria is useful in evaluating epidemiologic studies, but they cannot be used as the sole basis for drawing inferences about cause-and-effect relationships. In line with the criteria of coherence, plausibility, and analogy, epidemiologic studies are considered along with *in vivo* and *in vitro* studies in a comprehensive weight-of-evidence review. Epidemiologic support for causality is usually based on high-quality studies that report consistent results across many different populations and study designs and are supported by experimental data collected from *in vivo* and *in vitro* studies.

Biological response versus disease in human health

When interpreting research studies, it is important to distinguish between a reported biological response and an indicator of disease. This is relevant because exposure to ELF EMF may elicit a biological response that is simply a normal response to environmental conditions. This response, however, may not be a disease, cause a disease, or be otherwise harmful. There are many exposures or factors encountered in day-to-day life that elicit a biological response, but the response is neither harmful nor the cause of disease. For example, as a person walks from a dark room indoors to a sunny day outdoors, the pupils of the eye naturally constrict to limit the amount of light passing into the eye. This constriction of the pupil is a biological response to the change in light conditions. Pupil constriction, however, is neither a disease itself, nor is it known to cause disease.

3 Agency Reviews of ELF EMF and Health

Over the past several decades, a number of national and international scientific and health organizations have published reports or scientific statements with regard to the possible health effects of ELF EMF. These organizations assemble panels of experts with the knowledge and mandate to review relevant research and provide scientifically-grounded public health recommendations. Organizations that have reviewed the research on ELF EMF and health include those listed in Table 2. Overall, the conclusions of these agencies' reviews have been fairly consistent. After more than 45 years of research that includes thousands of peer-reviewed, scientific studies, none of these agencies has concluded that long-term exposure to ELF EMF at the levels commonly encountered in our environment is a confirmed cause of any adverse health effect. The reviews published by some of these agencies are further discussed below. Conclusions from recent agency reviews related to specific health outcomes, including child and adult cancers, are summarized in the relevant sub-sections of Section 4.

Table 2. Health and scientific agencies that conducted reviews of the ELF EMF scientific literature

Scientific Organization	Sponsor	Publication Dates
Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC)	Canada	1998, 2005
International Commission on Non-Ionizing Radiation Protection (ICNIRP)	n/a (International Chartered non-profit)	1998, 2003, 2010, 2020
NIEHS	United States	1998, 1999
IARC	United Nations	2002
National Radiological Protection Board (NRPB)	United Kingdom	2004
Swedish Radiation Protection Authority (SSI) / Swedish Radiation Safety Authority (SSM)*	Sweden	2005, 2006, 2007, 2008, 2009, 2010, 2013, 2014, 2015, 2016, 2018, 2019, 2020, 2021, 2022, 2024a, 2024b
WHO	United Nations	2007
SCENIHR / Scientific Committee on Health, Environmental and Emerging Risks (SCHEER)†	European Commission	2007, 2009, 2015, 2024
Health Council of the Netherlands (HCN)	The Netherlands	2009, 2022a, 2022b
The European Health Risk Assessment Network on Electromagnetic Fields (EFHRAN)	European Commission	2010, 2012

*The SSI was renamed in 2008.
†SCENIHR was renamed SCHEER in 2016.

Although not included in Table 2 above, the recent *Report on Carcinogens* from the NTP did not list ELF EMF as either "*Known To Be Human Carcinogens*" or "*Reasonably Anticipated To Be Human Carcinogens*" (NTP, 2021).

International Agency for Research on Cancer

As an agency of the WHO, IARC routinely assembles international working groups of experts to critically and systematically review and evaluate human, animal, and mechanistic evidence on the carcinogenicity of various human exposures as the first step (hazard identification) in a carcinogen risk assessment (IARC, 2019). These evaluations are published as IARC Monographs. Monograph 80 reviewed non-ionizing ELF EMF (IARC, 2002).

IARC uses specific categories to classify the overall evaluation of carcinogenicity of an agent to humans (Figure 1). Categories include (from highest to lowest risk): *carcinogenic to humans* (Group 1); *probably carcinogenic to humans* (Group 2A); *possibly carcinogenic to humans* (Group 2B); and *not classifiable as to its carcinogenicity to humans* (Group 3). These categories are intentionally meant to err on the side of caution, giving more weight to the possibility that the exposure is truly carcinogenic and less weight to the possibility that the exposure is not carcinogenic. As of March 2025, IARC has reviewed more than 1,000 substances and exposure circumstances to evaluate their potential carcinogenicity; eighty percent of substances and exposures fall in the categories of possible carcinogen (31%) or not classifiable (48%). Throughout the history of the IARC, only one agent has been classified as probably not a carcinogen, which illustrates the conservatism of the evaluations and the difficulty in proving the absence of an effect beyond all doubt.[4]

[4] Note that in 2019, IARC removed the category *Probably not a Carcinogen* (Group 4), as only one chemical (caprolactam) had ever been assigned to that category; this chemical was re-categorized into Group 3 (IARC, 2019).

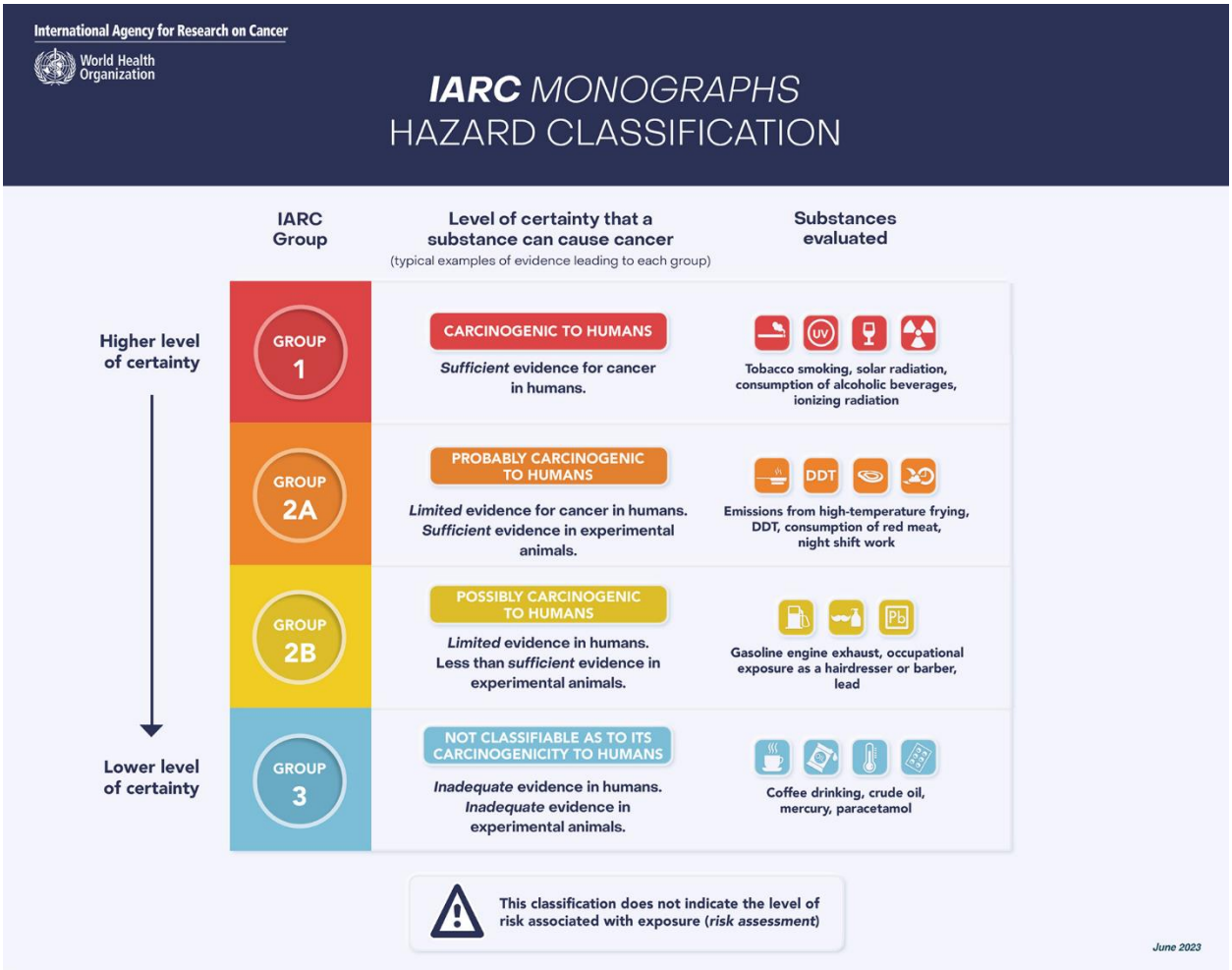

Figure 3. IARC Monographs Hazard Classification Chart.

(Source: IARC, 2023)[5] Not shown in Group 1 on the infographic are processed meats for which "An analysis of data from 10 studies estimated that every 50 gram portion of processed meat eaten daily increases the risk of colorectal cancer by about 18%."

After reviewing the scientific literature on ELF magnetic fields, IARC classified ELF magnetic fields as *possibly carcinogenic to humans (Group 2B)* (IARC, 2002). In the IARC classification system, a possible carcinogen denotes exposures for which there is limited evidence of carcinogenicity in studies of humans[6] and inadequate evidence of carcinogenicity in studies of

[5] WHO infographic available at https://www.iarc.who.int/infographics/iarc-monographs-classification/. Last updated June 16, 2023. Questions and answers on Cancer: Carcinogenicity of the consumption of red meat and processed meat. October 26, 2015. https://www.who.int/news-room/questions-and-answers/item/cancer-carcinogenicity-of-the-consumption-of-red-meat-and-processed-meat. Accessed March 19, 2025.

[6] *Limited evidence of carcinogenicity* from studies of humans describes a body of research where "A causal interpretation of the positive association observed in the body of evidence on exposure to the agent and cancer is credible, but chance, bias, or confounding could not be ruled out with reasonable confidence" (IARC, 2019, p. 31).

experimental animals[7]. For ELF magnetic fields, IARC concluded that there was *"limited evidence in humans for the carcinogenicity of extremely low frequency magnetic fields in relation to childhood leukaemia"* (IARC, 2002, p. 338). This classification was largely based on an association between childhood leukemia and a TWA magnetic-field exposure greater than 3 to 4 mG reported in two pooled analyses of epidemiologic studies (Ahlbom et al., 2000; Greenland et al., 2000). IARC further concluded that there was *"inadequate evidence in humans for the carcinogenicity of extremely low frequency magnetic fields in relation to all other cancers"* and *"inadequate evidence in experimental animals for the carcinogenicity of extremely low-frequency magnetic fields"* (IARC, 2002, p. 338). After reviewing the scientific literature on ELF electric fields, IARC classified ELF electric fields as "*not classifiable as to their carcinogenicity to humans (Group 3)"* (IARC, 2002, p. 338).

In March 2024, an Advisory Group of independent scientists assembled by IARC from 22 different countries met to recommend priorities for evaluations of carcinogenicity by the IARC *Monographs* program during the years from 2025 to 2029. The goal of the Advisory Group is to "ensure that the agents evaluated in the *Monographs* are selected on the basis of the latest scientific evidence relevant to carcinogenicity" (Berrington de Gonzalez et al., 2024, p. 1). In drawing their conclusions and developing their priority recommendations, the Advisory Group reviewed the evidence for each agent, regarding human exposure, cancer in humans, cancer in experimental animals, and carcinogen mechanisms. The IARC Advisory Group determined that for ELF magnetic fields, *"[e]xisting evidence does not appear to support a change in classification [of possibly carcinogenic to humans]"* (Berrington de Gonzalez et al., 2024, p. 2).

World Health Organization

The most comprehensive assessment of EMF was conducted by the WHO and published in June 2007 as their *Environmental Health Criteria (EHC) Monograph 238* (WHO, 2007a). The Task Group responsible for the report's overall conclusions consisted of 21 scientists from around the world with expertise in a wide range of scientific disciplines. Their review was conducted using standard scientific procedures, as outlined in its Preamble and described above in Section 2, and relied on the conclusions of previous reviews, where possible. The Task Group critically reviewed the cumulative epidemiologic and laboratory research through 2005, taking into account the strength and quality of the individual research studies, and mainly focused on evaluating studies published after the 2002 IARC review of ELF EMF and cancer. In their 2007 report, the WHO used the same terminology as IARC to describe the strength of evidence in support of causality between specific agents and cancer.

The WHO 2007a report provided the following overall conclusions:

[7] *Inadequate evidence of carcinogenicity* from studies in experimental animals describes a body of research in which "studies cannot be interpreted as showing either the presence or the absence of a carcinogenic effect because of major qualitative or quantitative limitations, or no data are available on cancer in experimental animals" (IARC, 2019, p. 33).

> *New human, animal, and in vitro studies published since the 2002 IARC Monograph, 2002 [sic] do not change the overall classification of ELF as a possible human carcinogen* (WHO, 2007a, p. 347).
>
> *Acute biological effects [i.e., short-term, transient health effects such as a small shock] have been established for exposure to ELF electric and magnetic fields in the frequency range up to 100 kHz that may have adverse consequences on health. Therefore, exposure limits are needed. International guidelines exist that have addressed this issue. Compliance with these guidelines provides adequate protection. Consistent epidemiological evidence suggests that chronic low-intensity ELF magnetic field exposure is associated with an increased risk of childhood leukaemia. However, the evidence for a causal relationship is limited, therefore exposure limits based upon epidemiological evidence are not recommended, but some precautionary measures are warranted* (WHO, 2007a, p. 355).

The current guidance from the WHO on its website states:

> *Despite the feeling of some people that more research needs to be done, scientific knowledge in this area is now more extensive than for most chemicals. Based on a recent in-depth review of the scientific literature [WHO 2007a report], the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields. However, some gaps in knowledge about biological effects exist and need further research … Science cannot provide a guarantee of absolute safety yet but the development of research is reassuring overall* (WHO, 2016).

Scientific Committee on Health, Environmental and Emerging Risks

The most recent weight-of-evidence review of EMF and health was released in 2024 by SCHEER. The Committee consists of independent scientific experts assembled to provide advice on public health and risk assessments to the Department of Health and Consumer Protection of the European Commission. The Committee addresses questions related to emerging or newly identified health and environmental risks and on broad, complex, or multidisciplinary issues requiring a comprehensive assessment of risks to consumer safety or public health. The 2024 report on the potential health effects of exposure to EMF serves as an update to the previous reviews published in 2015 (SCENIHR, 2015) and 2009 (SCENIHR, 2009). In performing its assessment of the literature, the Committee followed the scientific guidelines it had developed for the assessment of the quality and weight of the evidence of human health risks (SCENIHR, 2012; SCHEER, 2018).

The conclusions of the 2024 SCHEER review are consistent with earlier comprehensive reviews, including the previous 2015 SCENIHR report and the WHO 2007 review discussed above. SCHEER (2024) concluded that the available scientific evidence did not support a causal link between EMF exposure and any adverse health effects (including both cancer and non-cancer health outcomes). SCHEER's conclusions regarding the specific health outcomes reviewed in this report are summarized in the relevant subsections within Section 4 (*Current Scientific Consensus*). In addition to these outcomes, SCHEER (2024) also left unchanged the previous conclusions of the 2015 SCENIHR report that "*there was no convincing evidence for a causal relationship between ELF-MF exposure and self-reported symptoms*" (SCHEER, 2024, p. 2).

4 Current Scientific Consensus

The following sections identify and describe epidemiologic studies related to ELF EMF and health published between January 2022 and April 2024 in the research areas that have received the most attention—cancer, reproductive and developmental effects, neurodegenerative diseases, and cardiovascular disease. A summary of the conclusions of recent *in vivo* studies of carcinogenesis is also included. To provide additional context, the summaries for each health endpoint include an overall assessment of the research findings to-date and the conclusions of the most recent reports published by the scientific and health agencies listed in Section 3. Exponent summarized the epidemiolocal research through December 2021 in a previous report (Exponent, 2022), which includes more information on the earlier body of research.

A structured literature search was conducted using PubMed, a search engine provided by the National Library of Medicine and the National Institutes of Health that includes over 33 million up-to-date citations from MEDLINE and other life science journals for biomedical articles (http://www.pubmed.gov). A well-defined search strategy was used to identify English language literature indexed between January 2022 and April 2024.[8] All fields (e.g., title, abstract, keywords) were searched with various search strings that referenced the exposure and disease of interest.[9] A researcher with experience in this area reviewed the titles and abstracts of these publications for inclusion in this evaluation. The following specific inclusion criteria were applied:

1. **Outcome**. Epidemiologic studies evaluated cancer; reproductive or developmental effects; neurodegenerative diseases; or cardiovascular disease; *in vivo* studies evaluated carcinogenicity. Research on other outcomes was not included (e.g., psychological effects, behavioral effects, hypersensitivity).
2. **Exposure**. Studies evaluated ELF EMF at a frequency of 50 or 60-Hz.
3. **Exposure assessment methods**. Studies evaluated exposure beyond self-report of an activity or occupation, and estimated exposure through various methods including calculated EMF levels using distance from power lines, measured TWA exposure, and average exposure estimated from JEMs.
4. **Study design**. Study design included epidemiologic studies, meta-analyses, pooled analyses, human experimental studies, and *in vivo* studies of carcinogenicity. The review relies on the conclusions of the WHO with regard to *in vivo* studies in the areas of reproduction, development, neurology, and cardiology. Further, this report relies on the conclusions of the

[8] Since the literature search was performed in early May 2024, and there is sometimes a delay between the publication date of a study and the date it is indexed in PubMed, it is possible that some relevant studies published in or prior to April 2024 were not included in this update.

[9] EMF OR magnetic fields OR electric fields OR electromagnetic OR power frequency OR transmission line AND cancer (cancer OR leukemia OR lymphoma OR carcinogenesis) OR neurodegenerative disease (neurodegenerative disease OR Alzheimer's disease OR amyotrophic lateral sclerosis OR Lou Gehrig's disease) OR cardiovascular effects (cardiovascular OR heart rate) OR reproductive outcomes (miscarriage OR reproduction OR developmental effects).

WHO 2007 report (WHO, 2007a) regarding mechanistic data from *in vitro* studies since this field of study is less informative to the risk assessment process (IARC, 2002).

5. **Peer-review**. The study must have been peer-reviewed and published. Therefore, no conference proceedings, abstracts, or non-peer reviewed on-line materials were included.

Epidemiologic studies are evaluated below by outcome (childhood cancer; adult cancer; reproductive or developmental effects; neurodegenerative disease; and cardiovascular effects), followed by an evaluation of *in vivo* research on carcinogenesis.

Childhood health outcomes

Childhood leukemia

Overall Assessment

Childhood leukemia is the most prevalent form of cancer in children. Because of the statistical association between distance to power lines and line configuration e.g., Wertheimer and Leeper, 1979; Ahlbom et al., 2000; Greenland et al., 2000) summarized studies of measured and calculated magnetic fields and reported statistically significant association of childhood leukemia with estimated exposure above 3 or 4 mG. The strength of associations with estimated exposure has diminished over time with the publication of larger and higher quality studies. In particular, research in the past decade through April 2024 provides little new evidence for an association. The conclusion of the WHO (2007a) and other reviewing agencies has been that the scientific evidence does not confirm the existence of adverse health effects at exposures below scientifically established guideline values remains valid. The association between childhood leukemia and magnetic fields observed in the earlier studies remains unexplained and is unsupported by experimental *in vivo* studies.

Recent Conclusions of Agency Reviews

In their 2015 report, SCENIHR concluded that the epidemiologic data on childhood leukemia and EMF exposure reviewed for the report "*are consistent with earlier findings of an increased risk of childhood leukaemia with estimated daily average exposures above 0.3 to 0.4 μT [microtesla] [i.e., 3 to 4 mG]*" and noted that "*no mechanisms have been identified and no support is existing [sic] from experimental studies that could explain these findings, which, together with shortcomings of the epidemiological studies prevent a causal interpretation*" (SCENIHR, 2015, p. 164). In their 2024 report, SCHEER concluded that "*overall, there is weak evidence concerning the association of ELF-MF [magnetic field] exposure with childhood leukaemia*" (SCHEER, 2024, p. 9).

In their most recent review of the research, SSM concluded, "*[n]o new established causal relationships between EMF exposure and health risk have been identified. The studies presented in this report do not resolve whether the consistently observed association between ELF*

magnetic field (ELF-MF) exposure and childhood leukaemia in epidemiology is causal or not" (SSM, 2024b, p. 7).

In 2020, ICNIRP published a review of the research related to potential health effects of EMF exposure; the Commission's objective was to identify any data gaps in the body of literature on which they based their exposure guidelines (see Section 6) (ICNIRP, 2020a, 2020b). Regarding the research on childhood leukemia, ICNIRP did not recommend further epidemiologic studies on this topic, noting that any additional studies would be *"unlikely to advance the knowledge, as they will potentially be affected by the same types of biases as existing studies"* (ICNIRP, 2020a, p. 535). ICNIRP did recommend *"[f]urther studies on mechanisms and biological data from childhood leukemia experimental models"* while also stating, *"there is no support from animal experiments and there are no mechanistic data that can provide an explanation for any effect on biological structures at the exposure levels that have been identified in epidemiological studies"* (ICNIRP, 2020a, p. 536). The lack of evidence of a plausible biological mechanism between magnetic-field exposure and childhood leukemia development has been noted in other recent publications (e.g., Habash et al., 2019) and is discussed in the sub-section on *in vivo* studies related to carcinogenesis.

Summary of Childhood Leukemia Research (January 2022 – April 2024)

Amoon et al. (2022) prepared a pooled analysis of four studies of residential exposure to magnetic fields and childhood leukemia published following a 2010 pooled analysis by Kheifets et al. (2010a). The study by Amoon et al. (2022) compared the exposures of 24,994 children with leukemia to the exposures of 30,769 controls without leukemia in California, Denmark, Italy, and the United Kingdom. Exposure was assessed using residential measured or calculated magnetic fields. The exposure of these two groups to magnetic fields were found not to significantly differ. A decrease in the combined effect estimates in epidemiologic studies was observed over time, and the authors concluded that their findings, based on the most recent studies, "*do not rule out bias or confounding*" as possible explanations for the association and "*support conclusions of [the WHO and SCENIHR] that recent studies on magnetic fields and childhood leukaemia do not alter the previous assessment that magnetic fields are possibly carcinogenic to humans*" (Amoon et al., 2022, p. 1134).

Brabant et al. (2023) conducted a literature review and meta-analysis of studies of childhood leukemia and magnetic-field exposure that included 21 epidemiologic studies published from 1979 to 2020 in the overall analysis. The authors reported a statistically significant association, which they noted was "mainly explained by the studies conducted before 2000" (Brabant et al., 2023, p. 1). The authors reported a statistically significant association between childhood leukemia and measured or calculated magnetic-field exposures > 0.4 microtesla (μT) (> 4 mG); no statistically significant overall associations were reported between childhood leukemia and lower magnetic-field exposures (< 0.4 μT [< 4 mG]), or other surrogates for magnetic field exposure, including residential distance from power lines, or wire coding configuration. An association between childhood leukemia and electric blanket use was also reported. The overall

results were likely influenced by the inclusion of a large number of earlier studies; 10 of the 21 studies in the main analysis were published prior to 2000. Of the studies published prior to 2000, fewer studies were deemed to be of higher study quality, as determined by the authors, compared to studies published after 2000.

Crespi et al. (2024) evaluated the association between residential proximity to electricity transformers in multi-story residential buildings and childhood leukemia development in the international Transformer Exposure (TransExpo) study. Participants were required to live in an apartment building that contained a built-in transformer; exposure was estimated using the participants' apartment location relative to the transformer and categorized as high (located above or adjacent to the transformer), intermediate (located on the same floor as apartments in the high category), or unexposed (all other apartments). A registry-based pooled analysis with five countries' data included a total of 74 cases and 20,443 controls; 18 of the 74 cases were identified as intermediate or highly exposed. No significant associations were reported between proximity to residential transformers and childhood leukemia. Sensitivity analyses performed using the data from one of the five countries included (Finland), where a cohort study design was used, also reported no significant associations. The authors concluded that the evidence for an elevated risk of childhood leukemia from proximity to residential transformers was "*weak*."

Duarte-Rodríguez et al. (2024) conducted a population-based case-control study to examine the geographical distribution of childhood acute lymphoblastic leukemia (ALL) cases in Mexico City, Mexico. Cases and controls were recruited from public hospitals and matched by age and healthcare institution. Cases and controls were geolocated using the most recent residential address, and a spatial scan statistic was used to detect spatial clusters of cancer cases. The authors identified eight spatial clusters of cases, representing nearly 40% of all cases included in the study (n=1,054 cases). The accuracy and validity of this method for identifying clusters for a multifactorial disease were not evaluated by the authors. Furthermore, the size of some of these spatial cluster exceed 20 kilometers. The scales of these clusters are not informative to understand associations between local ELF EMF exposure and human health. The authors noted that six of the eight spatial clusters were located in proximity to high-voltage electric lines and high-voltage electric installations (distances not specified), and that the remaining two clusters were located near former petrochemical industrial facility sites. Since the study did not directly assess magnetic-field exposures and made no conclusions about magnetic-field exposure and cancer development, this study adds little value to the existing literature regarding a potential association between exposure to ELF EMF and childhood leukemia development.

Guo et al. (2023) reported conducting a systematic review and meta-analysis of studies published from 2015 to 2022 that evaluated associations between magnetic-field exposure and childhood leukemia development. Three meta-analyses were conducted to evaluate the relationship using different exposure metrics. In the first meta-analysis, magnetic-field levels ranging from 0.4 μT [4 mG] to 0.2 μT [2 mG] were associated with a statistically significant reduced risk of childhood leukemia development (i.e., a protective association). In the second analysis, exposure was based on wiring configuration codes, and the reported pooled relative risks estimates

demonstrated a statistically significant association with childhood leukemia. In the third meta-analysis, exposure was categorized into groupings of magnetic-field strength; no statistically significant associations with childhood leukemia were reported for any of the groupings, including for magnetic-field levels ≥ 0.4 μT [≥ 4 mG]. There are significant limitations of this study which prevent meaningful interpretations of the results. Most of the analyses of magnetic fields did not state whether measurements and calculations were included, and the authors provided no description of the methods used for their analyses nor any data tables to support their findings or even references to the number and type of studies included. In fact much of the article's introduction discusses ionization radiation, entirely unrelated to ELF EMF. The authors also did not report relevant metrics for evaluating meta-analyses such as study heterogeneity.

Malagoli et al. (2023) evaluated associations between exposure to magnetic fields from high-voltage power lines (≥ 132 kV) and childhood leukemia development in a case-control study of children in Italy. The study included 182 cases diagnosed with childhood leukemia between 1998 and 2019 and 726 controls matched based on age, sex, and Italian province. The authors assessed magnetic-field exposures by calculating the distance from each participant's residence to the nearest high-voltage power line and classifying that distance into one of three exposed categories (participants living < 100 meters, 100 to < 200 meters, or 200 to < 400 meters from the lines) or as unexposed (participants living ≥ 400 meters from the lines). The authors reported a non-statistically significant association between childhood leukemia and a residence distance of < 100 meters; no statistically significant associations were reported for any distance, including when stratified by age (< 5 or ≥ 5 years) or restricted to one subtype of leukemia, ALL.

Malavolti et al. (2024) examined the association between magnetic-field exposures from transformer stations and childhood leukemia in the same Italian study population as Malagoli et al. (2023). Magnetic-field exposures were estimated based on residential distance to the nearest transformer station, and participants were then categorized as exposed or unexposed using two different distance cut-points: 15 or 25 meters (i.e., exposed: residing within a radius of 15 or 25 meters from the transformer station; unexposed: residing ≥ 15 meters or exposed: ≥ 25 meters). No significant associations were reported for all leukemias or ALL specifically when either distance cut-point was used, and in fact no association at all (OR = 1.0) was observed when the more stringent cut-point of 15 meters was used. In sub-analyses that stratified by participant age (< 5 years vs. ≥ 5 years), no significant associations were reported for either age category.

Nguyen et al. (2022) investigated whether potential pesticide exposure from living in close proximity to commercial plant nurseries confounds the association between magnetic-field exposure and childhood leukemia development reported within the California study population that was previously analyzed in Crespi et al. (2016) and Kheifets et al. (2017). The authors of Nguyen et al. (2022) noted that while the association between childhood leukemia and magnetic-field exposure was "slightly attenuated" after adjusting for nursery proximity or when restricting to subjects living > 300 meters from nurseries, their results "*do not support plant nurseries as an explanation for observed childhood leukemia risks*." The authors further noted that close residential proximity to nurseries may be an independent risk factor for childhood leukemia. In

Nguyen et al. (2023), the authors extended their previous investigation (Nguyen et al., 2022) into whether pesticide exposure was an independent risk factor or confounder for childhood leukemia in the presence of magnetic-field exposure from high-voltage power lines by examining the potential impact of specific pesticide exposure factors (e.g., intended use, chemical class, active ingredient). The authors found no statistically significant associations between distance to high-voltage powerlines or magnetic-field exposure and childhood leukemia, including when adjusting for pesticide exposure. Several of the examined pesticides were determined by the authors to be potential independent risk factors for childhood leukemia.

Onyije et al. (2022) conducted an "*umbrella review*" (i.e., a review of systematic reviews, meta-analyses, and pooled analyses) of epidemiological studies published between 2003-2021 that evaluated environmental risk factors (including ELF-EMF) of childhood ALL, the most common type of childhood leukemia. Onyije et al. (2022) screened 1,486 publications and ultimately included 59 publications consisting of 42 systematic reviews and meta-analyses and 17 pooled analyses. Onyije et al. (2022) relied on A Measurement Tool to Assess Systematic Reviews (AMSTAR 2) to evaluate the quality of each systematic review.

None of the systematic reviews met criteria for a high quality of evidence rating and 7 of the 42 systematic received critically low-quality ratings and were excluded from the analysis. Two risk factors identified that were "convincingly associated with childhood ALL" were low doses of ionizing radiation in early childhood, and general pesticide exposure during maternal preconception/pregnancy. Eight studies included in the review evaluated ELF-EMF exposure. One study, Talibov et al. (2019) used occupational data (a JEM) to estimate paternal and maternal preconception as well as maternal pregnancy exposure to ELF-EMF and associations with childhood leukemia overall and by subtype in a case-control study of 9,723 childhood leukemia cases and 17,099 controls. ELF-EMF exposure was categorized as (≤ 0.1, > 0.1 to ≤ 0.2, and > 0.2 µT). Talibov et al. (2019) found no evidence of an association. Based on seven publications that evaluated ELF-EMF during childhood, Onyije et al. (2022) concluded there was "'some' evidence of ELF-EMF as a risk factor of childhood leukemia" largely due to all meta-analyses having RRs over 1.00. The studies, however, were inconsistent between reviews that relied on the same data. For instance, a pooled analysis of four studies by Amoon et al. (2022) found no association between ELF-EMF and ALL, but Seomun et al. (2021) which included the same four studies found positive associations. Onyije et al. (2022) provide a caveat about their findings by emphasizing the majority of the ELF-EMF studies are case-control studies known to be prone to selection and recall bias and 2) noting that while there have been decades of study on the epidemiological associations of ELF-EMF with childhood leukemia, concerns about bias as well as lack of biological plausibility have precluded discussions about causality. Inconsistency in epidemiologic studies has led to uncertainty regarding carcinogenicity of some of the risk factors for childhood leukemia as a result of information bias, participation and recall biases. Empirical associations were identified and no conclusion about causality were made.

Onyije et al. (2023) synthesized findings from systematic reviews and pooled analyses that evaluated environmental risk factors (including ELF-EMF) of childhood ALL. The studies

included in this brief review were not included in the Onyije et al. (2022) larger umbrella review, summarized above. Onyije et al. (2022) determined the strength of the evidence based on the magnitude of the association found in each study, the number of studies on a specific risk factor, and the heterogeneity between those studies. Evidence was classified as "*strong*," "*some*," "*little*," "*no*," or "*conflicting*," which was used when systematic reviews came to different conclusions. One new systematic review (Brabant et al., 2023) was included but it did not change the earlier evaluation by Onyije et al. (2022) of "some" evidence of an association between ELF-EMF and ALL.

Zagar et al. (2023) investigated the relationship between magnetic fields and childhood cancers, including childhood leukemia, in Slovenia. Cancer cases, including 194 cases of leukemia, were identified from the Slovenian Cancer Registry; cases were then classified into one of five calculated magnetic-field exposure levels (ranging from < 0.1 µT [1 mG] to ≥ 0.4 µT [4 mG]) based on residential distance to high-voltage transmission lines (e.g., 110 kV, 220 kV, and 400 kV). The authors reported that less than 1% of Slovenian children and adolescents lived in an area near high-voltage power lines. No statistically significant differences in the development of childhood cancers, including leukemia, brain tumors, or all cancers combined, were reported across the five exposure categories.

Childhood brain cancer

Overall Assessment

The results of one study identified during the period of this review evaluated below did not alter the classification of the epidemiologic data in this field as inadequate and the study did not report any convincing evidence for an association.

Recent Conclusions of Agency Reviews

In their 2015 report, SCENIHR concluded that "*no association has been observed for the risk of childhood brain tumours*" (SCENIHR, 2015, p. 158). The 2024 report by SCHEER did not provide specific conclusions on childhood brain cancer research but stated *"[a]s far as other neoplastic diseases [i.e., other than childhood leukemia] are concerned, the weight of evidence is uncertain, because of conflicting results from the lines of evidence (animal and human studies) examined"* (SCHEER, 2024, p. 27).

Summary of Childhood Brain Cancer Research (January 2022 – April 2024)

During the period of this review, one relevant epidemiologic study was identified. The study on childhood leukemia by Zagar et al. (2023) discussed in the previous section also investigated the association between brain tumor development and magnetic-field exposure. Similar to the report's results for childhood leukemia, among the 195 diagnosed cases of brain cancer in participants 0 to 29 years old, only one case occurred outside the lowest exposure category

(0.2 to 0.3 µT [2 to 3 mG]). None of the standardized incidence ratios the authors calculated were statistically significant. The authors concluded "*we cannot attribute … any tumor of the central nervous system up to 29 years … to the exposure to ELF MF [magnetic fields] near [high-voltage power lines]"* (Zagar et al., 2023, p. 67).

Onyije et al. (2024) carried out a systematic review and meta-analysis of epidemiological studies evaluating more than 60 modifiable risk factors (including ELF-EMF) of childhood brain tumors using data from cases diagnosed between 1953 and 2017. Eligible cohort and case-control studies reported effect estimates during either the preconception, or pregnancy, or postnatal period, or during more than one of these periods. Onyije et al. (2024) reviewed 4,044 publications and included 181 studies (85 case-control and 96 cohort) in their review. Eligible studies were evaluated for their methodological quality using the Joanna Briggs Institute (JBI) critical appraisal tool. Pooled effect sizes and corresponding 95% CI were calculated using random-effect models and case-control studies were evaluated separately from cohort studies.

Case control studies scored slightly higher on the JBI tool on average with 87.9%, compared to cohort studies with 80.7%. The analysis found that maternal exposure to x-rays during pregnancy (eight case control studies) and childhood x-ray exposure (seven case control and combined analysis studies) were not associated with childhood brain tumors. Childhood exposure to computed tomography (CT) scans did not show an association in three case control studies.

In contrast to the case control studies, cohort studies evaluating the association between CT scans and childhood brain tumors identified an association in six studies and in the combined analysis. Exposure to domestic radon and external background ionizing radiation in childhood "*were observed to have some support of an association*" in two cohort studies. Exposure to ultrasound and electric-heated waterbeds during pregnancy did not show an association (four case control studies), but an association was observed with maternal use of electric blankets during pregnancy (seven case control studies). Fifteen studies evaluated associations between ELF magnetic fields and childhood brain tumors. Nine of these studies evaluated ELF magnetic-field levels between ≤ 0.1 µT (≤ 1 mG) and ≤ 0.4 µT (≤ 4 mG) (three case control and six cohort studies), and three cohort studies evaluated associations when ELF magnetic fields were higher than ≥ 0.4 µT (≥ 4 mG). No association with childhood brain tumors was found separately or in combined analysis. Finally, three case-control studies evaluated exposure to powerlines (very low current configuration, ordinary high current configuration, and very high current configuration) and found no association with childhood brain tumors Based on these results, the authors did not include ELF-magnetic fields as a potential risk factor of childhood brain tumors

Adult health outcomes

Adult brain cancer

Overall Assessment

Epidemiologic studies on magnetic fields and adult brain cancer have overall limited value due to weaknesses in exposure assessment methodology and insufficient data on certain brain cancer subtypes. Recent research predominantly shows no consistent associations, which is supported by the conclusions of recent agency reviews regarding adult cancers.

Recent Conclusions of Agency Reviews

The 2015 report by SCENIHR concluded that *"adult cancers show no consistent associations"* (SCENIHR, 2015, p. 158). The 2024 report by SCHEER did not provide a specific update on adult brain cancer research but cited the review published by HCN in 2022 (HCN, 2022a), which is discussed in the next paragraph.

In their 2022a report, HCN investigated the relationship between exposure to magnetic fields and the risk of specific types of cancer in adults. Regarding adult brain cancer, the Committee concluded, "*[r]esearch in the residential environment shows no associations between living within 50 metres of a high-voltage power line and the risk of brain cancer. The research is limited in scale, however, and the Committee therefore feels that no statements can be made regarding a causal relationship. An association was indeed found in the case of occupational exposure to magnetic fields above the background level. The Committee sees this as an indication of a causal relationship between the risk of brain cancer and occupational exposure"* (HCN, 2022a, p. 30). Regarding studies of occupational exposure, the Committee noted, *"It is not possible to determine an exposure-effect relationship due to the nature of the studies"* but nonetheless, determined that *"[b]ased on the association found … the EPA classification 'indications of a causal relationship' … appl[ies] to the relationship between risk of brain cancer and occupational exposure to magnetic fields"* (HCN, 2022a, p. 31).

Summary of Adult Brain Cancer Research (January 2022 – April 2024)

Yoshikawa et al. (2023) conducted a systematic review and meta-analysis on modifiable risk factors for adult-onset glioblastoma, an aggressive and malignant type of brain tumor with a poor prognosis. The authors reviewed 1,045 publications and ultimately included 12 studies, comprising 7 case-control and 5 prospective cohort studies. Only 2 of the 12 studies evaluated exposure to magnetic fields and both were case-control studies (Thériault et al., 1994; Villeneuve et al., 2002). The rest of the studies evaluated either alcohol consumption, body mass index, Type II diabetes, or non-steroidal anti-inflammatory drugs use as risk factors for glioblastoma.

Villeneuve et al. (2002) conducted a case-control study using data from the Canadian National Enhanced Cancer Surveillance System to evaluate magnetic-field exposure as a risk factor for GBM. For the meta-analysis, ORs or hazard ratios (HR) were combined to calculate summary results and a fixed or random-effects model was employed based on study heterogeneity (measured via the Cochran Q test). In Villeneuve et al. (2002) a significant positive association between self-reported magnetic-field exposure and glioblastoma was only found when magnetic-field exposure was estimated to be ≥ 0.6 µT (≥ 6 mG) (OR 5.36; 95% CI 1.16–24.78). The CIs are very wide, suggesting a high degree of uncertainty in the OR of 5.36. Cases and controls were matched by age. In the second paper, Thérinault et al. (1994) conducted a case-control study of 65 controls and 18 glioblastoma cases drawn from three cohorts of male employees of electric utility companies. Cases and controls were matched by age. No significant association or dose response relationship between exposure to magnetic fields and glioblastoma were found. Yoshikawa concludes "*no significant association was found between exposure to magnetic fields and GBM [glioblastoma] risk*" due to the limited (self-report) nature of the exposure assessment in Villeneuve et al. (2002) and the lack of associations found in Thériault et al. (1994).

Breast cancer

Overall Assessment

In their 2007 review, the WHO concluded that the evidence did not support an association between ELF magnetic-field exposure and breast cancer development (WHO, 2007a). This conclusion has also been expressed by other reviewing agencies in more recent reviews (e.g., SSM, 2016, 2018). Since no new published studies were identified during the period covered in this report, the conclusion that there is no association remains valid.

Recent Conclusions of Agency Reviews

The SSM concluded in two of their more recent annual reports that with respect to female breast cancer, *"now it is fairly certain that there is no causal relation with exposure to ELF magnetic fields"* (SSM, 2016, p. 7), and with respect to male breast cancer, *"[t]o date, there is no established link between ELF-MF [magnetic field] exposure and breast cancer in men"* (SSM, 2018, p. 49). Reviews published by SSM since 2018 have not provided specific conclusions on adult breast cancer research.

In their 2022a report, HCN concluded, "*[o]verall, studies in the residential environment do not reveal any associations between exposure to magnetic fields and the risk of breast cancer. However, some individual studies suggest otherwise and the Committee therefore feels that no statements can be made regarding a causal relationship in the residential environment. An association was indeed found between exposure and disease in the case of occupational exposure to magnetic fields above the background level. This applies to both men and women. The Committee sees this as an indication of a causal relationship*" (p. 26). Of studies of occupational exposure and breast cancer in women or men, the Committee noted, *"It is not*

possible to determine an exposure-effect relationship due to the nature of the studies" (HCN, 2022a, p. 28).

Notably, the occupational environments often include exposures to multiple chemicals and physical agents which may or may not have been assessed in these studies.

Summary of Breast Cancer Research (January 2022 – April 2024)

No relevant epidemiologic studies on adult breast cancer were published during the period covered in this review.

Adult leukemia and lymphoma

Overall Assessment

The findings from the existing body of research on adult leukemia and ELF EMF have been inconsistent, and no pattern has been identified whereby studies of a particular design or quality are more likely to produce positive or negative associations. Results from recent studies have not altered the conclusions reached by the WHO that the evidence is "*inadequate*" to link magnetic fields to adult leukemia development. While some scientific uncertainty remains on a potential relationship between adult lymphohematopoietic malignancies and magnetic-field exposure because of continued deficiencies in study methods, the current database of studies provides inadequate evidence for an association.

Recent Conclusions of Agency Reviews

The 2015 report by SCENIHR concluded that *"adult cancers show no consistent associations"* (SCENIHR, 2015, p. 158). A similar conclusion was expressed by SCHEER (2024) after reviewing meta-analyses performed by HCN (HCN, 2022a), which SCHEER noted "*could not always find evidence of a statistically significant dose-response relationship*" (SCHEER, 2024, p. 25).

In their 2022a report, HCN concluded, *"[r]esearch in th[e] residential environment has identified an association between the proximity of high-voltage power lines and an increased risk of leukaemia in adults. An association has also been found between occupational exposure to magnetic fields above the background level and an increased risk of leukaemia. The Committee sees this as indications of a causal relationship*" (HCN, 2022a, p. 22).

Summary of Adult Leukemia and Lymphoma Research (January 2022 – April 2024)

Jalilian et al. (2022) examined the relationship between occupational magnetic fields and electric shock exposures and lymphoma within a large Nordic census-based cohort. The study included

cases of non-Hodgkin's lymphoma (n = 68,978), chronic lymphocytic leukemia (n = 20,615), and multiple myeloma (n = 17,736) diagnosed between 1961 and 2005 in Finland, Iceland, Norway, and Sweden. Cases were matched to controls by age, sex, and country. Occupational exposure to magnetic fields and electric shocks were assessed using JEMs. The authors reported no associations among workers exposed to magnetic fields or electric shocks for any of the cancers assessed; this included no associations among workers exposed to high levels (≥ 0.30 μT [≥ 3 mG]) of magnetic fields. The authors concluded that their results "*do not provide support for an association between occupational exposure to ELF [magnetic fields] and electric shocks and lymphoma risk*" and that further research into this area "*should not be a research priority*" (Jalilian et al., 2022, p. 1).

Odutola et al. (2023) examined whether occupational exposure to magnetic fields was associated with follicular lymphoma in an Australian case-control study that took place between 2011 and 2016. Cases (n=681) were 20-74 years old diagnosed with follicular lymphoma between 2011 and 2016 and controls were related (siblings) (n= 294) and unrelated (spouses/partners) (n= 179) participants of the same age. The authors estimated exposure using a self-administered questionnaire based on job titles. Briefly, job titles solicited from the questionnaire were mapped to the International Standard Classification of Occupations. Occupational exposure to ELF magnetic fields based on job title was then assigned using a previously published JEM (Bowman et al., 2007). Average intensity (μT), total duration (years), and lifetime cumulative exposure (μT-years) metrics were considered. Regression models were adjusted for the following confounders: age, sex, ethnicity, state, and smoking status. The authors found no significant associations between follicular lymphoma and occupational exposure to magnetic fields when using any of the exposure metrics. A strength of this study was its ability to confirm follicular lymphoma diagnosis from a linkage to a cancer-based registry. A limitation of the study was its reliance on a self-administered questionnaire, which is vulnerable to recall bias. The authors concluded "*[o]ur findings do not support an association between occupational ELF-MF exposure and FL [follicular lymphoma]*" and that "*[f]urther research using enhanced exposure assessments is warranted* …" (Odutola et al., 2023, p. 599).

Reproductive and developmental effects

Overall Assessment

Epidemiologic studies on reproductive or developmental effects and EMF exposure have historically suffered from limitations in study design, sample size, and exposure assessment method. Recent research has provided little, if any, new evidence for potential associations. Thus, the WHO's classification of the overall evidence in support of any causal inference as *inadequate* remains appropriate.

Recent Conclusions of Agency Reviews

The 2015 report by SCENIHR concluded, "*[r]ecent results do not show an effect of the ELF fields on the reproductive function in humans*" (SCENIHR, 2015, p. 185). In their 2024 report, SCHEER stated, "*[t]he available systematic reviews and meta-analyses have not shown an association between ELF-EMF exposure and pregnancy or reproductive outcomes"* (SCHEER, 2024, p. 2).

In their 2020 review, ICNIRP stated, *"[s]ubsequent [epidemiologic] studies [after 2010] do not support the hypothesis that ELF-MFs [magnetic fields] are related to adverse pregnancy outcomes, and the older laboratory studies did not find an association between ELF-MFs and reproduction and/or development … Overall, the evidence gathered so far does not indicate any data gaps that require research for guideline development"* (ICNIRP, 2020a, p. 534).

In their 2022a report, HCN concluded, *"[r]esearch in the residential environment shows no association between living in the vicinity of high-voltage power lines and the risk of testicular cancer. No associations were also found in the case of occupational exposure to magnetic fields above the background level. As research in the residential environment is limited and the results of the studies on occupational exposure vary, the Committee concludes that no statements can be made regarding a causal relationship"* (HCN, 2022a, p. 33).

Summary of Reproductive and Developmental Effects Research (January 2022 – April 2024)

Kashani et al. (2023) conducted a systematic review and meta-analysis to evaluate whether EMF exposure (of varying frequencies) is associated with fetal or childhood abnormalities. Fourteen studies were included in the systematic review and meta-analysis, with six of those studies evaluating ELF magnetic-field exposure (five studies examined maternal and childhood exposure to power lines and one study examined occupational exposure to 50-Hz fields). Associations between ELF magnetic fields and childhood and fetal abnormalities from these six studies were inconsistent, with three studies reporting standardized mean differences around the null (i.e., no effect observed). There were considerable limitations that may have affected the study's findings, including a small number of included studies, significant heterogeneity between studies, and evidence of significant publication bias. The authors noted that "*due to the limitations of the studies, … the effects of EMF on fetal and childhood abnormalities should be interpreted with caution*" (Kashani et al., 2023).

Zhou et al. (2023) carried out a systematic review and meta-analysis of ELF-EMF (1 Hz to 300 Hz) exposure and pregnancy outcomes. Seven studies evaluating miscarriage, stillbirth, birth defects, and preterm birth were included, with six of the seven studies labeled as high-quality following a quality assessment. The authors found that there was no significant increase in adverse pregnancy outcomes comparing pregnant women who lived closer to EMF sources compared to pregnant women who lived further from EMF sources (distances of near and far

were not defined in the study). The authors concluded that "*[n]o correlation has been found between maternal ELF-EMF exposure and miscarriage, stillbirth, neonatal birth defects and preterm delivery*" (Zhou et al., 2023, p. 5).

Neurodegenerative diseases

Summary of Neurodegenerative Disease Research (January 2022 – April 2024)

Chambers-Richards et al. (2023) conducted a systematic review and meta-analysis of studies that investigated the relationship of three "*environmental and occupational toxins*" (i.e., EMF, metals, and pesticides) to Parkinson's disease. The authors included 24 studies in their analysis, including 9 studies of occupational EMF exposure, ranging in publication date from 1998 to 2017; no evidence of heterogeneity or publication bias were noted among the 9 studies. No statistically significant association was reported between EMF exposure and Parkinson's disease , including when the lower quality studies were omitted from the analysis. The authors reported a statistically significant association between Parkinson's disease and pesticide exposure but not between Parkinson's disease and metals exposure. The authors concluded that their findings "*may suggest that the risk in the development of Parkinson's disease may be more markedly increased with the duration or frequency of exposure to pesticides, as opposed to exposure to metals and electromagnetic fields*" (Chambers-Richards et al., 2023, p. 81).

Duan et al. (2023) carried out a meta-summary of amyotrophic lateral sclerosis (ALS) and exposure to magnetic fields, which was one of 22 non-genetic risk factors evaluated across 67 studies for its association with ALS. Six of the 67 studies (including 5 case-control studies) looked at magnetic-field exposure and associations with ALS. Pooling results from these studies resulted in a significant increased odds of ALS among individuals with higher exposure to magnetic fields (exposure levels were not defined by the authors). However, the pooled OR for magnetic-field exposure (1.22) was below the minimum OR threshold of 1.3 set by the authors as the criterion for defining an exposure as an ALS risk factor. In addition, the authors identified "*substantial*" heterogeneity between studies evaluating magnetic-field exposure and ALS. Non-genetic significant risk factors with ORs over 1.3 from this meta-summary included heavy metals, pesticides, solvents, and previous head injury; several risk factors had statistically significant protective odds (OR < 0.7) against developing ALS including diabetes, kidney disease, and living in an urban setting. A strength of the study is that there was little evidence of publication bias for magnetic-field exposure studies. The authors concluded, "*we found no significant association between electromagnetic fields and the incidence of ALS, except the dose of exposure might affect the development of ALS*" (Duan et al., 2023, p. 8). The authors claim that the dose that might affect ALS development cannot be evaluated because details on what constitutes high and low exposure are not provided.

Goutman et al. (2023) evaluated occupational exposure, including "*electromagnetic radiation*," and associations with ALS in a case-control study of Michigan workers across various industries. All cases (n = 381) were patients at the University of Michigan's Pranger ALS clinic, while

controls (n = 272) were recruited from an online database for the University of Michigan. Participants enrolled from 2010 to 2020 and were asked to complete a written survey on their work history (up to their last four jobs) and occupational exposures they may have encountered at those jobs. Exposure to EMF was ascertained with a binary question, "[*were you] [e]xposed to power lines, transformation stations or other EM [sic]*?" In addition to EMF, the survey also asked participants to report on their exposure to particulate matter, volatile organic compounds, pesticides, metals, biologicals, combustion/diesel exhaust, radiation, and corrosion. Regression models were adjusted for age, sex, and military service. There was no observed association between EMF exposure and ALS, although the exposure assessment method (i.e., self-reported questionnaire data that did not ask separate questions for different frequencies of electromagnetic fields, such as mobile phone use) was a significant limitation of the study. The authors found occupational exposure to metals was significantly and positively associated with ALS, while corrosives were significantly and negatively associated. In a subsequent publication, Goutman et al. (2022) assessed the potential for EMF and other occupational exposures to be risk factors for ALS progression, including survival and onset segment (bulbar, cervical, lumbar), in the same study. EMF exposure was not significantly associated with ALS survival, but was significantly associated with cervical onset compared to lumbar. It is worth noting that the majority of exposures (seven of nine) were significantly associated with cervical onset compared to lumbar. The authors make no concluding statements on EMF and ALS but instead emphasized that occupational pesticide exposure and working in military operations were significantly associated with worse ALS survival.

Saucier et al. (2023) carried out three systematic reviews of studies that evaluated relationships between urbanization, air pollution, and water pollution and ALS development. The authors identified five studies that assessed whether EMF (of varying frequencies) and high-voltage infrastructure were significant urbanization risk factors for ALS, but they make no conclusion about magnetic-field exposure and ALS development based on these studies, therefore adding little value to the existing literature.

Sorahan and Nichols (2022) investigated magnetic-field exposure and mortality from motor neuron disease in a large cohort of employees of the former Central Electricity Generating Board of England and Wales. The study included nearly 38,000 employees first hired between 1942 and 1982 and still employed in 1987. Estimates of exposure magnitude, frequency, and duration were calculated using data from the power stations and the employees' job histories and were described in detail in a previous publication (Renew et al., 2003). Mortality from motor neuron disease in the total cohort was observed to be similar to national rates. No statistically significant dose-response trends were observed with lifetime, recent, or distant magnetic-field exposure; statistically significant associations were observed for some categories of recent exposure, but not for the highest exposure category. The authors concluded that their study "*does not indicate that occupational lifetime magnetic field exposures are a risk factor for MND [motor neuron disease] but the possible role of recent exposures would be worth investigating in the other available studies*" (Sorahan and Nichols, 2022, p. 188).

Vasta et al. (2023) investigated whether EMF exposure from power lines and repeater antennas affected ALS onset age and progression in a cohort of Italian ALS patients (n = 1,098) diagnosed between 2007 and 2014. Patients were geolocated at their time of diagnosis; data on the distribution of power lines and repeater antennas came from the Environmental Protection Agency of Piedmont. Power line exposure was determined using the patient's address at the center of circles of variable radii (ranging from 100 to 2,000 meters); for each radius, exposure was calculated as the length of the power lines included in the circle. Based on these calculations, patients were classified as either low or high exposure using the median exposure. There were no significant differences in the age of ALS onset or rate of ALS decline between participants living closer vs. farther away from power lines or repeater antennas. The authors concluded that "*[o]ur study suggests that exposure to electromagnetic fields could not be part of the prognostic factor…"* in ALS etiology (Vasta et al., 2023, p. 345).

Vitturi et al. (2023) conducted a systematic review and meta-analysis of case-control studies examining potential occupational risk factors related to multiple sclerosis, including solvents, mercury, pesticides, and low-frequency magnetic fields. The authors included 24 studies in their review but only one of the included studies investigated exposure to magnetic fields, thereby adding little new information to the existing body of research.

Overall Assessment

The overall evidence from recently published studies of EMF, electric shocks, and neurodegenerative diseases, which are of higher methodological quality compared to earlier studies in this area, do not alter the assessment that there is no consistent or convincing support for a causal association.

Recent Conclusions of Agency Reviews

In their 2015 report, SCENIHR concluded, *"[t]he reviewed studies] do not provide convincing evidence of an increased risk of neurodegenerative diseases, including dementia, related to ELF [magnetic field] exposure"* (SCENIHR, 2015, p. 186). In their 2024 report, SCHEER stated, *"[o]verall, there is moderate evidence (mainly from human studies) on the association between occupational exposure to ELF-EMF and amyotrophic lateral sclerosis, weak evidence for the association of occupational ELF-EMF exposure with Alzheimer's disease, and dementia, but only uncertain to weak evidence for residential exposure and these neurodegenerative diseases. No significant association can be established between EMF exposure and Parkinson's or multiple sclerosis disease"* (SCHEER, 2024, p. 2).

In their 2022b report on neurodegenerative diseases in adults, HCN had the following conclusions:

- Parkinson's disease: *"[w]ith regard to Parkinson's disease, the Committee considers a causal link between exposure to magnetic fields and the development of the disease to be unlikely"* (HCN, 2022b, p. 5).
- ALS and Alzheimer's disease: *"the Committee considers the results for the residential areas to be inadequate to infer a causal relationship between the proximity of power lines and the risk of developing either disease. The Committee considers the associations identified by the occupational studies to be suggestive of a causal relationship. The few data available from experimental studies do not provide further support for a causal link"* (HCN, 2022b, p. 5).
- Multiple sclerosis: *"… no association was found in either the residential or occupational studies. However, in both environments, the number of studies was too limited to make definitive statements about whether or not there is a causal link between exposure to magnetic fields and development of the disease"* (HCN, 2022b, p. 5).

Cardiovascular disease

Overall Assessment

In their 2007 review, the WHO concluded that the existing evidence does not support an association between magnetic fields and cardiovascular disease. Relevant epidemiologic studies published during the period since the WHO's review have not provided evidence to alter the WHO's conclusion. Some research suggests the existence of potential therapeutic benefits of EMF exposure for cardiovascular disease.

Recent Conclusions of Agency Reviews

Regarding research on cardiovascular outcomes, ICNIRP concluded in their 2020 review of potential research gaps that *"the research available at the time the ICNIRP 2010 Guidelines were drafted provided convincing null findings, which suggest there are no data gaps in this area that require research"* (ICNIRP, 2020b, p. 534).

Summary of Cardiovascular Disease Research (January 2022 – April 2024)

No relevant epidemiologic studies on cardiovascular disease were published during the period of this review. A recent review article by Wang et al. (2023) discussed the potential therapeutic benefits of EMF exposure, including at 60 Hz, in cardiovascular disease treatment.

In vivo studies related to carcinogenesis

Human health risk assessments are not based exclusively on epidemiological studies; experimental studies in animals and humans also play a key role (USEPA, 2002, 2005; NTP, 2015a). The importance of *in vivo* experimental studies is particularly great in assessing the

potential role of magnetic fields in carcinogenic processes (IARC, 1992, 2022).

The impetus for reviews of *in vivo* research by WHO and IARC was summarized by SCENIHR (2015) with its conclusion:

> *Motivated by the observed increased leukaemia risk in children, experimental studies have investigated the carcinogenic potential of magnetic fields using animals. These studies have tended to use traditional rodent models and do not support the epidemiological findings . ... Previously SCENIHR (2009) concluded that animal studies did not provide evidence that exposure to magnetic fields alone caused tumours or enhanced the growth of implanted tumours. The inclusion of more recent studies does not alter that assessment. In addition, these studies do not provide further insight into how magnetic fields could contribute to an increased risk of childhood leukaemia. (p. 161).*

A substantial body of *in vivo* research has been added to the literature since then and has been previously reviewed by Exponent. Below is a brief overview of the status of this research up to 2022, after which new research from January 2022 to April 2024 is reviewed.

Chronic bioassays

In chronic bioassays animals are exposed to high levels of magnetic fields over the course of the animals' entire lifetime and tissue evaluations are performed to assess the incidence of tumors in many organs. In its evaluation of four large chronic bioassay studies, the WHO (2007a) concluded "*[o]verall, there is no evidence that ELF exposure alone causes tumours*" (p. 322). Subsequent studies reported by the Ramazzini Institute, although of lesser quality, support this conclusion (Soffritti et al., 2015, 2016a, 2016b; Bua et al., 2018).

Tumor promotion studies

Other studies have looked for evidence that ELF field exposure can enhance tumor development in combination with known carcinogens. The WHO stated that "*evidence that ELF field exposure can enhance tumour development in combination with carcinogens is inadequate*" (WHO, 2007a, p. 322). More recently, as part of its evaluation of *in vivo* studies, SCENIHR (2015) concluded that "*inclusion of more recent studies does not alter that assessment. In addition, these studies do not provide further insight into how magnetic fields could contribute to an increased risk of childhood leukaemia*" (SCENIHR, 2015, p. 161). More recently, SHEER (2024) reviewed the studies by the Ramazzini Institute that reported interactions between magnetic fields and exposure to ionizing radiation (Soffritti et al., 2015, 2016a) and formaldehyde (Soffritti et al., 2016b), but criticized the results because of "*missing*" and "*selective*" tumor data. SCHEER also cited criticisms of these studies by the Swedish Radiation Safety Authority (Swedish Radiation Safety Authority (SSM), 2018, 2019).

Magnetic-field effects on *in vivo* cellular processes potentially relevant to cancer

Some experimental studies reviewed by the WHO reported an increase in genotoxic effects among exposed animals (e.g., DNA strand breaks in the brains of mice [Lai and Singh, 2004]), although the results have not been replicated (e.g., McNamee et al., 2005). More recent studies in which animals were exposed to higher levels of magnetic fields for longer exposure periods reported no increase in damage to DNA (Korr et al., 2014; Saha et al., 2014).

Alcaraz et al. (2014) reported an increase in micronuclei in erythrocytes of mice following exposure to a 2,000 mG, 50-Hz magnetic field, which had not been reported by others at lower levels of magnetic fields. Wilson et al. (2015) reported that magnetic fields up to 3,000 mG did not increase mutations in blood cells of mice or a dose-related increase in testes. A follow up study reported magnetic fields exposure before and after exposure to 100 mGy X-rays did not increase the amount of DNA breaks or have an effect on the repair of DNA damage (Woodbine et al., 2015).

Scientists are constantly investigating indicators of biological processes that might lead to DNA damage, including short-term effects on indicators of oxidation in tissues. Some investigators have reported some effects of magnetic fields on indicators of oxidative stress at very high levels of 80,000 to 200,000 mG (e.g., Li et al., 2015; Luo et al., 2016). Effects at lower, but still high levels (1,000 mG), are inconsistent, and longer exposures do not result in greater responses (Akdag et al., 2013; Glinka et al., 2013; Hassan and Abdelkawi, 2014; Manikonda et al., 2014).

Magnetic- and electric-field treatments on tumor growth

Studies have investigated the therapeutic potential of magnetic-field and electric-field exposures in the treatment of experimentally-induced tumors in animals. One reported that following the injection of breast cancer cells and a 40,000 mG magnetic field alone, tumor volume declined (Yadamani et al., 2018). Two other studies involving injection of Ehrlich carcinoma tumor cells + a 50,000 mG magnetic field (Rageh et al., 2020) or Walker-256 carcinosarcoma cells + a 2 kV/m, 50-Hz electric field (Orel et al., 2021) reported greater reductions in tumor size with EMF + concurrent chemical treatment than only chemical treatment.

Occupational biomarker studies

In recent years a number of cross-sectional epidemiology studies have compared markers for DNA and oxidative stress in blood samples from workers at electric generating plants with higher and lower exposures to EMF (Bagheri Hosseinabadi et al., 2019, 2020, 2021; Zendehdel et al., 2019, 2020; Touitou et al., 2020). Besides the cross section design, which precludes drawing conclusions about cause and effect relationships,[10] the small number of participants and

[10] In a cross-sectional study, the investigators determine the study subjects' exposure and outcome status at the same time; thus, these types of studies are not suitable to draw any conclusion on a potential causal association.

multiple methodological limitations in these studies are problematic. None of the DNA analyses in these studies met the criteria required to confirm a clear positive response (OECD, 2015).

Recent *in vivo* studies of carcinogenesis (January 2022 through April 2024)

No new cancer bioassays or tumor promotion studies were identified in the most recent evaluation period. Moreover, experimental studies of EMF on cellular processes in living animals and humans potentially relevant to cancer were not identified either in this period.

Occupational biomarker studies

A single new cross-sectional epidemiology study by Vemula et al. (2023) met the criteria for inclusion in this section. Vemula et al. (2023) analyzed blood samples of 342 women working night shifts in hospitals and business call centers in Hyderabad State, India (i.e., the exposed group) and 150 women not in that work (i.e., the control group) with ages between 19 and 45. While the title, abstract, and text of the paper alleged that the women in the first group had exposure to EMF and light at night, they presented neither evidence for this allegation nor for the absence or reduced levels of these exposures in the work experience of the women in the control group. The age, diet, and history of recent infection were used as selection criteria. The participants provided self-assessed information about nonspecific "*subjective symptoms related to EMFs exposure*" including headaches, dizziness, and tinnitus, among others. The blood samples were analyzed for DNA damage by the alkaline comet assay, and micronuclei in buccal epithelial cells, which involved assessments by technicians using light microscopy. Melatonin, a neurohormone, was quantified by a radioimmunoassay and expression of RNA genes by real time polymerase chain reaction (RT-PCR). The study used the length of employment as an indicator of the duration of alleged exposure (121 women, 1-6 days; 114 women, 1-4 weeks; 107 women,1-6 months).

The mean levels of DNA damage, micronuclei, and gene expression were reported to be significantly greater in the exposed group than the control group; the levels of melatonin were significantly lower in the exposed group than the control group. However, within the exposed group of women, the duration of employment had no or very little effect on the parameters measured and these data were not subjected to statistical analysis. The authors did not indicate whether they asked the participants if they took melatonin supplements, which would affect measured levels of melatonin. Neither did the authors ask if participants chewed betel leaves or tobacco, or smoked tobacco, which would contribute to buccal cell DNA damage. Even though the authors assumed that EMF and light at night would reduce melatonin levels, they did not investigate the relationship between melatonin levels and DNA damage within individuals in their data. We do not know, for example, if participants with high levels of melatonin also had high levels of DNA damage or buccal cell micronuclei, or the reverse. The authors offered no interpretation or details of the RT-PCR testing. As the authors did not report coding of the samples prior to analysis, the analyses of DNA damage and buccal cell micronuclei were not conducted in a blinded fashion, so were potentially susceptible to expectation bias. Overall, the

authors stated that "*[o]ur results warrant more epidemiological studies considering the confounding factors*." In addition, the design and methodological inadequacies of this study allowed confounding factors to prevent any clear interpretation of the results presented.

Assessment

Overall, the single *in vivo* study of EMF published since the last update does not alter the WHO's conclusion that the overall evidence from *in vivo* studies does not support the role of EMF exposure in either direct or indirect genotoxic effects arising from oxidative stress. The literature continues to show that there is inadequate evidence to suggest carcinogenic effects in animals or humans due to EMF exposure. This assessment is consistent with SHEER (2023), which states, "*[i]n conclusion, there is weak evidence regarding the involvement of interaction mechanisms (oxidative stress, genetic/epigenetic effects) on health risks from ELF-MF observed in epidemiological and in vivo studies*" (p. 19). The poor quality of the new study reviewed and of most previous studies, however, leaves much to be improved, so the recommendation that "*further studies on mechanisms and biological data from childhood leukemia experimental models are recommended*" is appropriate (ICNIRP, 2020, p. 535).

5 Standards and Guidelines

Following a thorough review of the research, scientific agencies establish exposure standards to protect against recognized health effects. The primary objective of a weight-of-evidence review is to identify the lowest exposure level below which no health hazards have been found (i.e., a threshold). Exposure limits or guidelines are then set well below the threshold level to account for any individual variability or sensitivities that may exist.

Several scientific organizations have published guidelines for exposure to ELF EMF based on acute health effects that can occur at very high field levels; guidelines for magnetic field exposures for workers and the general public are presented in Table 3. ICNIRP reviewed the epidemiologic and experimental evidence and concluded that there was insufficient evidence to warrant the development of standards or guidelines on the basis of hypothesized long-term adverse health effects such as cancer; rather, the guidelines put forth in their 2010 document set limits to protect against acute health effects (i.e., the stimulation of nerves and muscles) that occur at much higher field levels. ICNIRP recommends a residential screening value of 2,000 mG and an occupational exposure screening value of 10,000 mG (ICNIRP, 2010). If exposure exceeds these screening values, then additional dosimetry evaluations are needed to determine whether basic restrictions on induced internal electric field densities are exceeded. For reference, in a national survey conducted by Zaffanella and Kalton (1998) for the NIEHS's EMF Research and Public Information Dissemination program, only about 1.6% of the general public in the United States experienced exposure to magnetic fields of at least 1,000 mG during a 24-hour period.

The International Committee on Electromagnetic Safety (ICES) also recommends limiting high levels of magnetic-fields because of the risk of acute effects, although their guidelines are higher than ICNIRP's guidelines. ICES recommends a residential exposure limit (i.e., exposure reference level) of 9,040 mG and an occupational exposure limit of 27,100 mG for 60-Hz magnetic fields (ICES, 2019, 2020). Both guidelines incorporate large safety factors.

Table 3. Screening guidelines for Magnetic Field exposure

Organization	Exposure (60 Hz)	Magnetic field guideline
ICNIRP	Occupational	10,000 mG
	General Public	2,000 mG
ICES	Occupational	27,100 mG
	General Public	9,040 mG

Source: ICNIRP, 2010; ICES, 2019, 2020.

The ICNIRP and ICES guidelines provide guidance to national agencies and only become legally binding if a country adopts them into legislation. The WHO recommends that member countries

adopt the ICNIRP or IEEE ICES guidelines or use a scientifically sound framework for formulating any new guidelines (WHO, 2007a, 2007b).

There are no national or state standards in the United States limiting exposure to ELF EMF based on health effects. The State of Rhode Island also has not implemented any standards or guidelines related to ELF EMF. While both Florida and New York have enacted standards to limit magnetic fields at the edge of transmission line rights-of-way, these limits were not based on health considerations, but are to maintain the status quo so fields from new transmission lines are no higher than those from existing transmission lines (NYPSC, 1978, 1990; FDEP, 1989, 1996).

6 Summary

Over the past few decades, a number of national and international scientific organizations have published reports or scientific statements with regard to the possible health effects of ELF EMF. These include weight-of-evidence reviews published by SCENIHR in 2015 and the WHO in 2007. The conclusions of these reports are generally consistent; none of these agencies have concluded that exposure to ELF EMF at the levels we encounter in our everyday environment cause or contribute to adverse health effects. The current guidance from the WHO on its website states that "*[d]espite extensive research, to date there is no evidence to conclude that exposure to low level electromagnetic fields is harmful to human health*" (WHO, 2016).

Recent studies published on ELF EMF and health have not provided sufficient evidence to alter these basic conclusions of SCENIHR, the WHO, and other agencies. The weak statistical association between high, average magnetic fields and childhood leukemia reported in two pooled analyses in 2000 (Ahlbom et al., 2000; Greenland et al., 2000) has not been appreciably strengthened by subsequent research. To the contrary, the strength of the association has diminished over time, which is consistent with the findings of SCHEER in their most recent 2024 report, which concluded that "*overall, there is weak evidence concerning the association of ELF-MF [magnetic field] exposure with childhood leukaemia*" (SCHEER, 2024, p. 2). The previously reported association in some studies remains unexplained and unsupported by experimental studies. The recent *in vivo* experimental studies confirm the lack of experimental data for genotoxic effects of ELF EMF that would support a leukemogenic or other cancer.

Research reviewed on other cancer and non-cancer outcomes provided no substantial new information to alter the previous conclusions that the evidence is inadequate to conclude that ELF EMF exposure is harmful at typical environmental levels. While the large body of existing research does not confirm any likely harm associated with ELF EMF exposure at low levels, research on this topic likely will continue to reduce remaining uncertainty.

In conclusion, when recent studies are considered in the context of previous research, they do not provide evidence to alter the conclusion that ELF EMF exposure at the levels we encounter in our everyday environment is not a cause of cancer or any other disease process.

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APPENDIX B

Woonsocket Substation – Nasonville Substation
115 kV Transmission Line
Rhode Island Energy Facility Siting Board
Siting Report

AGENCY CORRESPONDENCE & PUBLIC OUTREACH

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New England Ecological Services Field Office
70 Commercial Street, Suite 300
Concord, NH 03301-5094
Phone: (603) 223-2541 Fax: (603) 223-0104

In Reply Refer To: 10/18/2024 12:38:02 UTC
Project code: 2025-0007919
Project Name: Nasonville - Woonsocket B23 and U181 Lines

Federal Action Agency (if applicable): Army Corps of Engineers

Subject: Record of project representative's no effect determination for 'Nasonville - Woonsocket B23 and U181 Lines'

Dear Alison Milliman:

This letter records your determination using the Information for Planning and Consultation (IPaC) system provided to the U.S. Fish and Wildlife Service (Service) on October 18, 2024, for 'Nasonville - Woonsocket B23 and U181 Lines' (here forward, Project). This project has been assigned Project Code 2025-0007919 and all future correspondence should clearly reference this number. **Please carefully review this letter.**

Ensuring Accurate Determinations When Using IPaC

The Service developed the IPaC system and associated species' determination keys in accordance with the Endangered Species Act of 1973 (ESA; 87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.) and based on a standing analysis. All information submitted by the Project proponent into IPaC must accurately represent the full scope and details of the Project.

Failure to accurately represent or implement the Project as detailed in IPaC or the Northern Long-eared Bat Rangewide Determination Key (Dkey), invalidates this letter. ***Answers to certain questions in the DKey commit the project proponent to implementation of conservation measures that must be followed for the ESA determination to remain valid.***

Determination for the Northern Long-Eared Bat

Based upon your IPaC submission and a standing analysis, your project has reached the determination of "No Effect" on the northern long-eared bat. To make a no effect determination, the full scope of the proposed project implementation (action) should not have any effects (either positive or negative), to a federally listed species or designated critical habitat. Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed

action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. (See § 402.17).

Under Section 7 of the ESA, if a federal action agency makes a no effect determination, no consultation with the Service is required (ESA §7). If a proposed Federal action may affect a listed species or designated critical habitat, formal consultation is required except when the Service concurs, in writing, that a proposed action "is not likely to adversely affect" listed species or designated critical habitat [50 CFR §402.02, 50 CFR§402.13].

Other Species and Critical Habitat that May be Present in the Action Area

The IPaC-assisted determination for the northern long-eared bat does not apply to the following ESA-protected species and/or critical habitat that also may occur in your Action area:

- Monarch Butterfly *Danaus plexippus* Candidate
- Tricolored Bat *Perimyotis subflavus* Proposed Endangered

You may coordinate with our Office to determine whether the Action may affect the animal species listed above and, if so, how they may be affected.

Next Steps

Based upon your IPaC submission, your project has reached the determination of “No Effect” on the northern long-eared bat. If there are no updates on listed species, no further consultation/ coordination for this project is required with respect to the northern long-eared bat. However, the Service recommends that project proponents re-evaluate the Project in IPaC if: 1) the scope, timing, duration, or location of the Project changes (includes any project changes or amendments); 2) new information reveals the Project may impact (positively or negatively) federally listed species or designated critical habitat; or 3) a new species is listed, or critical habitat designated. If any of the above conditions occurs, additional coordination with the Service should take place to ensure compliance with the Act.

If you have any questions regarding this letter or need further assistance, please contact the New England Ecological Services Field Office and reference Project Code 2025-0007919 associated with this Project.

Action Description
You provided to IPaC the following name and description for the subject Action.

1. Name

Nasonville - Woonsocket B23 and U181 Lines

2. Description

The following description was provided for the project 'Nasonville - Woonsocket B23 and U181 Lines':

> Rebuild of the existing B23 Transmission Line and Installation of new U181 Transmission Line

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@41.97006725,-71.54030831033093,14z

DETERMINATION KEY RESULT

Based on the information you provided, you have determined that the Proposed Action will have no effect on the Endangered northern long-eared bat (Myotis septentrionalis). Therefore, no consultation with the U.S. Fish and Wildlife Service pursuant to Section 7(a)(2) of the Endangered Species Act of 1973 (87 Stat. 884, as amended 16 U.S.C. 1531 *et seq.*) is required for those species.

QUALIFICATION INTERVIEW

1. Does the proposed project include, or is it reasonably certain to cause, intentional take of the northern long-eared bat or any other listed species?

   Note: Intentional take is defined as take that is the intended result of a project. Intentional take could refer to research, direct species management, surveys, and/or studies that include intentional handling/encountering, harassment, collection, or capturing of any individual of a federally listed threatened, endangered or proposed species?

   No

2. The proposed action does not intersect an area where the northern long-eared bat is likely to occur, based on the information available to U.S. Fish and Wildlife Service as of the most recent update of this key. If you have data that indicates that northern long-eared bats are likely to be present in the action area, answer "NO" and continue through the key.

   Do you want to make a no effect determination?

   Yes

PROJECT QUESTIONNAIRE

IPAC USER CONTACT INFORMATION

Agency: BSC Group
Name: Alison Milliman
Address: 1 Mercantile Street Suite 610
City: Worcester
State: MA
Zip: 01608
Email amilliman@bscgroup.com
Phone: 6178964532

LEAD AGENCY CONTACT INFORMATION

Lead Agency: Army Corps of Engineers

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New England Ecological Services Field Office
70 Commercial Street, Suite 300
Concord, NH 03301-5094
Phone: (603) 223-2541 Fax: (603) 223-0104

In Reply Refer To: 10/18/2024 12:36:47 UTC
Project Code: 2025-0007919
Project Name: Nasonville - Woonsocket B23 and U181 Lines

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

Updated 4/12/2023 - Please review this letter each time you request an Official Species List, we will continue to update it with additional information and links to websites may change.

About Official Species Lists

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Federal and non-Federal project proponents have responsibilities under the Act to consider effects on listed species.

The enclosed species list identifies threatened, endangered, proposed, and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. The Service recommends that verification be completed by visiting the IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested by returning to an existing project's page in IPaC.

Endangered Species Act Project Review

Please visit the "**New England Field Office Endangered Species Project Review and Consultation**" website for step-by-step instructions on how to consider effects on listed

species and prepare and submit a project review package if necessary:

https://www.fws.gov/office/new-england-ecological-services/endangered-species-project-review

NOTE Please do not use the **Consultation Package Builder** tool in IPaC except in specific situations following coordination with our office. Please follow the project review guidance on our website instead and reference your **Project Code** in all correspondence.

Northern Long-eared Bat - (**Updated 4/12/2023**) The Service published a final rule to reclassify the northern long-eared bat (NLEB) as endangered on November 30, 2022. The final rule went into effect on March 31, 2023. You may utilize the **Northern Long-eared Bat Rangewide Determination Key** available in IPaC. More information about this Determination Key and the Interim Consultation Framework are available on the northern long-eared bat species page:

https://www.fws.gov/species/northern-long-eared-bat-myotis-septentrionalis

For projects that previously utilized the 4(d) Determination Key, the change in the species' status may trigger the need to re-initiate consultation for any actions that are not completed and for which the Federal action agency retains discretion once the new listing determination becomes effective. If your project was not completed by March 31, 2023, and may result in incidental take of NLEB, please reach out to our office at newengland@fws.gov to see if reinitiation is necessary.

Additional Info About Section 7 of the Act
Under section 7(a)(2) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to determine whether projects may affect threatened and endangered species and/or designated critical habitat. If a Federal agency, or its non-Federal representative, determines that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Federal agency also may need to consider proposed species and proposed critical habitat in the consultation. 50 CFR 402.14(c)(1) specifies the information required for consultation under the Act regardless of the format of the evaluation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

https://www.fws.gov/service/section-7-consultations

In addition to consultation requirements under Section 7(a)(2) of the ESA, please note that under sections 7(a)(1) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species. Please contact NEFO if you would like more information.

Candidate species that appear on the enclosed species list have no current protections under the ESA. The species' occurrence on an official species list does not convey a requirement to

consider impacts to this species as you would a proposed, threatened, or endangered species. The ESA does not provide for interagency consultations on candidate species under section 7, however, the Service recommends that all project proponents incorporate measures into projects to benefit candidate species and their habitats wherever possible.

Migratory Birds

In addition to responsibilities to protect threatened and endangered species under the Endangered Species Act (ESA), there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts see:

https://www.fws.gov/program/migratory-bird-permit

https://www.fws.gov/library/collections/bald-and-golden-eagle-management

Please feel free to contact us at **newengland@fws.gov** with your **Project Code** in the subject line if you need more information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat.

Attachment(s): Official Species List

Attachment(s):

- Official Species List

OFFICIAL SPECIES LIST

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

New England Ecological Services Field Office
70 Commercial Street, Suite 300
Concord, NH 03301-5094
(603) 223-2541

PROJECT SUMMARY

Project Code: 2025-0007919
Project Name: Nasonville - Woonsocket B23 and U181 Lines
Project Type: Transmission Line - Maintenance/Modification - Above Ground
Project Description: Rebuild of the existing B23 Transmission Line and Installation of new U181 Transmission Line
Project Location:

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@41.97006725,-71.54030831033093,14z

Counties: Providence County, Rhode Island

ENDANGERED SPECIES ACT SPECIES

There is a total of 3 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

MAMMALS

NAME	STATUS
Northern Long-eared Bat *Myotis septentrionalis* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9045	Endangered
Tricolored Bat *Perimyotis subflavus* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/10515	Proposed Endangered

INSECTS

NAME	STATUS
Monarch Butterfly *Danaus plexippus* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9743	Candidate

CRITICAL HABITATS

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

YOU ARE STILL REQUIRED TO DETERMINE IF YOUR PROJECT(S) MAY HAVE EFFECTS ON ALL ABOVE LISTED SPECIES.

IPAC USER CONTACT INFORMATION

Agency: BSC Group
Name: Alison Milliman
Address: 1 Mercantile Street Suite 610
City: Worcester
State: MA
Zip: 01608
Email amilliman@bscgroup.com
Phone: 6178964532

Catherine Colliton

From: Jordan, Paul (DEM) <paul.jordan@dem.ri.gov>
Sent: Thursday, May 2, 2024 10:27 AM
To: Alison Milliman
Cc: MRSmith1
Subject: RE: The Narragansett Electric Company - Request for DEM Natural Heritage Data
Attachments: WoonsocketSub_HeritageData.shp.zip

Thanks Allison. Shapefile attached.
PJ

Paul Jordan
Data Analyst II / GIS Administrator / LWCF ASLO
Rhode Island Department of Environmental Management
Division of Planning & Development
235 Promenade Street, Providence, RI 02908
401.537.4497 paul.jordan@dem.ri.gov

From: Alison Milliman <AMilliman@bscgroup.com>
Sent: Thursday, May 2, 2024 10:14 AM
To: Jordan, Paul (DEM) <paul.jordan@dem.ri.gov>
Cc: MRSmith1 <MRSmith1@RIEnergy.com>
Subject: RE: The Narragansett Electric Company - Request for DEM Natural Heritage Data

Sorry about that! Thank you,

Alison

Alison Milliman, CPESC (she, her)
Sr. Project Manager

1 Mercantile Street, Suite 610 / Worcester, MA 01608
O: 508-792-4500 / D: 617-896-4532 / C: 401-742-0487
amilliman@bscgroup.com
www.bscgroup.com [bscgroup.com]

BSC GROUP

From: Jordan, Paul (DEM) <paul.jordan@dem.ri.gov>
Sent: Thursday, May 2, 2024 10:10 AM
To: Alison Milliman <AMilliman@bscgroup.com>

Cc: MRSmith1 <MRSmith1@RIEnergy.com>
Subject: RE: The Narragansett Electric Company - Request for DEM Natural Heritage Data

Hi Allison – there's a problem with the shapefile. The .shx file is missing.

Paul Jordan
Data Analyst II / GIS Administrator / LWCF ASLO
Rhode Island Department of Environmental Management
Division of Planning & Development
235 Promenade Street, Providence, RI 02908
401.537.4497 paul.jordan@dem.ri.gov

From: Alison Milliman <AMilliman@bscgroup.com>
Sent: Thursday, May 2, 2024 9:43 AM
To: Jordan, Paul (DEM) <paul.jordan@dem.ri.gov>
Cc: MRSmith1 <MRSmith1@RIEnergy.com>
Subject: The Narragansett Electric Company - Request for DEM Natural Heritage Data

Hi Paul,

Please find attached a shapefile of the area of an upcoming transmission line maintenance project that crosses Natural Heritage Area. We would like to request the data in order to complete the field surveys for avoidance measures please?

Please let me know if you have any questions/ need anything else.

Thank you,

Alison

Alison Milliman, CPESC (she, her)
Sr. Project Manager

1 Mercantile Street, Suite 610 / Worcester, MA 01608
O: 508-792-4500 / D: 617-896-4532 / C: 401-742-0487
amilliman@bscgroup.com
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BSC GROUP

Via Email

Public Archaeology Laboratory

December 18, 2024

Jeffery Emidy
Executive Director and State Historic Preservation Officer
Rhode Island Historical Preservation & Heritage Commission
Old Colony House, 150 Benefit Street
Providence, Rhode Island 02903

Attn.: Elizabeth Totten, Review & Compliance Coordinator

Re: TNEC, Nasonville to Woonsocket Upgrades Project – Burrillville & North Smithfield, RI
Historic Architectural Reconnaissance Survey and Effects Assessment
PAL #4704

Dear Mr. Emidy:

As you are aware, The Narragansett Electric Company (TNEC) is planning to install a new 115kV electric transmission line within the existing Line B23 right-of-way (ROW) between the Nasonville and Woonsocket substations in Burrillville and North Smithfield, Rhode Island. The Public Archaeology Laboratory, Inc. (PAL) prepared the enclosed documentation to facilitate consultation with the Rhode Island Historical Preservation & Heritage Commission (RIHPHC) with the U.S. Army Corps of Engineers (USACE) regarding the Project's potential to affect aboveground historic architectural properties. Please find enclosed the following documentation for your review:

- *Historic Architectural Reconnaissance Survey & Effects Assessment, TNEC Nasonville Substation to Woonsocket Substation Upgrade Project, Burrillville & North Smithfield, Rhode Island – September 2024.*

Thank you for your time and attention to this matter. If you have any questions or require additional information, please do not hesitate to contact Elizabeth Warburton, Senior Architectural Historian, or me, at your convenience.

Sincerely,

Gregory R. Dubell, RPA
Energy Projects Manager

Enclosure

cc: Marc Smith, TNEC (w/encl. – via email)
Amy Willoughby, TNEC (w/encl. – via email)
Alison Milliman, BSC Group (w/encl. – via email)
Kathleen Tucker, U.S. Army Corps of Engineers (w/encl. – via email)
Nathan Dubinin, U.S. Army Corps of Engineers (w/encl. – via email)

Via email

Public Archaeology Laboratory

July 23, 2024

Jeffery Emidy
Executive Director
State Historic Preservation Officer
Rhode Island Historical Preservation & Heritage Commission
1 Capitol Hill, 2nd Floor
Providence, Rhode Island 02908

Re: The Narragansett Electric Company, Nasonville to Woonsocket Upgrades Project – Burrillville & North Smithfield, RI
Phase I Site Identification Archaeological Survey Permit Application
PAL #4704

Dear Mr. Emidy:

The Narragansett Electric Company (TNEC) is planning to install a new 115kV electric transmission line within the existing Line B23 right-of-way (ROW) between the Nasonville = and Woonsocket Substation in Burrillville and North Smithfield, Rhode Island. TNEC proposes to replace and maintain approximately 76 structures, improve grounding, and will likely require access road improvements. On behalf of TNEC, The Public Archaeology Laboratory, Inc. (PAL) completed a cultural resource due diligence for the proposed Project (see enclosed Cultural Resource Due Diligence).

Please find enclosed an application and the following scope of services for PAL to perform a Phase I archaeological site identification survey for the Project:

> *Scope of Services, Phase I Site Identification Archaeological Survey – The Narragansett Electric Company Nasonville to Woonsocket Upgrades Project, Burrillville and North Smithfield, Rhode Island – June 14, 2024*

Thank you for your time and attention to this matter. If you have any questions or require additional information, please do not hesitate to contact Joseph N. Waller, Jr., Principal Investigator, or Gregory R. Dubell, Senior Project Manager, at your convenience.

Sincerely,

Deborah C. Cox, RPA
President

26 Main Street Pawtucket, RI 02860 | 401.728.8780 Main | 401.728.8784 Fax
palinc.com

Enclosures

cc: Nicholas Spagnoletti, Rhode Island Energy (w/encl. – via email)
Marc Smith, Rhode Island Energy (w/encl. – via email)
Alison Milliman, BSC Group (w/encl. – via email)
Keith Goulet, U.S. Army Corps of Engineers (w/encl. – via email)
John Brown, III, Narragansett Indian Tribe (w/encl. – via email)
Cora Peirce, Narragansett Indian Tribe (w/encl.)
Mark Andrews, Narragansett Indian Tribe (w/encl.)
Bettina Washington, Wampanoag Tribe of Gay Head (Aquinnah) (w/encl. – via email)
David Weeden, Mashpee Wampanoag Tribe (w/encl. – via email)
Nakia Hendricks, Jr., Mashpee Wampanoag Tribe (w/encl. – via email)

APPENDIX C

Woonsocket Substation – Nasonville Substation
115 kV Transmission Line
Rhode Island Energy Facility Siting Board
Siting Report

VISUAL SIMULATIONS

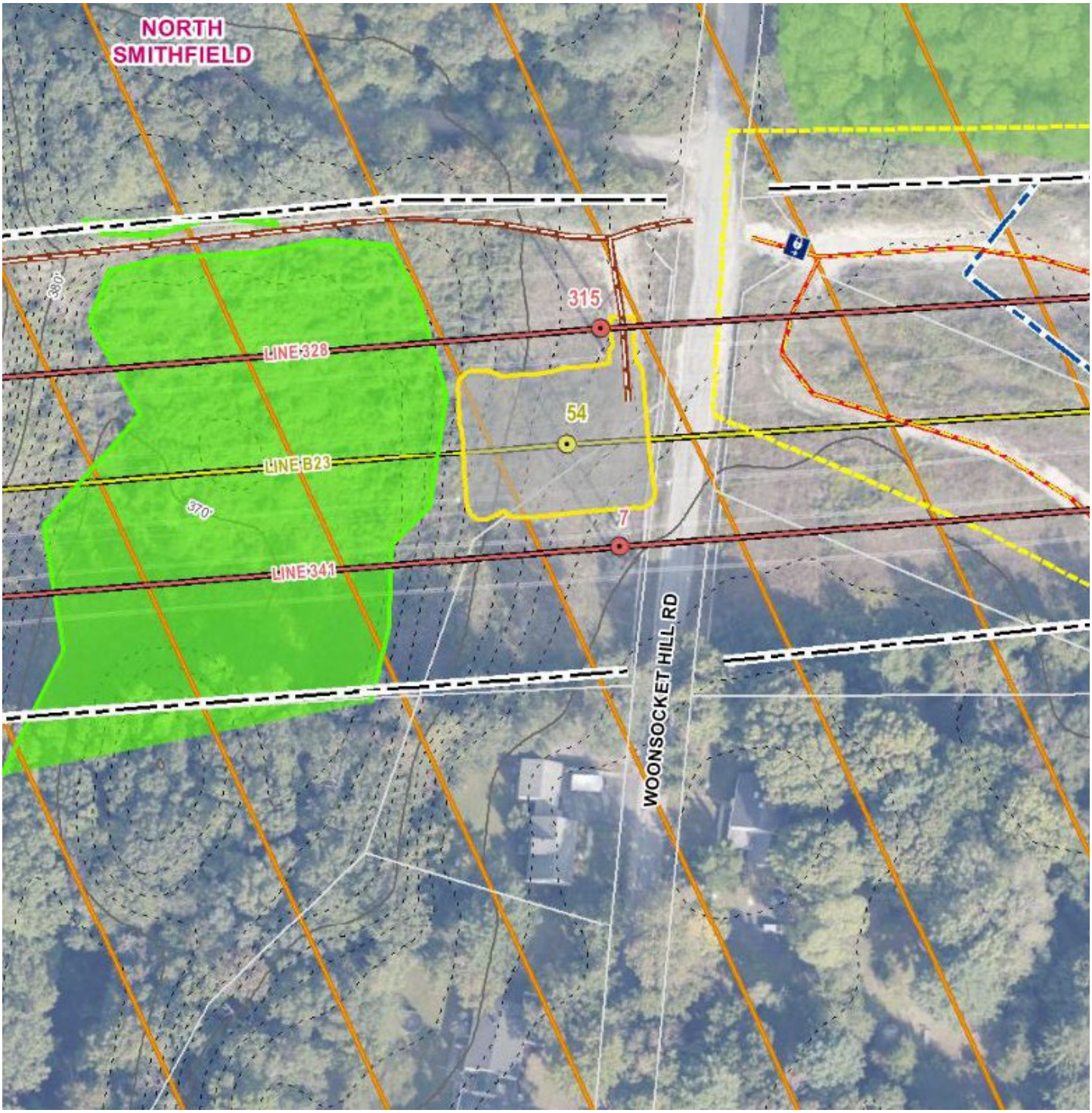

NORTH
SMITHFIELD
380'
315
LINE 328
54
LINE B23
370'
7
LINE 341
WOONSOCKET HILL RD

Photo #2: Existing conditions of 917 Woonsocket Hill Rd. in North Smithfield, RI.

Photo #2a: Visual sim of the proposed line 'B23', Structure 54 with weathered steel.

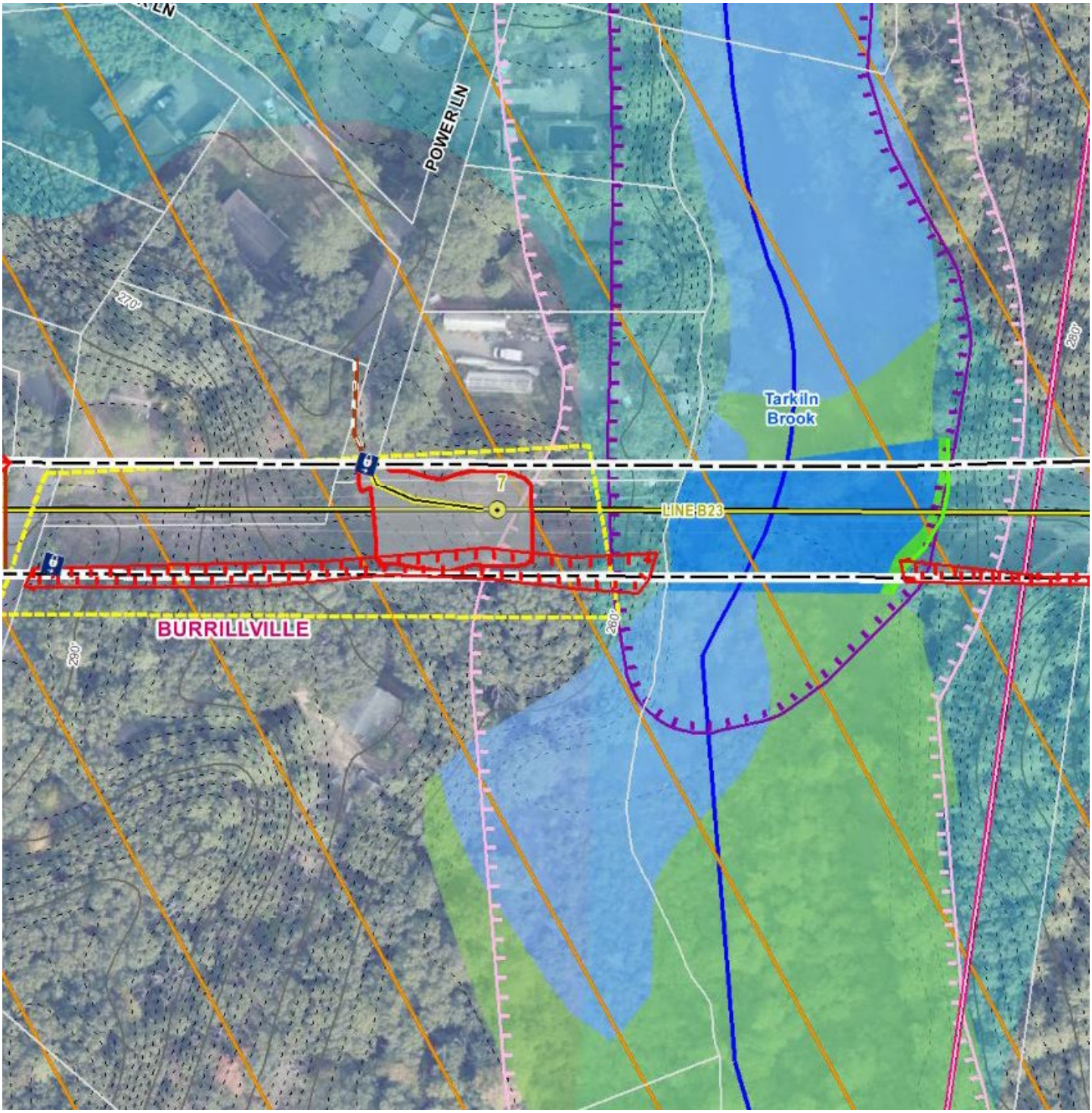

POWER LN
270'
Tarkiln
Brook
7
LINE B23
BURRILLVILLE
280'
230'

Photo #2: Existing conditions of 45 Power Ln. in Burrillville, RI.

Photo #2a: Visual sim of the proposed line 'B23', Structure 7 with weathered steel and and D-line, Structure Distro 12.

APPENDIX D

Woonsocket Substation – Nasonville Substation
115 kV Transmission Line
Rhode Island Energy Facility Siting Board
Siting Report

2022 NORTHWEST RHODE ISLAND STUDY

Northwest Rhode Island (NWRI) Area Study

Conor Rochford

Revision 1 - September 2022

Reviewed by: Ryan Constable Date: 9/12/2022

Ryan Constable, Manager
Distribution Planning & Asset Management, RI
Electric Operations

Approved by: Kathy Castro Date: 9/12/2022

Kathy Castro, Director
Asset Management & Engineering, RI Electric
Operations

Table of Contents **Pages**

LEGEND	
Al	Aluminum wire or cable
AMCB	Air Magnetic Circuit Breaker
ARP	Asset Replacement Program
Cal/cm^2	Calories/square centimeter
CAPEX	Capital expenditure (budget expenditure type)
CKAIDI	Circuit Average Interruption Duration Index
CKAIFI	Circuit Average Interruption Frequency Index
Cu	Copper wire or cable
CT	Current Transformer
DPG	Distribution Planning Guide rev 1, dated February 2011
EMS	Energy Management System
GIS	Geographic Information System
ISO	Independent System Operator
kV	Kilovolts
LTC	Load Tap Changer
MOV	Metal Oxide Varistor
MVA	Megavolt Ampere
MVAR	Megavolt Ampere Reactive
MW	Megawatts
MWh	Megawatt hour
NE	New England
NWA	Non-Wires Alternative
OPEX	Operations/Maintenance expenditure (budget expenditure type)
PT	Potential Transformer
RAPR	Remote Access Pulse Recorder
SAIFI	System Average Interruption Frequency Index
SAIDI	System Average Interruption Duration Index
SN	Summer Normal Rating of Equipment
SE	Summer Emergency Rating of Equipment
Spca	Spacer Cable
VCB	Vacuum Circuit Breaker

1. EXECUTIVE SUMMARY

A comprehensive study of the Northwest Rhode Island area was performed to identify existing and potential future distribution system performance concerns. System evaluation included comparison of equipment loading to thermal (capacity) limits, contingency response capability (Distribution Planning Criteria), voltage performance (ANSI A/B requirements), breaker operating capability, regulator operating capability, distribution arc flash review, reactive compensation performance, asset condition, safety, and environmental issues. The recommendations provide a comprehensive solution to address all the system performance concerns existing and anticipated in the study area through 2033.

The most significant issue in the study area is contingency load-at-risk due to loss of the transformer at Nasonville #127 substation.

An alternative analysis was conducted to determine the facilities necessary to address the identified issues providing best system performance at the least cost. The alternative analysis considered Non-Wire Alternatives (NWA) in addition to traditional wire solutions.

The results of the alternative analysis identified three main plans to address existing area problems and to provide for future needs within the study area through the year 2033. Each plan provides a comprehensive solution to address all capacity concerns in the study area. Some significant asset condition, reactive compensation, and reliability solutions that are independent of the main plans are also recommended.

The first main plan provides a new 115kV overhead supply line from [redacted] Substation to Nasonville Substation and expanding Nasonville #127 substation with a second transformer and a straight bus. This option eliminates any load at risk due to loss of the T271 transformer at Nasonville #127 substation. This option also adds up to four feeders significantly improving the system's ability to respond to a contingency on all four existing feeders out of the Nasonville #127 substation. Alternatives considered rebuilding Nasonville #127 substation and bringing a new (second) 115 kV overhead supply line from [redacted] Substations or a 34.5kV overhead supply line from new Iron Mine Hill Substation to Nasonville #127 substation. Non-wires alternatives were also considered.

The second significant plan recommendation is to rebuild Centredale #50 with two new modular 23kV/12.47kV transformers and two new 12.47 kV feeders and convert all three 4kV feeders to 12.47kV. The primary driver of this project is the asset condition issues at Centredale #50 substation, which include the 23kV transfer scheme equipment, 50F2 feeder recloser, regulators and two (501, 502) air-breaks. Centredale #50 substation also has worker clearance issues with the 50F2 voltage regulators.

The third plan recommendation is to replace 451 and 452 Motor Operated Air breaks (MOABs) and control cabinet at West Greenville #45 substation. The primary driver of this project is the asset condition issues at West Greenville #45 substation.

Various other recommendations of smaller scale are also made to resolve issues identified from the complete area system evaluation.

The spending by fiscal year for all study recommendations is shown in Table 1.1 below.

TABLE 1.1: Cost Summary for all Northwest Rhode Island Area Study Plans

Spend ($M)	FY24	FY25	FY26	FY27	FY28	FY29	FY30	Total
CapEx	$7.0	$5.4	$7.5	$10.5	$19.7	$9.6	$4.8	$64.6
OpEx	$0.1	$0.1	$0.0	$0.0	$0.2	$0.5	$0.0	$0.9
Removal	$0.7	$0.4	$0.3	$0.1	$0.7	$1.6	$0.0	$3.6
Total	**$7.7**	**$5.8**	**$7.8**	**$10.6**	**$20.6**	**$11.7**	**$4.8**	**$69.2**

2. INTRODUCTION

2.1 Purpose

A comprehensive study of the Northwest Rhode Island Area Study was performed to identify existing and potential future distribution system performance concerns. System evaluation included comparison of equipment loading to thermal (capacity) limits, contingency response capability (Distribution Planning Criteria), voltage performance (ANSI A/B), breaker operating capability, regulator operating capability, distribution arc flash review, reactive compensation performance, asset condition, and safety and environmental issues. The recommendations provide a comprehensive solution to address all the system performance concerns existing and anticipated in the study area through 2033.

2.2 Problem

An initial system assessment based on the Annual Planning process and substation Asset Condition Reports revealed a variety of issues in the Northwest Rhode Island (NWRI) Area Study. Consultation with Operations personnel to review asset information was also conducted.

3. BACKGROUND

3.1 Scope

3.1.1 Geographic Scope

The Northwest Rhode Island study area consists of the towns of Burrillville, North Smithfield Smithfield, Glocester, Scituate, Foster, a portion of Johnston. The study area is bounded by Massachusetts towns North Attleboro and Plainville to the east and Wrentham, Bellingham, Blackstone, Millville, and Uxbridge to the North. The study area borders Pascoag Utility District to the northwest. Connecticut towns Putnam, Killingly, and Sterling bound the study area on the west. The Central RI West and Central RI East study areas bound the study area to the south. The Providence and Blackstone Valley South study areas bound the study area to the east.
The study area is shown geographically in Appendix 7.1.

3.1.2 Electrical Scope

Four 115kV transmission lines and four 23kV sub-transmission lines supply the ten substations in the area. The substation supply and nominal voltage are as follows:

- Centredale #50 (23/12.47kV, 23/4.16kV); supplied by 2219 or 2211
- Chopmist #34 (115/23kV, 23/13kV); supplied by 2227 or 2221
- Farnum #105 (115/23kV); supplied by H-17
- Farnum Pike #23 (115/12.47kV); supplied by [redacted]
- Nasonville #127 (115/13.8kV); supplied by B-23
- Manton #69 (23/12.47kV); supplied by 2211
- Putnam Pike #38 (115/12.47kV); supplied by [redacted]
- West Greenville #45 (23/12.47kV); supplied by 2227 or 2221
- Wolf Hill #19 (115/23kV); supplied by [redacted]
- [redacted]

These substations are the source of 33 distribution feeders in the area that covers about 11% of RI's load and serve approximately 40,000 customers (about 200MW). One-line diagrams of the transmission system, sub-transmission system, and eight substations in the study area can be found in Appendix 7.2.

3.2 Area Load and Load Forecast

The study area is summer peaking and summer limited, during which the peak electrical demand is approximately 287MVA. This study used the 2019 forecast developed by National Grid, the "2019 New England Electric Peak Forecast". It utilized the 95/5 extreme weather scenario case after Distributed Energy Resource Impacts. This includes forecast impacts from distributed generation, energy efficiency, demand response, electric vehicles, and heating electrification. Table 3.1 shows the forecasted load growth rate for the study area from 2019 to 2033

TABLE 3.1 – Forecasted Load Growth Rate from 2019 to 2033 for Study Area

Blackstone Valley North

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
8.2%	0.1%	0.0%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%

North Central RI

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
7.2%	-0.7%	-0.7%	-0.5%	-0.5%	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%

The average growth rate for Blackstone Valley North area through 2033 is 0.6% and for North Central RI area is 0.1%.

Distributed Generation (DG)

The impacts of existing DGs are included in the load readings and used as the foundation for analysis. There are existing records of large photovoltaic sites (>500kW) in the study area. Currently there is about 22.2MW of connected DGs in the study area and about 97MW proposed DGs in queue.

TABLE 3.2 – Connected & Proposed Distributed Generation

Substation	Connected (MW)	Proposed (MW)	Proposed DG Under Study (MW)
Farnum Pike	2.78	12.64	8
Nasonville	2.83	29.27	9.5
[redacted]	8.64	31.31	13.7
Chopmist	6.24	11.81	
Putnam Pike	1.7	12.28	11.8
West Greenville			
Centredale			
Manton			
Farnum			
Total	**22.19**	**97.31**	

The study considered the existing 22.19MW of Distributed Generation during analysis. Pending DG was not included in the analysis because the forecast already included DG reductions.

3.3 Active Projects

No currently active projects were identified.

3.4 Other Studies in Progress

The following studies were being conducted in parallel to this area study for load or DG interconnection. The interconnection study recommendations were not considered in this area study due to the uncertainty of completion. However, the area study was conducted to avoid impacts to the interconnection studies. If area study recommendations would also benefit the interconnection customer, or vice versa, appropriate cost allocation method would be developed. For such a case, the Company will explore opportunities to coordinate the timing of the system related work with the interconnection work to maximize efficiencies.

- Iron Mine Hill PV – Four applications totaling 44MW

3.5 Limitations on Infrastructure Development

No significant limitations on infrastructure development were identified prior to plan development.

3.6 Assumptions & Guidelines

The current Distribution Planning Guide rev 1, February 2011 (“DPG”) was used when performing this study. The guide describes the normal and contingency analysis, as well as considerations for safety, the environment, reliability, reactive compensation, load balance, voltage, and efficiency. This guide was adopted by RI Energy from National Grid for use in distribution planning studies.

Arc Flash Information Tables were developed to supplement EOP G035 - Arc Flash Awareness and Mitigation and assist in the selection of appropriate personal protection equipment (PPE) for

compliance with OSHA regulations at 29 CFR 1910.269 and 1926 Subpart V. The incident energy and recommended work method in the information tables were assessed to determine if solutions were necessary through the area study.

The Distribution Planning department uses the Siemens PTI PSS/e loadflow program to analyze the transmission and sub-transmission system. This is the same program that is used by ISO NE and Rhode Island Energy's Transmission Planning department

The CYMdist 8.01 Revision 5.0 program was used to analyze radial three-phase unbalanced systems (distribution feeders). Databases are extracted from the GE-SmallWorld GIS System into a Microsoft Access format. The arc flash module of this program was used for relevant analysis.

The ASPEN program was used to determine short circuit duty values at all substations.

4. PROBLEM IDENTIFICATION

4.1 Thermal Loading

4.1.1 Normal Configuration – Thermal Loading

Table 4.1.1 below shows the projected normal feeder loading on the distribution system for the main limiting element of each circuit. The 2019 summer peak loads for all feeders, transformers and supply lines were taken as the starting point for all normal loading values. By the end of the study period (2033) one feeder (127W43) is forecasted to exceed their summer normal (SN) capacity and another two are forecasted to be loaded above 90% of SN rating. Loading of distribution line sections of each feeder were analyzed using the CYME software.

TABLE 4.1.1 - Projected Summer Normal Feeder Loading

Substation	ID	Feeder	19 % SN	33 % SN
CENTREDALE 50	T3	50F2	84%	79%
CHOPMIST 34	T1	34F1	85%	80%
CHOPMIST 34	T2	34F2	78%	74%
CHOPMIST 34	T3	34F3	61%	58%
FARNUM PIKE 23	T1	23F1	57%	53%
FARNUM PIKE 23		23F3	83%	78%
FARNUM PIKE 23		23F5	93%	87%
FARNUM PIKE 23	T2	23F2	41%	39%
FARNUM PIKE 23		23F4	21%	20%
FARNUM PIKE 23		23F6	77%	72%
MANTON 69	T1	69F1	88%	82%
MANTON 69		69F3	98%	92%
PUTNAM PIKE 38	T1	38F1	99%	93%
PUTNAM PIKE 38		38F3	44%	41%
PUTNAM PIKE 38		38F5	74%	72%
PUTNAM PIKE 38	T2	38F2	72%	67%
PUTNAM PIKE 38		38F4	82%	77%
PUTNAM PIKE 38		38F6	82%	77%
CENTREDALE 50	T1	50J1	60%	56%
CENTREDALE 50		50J3	64%	60%
FARNUM	T1	105K1	10%	10%
NASONVILLE	T271	127W40	63%	63%
NASONVILLE		127W41	18%	18%
NASONVILLE		127W42	78%	79%
NASONVILLE		127W43	101%	103%
[redacted]		26W1	44%	44%
		26W3	75%	75%
		26W5	58%	58%
		26W7	49%	49%
WEST GREENVILLE 4	T1	45F2	21%	20%

The CYME three phase load flow program was used to identify distribution feeder elements /sections that may be overloaded. Field checks were conducted as necessary to confirm equipment details.

Feeder Projected Overloads:

- Farnum Pike feeder 23F3 - approximately 0.3 miles of 1/0 ACCC 3-phase section on a mainline on Route 116 (see Figure 1)
- Putnam Pike feeder 38F3 – approximately 0.6 miles of 3-phase small conductor (4/0 AL) section on a main line on Sanderson Rd (see Figure 2).

Transformer Projected Overloads:

- None.

Supply Line Projected Overloads:

- None.

Figure 1 Farnum Pike 23F3 Overload

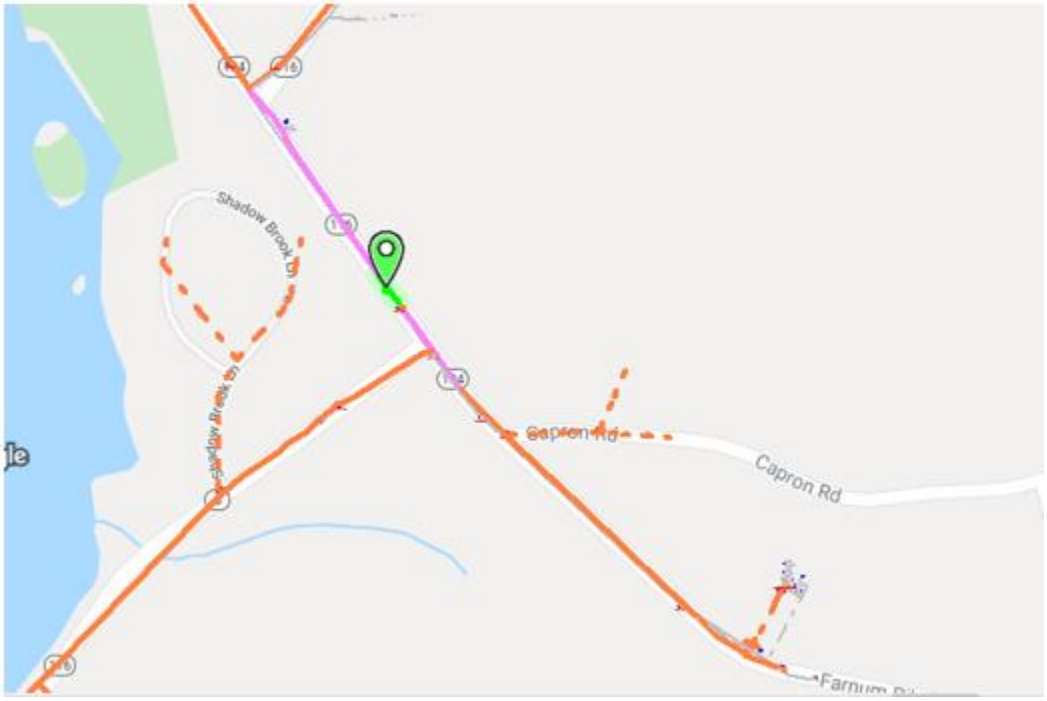
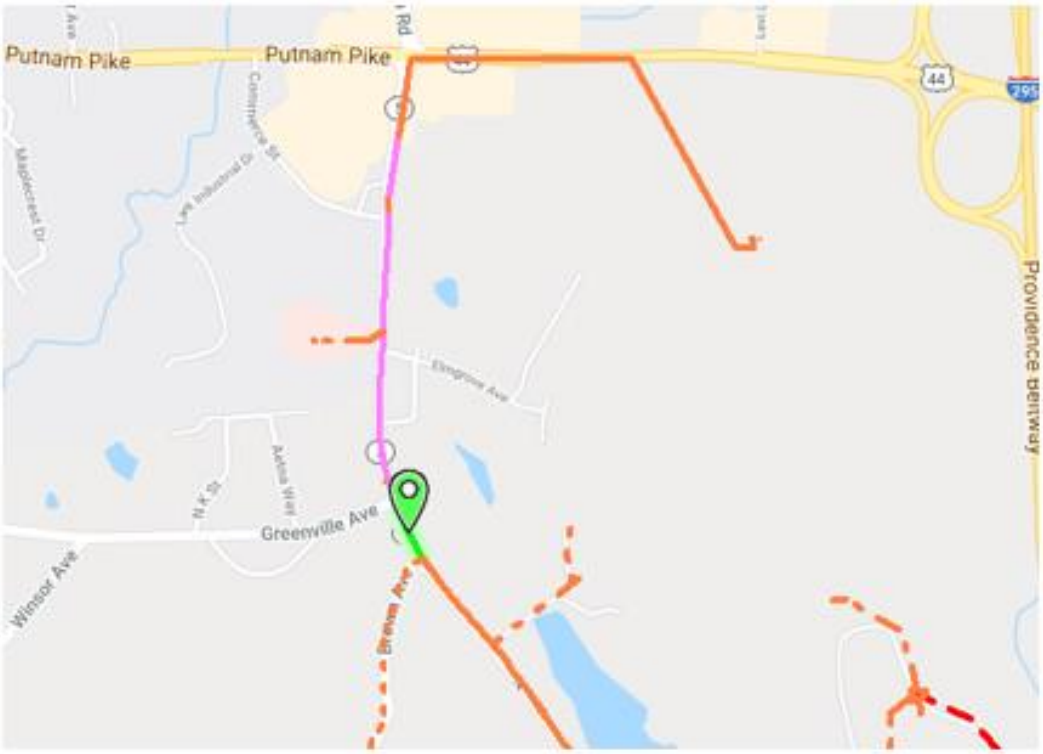


Figure 2 Putnam Pike 38F3 Overload



4.1.2 Contingency Configuration - Thermal Loading

A contingency analysis was performed for all transformers, supply lines and feeders in the study area. This analysis calculates the load-at-risk 'exposure' assuming a worst-case component failure. The assumptions made for this analysis include:

- A one-hour switching time to restore load up to emergency rating of neighboring feeders
- Overhead failed component can be repaired within four hours, a cable can be repaired within 12 hours, and a substation transformer can be replaced within 24 hours.
- The load-at-risk calculations utilize the summer emergency ratings of the equipment.

Feeder Load-at-Risk:

- 127W43 out of Nasonville substation – greater than 16MWhr of risk.

Transformer Load-at-Risk:

- Nasonville #127 T271 - greater than 240MWhr of risk.

Supply Line Load-at-Risk

- None.

4.2 Voltage Performance

The CYME program models all three phases of each distribution feeder for its entire length starting at the substation. ANSI A/B voltage ranges are used to identify issues. ANSI A range is used for normal configurations and considers a +/-5% voltage band around nominal voltage. This equates to service voltage of 126V to 114V on a 120V base. Secondaries and services are not modeled. Therefore, a 3V drop in the distribution transformer and customer secondary wire can be assumed.

The PSSE program models all sub-transmission line for its entire length starting at the substation.
Voltage performance was analyzed utilizing CYME and PSSE.

Feeder Voltage Results:

- Voltages predicted below the lower limit
  - West Greenville 45F2 - 3-phase mainline section (see Figure 3)
  - Chopmist 34F2 - 3-phase mainline section (see Figure 4)
  - Chopmist 34F3 – single phase step-down transformer area on Joe Sarle and Dexter Saunders Roads (see Figure 5)
- Voltages predicted above the higher limit
  - None

.

Transformer Voltage Results:

- Voltages predicted below the lower limit
  - None
- Voltages predicted above the higher limit
  - None

Supply Line Voltage Results:

- Voltages predicted below the lower limit
  - None
- Voltages predicted above the higher limit
  - None

Figures below show feeder location with low voltage areas highlighted in red.

Figure 3 West Greenville 45F2 Voltage Profile

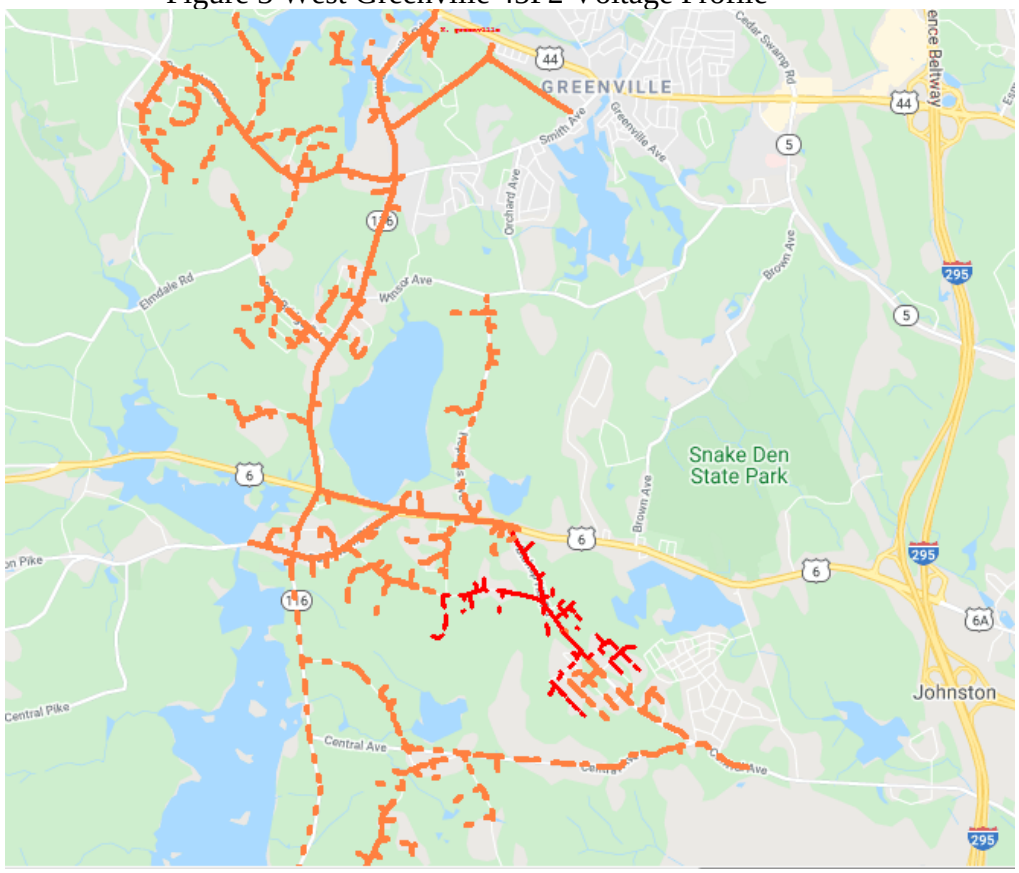


Figure 4 Chopmist 34F2 Voltage Profile

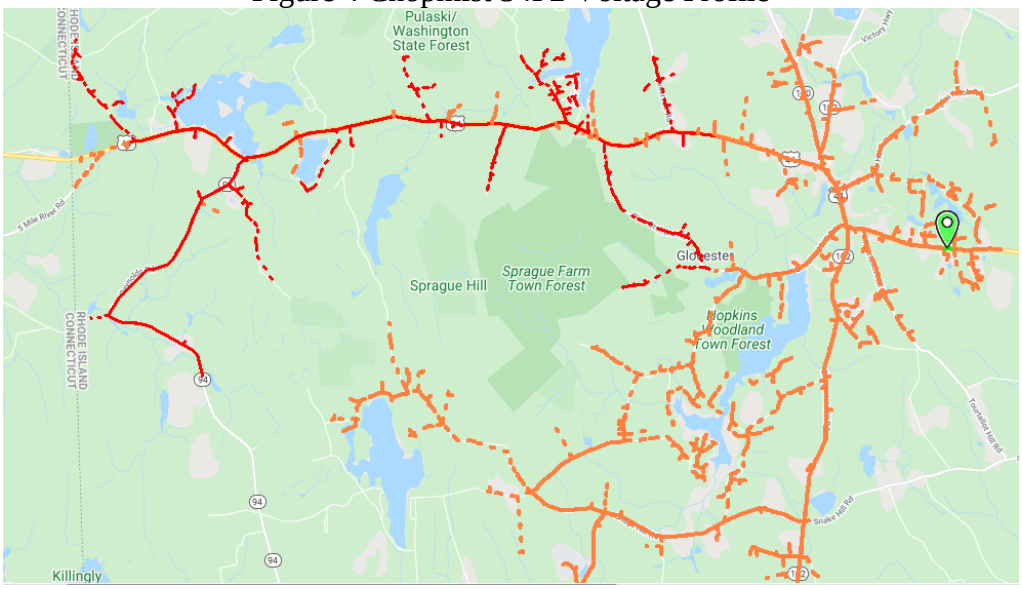
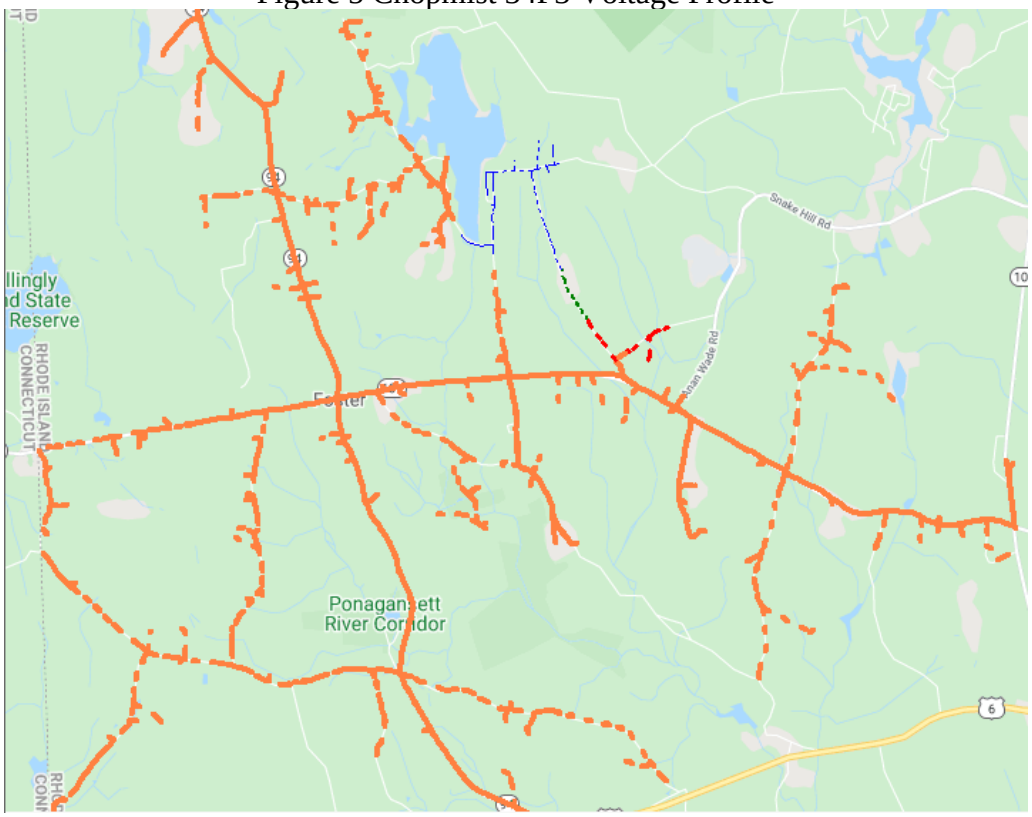


Figure 5 Chopmist 34F3 Voltage Profile



4.3 Asset Condition

In collaboration with Substation Operations, Substation Operations & Maintenance Services, Substation Engineering, and Asset Management a determination was made that the substations listed below require no significant asset condition work.

- Farnum #105
- Farnum Pike #23
- Nasonville #127
- Manton #69
- Putnam Pike #38
- Wolf Hill #19
- [redacted]

Asset condition assessments were reviewed for the following substations. One-line diagrams for all substations can be found in Appendix 7.2.

- Centredale #50
- West Greenville #45

All issues were validated with Substation Operations, Substation Operations & Maintenance Services, and Asset Management. Below is a comprehensive summary of updated issues that includes various consultations with study team members.

Centredale #50

- 23kV transfer scheme equipment
- 50F2 feeder recloser
- 50F2 regulators (including worker clearance issues)
- 501 and 502 airbreaks.
- 4.16kV bus pin type insulators
- Cable type bus conductors.

West Greenville #45

- 451 and 452 motor operated airbreaks (MOABs)
- Transfer scheme control equipment

4.4 Additional Analyses

4.4.1 Reliability Performance

A reliability review was conducted to check feeder indices (CKAIDI and CKAIFI) against statewide targets. For calendar year 2019, the SAIFI and SAIDI targets for Rhode Island were 1.05 and 71.9 minutes, respectively. These targets were adjusted to find the circuits with the highest 5% reliability statistics (CKAIFI>3, CKAIDI> 222). Table 4.5 below shows CKAIDI or CKAIFI 3 year (2017, 2018, 2019) average performance. Based on the reliability analysis 3 feeders (Chopmist 34F2 34F3 and West Greenville 45F2 feeders) were found that exceed SAIFI & SAIDI 3-year average.

TABLE 4.5 – Study Area Reliability

Feeder	3 year_avgCKAIFI	3 year_avgCKAIDI
53-105K1	1.63	119.75
53-127W40	1.57	113.45
53-127W41	1.91	185.84
53-127W42	0.90	96.97
53-127W43	0.33	11.00
53-23F1	0.60	75.92
53-23F2	1.73	105.29
53-23F3	1.01	99.43
53-23F4	0.28	28.22
53-23F5	0.29	32.53
53-23F6	0.45	31.11
53-26W1	2.53	117.12
53-26W3	0.86	37.51
53-26W5	1.45	84.11
53-26W7	0.85	103.68
53-34F1	1.47	200.33
53-34F2	3.32	232.66
53-34F3	3.10	312.20
53-38F1	1.46	122.70
53-38F2	0.19	20.96
53-38F3	1.05	57.85
53-38F4	0.09	12.95
53-38F5	0.38	44.84
53-38F6	0.34	35.22
53-45F2	3.26	235.84
53-50F2	0.32	33.79
53-50J1	0.07	7.62
53-50J2	0.00	0.00
53-50J3	0.34	17.09

Analyzing the data above it was identified that majority of the outages for feeders 34F2 34F3 and 45F2 were tree related (about 250 out of 334).

ABLE 4.6 – Outage Review

Feeders: 34F2, 34F3 and 45F2	Count of Events
Animal	9
Construction by Company Contractor	1
Deterioration	15
Device Failed	12
Distribution transformer overload	1
Insulation failure - other	2
Lightning	14
Non-Company Activities	4
Tree - Broken Limb	107
Tree - Vines	6
Tree Fell	94
Tree Growth	4
Unknown	41
Vehicle	19
(blank)	5
Grand Total	**334**

4.4.2 Arc Flash

On April 1, 2014, the United States Department of Labor's Occupational Safety and Health Administration ("OSHA") issued final rule 1910.269 requiring the employer to assess the workplace to identify employees exposed to hazards from flames or electric arcs. 1910.269 proposed compliance dates of January 1, 2015 and April 1, 2015 for completion of the hazard assessment and implementation of the assessment results respectively. As the industry adjusted to these new requirements and calculation methods, the dates were adjusted to March 31, 2015 and August 31, 2015.

As described above, arc flash regulations were issued, and analysis methods were reviewed and adjusted during this study. A review using CYME fault current analysis and protection coordination values with ArcPro incident energy calculations provided an analysis of distribution feeders in compliance with OSHA requirements. Appendix 7.3 shows the results of the updated review. No feeder in the study area indicated incident energies above 8 calories per centimeter squared (cal/cm2).

4.4.3 Fault Duty/Short Circuit Availability

The CYME program was used to calculate the maximum fault current on each feeder. These values were compared to the station breaker's interrupting capability and voltage regulator maximum fault current withstand. The table in Appendix 7.3 summarizes the results of this analysis. All feeders in the study area have sufficient interrupting capability.

4.4.4 Reactive Compensation

Reactive compensation was analyzed at the low side of station transformers to determine if station capacitor banks are needed and at the first node of each feeder to determine if additional line capacitor banks are needed. Areas with PF less than 0.98, large customers with high VAR demand, and low voltage areas were the focus of this analysis. This analysis indicates the need for a total of 10 Smart / Advanced Capacitor banks with total of 7500KVARs to adjust low power factors for the area. The table in Appendix 7.4 illustrate stations and lines where additional reactive compensation may be needed.

5. PLAN DESCRIPTION, COMPARISON, AND RECOMMENDATION

The study solutions are comprised of three significant area plans that are supplemented with several minor solutions to resolve issues not addressed by the area plans. Each plan provides a comprehensive solution to address all capacity and asset condition concerns in the study area. Some reactive compensation, and reliability solutions that are common to all plans are also recommended. The following sections describe details of each plan, propose alternatives where relevant, and conclude with a comparison and recommendation.

5.1 Nasonville Area

The following plans address the normal and contingency issues in the Nasonville Substation area described in Sections 4.1.1 and 4.1.2. The primary concern is the transformer contingency issue. To mitigate Nasonville substation contingency loading issue 5 alternatives were evaluated. These five alternatives also address the other area concerns.

5.1.1 Option 1-New 115kV supply line from [redacted] and station expansion.

This option recommends installing a new 115kV bay at [redacted] substation to bring a new 115 kV overhead supply line to Nasonville substation. The Nasonville substation will also be expanded by adding a second transformer and 13kV straight bus.

The scope summary and cost estimate of this plan is shown below.

- Install a new 115kV radial line from [redacted] to Nasonville in the existing ROW (~6 miles)
- Install one new 55 MVA 115/13/8kV transformer at Nasonville substation
- Install a new 13.8kV straight bus metalclad switchgear at Nasonville substation
    - The new straight bus metalclad will add 4 new feeder positions. Two existing feeders will be moved to this new bus.
- Replace the existing 115kV protection on the existing Nasonville transformer (271TR) with a circuit switcher.

A marked up one-line diagram detailing the scope can be found in Appendix 7.5 and cost estimates are shown below.

Spend (SM)	Total
CapEx	$54.426
OpEx	$0.723
Removal	$2.228
Total	$57.377

5.1.2 Option 2–New 115kV supply line from [redacted] and station rebuild.

This option recommends installing a new 115kV bay at [redacted] substation to bring a new 115 kV overhead supply line to Nasonville substation. The Nasonville substation will also be rebuilt in a breaker-and-a-half configuration with two transformers.

- Install a new 115kV bay at [redacted]
- Install a new 115kV radial line from [redacted] to Nasonville in the existing ROW (~6 miles)
- Install two new 55 MVA 115/13/8kV transformers at Nasonville substation
- Install a new 13.8kV breaker and a half metalclad switchgear at Nasonville substation
    - The metalclad will have provision for up to 8 – 13.8kV feeder positions (4 existing and 4 new)
- Replace the existing 115kV protection on the existing Nasonville transformer (271TR) with a circuit switcher.

Spend (SM)	Total
CapEx	$63.513
OpEx	$0.723
Removal	$2.436
Total	$66.672

5.1.3 Option 3–New 115kV supply line from [redacted] and station expansion.

This option brings a new 115kV overhead line from [redacted] substation and expands Nasonville with a second 115kV/13.8kV transformer and a 13.8kV metalclad straight bus. This requires installation of a new 115 kV radial line with two breaker bays at [redacted] substation to bring a new 115kV line through the existing ROW.

- Install a new 115kV bay at [redacted] substation
- Install a new 115kV radial line from [redacted] to Nasonville in the existing ROW (~6 miles)
- Install one new 55 MVA 115/13/8kV transformer at Nasonville substation
- Install a new 13.8kV straight bus metalclad switchgear at Nasonville substation
    - The new straight bus metalclad will add 4 new feeder positions. Two existing feeders will be moved to this new bus.

- Replace the existing 115kV protection on the existing Nasonville transformer (271TR) with a circuit switcher.

Spend (SM)	Total
CapEx	$60.046
OpEx	$0.533
Removal	$2.145
Total	$62.724

5.1.4 Option 4–New 34.5kV supply line from the Iron Mine Hill Substation and station expansion

This option brings a new 34.5 kV overhead supply line from the Iron Mine Hill substation to Nasonville and adds a new 34.5/13.8KV transformer and straight bus with two feeder positions at Nasonville substation. This new supply line will be brought into the Nasonville substation throughout the existing transmission ROW.

.

- Utilize one of the two 34.5kV breaker positions at the new Iron Mine Hill substation
- Route a new 34.5kV supply line into Nasonville through existing ROW (~6.5 circuit miles)
- Install a new 40 MVA 34.5/13.8kV transformer and straight bus metalclad with two new feeder positions
- Replace the existing 115kV protection on the existing Nasonville transformer (271TR) with a circuit switcher.

The Iron Mine Substation was installed to serve a large solar farm. This option will require substantial reimbursement to the original solar developer for this system improvement.

Spend (SM)	Total
CapEx	$52.689
OpEx	$0.733
Removal	$1.645
Total	$55.067

5.1.5 Option 5–Non-wires Alternative

Non-Wires Alternatives (NWA) were evaluated, however the load reduction required was greater than 20% of the area load, and therefore NWA was not selected as a viable option.[1]

[1] On August 23, 2022, an event occurred that is similar to the contingency evaluated in this study. Robust use of area distributed generation and energy storage was used to assist the restoration and mitigate customer interruption risks aligned with non-wire alternative concepts. While the distributed resources did help, they were insufficient to provide complete relief. Furthermore, the intermittency of certain resources became problematic during the restoration.

5.1.6 Recommended Option and Timeline

Options 1 and 4 are economically comparable and address all identified issues. However, option 1 provides greater operational flexibility and hosting capacity than option 4. Specifically, option 1 would include installation of a 55MVA transformer and provisions for 4 feeder positions versus option 2 would include installation of a 40MVA transformer and two feeder positions. Therefore option 1 is recommended.
Project timelines and cash flows, including Preliminary Study and Investigation (PS&I) charges, are shown below.

[redacted]-Line													
FP	**Type**	**Spend ($M)**	**FY22**	**FY23**	**FY24**	**FY25**	**FY26**	**FY27**	**FY28**	**FY29**	**FY30**	**Total T-Line**	**Total With PS&I**
C087751	T-Line	CapEx	$0.000	$0.000	$1.025	$0.750	$3.088	$6.176	$12.352	$6.176	$3.088	$32.381	$32.656
C087751	T-Line	OpEx	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.217	$0.506	$0.000	$0.723	$0.723
C087751	T-Line	Removal	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.668	$1.558	$0.000	$2.226	$2.226
		Total		**$0.000**	**$1.025**	**$0.750**	**$3.088**	**$6.176**	**$13.237**	**$8.241**	**$3.088**	**$35.330**	**$35.605**
[redacted]-Sub													
FP	**Type**	**Spend ($M)**	**FY22**	**FY23**	**FY24**	**FY25**	**FY26**	**FY27**	**FY28**	**FY29**	**FY30**	**Total T-Sub**	**Total With PS&I**
C087752	T-Sub	CapEx	$0.000	$0.000	$0.800	$0.750	$0.444	$0.887	$1.775	$0.887	$0.444	$5.937	$5.987
C087752	T-Sub	OpEx	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
C087752	T-Sub	Removal	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
		Total		**$0.000**	**$0.800**	**$0.750**	**$0.444**	**$0.887**	**$1.775**	**$0.887**	**$0.444**	**$5.937**	**$5.987**
Nasonville D-Sub													
FP	**Type**	**Spend ($M)**	**FY22**	**FY23**	**FY24**	**FY25**	**FY26**	**FY27**	**FY28**	**FY29**	**FY30**	**Total**	**Total**
C087770	D-Sub	CapEx	$0.000	$0.000	$0.875	$0.750	$1.170	$2.340	$4.680	$2.340	$1.170	$13.200	$13.325
C087770	D-Sub	OpEx	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
C087770	D-Sub	Removal	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
		Total		**$0.000**	**$0.875**	**$0.750**	**$1.170**	**$2.340**	**$4.680**	**$2.340**	**$1.170**	**$13.200**	**$13.325**
Nasonville T-Sub													
FP	**Type**	**Spend ($M)**	**FY22**	**FY23**	**FY24**	**FY25**	**FY26**	**FY27**	**FY28**	**FY29**	**FY30**	**Total**	**Total**
C087747	D-Sub	CapEx	$0.000	$0.000	$0.770	$0.750	$0.114	$0.228	$0.456	$0.228	$0.114	$2.640	$2.660
C087747	D-Sub	OpEx	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
C087747	D-Sub	Removal	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
		Total		**$0.000**	**$0.770**	**$0.750**	**$0.114**	**$0.228**	**$0.456**	**$0.228**	**$0.114**	**$2.640**	**$2.660**
Nasonville D-Line													
FP	**Type**	**Spend ($M)**	**FY22**	**FY23**	**FY24**	**FY25**	**FY26**	**FY27**	**FY28**	**FY29**	**FY30**	**Total**	**Total**
C087771	D-Line	CapEx	$0.000	$0.000	$0.037	$0.054	$0.107	$0.054	$0.027	$0.000	$0.000	$0.268	$0.278
C087771	D-Line	OpEx	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
C087771	D-Line	Removal	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.002	$0.000	$0.000	$0.002	$0.002
		Total		**$0.000**	**$0.037**	**$0.054**	**$0.107**	**$0.054**	**$0.029**	**$0.000**	**$0.000**	**$0.270**	**$0.280**
		Total for Nasonville	**$0.000**	**$0.000**	**$3.507**	**$3.054**	**$4.923**	**$9.685**	**$20.177**	**$11.696**	**$4.816**	**$57.377**	**$57.857**

5.2 Centredale Substation Area

A wide range of issues were identified at Centredale #50 substation in Section 4. The primary concerns are asset condition and safety issues detailed in Section 4.3. Three options were considered to resolve all the issues that have been identified.

5.2.1 Option 1-Rebuild Centredale #50 Substation and Convert 4kV

This option will convert all the 4.16kV load to 12.47kV utilizing feeder ties.
Rebuild the existing 23kV/12.47kV installation with two (2) new 23kV/12.47kV 7.5/9.375 MVA transformers and two (2) 12.47kV feeders.

- Install two new 9.375MVA 23/12.47kV modular feeder positions
- Install a new control house
- Convert all the 4.16kV distribution load to the new 12.47kV feeder
- Remove all existing assets

A marked up one-line diagram detailing the scope can be found in Appendix 7.5 and cost estimates are shown below.

Spend (SM)	Total
CapEx	$7.249
OpEx	$0.150
Removal	$0.862
Total	$8.261

5.2.2 Option 2–Rebuild Centredale #50 in current configuration

This option rebuilds the existing 23kV/4kV installation with one (1) 23/4kV transformer, three (3) 4kV reclosers and three (3) sets of 4kV regulators. It rebuilds the existing 23kV/12.47kV installation with one (1) new 23kV/12.47kV 7.5/9.375 MVA transformer and one (1) 12.47kV feeder and a new control house.

- Install a new 9.375MVA 23/12.47kV modular feeder position
- Install a new control house
- Transfer the existing 12.47kV feeder to the new one
- Remove the existing 23kV and 12.47kV equipment
- Install a new 23/4.16kV transformer and two 4.16kV feeder positions
- Remove all existing 23kV and 4.16kV equipment

Spend (SM)	Total
CapEx	$10.535
OpEx	$0.000
Removal	$0.401
Total	$10.936

5.2.3 Option 3–Non-wires Alternative

Non-Wires Alternatives (NWA) were evaluated; however, the primary driver was asset condition, and therefore NWA was not selected as a viable option.

5.2.4 Recommended Option and Timeline

Option 1, rebuilding Centredale #50 substation with two new transformers and two 12.47 kV modular feeders and converting 4kV side, is the recommended plan. This plan was selected as it provides most operational flexibility by eliminating the 4kV island and is less costly compared with option 2. Project timelines and cash flows, including Preliminary Study and Investigation (PS&I) charges, are shown below.

Centredale D-Line													
FP	Type	Spend ($M)	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	Total D-Line	Total With PS&I
C087784	D-Line	CapEx	$0.000	$0.000	$0.635	$1.464	$0.878	$0.000	$0.000	$0.000	$0.000	$2.927	$2.977
C087784	D-Line	OpEx	$0.000	$0.000	$0.030	$0.075	$0.045	$0.000	$0.000	$0.000	$0.000	$0.150	$0.150
C087784	D-Line	Removal	$0.000	$0.000	$0.148	$0.369	$0.221	$0.000	$0.000	$0.000	$0.000	$0.738	$0.738
		Total		**$0.000**	**$0.813**	**$1.908**	**$1.145**	**$0.000**	**$0.000**	**$0.000**	**$0.000**	**$3.815**	**$3.865**
Centredale D-Sub													
FP	Type	Spend ($M)	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	Total D-Sub	Total With PS&I
C087783	D-Sub	CapEx	$0.000	$0.000	$0.482	$0.864	$1.729	$0.864	$0.432	$0.000	$0.000	$4.322	$4.372
C087783	D-Sub	OpEx	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
C087783	D-Sub	Removal	$0.000	$0.000	$0.000	$0.000	$0.037	$0.087	$0.000	$0.000	$0.000	$0.124	$0.124
		Total	**$0.000**	**$0.000**	**$0.482**	**$0.864**	**$1.766**	**$0.951**	**$0.432**	**$0.000**	**$0.000**	**$4.446**	**$4.496**
		Total for Centredale	**$0.000**	**$0.000**	**$1.295**	**$2.772**	**$2.911**	**$0.951**	**$0.432**	**$0.000**	**$0.000**	**$8.261**	**$8.361**

5.3 Common Solutions

West Greenville Substation

Replace the 451 and 452 Motor Operating Air Breaks and control cabinet to address the asset condition issues detailed in Section 4.3.

- Install new swing panel for controls for the new 451 and 452 switches.
- Replace the existing DC panel.
- Install new conduits from the 451 and 452 MOD controls to control enclosure.
- Replace Two (2) 23kV motor operated air break switches.
- Replace One (1) 250VDC panel inside control enclosure.

A marked up one-line diagram detailing the scope can be found in Appendix 7.6 and cost estimates are shown below.

Spend ($M)	Total
CapEx	$0.401
OpEx	$0.000
Removal	$0.029
Total	**$0.430**

Farnum Pike 23F3 Feeder

Reconductor 0.3 miles of mainline conductor from pole 155 to pole 167 on Farnum Pike Route 116 with 3-477 aluminum to address predicted overload described in Section 4.1.1.

Spend ($M)	Total
CapEx	$0.145
OpEx	$0.010
Removal	$0.075
Total	**$0.230**

Putnam Pike 38F3 Feeder

Reconductor 0.6 miles of 4/0 aluminum section from pole 1 to pole 22 Sanderson Rd with 3 phase-477 aluminum open wire and balancing the load to address the predicted overload described in Section 4.1.1.

Spend ($M)	Total
CapEx	$0.290
OpEx	$0.020
Removal	$0.148
Total	**$0.458**

West Greenville 45F2 Feeder

Install a 333 KVA line regulator on Hartford Pike near West Greenville Road to address the voltage issues identified in Section 4.2.

Spend ($M)	Total
CapEx	$0.091
OpEx	$0.000
Removal	$0.006
Total	**$0.097**

Chopmist 34F2 Feeder

Install a 333 KVA line regulator on Chopmist Hill Road to address the voltage issues identified in Section 4.2.

Spend ($M)	Total
CapEx	$0.091
OpEx	$0.000
Removal	$0.006
Total	**$0.097**

Chopmist 34F3 Feeder

Convert approximately 3.5 miles of single phase 2.4kV construction to 7.2kV construction along Joe Sarle and Dexter Saunders Roads. Remove the stepdown transformer at pole 1 Joe Sarle Road. This project addresses the voltage issues identified in Section 4.2.

Spend ($M)	Total
CapEx	$1.066
OpEx	$0.031
Removal	$0.289
Total	**$1.386**

Line Reactive Compensation

Install 10 advanced capacitor banks with total of 7500KVARs per Table 5.1.

TABLE 5.1 – Distribution Mainline Power Factor Correction*

Feeder	Size	Location	Purpose
105K1	600kVAR	OH section 276003962 on Wellington Road	Reactive compensation
26W1	900kVAR	OH section 276086128 on Greenville Road	Reaction compensation
26W3	(2) 900kVAR	OH section 276009707 on Sayles Hill Road & on OH section 191402261 on Railroad Street	Reaction compensation

26W7	(2) 900kVAR	OH section 276091868 on Graham Drive & on OH section 276095683-1 on Tifft Road	Reaction compensation
34F3	(2) 600kVAR	OH section 275574523 on Joe Sarle Road & on OH section 275576877 on Mount Hygeia Road	Reaction compensation
38F2	(2) 600kVAR	OH section 275611135 on Putnam Pike (44) road & on OH section 198629958 on Sedar Swamp Road	Reaction compensation

*All distribution line capacitors included in the recommendations above are to be installed with the latest sensors, controls, and communication capabilities per standards.

Spend ($M)	Total
CapEx	$0.250
OpEx	$0.000
Removal	$0.002
Total	**$0.252**

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6 CONCLUSION

The comprehensive system analysis revealed that the most significant issues in the area are related to contingency loading and asset condition concerns. The two main recommendations are to address the contingency loading at Nasonville #127 substation and asset condition issues at Centredale #50 substation. Several common recommendations address various small-scale loading, voltage, and asset issues within the study area. The spending by fiscal year for all study recommendations is shown in Table 6.1 below.

TABLE 6.1: Cost Summary for all Northwest Rhode Island Area Study Plans

Spend ($M)	FY24	FY25	FY26	FY27	FY28	FY29	FY30	Total
CapEx	$7.0	$5.4	$7.5	$10.5	$19.7	$9.6	$4.8	$64.6
OpEx	$0.1	$0.1	$0.0	$0.0	$0.2	$0.5	$0.0	$0.9
Removal	$0.7	$0.4	$0.3	$0.1	$0.7	$1.6	$0.0	$3.6
Total	**$7.7**	**$5.8**	**$7.8**	**$10.6**	**$20.6**	**$11.7**	**$4.8**	**$69.2**

7 APPENDIX

7.1 – Area Map

7.2 – One-Line Diagrams

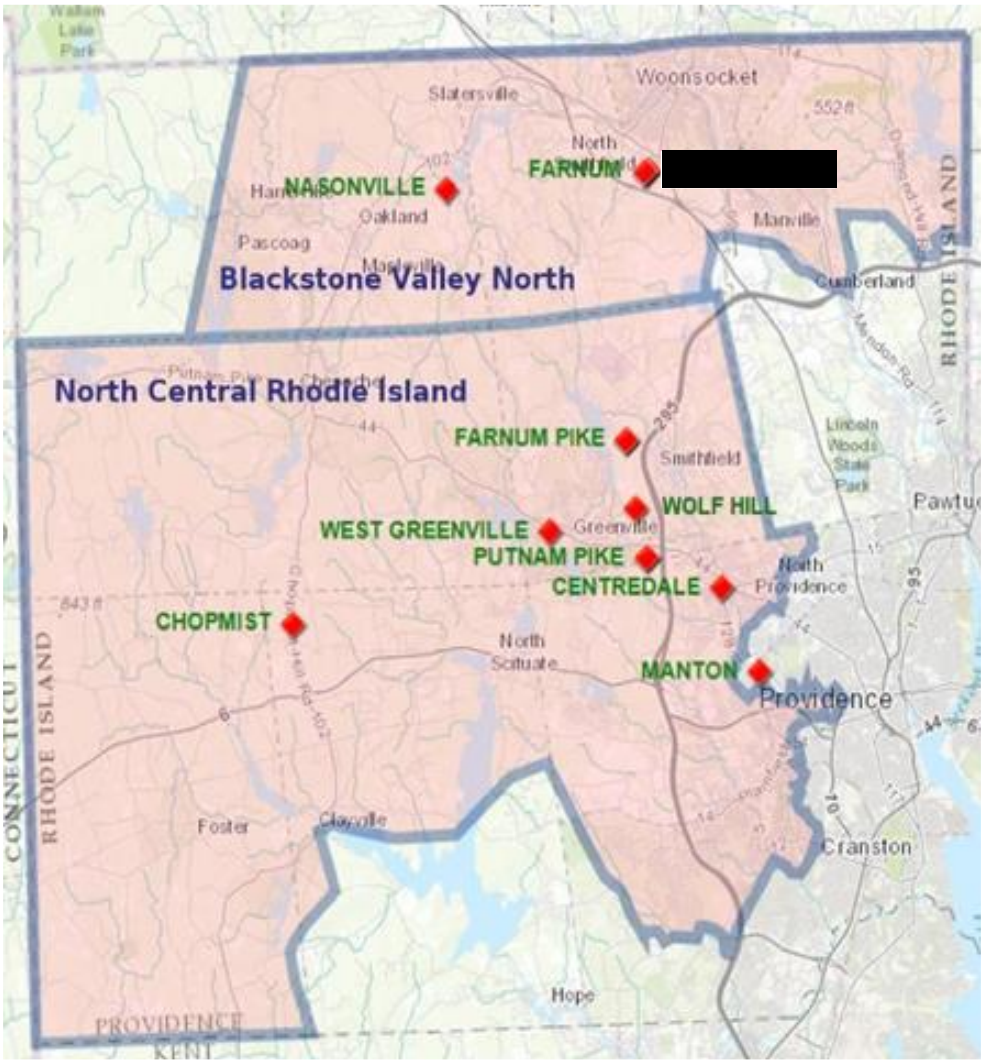
7.3 - Arc Flash and Fault Duty Analysis

7.4 – Reactive Compensation

7.5 – Plan Development

7.6 – Non-Wires Alternative Criteria

7.1 Area Map



7.2 One-Line Diagrams

FIGURE 7.2.1 – 115 KV SUPPLY SYSTEM ONE-LINE DIAGRAM

FIGURE 7.2.2 – 115 KV SUPPLY SYSTEM ONE-LINE DIAGRAM

FIGURE 7.2.3 – 23kV SUPPLY SYSTEM ONE-LINE DIAGRAM

FIGURE 7.2.4 – 23kV SUPPLY SYSTEM ONE-LINE DIAGRAM

FIGURE 7.2.5 – 23kV SUPPLY SYSTEM ONE-LINE DIAGRAM

FIGURE 7.2.6 – 23kV SUPPLY SYSTEM ONE-LINE DIAGRAM

FIGURE 7.2.7 – WEST GREENVILLE #45 ONE LINE DIAGRAM

FIGURE 7.2.8 – CHOPMIST #34 SUBSTATION ONE-LINE DIAGRAM

FIGURE 7.2.9 – CENTREDALE #50 SUBSTATION ONE-LINE DIAGRAM

FIGURE 7.2.10 – FARNUM #105 SUBSTATION ONE-LINE DIAGRAM

FIGURE 7.2.11 – FARNUM PIKE #23 SUBSTATION ONE-LINE DIAGRAM

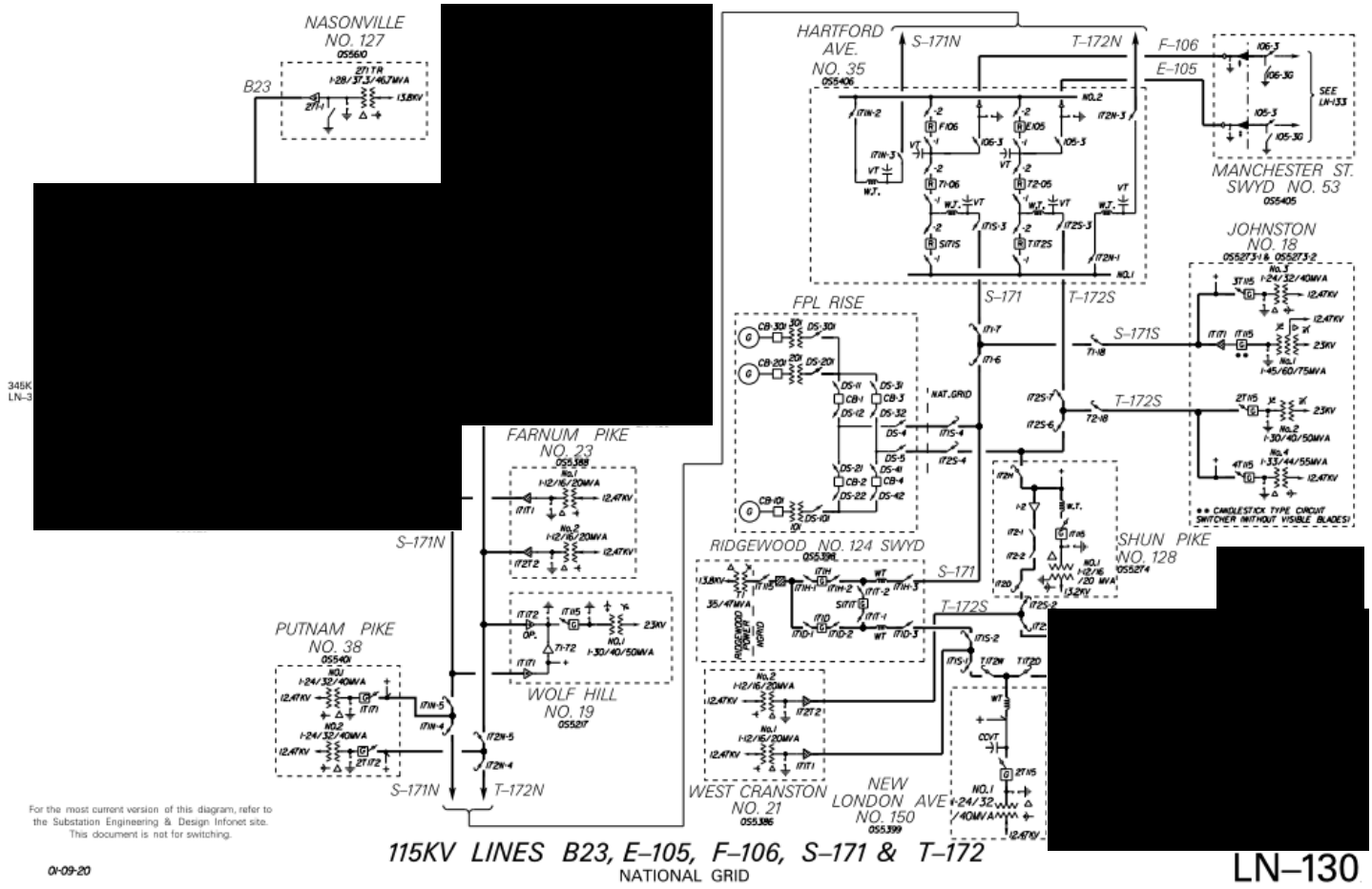
FIGURE 7.2.12 – NASONVILLE #127 SUBSTATION ONE-LINE DIAGRAM

FIGURE 7.2.13 – MANTON #69 SUBSTATION ONE-LINE DIAGRAM

FIGURE 7.2.14 – PUTNAM PIKE #38 SUBSTATION ONE-LINE DIAGRAM

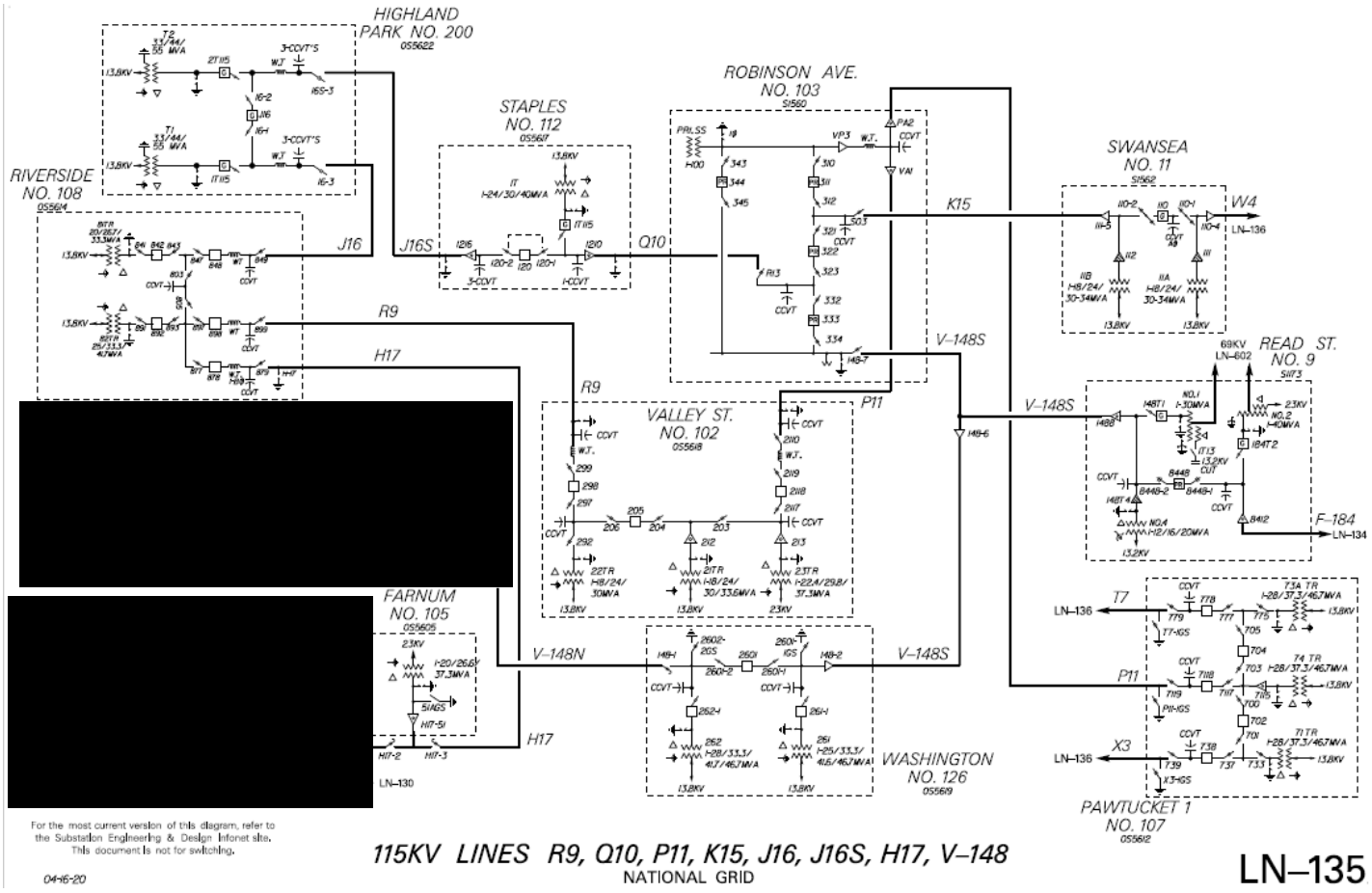
FIGURE 7.2.15 – WOONSOCKET #26 SUBSTATION ONE-LINE DIAGRAM

FIGURE 7.2.1 – 115 KV SUPPLY SYSTEM ONE-LINE DIAGRAM



This document has been redacted for Critical Energy/Electric Infrastructure Information (CEII).

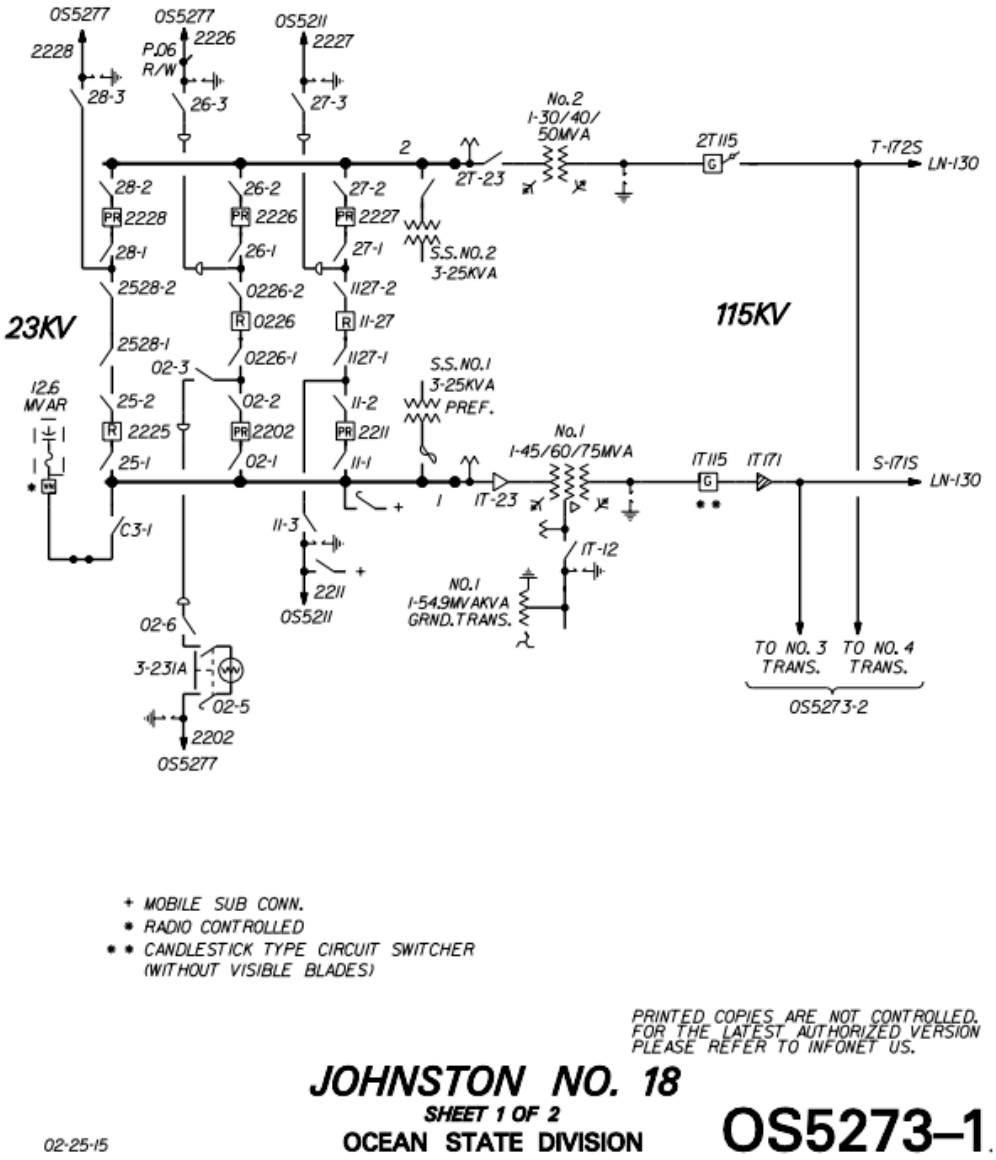
FIGURE 7.2.2 – 115 KV SUPPLY SYSTEM ONE-LINE DIAGRAM



115KV LINES R9, Q10, P11, K15, J16, J16S, H17, V–148
NATIONAL GRID

LN–135

FIGURE 7.2.3 – JOHNSTON #18 (23kV SUPPLY SYSTEM) ONE-LINE DIAGRAM



+ MOBILE SUB CONN.
* RADIO CONTROLLED
* * CANDLESTICK TYPE CIRCUIT SWITCHER
(WITHOUT VISIBLE BLADES)

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JOHNSTON NO. 18
SHEET 1 OF 2
OCEAN STATE DIVISION

02-25-15

OS5273–1

FIGURE 7.2.4 – WOLF HILL #19 (23kV SUPPLY SYSTEM) ONE-LINE DIAGRAM

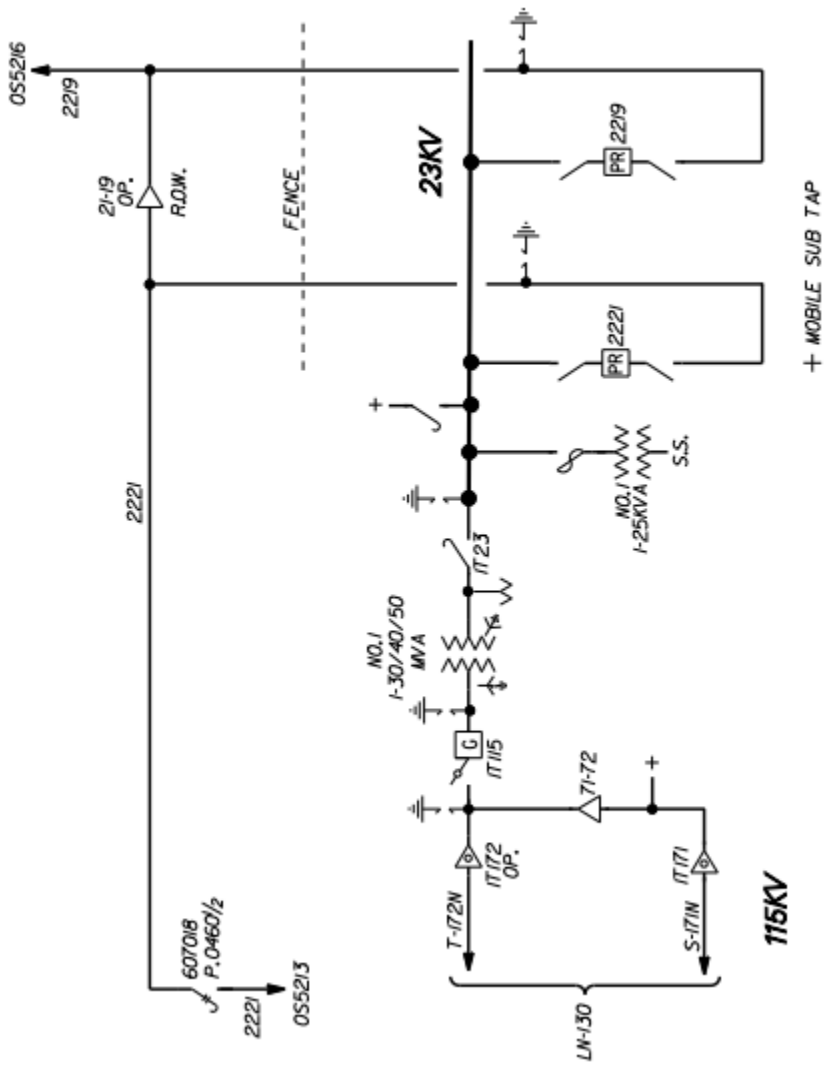


FIGURE 7.2.5 – 23kV FEEDERS 2211 & 2227 ONE LINE DIAGRAM

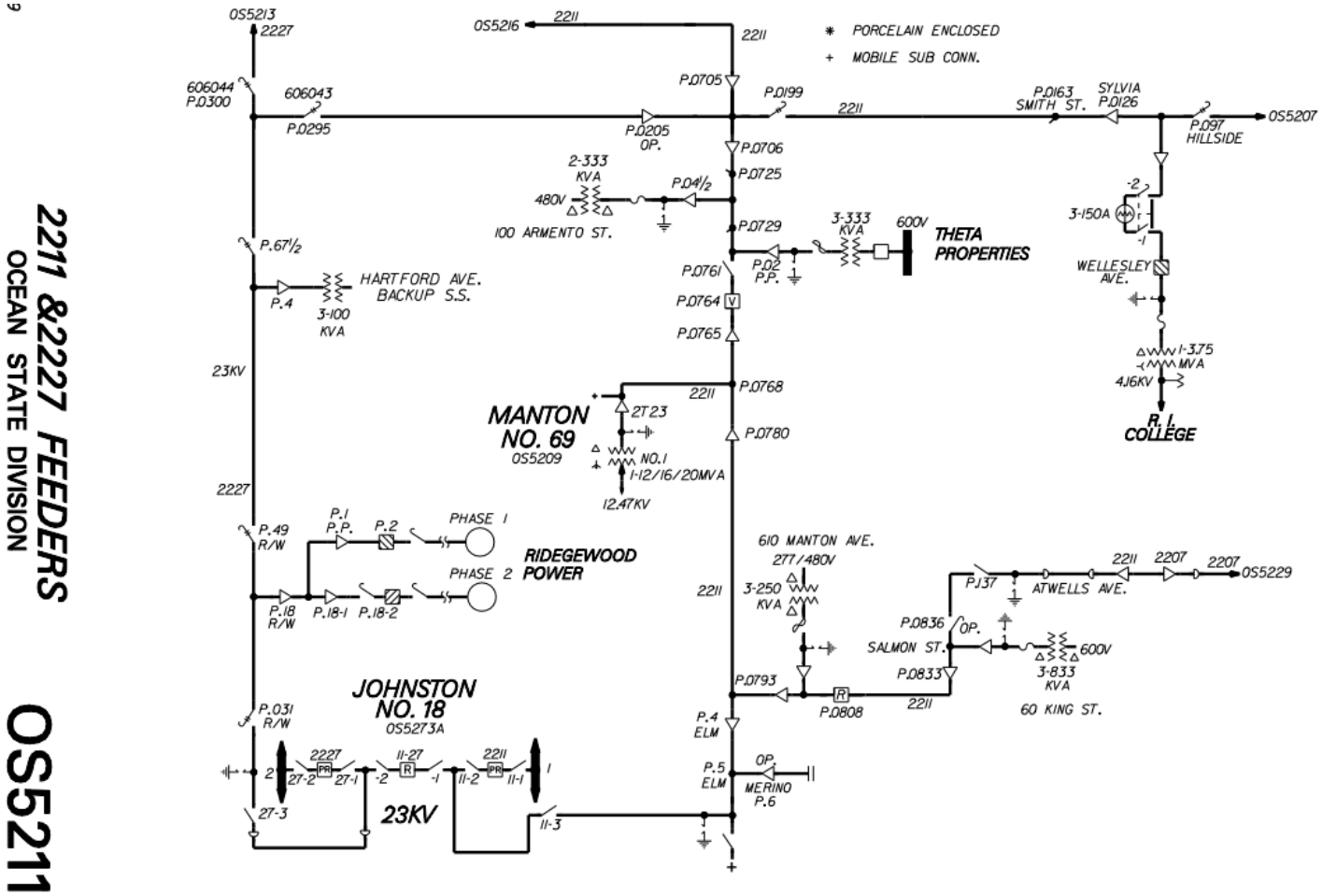


FIGURE 7.2.6 – 23kV FEEDER 2219 ONE LINE DIAGRAM

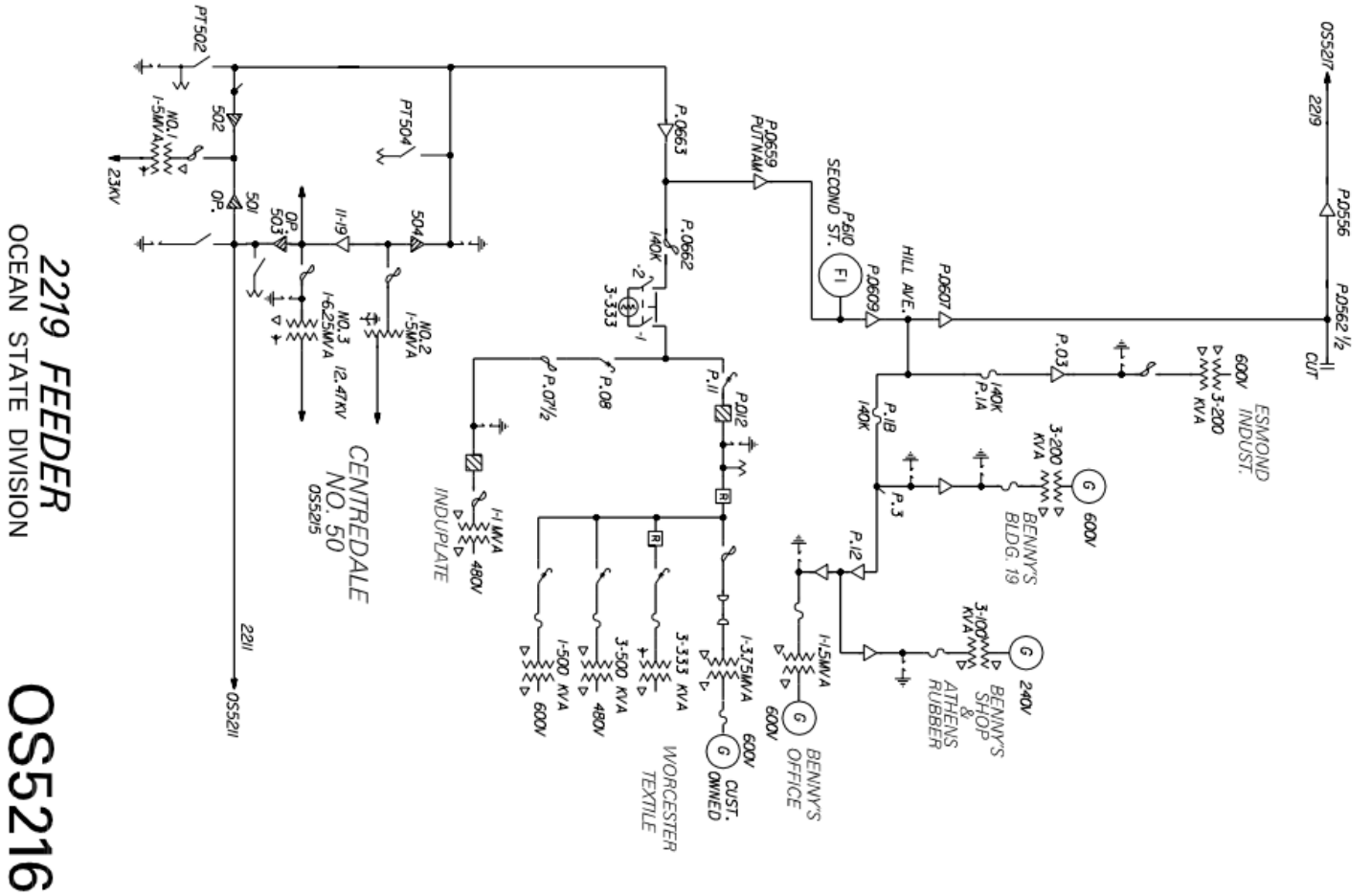


FIGURE 7.2.7 – WEST GREENVILLE #45 ONE LINE DIAGRAM

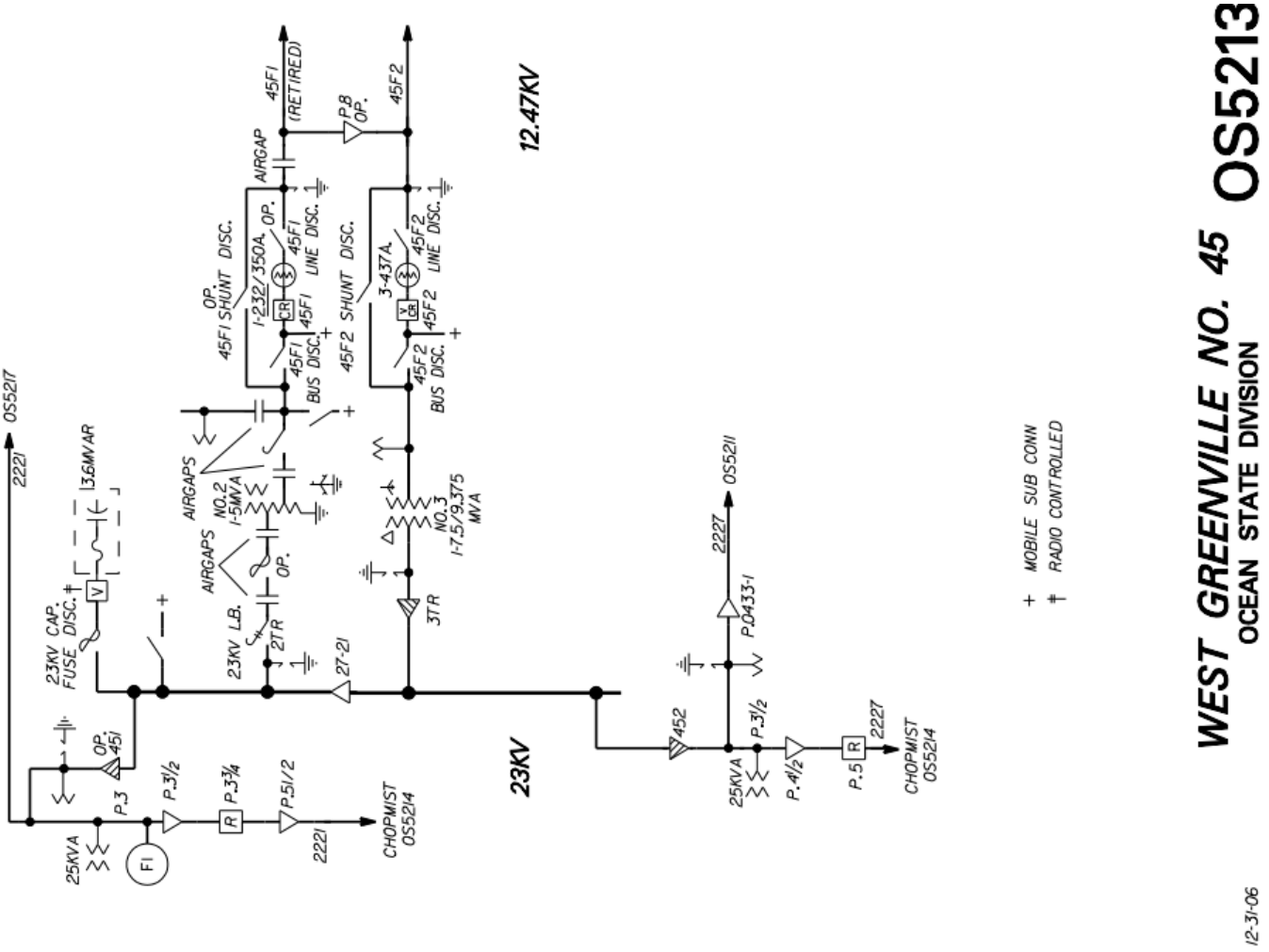


FIGURE 7.2.8 – CHOPMIST #34 SUBSTATION ONE-LINE DIAGRAM

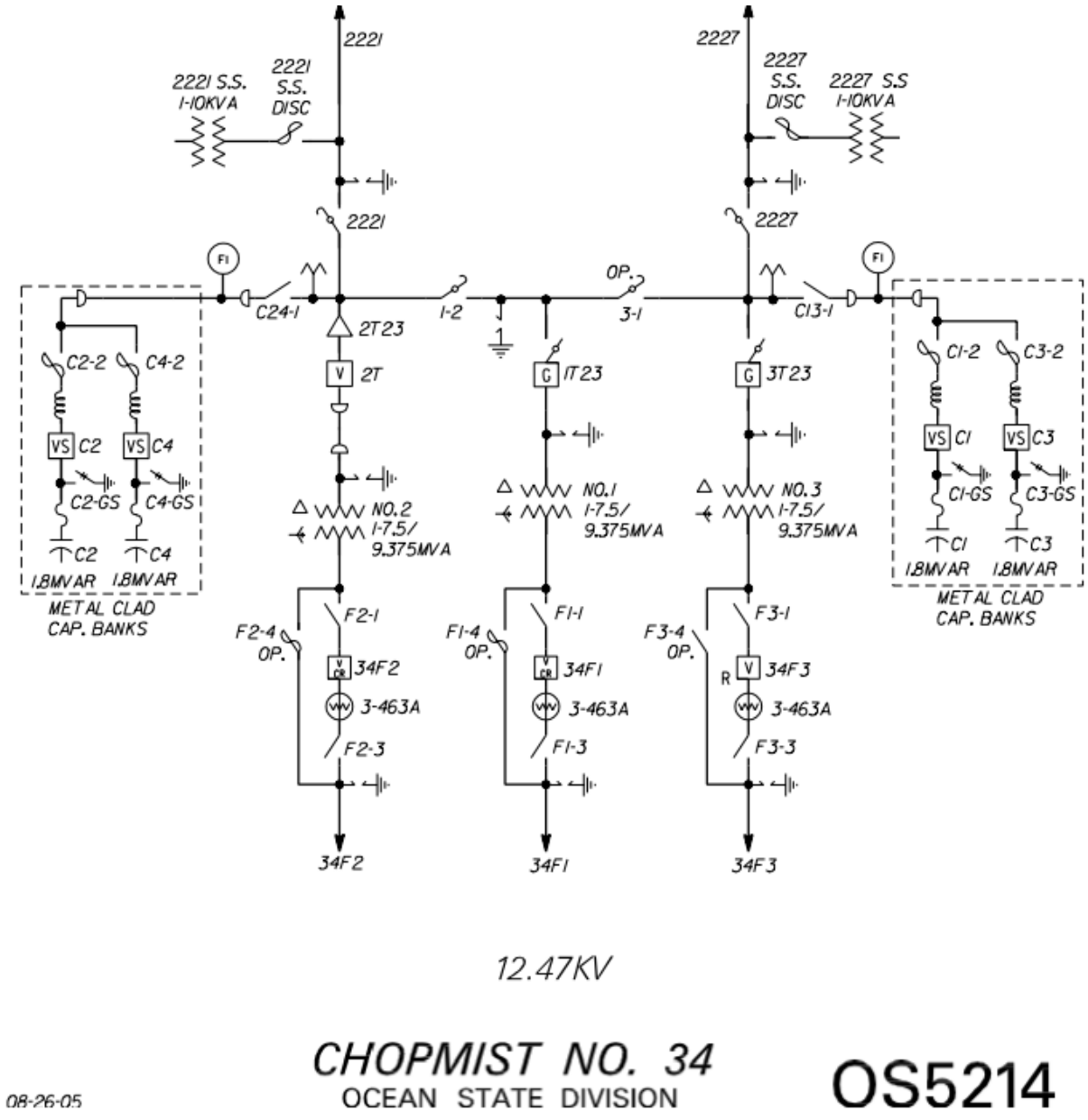
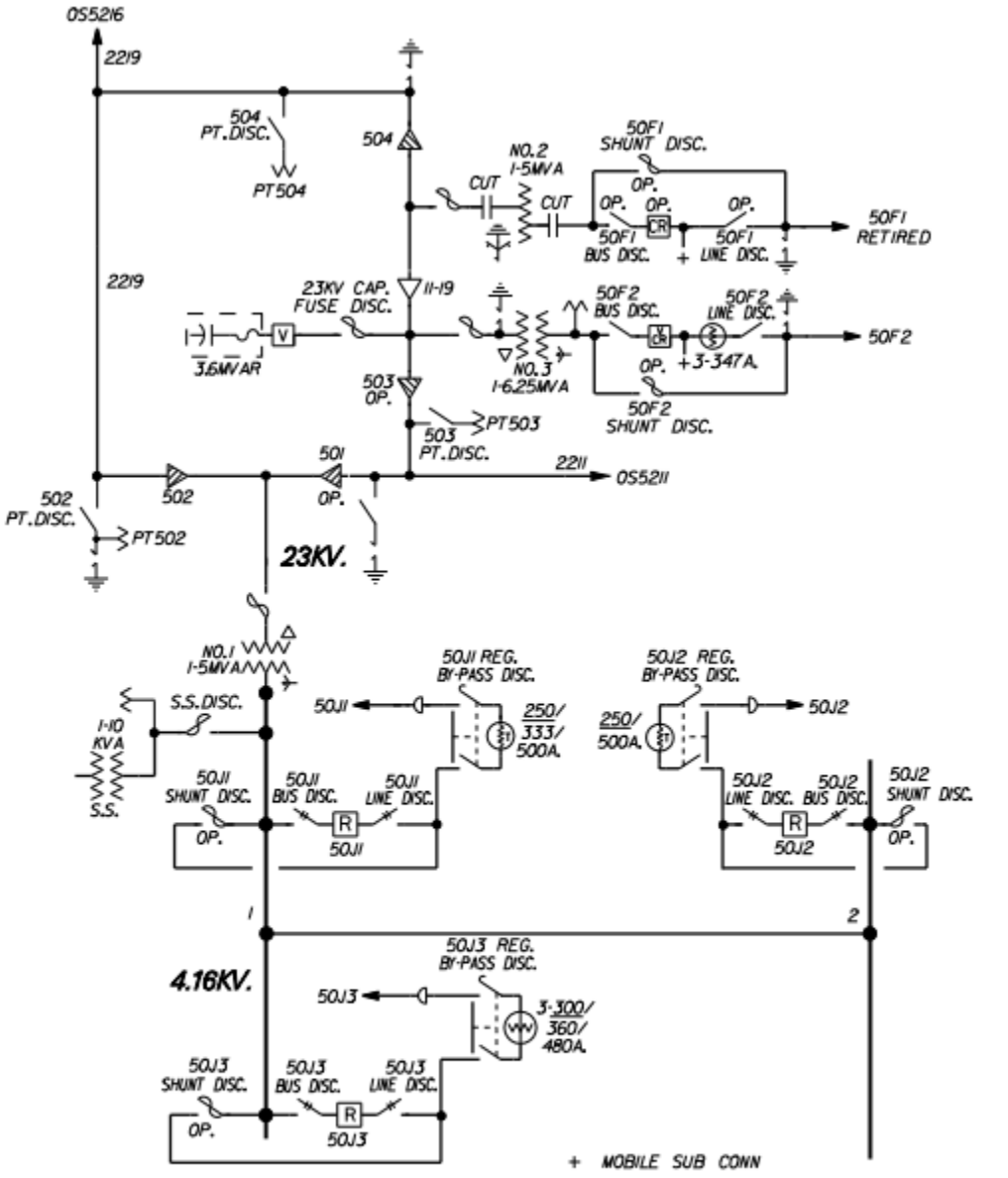


FIGURE 7.2.9 – CENTREDALE #50 SUBSTATION ONE-LINE DIAGRAM



09-29-06

CENTREDALE NO. 50
OCEAN STATE DIVISION

OS5215

FIGURE 7.2.10 –FARNUM #105 SUBSTATION ONE-LINE DIAGRAM

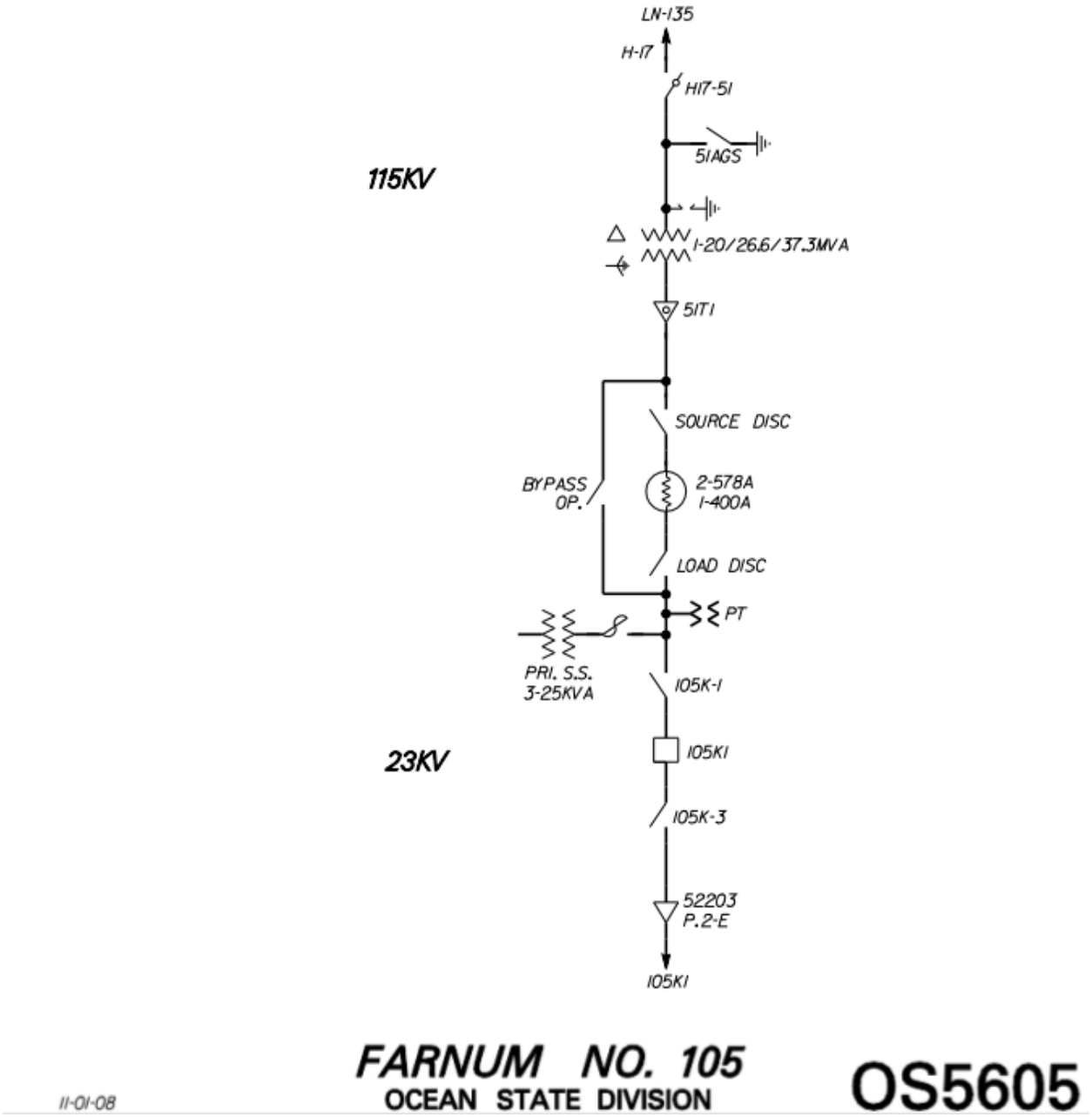


FIGURE 7.2.11 –FARNUM PIKE #23 SUBSTATION ONE-LINE DIAGRAM

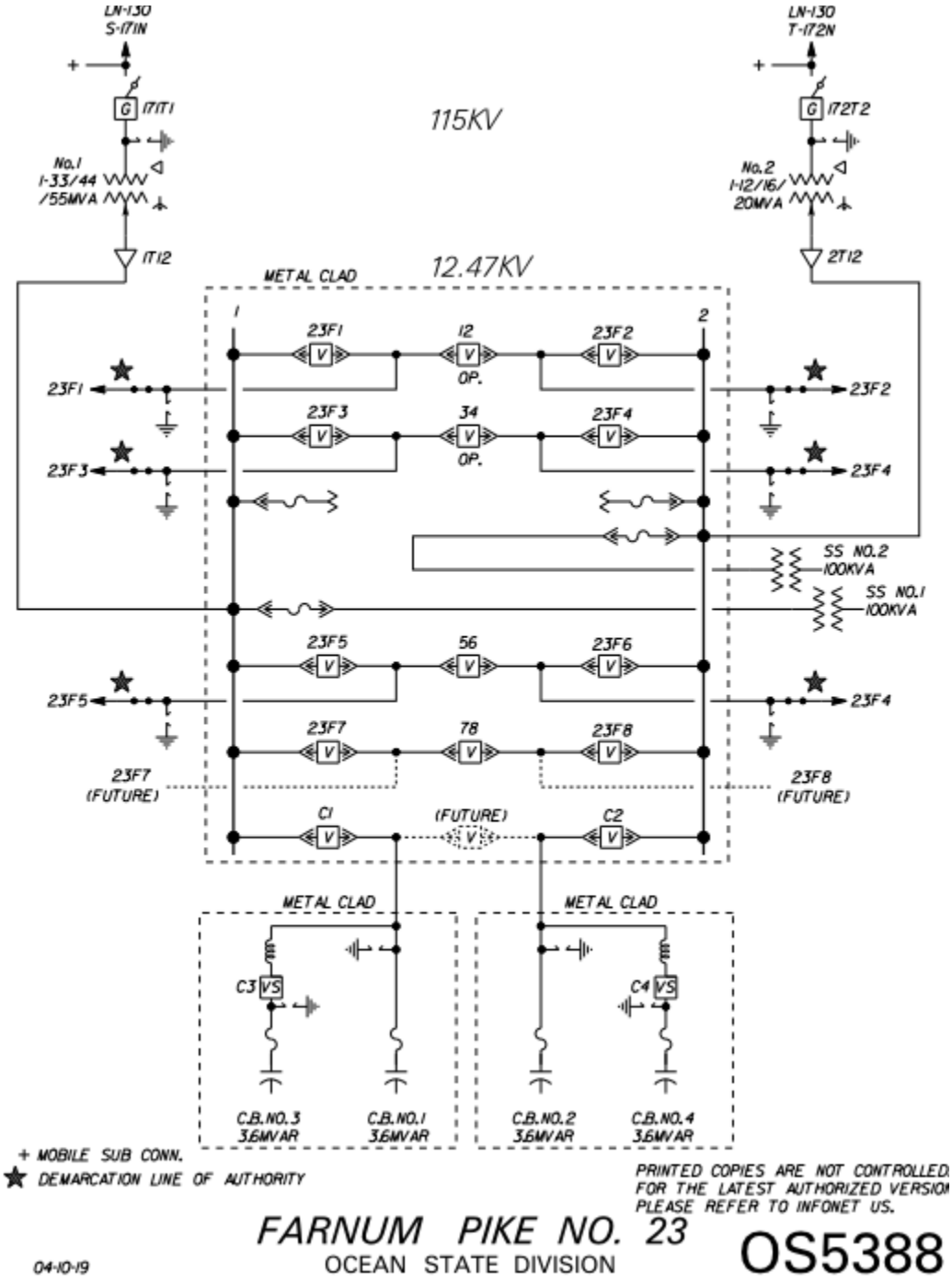


FIGURE 7.2.12 – NASONVILLE #127 SUBSTATION ONE-LINE DIAGRAM

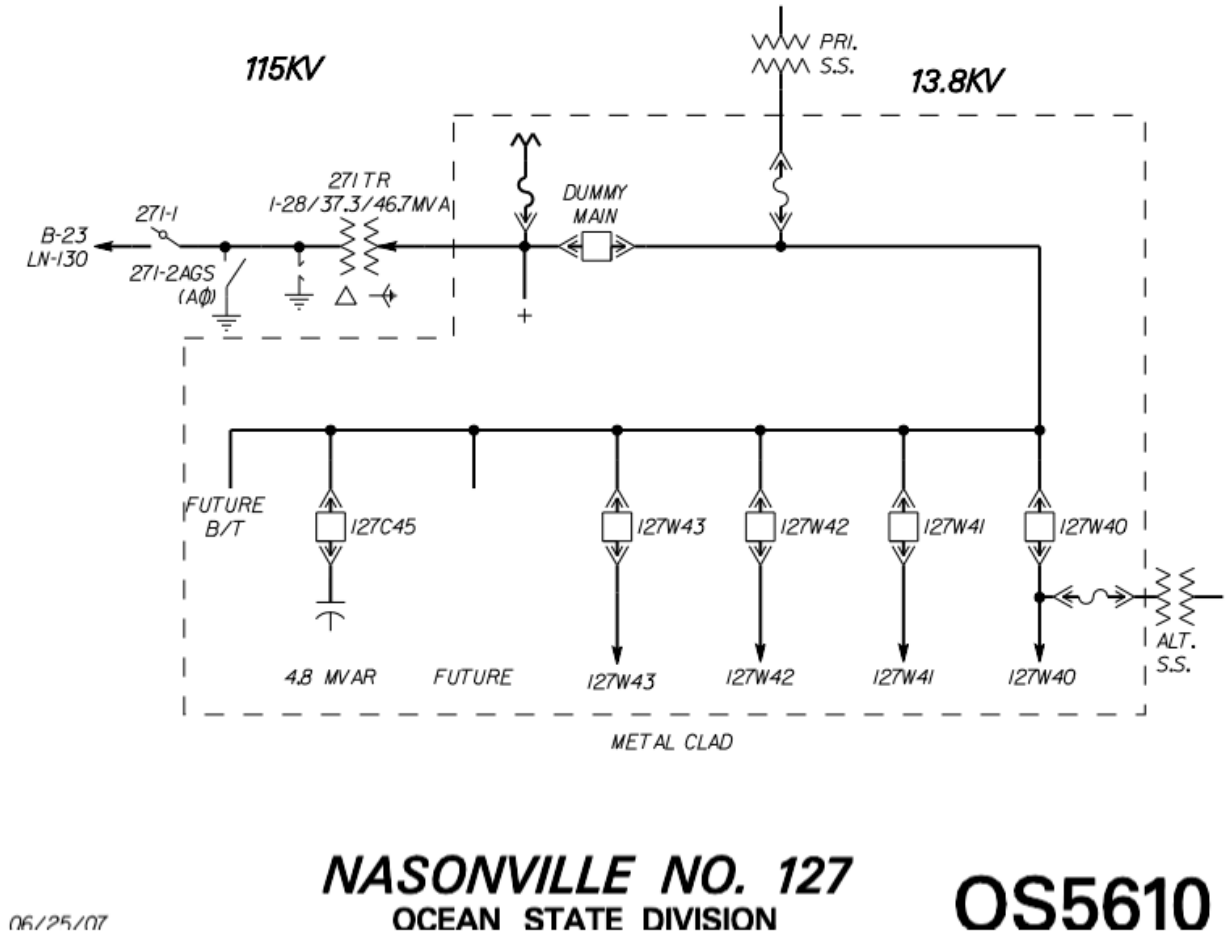


FIGURE 7.2.13 – MANTON #69 SUBSTATION ONE-LINE DIAGRAM

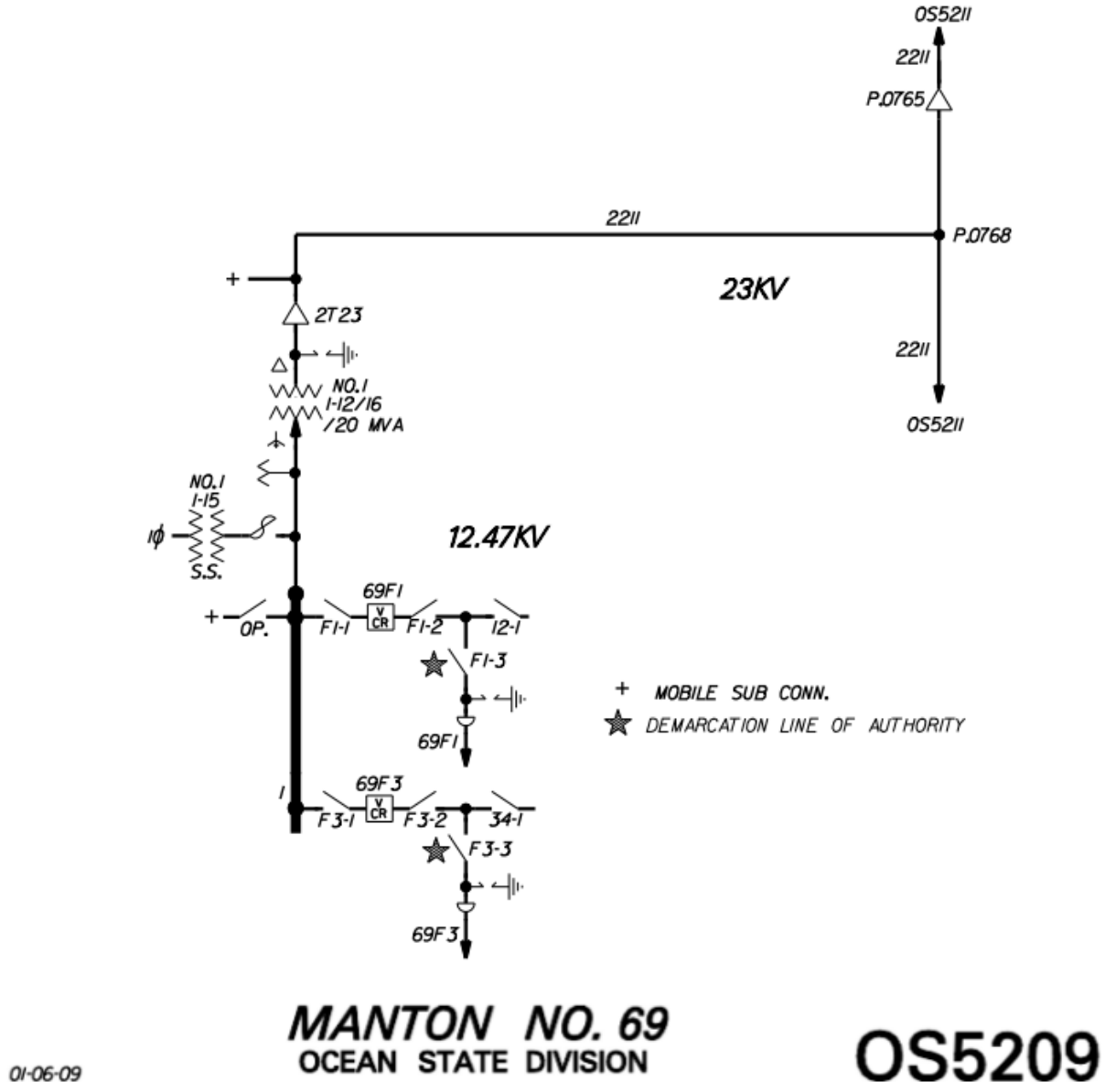


FIGURE 7.2.14 – PUTNAM PIKE #38 SUBSTATION ONE-LINE DIAGRAM

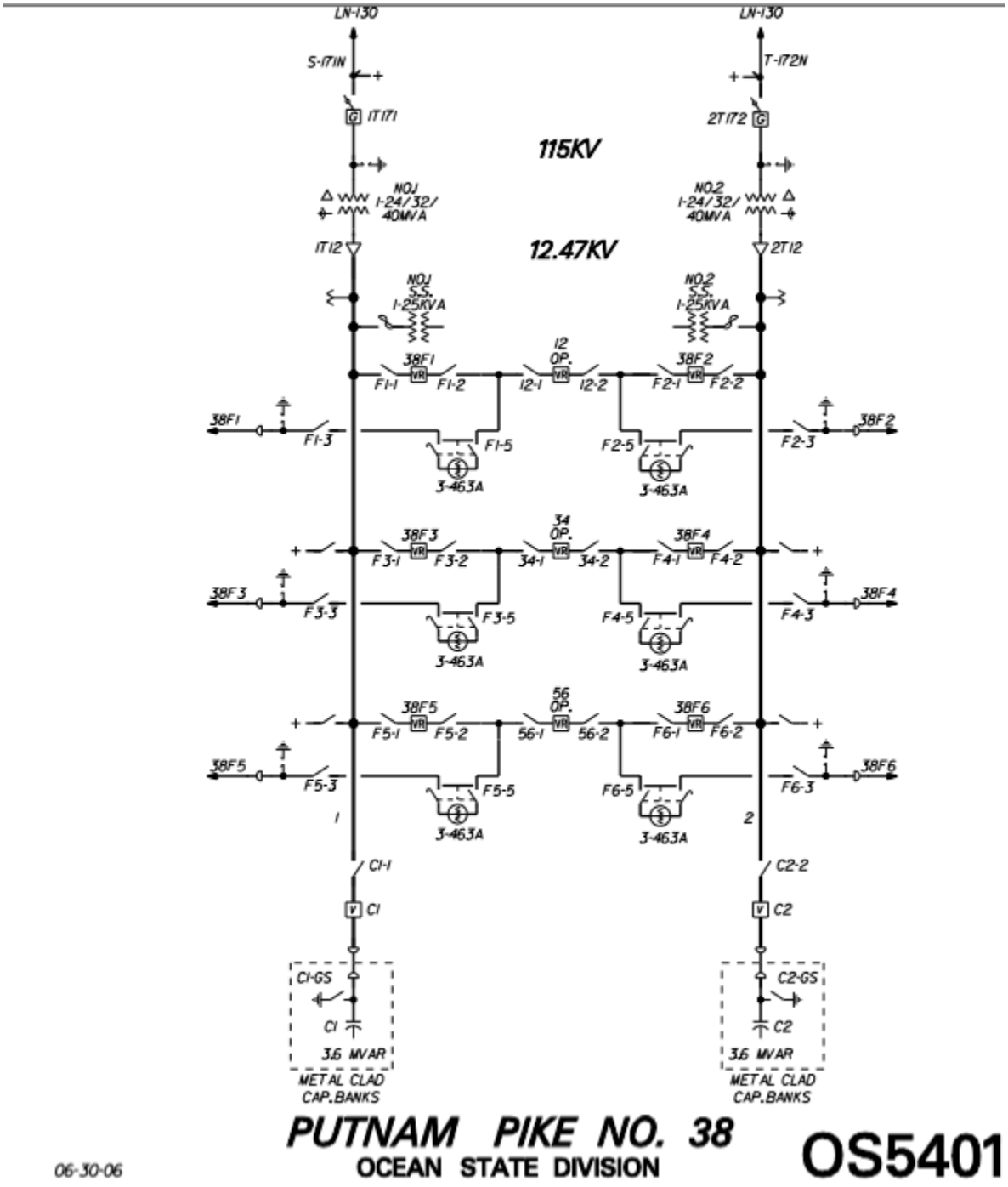
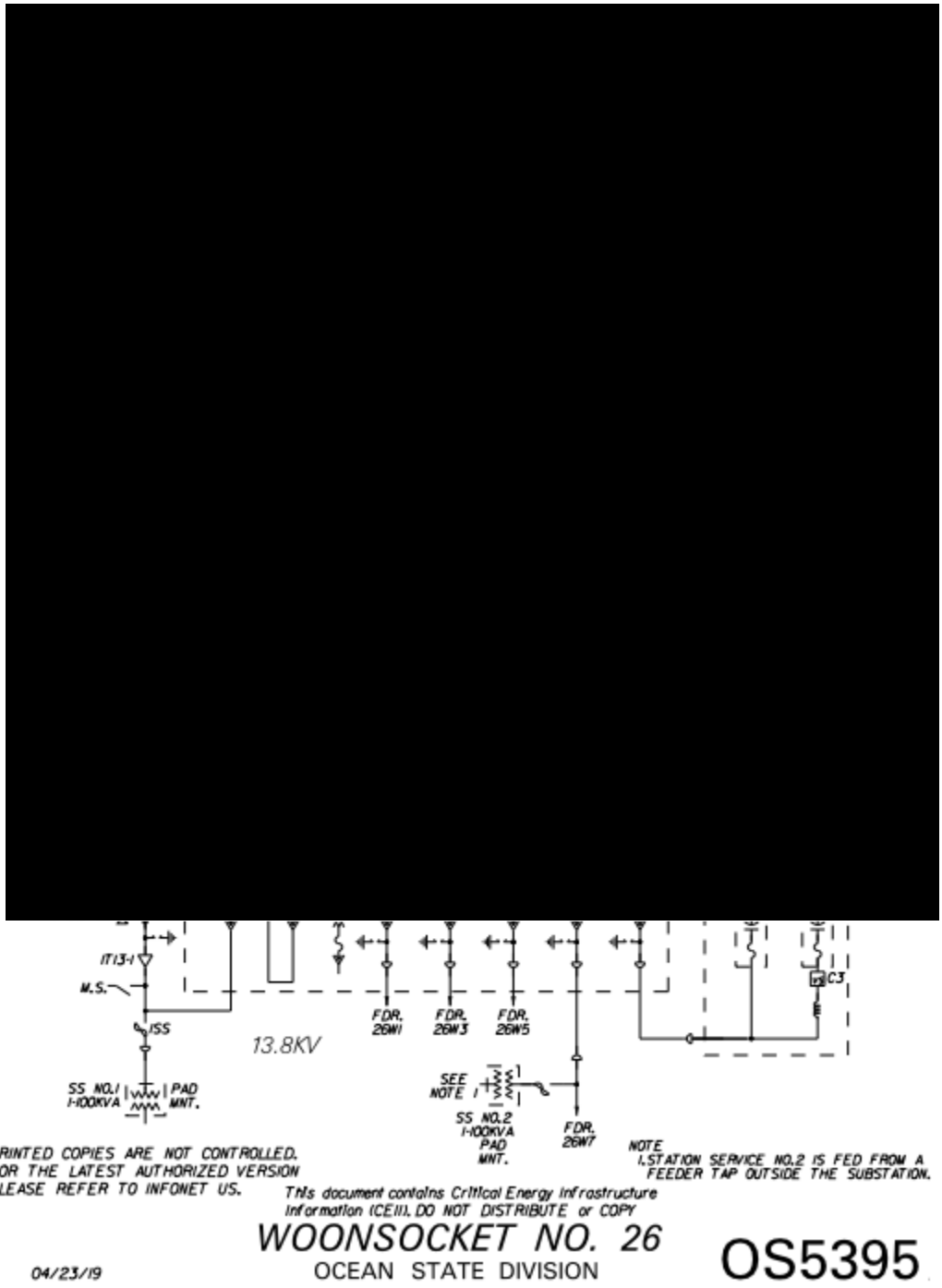


FIGURE 7.2.15 –WOONSOCKET #26 SUBSTATION ONE-LINE DIAGRAM



7.3 Arc Flash and Fault Duty Analysis

Substation	ID	OH Feeder, UG Feeder	Breaker IC	Vred Duty	Arc Flash cal/cm^2
CENTREDALE 50	T3	50F2	sufficient	sufficient	<8
CHOPMIST 34	T1	34F1	sufficient	sufficient	<8
CHOPMIST 34	T2	34F2	sufficient	sufficient	<8
CHOPMIST 34	T3	34F3	sufficient	sufficient	<8
FARNUM PIKE 23	T1	23F1	sufficient	sufficient	<8
FARNUM PIKE 23		23F3	sufficient	sufficient	<8
FARNUM PIKE 23		23F5	sufficient	sufficient	<8
FARNUM PIKE 23	T2	23F2	sufficient	sufficient	<8
FARNUM PIKE 23		23F4	sufficient	sufficient	<8
FARNUM PIKE 23		23F6	sufficient	sufficient	<8
MANTON 69	T1	69F1	sufficient	sufficient	<8
MANTON 69		69F3	sufficient	sufficient	<8
PUTNAM PIKE 38	T1	38F1	sufficient	sufficient	<8
PUTNAM PIKE 38		38F3	sufficient	sufficient	<8
PUTNAM PIKE 38		38F5	sufficient	sufficient	<8
PUTNAM PIKE 38	T2	38F2	sufficient	sufficient	<8
PUTNAM PIKE 38		38F4	sufficient	sufficient	<8
PUTNAM PIKE 38		38F6	sufficient	sufficient	<8
CENTREDALE 50	T1	50J1	sufficient	sufficient	<8
CENTREDALE 50		50J3	sufficient	sufficient	<8
NASONVILLE	T271	127W40	sufficient	sufficient	<8
NASONVILLE		127W41	sufficient	sufficient	<8
NASONVILLE		127W42	sufficient	sufficient	<8
NASONVILLE		127W43	sufficient	sufficient	<8
[redacted]		26W1	sufficient	sufficient	<8
		26W3	sufficient	sufficient	<8
		26W5	sufficient	sufficient	<8
		26W7	sufficient	sufficient	<8
WEST GREENVILLE 45	T1	45F2	sufficient	sufficient	<8

7.4 Reactive Compensation

Substation	Feeder	PF at feeder head before	PF at feeder head After	New Cap Bank
Farnum 105	105K1	89.49%	99.66%	(1) 600KVAr
[redacted]	26W1	97.30%	99.93%	(1) 900KVAr
	26W3	97.60%	100	(2) 900 KVAr
	26W7	94.50%	99.70%	(2) 900 KVAr
Centredale 50	50F2	97.28%	Station Rebuild	N/A
Centredale 50	50J1	93.72%	Station Rebuild	N/A
Centredale 50	50J2	90.03%	Station Rebuild	N/A
Chopmist 34	34F3	95.80%	99.23	(2) 600kVAr
Putnam Pike 38	38F2	97.40%	100	(2) 600kVAr

7.5 Plan Development

FIGURE 7.5.1 – WOONSOCKET #26 SUBSTATION PROPOSED ONE-LINE

FIGURE 7.5.2 – ROUTE MAP NEW 115KV LINE WOONSOCKET - NASONVILLE

FIGURE 7.5.3 – NASONVILLE #127 SUBSTATION EXPENTION ONE-LINE

FIGURE 7.5.4 – CENTREDALE #50 SUBSTATION REBUILD

FIGURE 7.5.5 – WEST GREENVILLE #45 SUBSTATION MOTOR OPERATED AIRBRAK REPLACEMENT

FIGURE 7.5.1 – WOONSOCKET #26 SUBSTATION PROPOSED ONE-LINE

FIGURE 7.5.2 – ROUTE MAP NEW 115KV LINE [redacted] – NASONVILLE

FIGURE 7.5.3 – NASONVILLE #127 SUBSTATION EXPANSION ONE-LINE

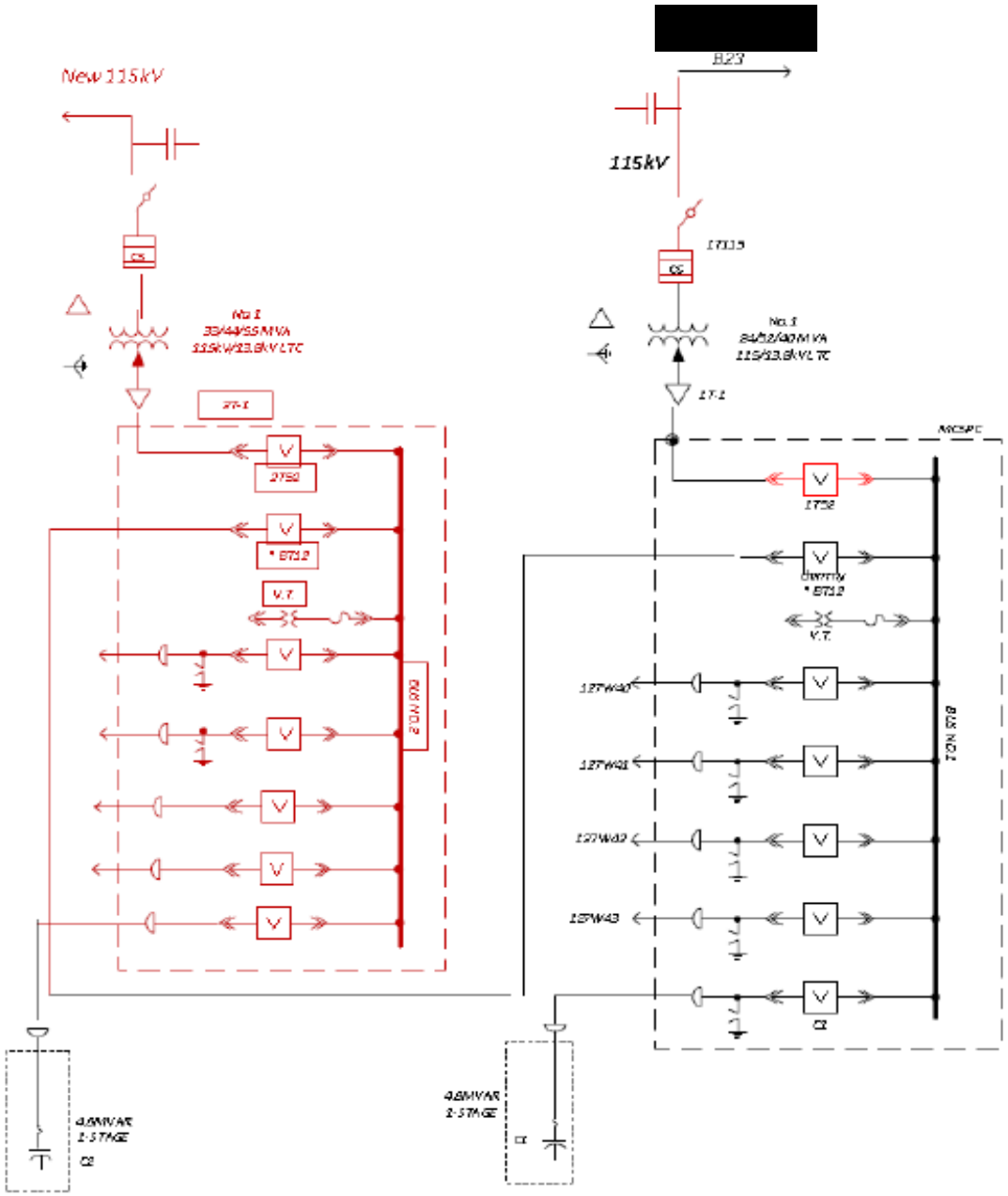


FIGURE 7.5.4 – CENTREDALE #50 SUBSTATION REBUILD

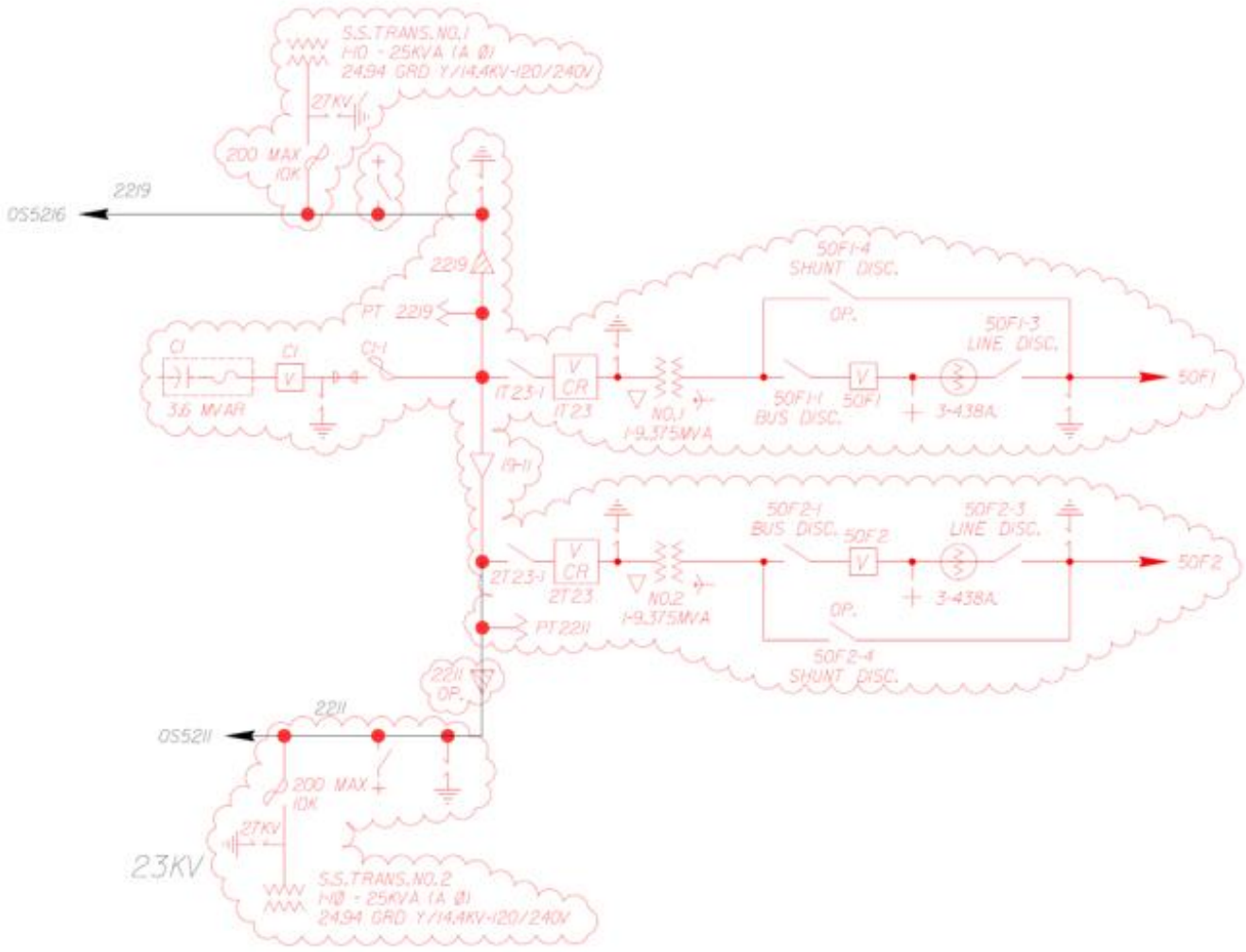
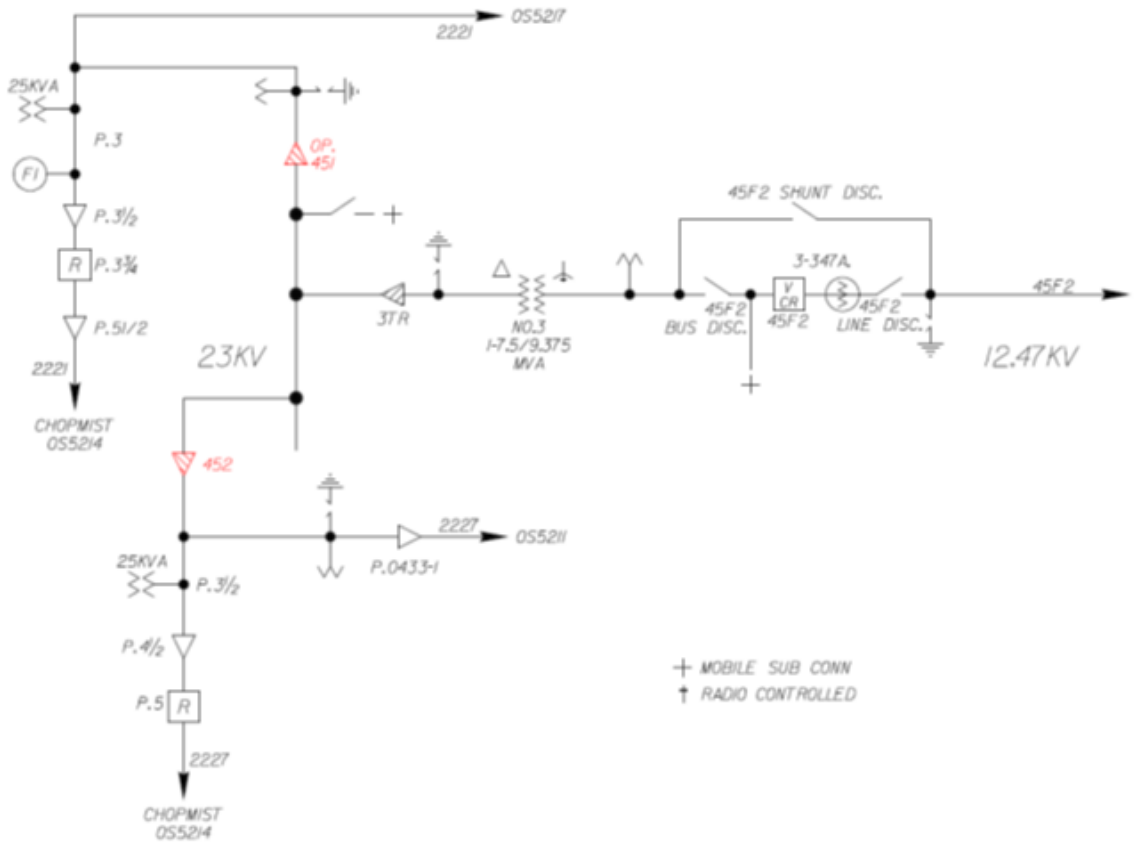


FIGURE 7.5.5 – WEST GREENVILLE #45 SUBSTATION MOTOR OPERATED AIRBRAK REPLACEMENT

5.0 PROPOSED OPERATING DIAGRAM



7.6 Non-Wires Alternative Criteria

Where an issue has been identified, a Non-Wires Alternative may also be considered as an option to defer a transmission, sub-transmission, or distribution wires solution for a period of time. Considering Non-Wires Alternatives to every wires solution is not practical given the low cost of a large volume of potential wires solutions, the magnitude of load relief required in certain situations, the time to acquire Non-Wires Alternatives (and verify their availability) or instances where the issue is poor operating condition of the asset. As a result, Non-wires Alternatives are screened against the following four guidelines:

A. The Wires solution, based on Engineering judgment, will likely be more than $1M;
B. If load reduction is necessary, then it will be less than 20 percent of the total load in the area of the defined need;
C. Start of construction is at least 36 months in the future; and
D. The need is not based on Asset Condition.

APPENDIX E

Woonsocket Substation – Nasonville Substation
115 kV Transmission Line
Rhode Island Energy Facility Siting Board
Siting Report

EASEMENT

Book 32 Page 536 NSMIRI W-PAS 16-001

KNOW ALL MEN BY THESE PRESENTS,

THAT we, [redacted], her husband of Burrillville, Providence County, Rhode Island (hereinafte called the Grantors) in consideration of One Dollar paid the receipt whereof is hereby acknowledged, hereby give, grant, bargain, sell and convey unto RHODE ISLAND POWER TRANSMISSION COMPANY, a Rhode Island corporation, (hereinafter called the Grantee), its successors and assigns, the perpetual right and easement to erect, maintain, operate and patrol a single or double line of poles, which lines may be erected simultaneously or at any future time, with wires and cables strung upon and from the same for the transmission of high and low voltage electric current, and for telephone use, with all necessary foundations, anchors, guys, braces and appurtenances to properly support and protect the same over, across and upon our lands situated in the town of North Smithfield and Burrillville, Providence County, Rhode Island. Said lines to enter from land now or formerly of Hannah P. Smith and cross to land now or formerly of Fayette E. Bartlett.

Together with the right to cut and remove at any and all times, without further payment therefor, trees and underbrush within a strip not exceeding 50 feet in width for a single pole line, and if at any future time a second pole line is constructed, payment being made therefor before its construction at the amount per pole hereinafter specified, the width of said strip may then or thereafter be increased by not more than 25 feet; the exact location of each line to become determined by and upon the erection and operation of each line, both lines erected hereunder to be within said strip.

And the Grantors hereby for themselves and their heirs, executors and administrators covenant with the Grantee, its successors and assigns, that they are lawfully seized in fee simple of the granted premises, that they have good right to sell and convey the same as aforesaid, and will warrant and defend the same to the Grantee, its successors and assigns, forever, against the lawful claims and demands of all persons.

It being understood and agreed that the Grantee, its successors and assigns, shall pay all taxes that may be assessed on the poles, wires and cables erected hereunder, and that said Grantee, its successors and assigns, shall have the right to enter said lands for the construction, maintenance, operation and removal of said lines at any and all times. It is further understood and agreed that the Grantee, its successors and assigns, shall pay to the Grantors, their heirs or assigns, before constructing each line, the further sum of Five Dollars ($5.00) a pole for each pole that shall be erected on each line, which payments shall be accepted by the Grantors, their heirs or assigns, in full satisfaction for the rights granted and for any damages that may be occasioned by the exercise of such rights.

This deed is given also in release of any and all dower and curtesy interests and all other interests by statute or otherwise of the Grantors hereto.

No oral promise, understanding or agreement affecting or changing this easement as herein set forth shall have any force or effect thereon, or on the parties hereto.

IN WITNESS WHEREOF, the aforementioned Grantors hereunto set their hands and seals this 27th day of October 1914.

Signed and sealed in presence of)
James S. Slater)

[redacted] (LS)
[redacted] (LS)

STATE OF RHODE ISLAND, &C.

COUNTY OF PROVIDENCE, SC. In Burrillville in said County on the twenty-seventh day of October 1914, before me personally appeared the above named Grantors [redacted] and [redacted] each and all to me known, and known by me to be the parties executing the foregoing instrument, and they severally acknowledged said instrument, by them executed to be their free act and deed.

JAMES S. SLATER (LS)
Notary Public.

Recei ved for record January 4th, A. D. 1915 at 8: o'Clock A.M.
Recorded by [illegible] Town Clerk.