EXHIBIT
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Analysis of the Potential Cumulative Impact of the Facilities of the Millennium Pipeline Company, L.L.C. and the New York Regional Interconnection

NEW YORK STATE

PREPARED FOR

NYRI
New York Regional Interconnection

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ESS Project No. P252-009.2

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ESS Group, Inc.

ANALYSIS OF THE POTENTIAL CUMULATIVE IMPACT OF THE FACILITIES OF THE MILLENNIUM PIPELINE COMPANY, L.L.C. AND THE NEW YORK REGIONAL INTERCONNECTION
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EXECUTIVE SUMMARY

The Millennium Pipeline and New York Regional Interconnection (NYRI) Proposed Route cumulative impact analysis was completed in fulfillment of the NYRI and New York State Public Service Commission (NYSPSC) agreed-to Stipulation filed on March 15, 2007. The Stipulation (II, A.) requested the Cumulative Impact Study along the Millennium Right-of-way (ROW) and the Proposed Route, where adjacent, from the Town of Deposit in Delaware County to a point in the Town of Deerpark, Orange County. The overall length of the NYRI Proposed Route Transmission Corridor between those locations is approximately 60.7 linear miles, of which the NYRI Proposed Route Transmission Corridor is adjacent to the Millennium Pipeline ROW for 33.7 miles (56%). NYRI considered potential impacts related to project design, construction, operation, maintenance and safety as identified in the Stipulation. This Cumulative Assessment report also addresses an additional request from the New York State Department of Environmental Conservation (NYSDEC) by letter dated August 20, 2007, for a study of cumulative impacts on forest fragmentation and associated impacts to forest dwelling bird species along the Proposed Route, west and south of the Catskills (See letter in Attachment A). The Millennium Pipeline was licensed by the Federal Energy Regulatory Commission (FERC) in December, 2006. Construction of the Millennium Pipeline commenced on July 3, 2007 and is expected to be completed in November 2008. Since this is before NYRI begins construction, there would be no overlap of actual "construction" of the two projects in terms of equipment, crews, and construction disturbance.

The NYRI route is not adjacent to the Millennium Pipeline for the entirety of the study distance and cumulative impacts are not expected along all 60 miles of the NYRI route alignment. NYRI defined a Study Area where the NYRI proposed route ROW is within 400 feet of the Millennium Pipeline existing ROW (where the two routes are "adjacent").

NYRI met with the Millennium Pipeline Company on April 12, 2007 to discuss potential design, construction, operational, maintenance, and safety impacts regarding the siting of NYRI's proposed project adjacent to the Millennium Pipeline ROW. NYRI has addressed the Millennium Pipeline Company concerns about controlling and limiting harmonics, project ROW overlap, cathodic protection systems, blasting setbacks and other operation and maintenance details further explained in this report.

Cumulative environmental impacts were considered to be limited to the 33.7 adjacent miles and to impacts that will still exist or may be repeated again after construction of the Millennium Pipeline. The environmental resources assessed in this study for potential cumulative impacts include vegetation clearing, wetlands, hydrology, threatened and endangered species, active agricultural fields and forest fragmentation.

Other cumulative impacts were considered based on the environmental resources studied as part of the Supplemental Article VII application (Exhibit 4), but were not included for a detailed review due to the limited potential for any cumulative impact. These include land use, geology, topography, floodplains, hazardous materials, noise and electric magnetic fields. There are no major potential cumulative impacts that have been identified for either visual or cultural/historic resources where NYRI and the Millennium Pipeline are adjacent.

The Millennium Pipeline ROW width is 50 feet with an additional 25-foot temporary construction ROW. NYRI's Proposed Route, when adjacent to the Millennium Pipeline is 150 feet wide, 75 feet on either side of the NYRI centerline. NYRI proposes a minimum separation distance of 100 feet between the NYRI and Millennium Pipeline center lines. Approximately 640 acres will be cleared and maintained within the Proposed Route Transmission Corridor in the Study Area. The majority of the total 640 acres (88 percent) are currently forested. The cumulative vegetation clearing area along the 33.7 linear mile study area will be approximately 840 acres. Temporary clearing will only occur along the Millennium Pipeline ROW (100 acres) and will then be allowed to revegetate.

While detailed ground survey information is not available which would permit NYRI to locate structures based on engineering design, NYRI did develop a reasonable representation of structure locations along the route to facilitate the visual impact assessment. This representation was also used to facilitate the cumulative impact assessment. The impacts from construction activities to wetlands from the two projects will primarily be from vegetation clearing for construction and operation of the transmission line and pipeline, access road construction and structure foundation construction in wetlands where the pipeline will also be installed. Impacts from vegetation clearing will be wetland specific depending on the type of wetland and species of vegetation present. Structure placement will only be a potential cumulative impact within DEC wetland EL-21 near NYRI Station Number 144 in the Town of Highland, as structures have the potential to be placed in upland areas for the other DEC wetlands in the Study Area. Cumulative impacts on wetlands from operation of the two projects will be due primarily to vegetation maintenance along the ROWs.

Since the NYRI project will not be putting structures or transmission lines within streams in the Study Area, the cumulative impact from construction activities to streams from both projects will primarily be from vegetation clearing, and where NYRI structure foundations and access roads are in close proximity to streams and the Millennium Pipeline crossing location. There is one access road crossing a stream which both NYRI and the Millennium Pipeline project will utilize for construction. The access road is near NYRI Station Number 106 (and Millennium Station Number 284.3) and crosses Sands Creek in the Town of Hancock, Delaware County. Based on the representative structure locations, six NYRI transmission tower structures were identified within 100 feet of a stream that the Millennium Pipeline also crosses. Other transmission structures are located further than 100 feet from stream resources. Due to the proximity of the Proposed Route to surface waters, it is anticipated that some project structures will be located in areas of shallow groundwater and in areas of surficial and sub-surface water run-off into streams. Since the projects will be constructed at least two years apart, and impacts will be minimized and mitigation measures applied site specifically, the potential for cumulative impacts to water quality and fish and wildlife will be minimal.

Based on the Federal Energy Regulatory Commission (FERC) Biological Assessment for the Millennium Pipeline, and NYRI's communications with NYSDEC, the Bald eagle and Timber rattlesnake is the most likely endangered fauna species found within the Cumulative Impact Study area.

The potential cumulative impacts to Bald eagles from the two projects will be from displacement of suitable habitat as a result of tree removal during construction and right-of way (ROW) maintenance, displacement from habitat by the presence of vehicles and machinery during construction and ROW maintenance, and prey displacement (fish & small mammals) during construction. The potential cumulative impacts to Timber rattlesnakes from the two projects would be from displacement of suitable habitat as a result of construction activities if explosives or excessive vibration of construction equipment were to occur in locations where Timber rattlesnakes are known to occur. NYRI has requested information from the NYSDEC regarding the location of Timber rattlesnake habitat along the Proposed Route as part of NYRI's response to the NYSPSC Stipulation regarding Threatened and Endangered Species (See Supplemental Article VII Application, Appendix O). Once this information is obtained, NYRI will be able to assess the potential cumulative impacts to Timber rattlesnake habitat and propose minimization and mitigation techniques to avoid potential impacts.

Both projects will cross a total of just under three miles of active agricultural fields in the 33.7 mile study area. Agricultural soils will be disturbed during construction, but permanent impacts will be minimized through compliance with various environmental management plans (such as topsoil stockpiling and soil decompaction) to protect soil resources in farmlands. Operation of the two projects together would not affect farming of existing agricultural fields. Farming can occur above a pipeline buried to permitted depth. Transmission line structures will be located out of active farm fields to the extent practicable.

There are no major potential cumulative impacts that have been identified for visual resources within the Cumulative Impact Study area. The overall cumulative impact from a visual resource perspective will be a wider clearing area from the two projects that will be visible primarily at road crossings and other vantage points.

Twenty-nine archeological resources were identified within the Study Area and include 17 historic sites and 12 precontact sites. No National Historic Listed or Eligible sites were identified. The sites include quarries, camps, a sawmill complex, wells, a barn and traces of occupation. The Area of Potential Effect will be determined after Certification of the NYRI Route and appropriate avoidance and mitigation measures will be developed to avoid any potential cumulative impacts with construction of the Millennium Pipeline Project.

In order to address potential impacts to woodland bird species from forest fragmentation, analyses were performed on the areas of forested land intersected by the Proposed Route in Greenfield areas within the cumulative impact Study area. The forest cover in the Study Area is a mix of deciduous and coniferous trees and includes a total of 22,208 acres in 50 separate tracts or 'patches' of forest that are intersected by the Proposed Route. Of these 50 forest patches, 37 patches with a combined area of 14,298 acres would be affected by fragmentation. Forest fragmentation would occur along 18.61 miles of the Greenfield sections of the Proposed Route with 37 patches of contiguous forest being converted into 84 smaller patches of forest.

The two largest forest patches (1,365 acres and 1,911 acres) would be minimally affected by the Proposed Route crossing. The 1,365 acre forest patch would be fragmented into two smaller forest patches with sizes of 1,105 acres and 237 acres, while the 1,911 acre patch would be converted into two smaller patches with sizes of 1,902 acres and 6 acres (not including the cleared ROW area).

The creation of edge habitat along a transmission line ROW in forested areas appears to have both positive and negative effects on bird populations, wildlife, and local ecosystems. Whether the effect is positive or negative is species-specific. Those species that favor earlier successional, shrubland habitats will likely experience positive effects as a result of the project. Forest interior species that require contiguous blocks of forest for habitat may only experience temporary negative impacts as they are able to move to nearby suitable habitat. The quality of the existing forest habitat along the route will also play a role in determining the effects on interior forest bird species. If suitable habitat exists, it will likely still support a variety of bird species. If forest habitat is marginal, there may be more negative effects on species. The characteristics of the wider landscape in which the transmission line will be constructed are a significant factor in determining positive or negative impacts on a particular species. If the wider regional landscape is primarily fragmented, the overall effect may be negative. However, if the wider landscape still contains large blocks of contiguous forest, the overall effect may be positive by providing a greater diversity of habitat in the region. Areas that are impacted by fragmentation may also be re-colonized by birds from source populations in larger blocks of adjacent forest. Considering that the majority of the Cumulative Impact Study area passes through a broader landscape which still contains large blocks of contiguous forested habitat, it is unlikely that the fragmentation which will result from the project will have any long-term negative impacts on woodland bird species.

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1.0 INTRODUCTION

NYRI completed an analysis to assess the potential cumulative engineering design, construction, operation, maintenance, safety and environmental impact of the construction and operation of the NYRI HVDC transmission line and the Millennium natural gas pipeline. Environmental impacts were evaluated in light of the potential environmental impacts as determined by the Federal Energy Regulatory Commission (FERC), of the Millennium Phase 1 Pipeline facilities (Millennium) where the proposed NYRI route is adjacent to the Millennium Pipeline right-of-way (ROW). This analysis was completed in fulfillment of the NYRI and New York State Public Service Commission (NYSPSC) agreed-to Stipulation filed on March 15, 2007. The Stipulation (II, A.) requested the Cumulative Impact Study along the two ROWs, where adjacent, from the Town of Deposit, Delaware County to a point in the Town of Deerpark, Orange County, approximately two miles east of the Sullivan/Orange County line (see Figure 1). The overall length of the Proposed Route between those locations is approximately 60.7 linear miles.

In order to develop a cumulative impact assessment based on the best available information, NYRI legal counsel consulted with the Department of Public Service, New York State Department of Environmental Conservation (NYSDEC), and FERC staffs to identify any known similar cumulative impact studies. The correspondence sent to these agencies is provided in Attachment A. NYRI legal counsel also consulted with the NYS Reliability Council (and New York Independent System Operator NYISO) to identify any rules or procedures regarding proposed construction and operation of NYRI's proposed transmission line adjacent to the Millennium Pipeline. Neither the NYS Reliability Council nor NYISO indicated that there were any specific procedures that should be followed.

NYRI considered potential impacts related to project design, construction, operation, maintenance and safety as identified in the Stipulation. The analysis relied on meetings with the Millennium Pipeline Company LPC, and the FERC Final Environmental Impact Statement (FEIS) and Final Supplemental Environmental Impact Statement (FSEIS), including the Biological Assessment, of the Northeast (NE)-07 Project (of which the Millennium Pipeline is a part), and the Millennium Pipeline Alignment Sheets (specifically Sheets 85 through 136 of 173). This study also relies upon NYRI's technical information gathered for and reported in the Article VII Supplemental Application.

This Cumulative Impact Assessment report also addresses an additional request from the NYSDEC by letter dated August 20, 2007, for a study of cumulative impacts on forest fragmentation and associated impacts to forest dwelling bird species along the Proposed Route, west and south of the Catskills (see letter in Attachment A). The Forest Fragmentation Study is included in Attachment B.

2.0 BACKGROUND

2.1 The Millennium Pipeline Project

The Millennium Pipeline Project proposed by the Millennium Pipeline Company, LPC (Docket Nos. CP98-150 et al.) and the related abandonment project proposed by Columbia Gas Transmission Corporation (Docket Nos. CP98-151 et al.) (Columbia A-5 pipeline) were approved by FERC on September 19, 2002. The NE-07 Project (of which Millennium is now a part) modified the project and was granted conditional authorization by FERC on December 21, 2006. The NE-07 Project includes construction and operation of certain facilities approved for the Millennium Pipeline Project, with some additions and modifications, as well as facilities proposed by Empire State Pipeline and Empire Pipeline, Inc, Algonquin Gas Transmission System, LLC, and Iroquois Gas Transmission System, LP. Throughout the remainder of this analysis, the NE-07 Project will be referred to generally as the "Millennium Pipeline Project" or "Millennium Pipeline" as appropriate.

2.2 Route Alignment Overview

As requested in the Stipulation (II,A), the cumulative impacts study was conducted where the NYRI route parallels the Millennium Pipeline, generally over 60.7 miles through nine towns beginning in the Town of Deposit in Delaware County to a point in the Town of Deerpark, approximately two miles east of the Sullivan/Orange County line. The study area corresponds to Stations 100 through 160 along the NYRI Proposed Route and Stations 278 through 335.5 along the Millennium Route. The Cumulative Impact Study area is shown on Figure 1. The NYRI route is not adjacent (as defined below) to the Millennium Pipeline for the entirety of the study distance and cumulative impacts are not expected along all 60 miles of the NYRI route alignment. Orthophotography maps at a 1:400 scale showing the NYRI route and the Millennium Pipeline route alignments are provided in Attachment C. Other existing electric transmission line alignments are also included for reference.

Table 1 provides a description of the NYRI route where it is adjacent to (33.7 miles) and where it departs from (27.0 miles) the Millennium pipeline. Adjacent was defined to mean that the closest edge of the NYRI Proposed Route Transmission Corridor was within 400 feet of the closest edge of the Millennium Pipeline ROW which could result in cumulative impacts. This table was developed by buffering off 400 feet between the Millennium Pipeline ROW and the NYRI Proposed Route Transmission Corridor. Where the NYRI Proposed Route Transmission Corridor overlapped the 400 foot buffer, the NYRI route was considered to be adjacent to Millennium Pipeline (the Cumulative Impact Study area, or study area) and where it did not it was considered to "depart" from the Millennium Pipeline.

Over the 60 miles where the aboveground NYRI project could potentially be adjacent to the largely underground Millennium project, an analysis was conducted of each mile of the route. The total distance where NYRI is actually adjacent to Millennium Pipeline ROW (within 400 feet) and could have potential cumulative impacts is approximately 33.7 miles. The NYRI proposed route departs from the Millennium Pipeline for approximately 27 miles. The rationale for each segment of the NYRI Proposed Route to depart the Millennium Pipeline is summarized in Table 1. Generally, the NYRI route departed from Millennium Pipeline route to avoid existing buildings, the Upper Delaware Wild Scenic and Recreational River Corridor, and the Mongaup WMA.

2.3 NYRI and Millennium Pipeline Right-of-Ways

The permanent Millennium Pipeline ROW width is 50 feet with a nominal additional 25-foot construction ROW which will be abandoned after the project is constructed. NYRI's Proposed Route Transmission Corridor is 150 feet wide, 75 feet on either side of the NYRI centerline. Figure 2 shows the proposed widths of the NYRI Proposed Route Transmission Corridor and Millennium Pipeline ROW and their relationship when adjacent.

Along the Millennium Pipeline Project, a 150-foot incremental clearing width will be needed. As shown in Exhibit 4, Section 4.4 on Figure 4.4.2-1, where the transmission line is located off-railroad, there will be one clearing zone (Zone A). Off-railroad portions of the Proposed Route will have a 150 foot zone (Zone A) where vegetation will be cleared completely for construction and maintained by herbicides, but vegetation maturing less than 24 feet in height will be allowed to regenerate. Clearing by mechanized equipment will be used where possible; however, in environmentally sensitive areas, hand clearing may be required. Outside of Zone A, there may be an occasional tree that, should it fall, may cause potential danger to the transmission line. Any such danger tree would be removed following acquisition of rights from the property owner.

Where the NYRI Proposed Route Transmission Corridor and Millennium Pipeline ROW are parallel and directly adjacent, the centerlines of the two projects will be a minimum of 100 feet apart.

2.4 Project Schedules

The Millennium Pipeline Project began construction of approximately 12 miles of pipeline in several locations in May of 2007 and proposes to complete construction of the majority of the route during 2008. NYRI proposes to begin construction during the third quarter of 2009 or early 2010. Consequently, Millennium Pipeline construction is expected to be completed before NYRI begins construction and there would be no overlap of actual "construction" of the two projects in terms of equipment, crews, and construction disturbance.

3.0 CUMULATIVE IMPACT ASSESSMENT

3.1 Engineering Design, Construction, Operation, Maintenance and Safety

NYRI met with the Millennium Pipeline Company on April 12, 2007 to discuss potential design, construction, operational, maintenance, and safety impacts regarding the siting of NYRI's proposed project adjacent to the Millennium Pipeline ROW.

3.1.1 Project Design

NYRI proposes to use lattice tower structures along the Proposed Route in the Study area. A description, including drawings, of the tower types, structure foundations and grounding is presented in Exhibit E-1. These designs meet the requirements of the National Electric Safety Code and are consistent with good engineering design practices.

As described in Exhibit E-2, both AC and DC filters will be designed and installed at each converter station to control and limit harmonics on the transmission line conductors. During final design, a harmonics study will be undertaken to ensure that the resulting harmonics are in conformance with the design criteria for the project.

NYRI proposes to use a 150 foot wide corridor along the route alignment contiguous with the Millennium Pipeline. Millennium's right-of-way is 50 feet wide. NYRI proposes to design the transmission line with a minimum structure centerline to pipeline centerline separation distance of 100 feet. With this separation, NYRI's Proposed Route Transmission Corridor and the Millennium right of way will be abutting with no overlap. This will allow for uninhibited use of Millennium's 50 foot ROW. See figure 2.

3.1.2 Electrical Design

NYRI engaged Exponent, Inc., a consulting firm with expertise on electromagnetic effects, to undertake an assessment of the potential effects of the proposed DC transmission line on the adjacent Millennium pipeline, its cathodic protection systems, and pipeline integrity and monitoring systems. Their report is presented in Attachment D.

In brief, (1) the maximum level of the DC magnetic field from the proposed transmission line is too weak to produce any detrimental effect on the pipeline; (2) the electric field is within relevant guidelines; (3) due to the metallic return conductor, the ground current will be negligible; (4) leakage current across the insulators to ground will be negligible; (5) any inductive coupling will be too weak to result in interference with cathodic protection and monitoring systems; (6) internal monitoring devices are shielded from electromagnetic effects; (7) and interference to radio frequency or wired communications systems will be negligible.

Fault current to ground would be large enough to potentially interfere with the pipeline. However, the fault current, and any interference produced, will be of short duration. Fault clearing is significantly faster on DC systems than AC systems.

At the time of the study Millennium's plans for corrosion control and integrity testing and monitoring had not been designed. Thus, the Exponent work relied on exemplar equipment.

3.1.3 Construction

Construction of the proposed transmission line is described in Exhibit 4 section 4.6. Equipment, materials and workers will move along the transmission line ROW to each work location. Two aspects of construction are of particular interest regarding potential impacts to the pipeline: crossing the pipeline with equipment, and blasting or otherwise creating vibration or shock loads that might impact the pipeline.

During development of the EM&CP, each physical crossing of the pipeline by a NYRI access road will be reviewed with the Millennium Pipeline Company and appropriate protection measures will be identified and implemented.

NYRI will incorporate in its construction specification that no blasting will be permitted within 200 feet of the pipeline. In preparation of the construction specification NYRI will review with the Millennium Pipeline Company rock drilling and other typical excavation and construction methods to ensure concerns regarding pipeline integrity are addressed.

3.1.4 Operation and Maintenance

It is expected that both facilities will be operated and maintained in accordance with their respective owner and any regulatory requirements. Based on mapping provided, the minimum separation from a Millennium Pipeline Company blow down valve to the NYRI transmission line is 100 feet. An ignition source calculation indicates that the capacitive current is less than 5mA which is the recommendation to avoid a spark with sufficient energy to cause ignition of fuel.

NYRI and Millennium agreed to discuss development of a Joint Operating Agreement when both projects are further along. It is expected that any such agreement will primarily address emergency notification and action procedures.

3.1.5 Mitigation Measures

NYRI increased its proposed centerline to centerline separation from 50 feet to 100 feet to eliminate any overlap with the Millennium Pipeline ROW. This change accommodates the Millennium Pipeline Company's need for uninhibited use of their right of way.

NYRI will develop a construction specification that prohibits blasting within 200 feet of the pipeline and will address the Millennium Pipeline Company's concerns with construction techniques that may result in vibration or shock loads that may impact the integrity of the pipeline.

At this time the need for any additional mitigation measures has not been identified. However, as both projects progress and detailed design information becomes available, the need for other mitigation measures or engineering accommodations may be identified.

3.2 Cumulative Environmental Impacts

Existing conditions for the environmental resources addressed in this study are described in the Exhibits of NYRI's Article VII Supplemental Application and in Millennium's FERC proceeding filings (previously cited). Existing conditions are not repeated in this report, but are incorporated by reference.

Since the two projects will not be constructed at the same time, and the NYRI route is only adjacent to the Millennium Pipeline for approximately 33.7 miles, the cumulative environmental impacts were considered to be limited to the 33.7 adjacent miles and to impacts that will still exist or may be repeated again after construction of the Millennium Pipeline. The environmental resources assessed in this study for potential cumulative impacts include vegetation clearing, wetlands, hydrology, threatened and endangered species, active agricultural fields and forest fragmentation.

Other cumulative impacts were considered based on the environmental resources studied as part of NYRI's Supplemental Article VII application (Exhibit 4), but were not included for a detailed review due to the limited potential for any cumulative impact. These include land use, geology, topography, floodplains, hazardous materials, and noise. There are no major potential cumulative impacts that have been identified for either visual or cultural/historic resources where NYRI and the Millennium Pipeline are adjacent.

3.2.1 Vegetation Clearing

Approximately 200 acres of vegetation are cleared by mowing within the 50-foot-wide Millennium Pipeline ROW along the 33.7 mile distance where the Millennium Pipeline is adjacent to the NYRI Proposed Route. Within the 25-foot-wide Millennium Pipeline temporary construction ROW, vegetation will be temporarily cleared over an additional 100 acres, than allowed to revegetate following construction.

Along the Millennium Pipeline Project, a 150-foot incremental clearing width will be needed. As shown in Exhibit 4, Section 4.4 on Figure 4.4.2-1, there will be one clearing zone (Zone A). Off-railroad portions of the Proposed Route will have a 150 foot zone (Zone A) where vegetation will be cleared completely for construction and maintained by herbicides, but vegetation maturing less than 24 feet in height will be allowed to regenerate. Clearing by mechanized equipment will be used where possible; however, in environmentally sensitive areas, hand clearing may be required. Outside of Zone A, there may be an occasional tree that, should it fall, may cause potential danger to the transmission line. Any such danger tree would be removed following acquisition of rights from the property owner.

Approximately 640 acres will be cleared and maintained by herbicides within the Proposed Route Transmission Corridor in the Study Area. The majority of the total 640 acres (88 percent) are currently forested.

The widths of the Millennium Pipeline ROW and the Proposed Route Transmission Corridor, and areas of vegetation clearing, are shown on Figure 2.

The cumulative vegetation clearing area along the 33.7 linear mile study area will be approximately 840 acres. Temporary clearing will only occur along the Millennium Pipeline ROW (100 acres) and will then be allowed to grow. Potential effects due to forest fragmentation from vegetation clearing are discussed in the Impact of Forest Fragmentation on Woodland Birds Study included in Attachment B.

3.2.2 Wetlands

Based on the Millennium Pipeline Alignment Sheets, the Millennium Pipeline ROW will cross through 46 wetlands, for a total distance of 12,455 linear feet (2.36 miles) within the study area. The Millennium Pipeline will cross these wetlands underground. The Alignment sheets include wetlands that were delineated by the Millennium Pipeline Company.

A desktop analysis based on the NYSDEC wetlands database and the National Wetlands Inventory (NWI) was completed to determine wetland crossings. NYRI will complete wetland delineations once the route is certified and during the EM&CP phase of the project. Based on actual field delineations, additional wetlands may be identified that were not captured in the NWI database. Based on the NYSDEC State wetlands database and the National Wetland Inventory, NYRI will cross approximately 22 wetlands in the study area. Using 2004 orthophotographs and the NYSDEC and NWI datasets, NYRI calculated the Proposed Route will cross these wetlands for a total distance of 10,427 linear feet. NYRI will cross these wetlands in an overhead configuration. All of the wetlands except one are narrow enough at the Proposed Route crossing location such that they can be spanned by the transmission line conductors with structures located in upland areas.

However, there is one state jurisdictional wetland (DEC wetland EL-21 near Station Number 144 in the Town of Highland) that may be too wide to span, and may require that a structure be placed within the wetland boundary. The Millennium Pipeline will also be crossing through this wetland for a distance of 1,090 feet. The amount of fill (concrete) required for the transmission tower foundation is dependent on the structure type selected during final design. If a pile type foundation is used, the amount of fill for the piles and cap typically range between 60 and 80 cubic yards per structure; the cap would occupy approximately 250 square feet (0.1 acres) that would need to be filled within the Proposed Route Transmission Corridor. Typical foundations are shown in Exhibit E-1 of the Article VII Supplemental Application. Beyond this one possible one structure, the impacts to wetlands will be limited. Please see Exhibit 4, Section 4.13 of the NYRI Article VII Supplemental Application for further details on mitigation for potential wetland impacts.

The cumulative impact from construction activities to wetlands from the two projects will primarily be from vegetation clearing for construction and operation of the transmission line and pipeline, access road construction and structure foundation construction in wetlands where the pipeline will also be installed. Impacts from vegetation clearing will be wetland specific depending on the type of wetland and species of vegetation present. NYRI vegetation disposal will generally be onsite in upland areas. Placement of access roads will typically be outside of wetland areas where possible, and NYRI will not have any permanent access roads within wetlands. Structure placement will only be a cumulative impact within the DEC wetland indicated above (DEC Wetland EL-21) as structures will be placed in upland areas wherever possible. Cumulative impacts on wetlands from operation of the two projects will be due primarily to vegetation maintenance along the ROWs of the two projects. All vegetation will be removed and will be maintained within the 50-foot-wide Millennium pipeline ROW. Off-railroad portions of the Proposed Route will have a 150 foot zone (Zone A) where vegetation will be cleared for construction, but vegetation maturing less than 24 feet in height will be allowed to regenerate (see Exhibit 4, Section 4.13.3.1 of the Supplemental Article VII filing).

3.2.3 Hydrology

Based on the Millennium Alignment sheets and the FERC SFEIS, the Millennium Pipeline project will cross approximately 52 streams and rivers (collectively referred to as streams) within the study area. Some streams are crossed multiple times. Of the 52 stream crossings, 29 crossings will occur at perennial streams, 21 at intermittent streams, one at an ephemeral stream, and one type was not reported. None of the crossings will occur on streams classified as drinking water sources (Classes A or AA). Six of the streams crossed are Class B waters (suitable for swimming and contact recreation). The remaining crossings are Class C waters, which support fisheries (as do the other classifications) and are suitable for non-contact activities. Twelve of the streams crossed support trout spawning; 15 of the streams crossed support trout populations. Approximately 28 stream crossings are expected to be minor, and 18 will be intermediate.

Millennium considers minor crossings to be waterbodies less than or equal to 10 feet wide at the point of crossing, and intermediate crossings to be waterbodies more than 10 feet wide and less than or equal to 100 feet wide at the point of crossing and major crossings to be crossings of waterbodies greater than 100 feet wide at the point of crossing (FERC 2006b v1 p.4-52). Although both projects will cross the East Branch of the Delaware River, the routes will cross the River approximately 725 feet apart from each other, west of NYRI station 109, and east of Millennium station 287. The NYRI route will be in an overhead configuration across the East Branch of the Delaware River.

The NYSDEC Streams Classification database was used to identify potential streams crossed by the NYRI proposed route. Within the Study Area, the NYRI Proposed Route will cross 36 streams, with some streams crossed multiple times. None of the crossings will occur on streams classified as drinking water sources (Classes A or AA). Twenty-five of the stream crossings are on streams that are Class C waters and eight are Class B waters. Eighteen of the stream crossings support trout populations and eight support trout spawning. All of the stream crossings will be in an overhead configuration within the Study Area (where the two routes are within 400 feet of each other). The only underground stream crossing along the NYRI Proposed Route where it is in the vicinity of the Millennium Pipeline project is on the Rio Reservoir and this crossing is 3000 feet south of the Millennium Pipeline crossing. For more details regarding the NYRI Rio Reservoir Crossing, please refer to Exhibit 4, Section 4.6 (Construction) of the Article VII Supplemental Application..

The distance between NYRI transmission line structures will typically range between 800 feet and 1,200 feet when adjacent to utility ROWs and in Greenfield areas. Therefore, there is considerable flexibility in the placement of the individual structures to minimize impacts to water quality and NYRI has proposed structures as far as practicable from stream resources.

Since the NYRI project will not be putting structures or transmission lines within streams in the Study Area, the cumulative impact from construction activities to streams from both projects will primarily be from vegetation clearing, and where NYRI structure foundations and access roads are in close proximity to streams and the Millennium Pipeline crossing location.

Impacts from vegetation clearing in proximity to streams will be site specific depending on the type of vegetation present and proximity of the two projects. The clearing will result in a maximum incremental clearing of approximately 150 feet from the NYRI Project in addition to the nominal 75 foot width (50 feet permanent and 25 feet temporary) cleared by for the Millennium

Pipeline Project. In addition, the Millennium Pipeline Alignment sheets show a wider (greater than 25 feet) clearing at streams, wetlands and road crossings. Vegetation clearing at these locations could increase from between 50 to 150 feet depending on site conditions[1]. Removal of trees and tall shrubs may have a greater potential impact on streams because they provide shade which moderates water temperatures for fish and wildlife. These areas may also be more prone to erosion and sedimentation after vegetation removal if herbaceous plants are not already established in the understory. These types of impact will be minimized by creating buffer zones where appropriate. Buffer zones will be located at stream crossings and will consist of shrubs and low-growing vegetation that can be easily controlled so as not to interfere with clearance requirements. The width, extent, and location of these buffer zones will be determined once the project route is certified and the centerline determined, structures located, and heights finalized. All construction areas that occur near a stream will utilize temporary barriers such as silt fences and hay bales to prevent siltation from entering the water resource. These barriers will typically remain in place and be maintained until construction and re-vegetation is complete.

There is one access road crossing a stream which NYRI and the Millennium Pipeline project will utilize for construction. The access road is near NYRI Station Number 106 (and Station Number 284.3) and crosses Sands Creek in the Town of Hancock in Delaware County. The access road is an existing unimproved road. Sands Creek is designated as a Class C stream by the NYSDEC and it is also a trout spawning stream. Potential cumulative impacts may include water quality impairments to fish and wildlife habitat depending on the time of year the access road is used for construction and/or maintenance and the amount of flow in the stream. Since the projects will be constructed at least two years apart, the potential for cumulative impacts to water quality and fish and wildlife will be minimal.

Transmission line structure placement adjacent to streams where the Millennium Project crosses may be a potential cumulative impact. Using the reasonable representation of structure locations, six transmission tower structures were identified within 100 feet of a stream that the Millennium Pipeline also crosses. These structures are located at NYRI Station number 115 at Bouchoux Brook or Leonard Creek, station number 133 at Mitchell Pond Brook, station number 134 at Mitchell Pond Brook, station number 132, Tributaries of Delaware River, station number 110, Tributaries of East Brach Delaware River, and station number 122, Tributaries of Hankins Creek. However, the final placement of these structures has not been determined. Based on final design these structure locations could change which may result in placement beyond 100 feet of the streams. Other transmission structures were located further than 100 feet from stream resources.

Due to the proximity of the Proposed NYRI Route to surface waters, it is anticipated that some project structures will be located in areas of shallow groundwater and in areas of surficial and sub-surface water run-off into streams. To avoid cumulative impacts from siltation into streams, NYRI dewatering activities will be conducted throughout the construction phase. All collected

[1] Because of the uncertain nature of the amount of clearing Millennium may undertake at these locations, it has not been included in the total clearing acreage.

water will be disposed in such a manner as to control sedimentation and siltation. This may include collection and pre-treatment (sediment filtration, etc.) of water prior to disposal. Re-introduction of water into streams will be conducted in accordance with appropriate regulatory requirements. Water discharged into vegetative areas will use appropriate control systems (i.e. energy dispersion baffles) to prevent soil erosion.

Please reference Exhibit 4, Section 4.12.3 of the Article VII Supplemental Application for more details on minimization of potential impacts to streams from NYRI construction activities.

Cumulative impacts on streams from operation of the two projects will be due primarily to vegetation maintenance along the ROWs. Vegetation clearing will be maintained within the 50-foot-wide Millennium pipeline ROW. Off-railroad portions of the Proposed Route will have a 150 foot zone (Zone A) where vegetation will be cleared completely for construction and maintained by herbicides, but vegetation maturing less than 24 feet in height will be allowed to regenerate.

3.2.4 Threatened and Endangered Species

The Biological Assessment for the NE-07 Project (FERC, October 2006a), which contains the Millennium Phase 1 Project, identified four federally listed threatened or endangered species along portions of the Millennium Pipeline route in the counties where NYRI is adjacent to the Millennium Project. The Bald eagle was identified in Delaware, Sullivan, and Orange Counties. The Indiana bat was identified in Orange County. The bog turtle was identified in Orange County. The dwarf wedge mussel was identified in Orange County, but only in the Neversink River, which is east and outside of the study area for cumulative impacts. Suitable habitat was also found for the migration/transitory periods of the Indiana bat in the Biological Assessment, although none was identified within areas that correspond to this study area (FERC, 2006a).[2]

The NYSPSC Stipulations for the NYRI project signed March 15, 2007 identified four threatened and endangered species of concern that warranted study along specific portions of the proposed NYRI route, to evaluate potential impacts and, if needed, develop mitigation measures. Of the four species, two, the Bald eagle and the Timber rattlesnake, were identified for assessment within the Cumulative Impact Study area, specifically within Delaware, Sullivan, and Orange Counties.

The remaining two species of concern were not identified for assessment in the Cumulative Impact Study area. These were the Indiana bat, a state- and federally listed endangered species, also required for assessment in Orange County well east of the study area and in a limited portion of Oneida County; and the Bog turtle, in areas where the NYRI project co-aligns

[2] Within the study area, both projects will traverse seven areas identified on the Millennium alignment sheets (ES-1 through ES-6) as containing habitats suitable for threatened and/or endangered species. All the habitats were in Delaware County, with the southeastern most area (ES-6) shown as spanning Delaware and Sullivan Counties. The specific species of concern for each of the six endangered species areas was not reported on the alignment sheets, or in the available FERC filings reviewed as part of this study (FERC, October 2001; FERC, October 2006a; FERC, October 2006b).

with an existing railroad ROW in Orange County, to the east of this study area, and along a short section on the northern end of the line in the town of New Hartford, Oneida County.

Based on the Biological Assessment, which contains the Millennium Pipeline, and NYRI's communications with NYSDEC, the Bald eagle and Timber rattlesnake are the most likely endangered species found within the Cumulative Impact Study area. For a detailed review of existing conditions and potential impacts to the Bald eagle and Timber rattlesnake from NYRI, please refer to Exhibit 4, Section 4.10 and Appendix O of the Article VII Supplemental Application. Appendix O also includes a discussion of potential operational impacts from electric transmission lines to the Bald eagle.

3.2.4.1 Bald Eagles

The potential cumulative impacts to Bald eagles from the two projects will be from displacement of suitable habitat as a result of tree removal during construction and right-of way (ROW) maintenance, displacement from habitat by the presence of vehicles and machinery during construction and ROW maintenance, and prey displacement (fish & small mammals) during construction.

The Mongaup River and Rio Reservoir has been identified as a significant Bald eagle area. The area hosts one of the largest Bald eagle wintering sites in the state, and also supports several active eagle nests (NYSDEC 2007). The Millennium Pipeline will be an underground installation and the proposed route for the NYRI transmission line will be underground for 1.1 miles in this area. As described earlier, the crossings are more than 3000' apart and there will be several years between construction of the two projects. Because the NYRI transmission line will be underground, risks to Bald eagles from collisions and electrocution will be eliminated in these areas.

The Millennium Pipeline Project will be installed in the Columbia A-5 existing cleared, maintained 50 foot ROW. An additional nominal 25 foot temporary construction ROW will be needed to construct the pipeline, but will be allowed to return back to a vegetated state once construction is complete. Undergrounding the NYRI transmission line requires clearing within the ROW. The construction ROW width will be 50 feet in this area, which will serve as a permanently maintained ROW. Vegetation clearing will include 102-foot x 133-foot footprints for the transition stations on either side of the Rio Reservoir. Installation of the transition stations will also require some additional clearing outside of the footprints. Potential perching and roosting habitat may be impacted; however, surrounding lands in this area provide similar habitat that can utilized by any displaced eagles. A portion of the cleared area will be left to revegetate naturally upon completion of construction. The presence of vehicles and construction equipment during construction may temporarily displace bald eagles. The adjacent lands should provide suitable habitat for temporarily displaced bald eagles. Construction activities may cause temporary prey displacement but there are adjacent lands and water bodies that should provide suitable foraging areas for the Bald eagle.

The confluence of Basket Creek and the Delaware River was identified as a Bald eagle activity area as a result of a NYRI field survey conducted on February 23 and 24, 2007. Basket Creek and the surrounding hills are likely used as a wintering roost location and possible nesting location. Bald eagles were observed traveling along Basket Creek between the steep ridges that border the creek. The NYRI transmission line will cross Basket Creek approximately 1,100 feet northeast of where the Millennium Pipeline crosses the creek.

3.2.4.2 Timber Rattlesnakes

The potential cumulative impacts to Timber rattlesnakes from the two projects would be from displacement of suitable habitat as a result of construction activities if explosives or excessive vibration of construction equipment were to occur in locations where Timber rattlesnakes are known to occur.

The Millennium Pipeline project identified 14 locations where Timber rattlesnakes are known to occur in proximity to the pipeline. Millennium incorporated a line change to the route to avoid impacts to one known den site (FERC 2001). Millennium also proposed to comply with the NYSDEC's recommendations to either restrict construction to the period between November 1 and March 15 or hire a snake monitor if construction would occur between March 16 and October 31 in these locations.

NYRI has requested information from the NYSDEC regarding the location of Timber rattlesnake habitat along the Proposed NYRI Route as part of NYRI's response to the NYSPSC Stipulation regarding Threatened and Endangered Species (Appendix O of the Article VII Supplemental Application). Once this information is obtained, NYRI will be able to assess the potential cumulative impacts to Timber rattlesnake habitat and propose minimization and mitigation techniques to avoid potential impacts.

3.2.5 Active Agricultural Fields

Areas where the Millennium Pipeline ROW will cross active agricultural fields were identified on the alignment sheets. The orthophotography assisted in identifying agricultural fields that appeared to be active and that NYRI would cross.

Based on the Millennium alignment sheets, the Millennium Pipeline ROW will traverse 14 active agricultural fields, totaling approximately 6,200 linear feet distance in the study area. Millennium has committed to employ at least one agricultural inspector, in addition to other environmental inspectors, who would be responsible for seeing that construction activities in agricultural areas are conducted in accordance with the agricultural conditions of that project's Environmental Construction Standards (ECS) (FERC 2001). The ECS reportedly incorporates specific recommendations by the New York State Department of Agriculture & Markets (NYSDA&M) to minimize potential construction impacts in agricultural areas. Potential impacts include soil erosion, soil compaction and damage to soil structure, loss of soil fertility, changes to soil drainage, introduction of noxious weeds or soil pests to agricultural fields due to movement of construction equipment, and poor revegetation.

NYRI's Proposed Route does not cross any commercial orchards or known active sugar bushes, but does cross other agriculture lands in the study area. The Proposed Route will traverse 12 active agricultural fields, totaling approximately 8,900 linear feet distance in the study area. Permanent impacts to agriculture lands will be minimized by selective siting of structures to minimize placement in active agriculture fields, restricting activity in active fields to within clearly marked areas, and implementing topsoil protection and restoration measures. Existing access roads will be utilized to the extent feasible, new access roads will be sited along hedgerows and at the edges of fields, as possible.

NYRI will develop appropriate construction plans for active agriculture fields in consultation with a qualified Agriculture and Soil Conservation Specialist/Inspector (Ag Specialist), as recommended in the Pipeline Right-of-Way Construction Project guidance document (NYSDAM 1997).

Both projects will cross a total of just under three miles of active agricultural fields in the 33.7 mile study area. Easements will be obtained from land owners for each project's ROW across private property, to allow for construction and operation. Agricultural soils will be disturbed during construction, but permanent impacts will be minimized through compliance with various environmental management plans to protect soil resources in farmlands.

Operation of the two projects together would not affect farming of existing agricultural fields. Farming can occur above a pipeline buried to a permitted depth and under an overhead electric transmission line. Transmission line structures will be located out of active farm fields to the extent practicable.

3.2.6 Other Resources

There are no major potential cumulative impacts that have been identified for either visual or cultural/historic resources where NYRI and the Millennium Pipeline are adjacent. The overall cumulative impact from a visual resource perspective will be a wider clearing area from the two projects. The cumulative impact of the clearing from Millennium and NYRI will be visible primarily at road crossings and other viewing vantage points. These areas can be seen on the Viewshed maps in Appendix M and the 1:400 orthophotography in Appendix A of the Supplemental Article VII Application.

Twenty-nine archeological resources were identified within the Study Area and include 17 historic sites and 12 precontact sites. No National Historic Listed or Eligible sites were identified. The sites include a sawmill complex, quarries, camps, wells, a barn and traces of occupation. These sites are mapped on the orthophotographs in Attachment C and presented in Table 2. No specific cumulative impacts have been identified based on preliminary information from the Article VII Supplemental Application preparation.

The Area of Potential Effect (APE) will be determined after Certification of the NYRI Route through field studies conducted during preparation of the EM&CP. The APE is defined as the geographic area or areas that may be directly or indirectly impacted by an undertaking. The APE for archeological resources consists of any areas where ground-disturbing activities will occur. Determination of the APE needs to consider any areas of direct construction impact including tower foundations, underground cable installations; as well as temporary and permanent access roads; laydown areas; staging areas; areas where grading, clearing, cutting, or filling will occur; or any other areas that a construction contractor may have access to in association with a project. Please refer to Exhibit 4, Section 4.9 of the Article VII Supplemental Application regarding potential effects and mitigation for cultural resources.

REFERENCES

Avian Power Line Interaction Committee [APLIC]. 2006. *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006.* Edison Electric Institute, APLIC, and the California Energy Commission. Washington, D.C. and Sacramento, California.

APLIC and USFWS. 2005. *Avian Protection Plan (APP) Guidelines.* http://www.eei.org/industry_issues/environmental/land/wildlife_and_endangered_species/AvianProtectionPlanGuidelines.pdf. Accessed May 30, 2007)

FERC, October 2006a. Biological Assessment: Northeast (NE)-07 Project. Washington, D.C.

FERC. October 2001. Final Environmental Impact Statement: Millennium Pipeline Project. Washington D.C.

FERC. October 2006. Final Supplemental Environmental Impact Statement: Millennium Pipeline Project. Volumes 1 and 2. Washington D.C.

Millennium Pipeline Project (Corning to Ramapo) Alignment Sheets. Sheets 86 to 136 of 173. FERC Supplemental Issue 7-27-06. Stamped draft dated January 6, 2007.

Millennium Pipeline Company, Personal Communication, April, 2007.

NYSDEC 2007. Mongaup Valley BCA Management Guidance Summary http://www.dec.ny.gov/animals/27139.html. (Accessed June 1, 2007)

Tables

ESS Group, Inc.

Table 1: Description of NYRI Proposed Route and Millennium Pipeline Route in Cumulative Impact Study Area

Proposed NYRI Route Station Number (#)	Adjacent (Miles*)	Departs (Miles)	Route Intersections and Rationale for NYRI ROW Departure
100-103	3.5		Begins just south of Columbia Lake Road in Deposit.
103-104		0.8	Runs adjacent to NYSEG ROW
104-105	0.4		Runs adjacent to Millennium starting at town boundary between Deposit and Hancock.
104-105		0.5	Runs adjacent to NYSEG ROW
105-106	0.3		Runs adjacent to Millennium starting at #106.
105-106		0.7	Runs adjacent to NYSEG ROW
106-109	0.2		Runs adjacent to Millennium between #108 and #109.
106-109		3.0	Departs to avoid buildings along County Route 67 and proximity to Village of Hancock reservoir.
109-113	4.0		Runs adjacent to Millennium on south side of river; departs after crossing State Highway 97.
113-114		1.0	Departs to avoid buildings along State Route 97 and Abe Lord Creek Road.
114-121	6.6		Runs adjacent to Millennium from #114 to Basking Brook.
121-122		1.0	Departs by dog-leg at Basking Brook to avoid mapped Upper Delaware Wild & Scenic Recreational River (UDWSRR) corridor.
122-123	1.1		Runs adjacent to Millennium to after County Road 94.
123-131		8.2	Departs just south of County Road 94 to just north of Delaware/Cochecton town line, to avoid mapped UDWSRR corridor and buildings on Turnpike Road.
131-134	3.0		Runs adjacent to Millennium from just north of Delaware/Cochecton town line to just south of #134.
134-138		4.1	Departs just south of #134 split to avoid structures on Brook, Mitchell, and Ponds Roads, County Route 116, Stony and Mohn Roads.
138-140	2.00		Runs adjacent to Millennium starting at Mohn Road.
138-140		0.3	Departs to avoid structures along north side of Tyler Road.

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Proposed NYRI Route Station Number (#)	Adjacent (Miles*)	Departs (Miles)	Route Intersections and Rationale for NYRI ROW Departure
140-147	7.5		Runs adjacent to Millennium to northwest of lake in Highland.
147-155		7.6	Departs just south of #147 to west of State Highway 42, to avoid entire Mongaup Conservation Easement and all but approximately 140 linear feet of the Mongaup Valley Wildlife Management Area. Traverses floor of Rio Reservoir, approximately 3,100 feet south of Millennium open-cut trench.
155-160	5.1		Adjacent to and north of O&R ROW which is adjacent to Millennium. Segment starts approximately 3,500 feet west of State Highway 42. Departs after #160.

*Adjacent = NYRI Proposed Route right-of-way is within 400 feet of Millennium right-of-way

Adjacent Total:	33.67 miles
Departs Total:	27.03 miles
	60.7 miles

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Table 2. Archaeology Resources within the Cumulative Impact Study Area

Site ID	County	Municipality	OPRHP Site #	NYSM #	Site Identifier	Cultural Affiliation	Description	Location	Milemarker
182	Delaware	Hancock	02509.000064		Historic structural remains, DEL-500	Historic	Structural remains	700' SW	99.5-103
183	Delaware	Deposit	025.06.000018		DEL-186	Historic	Quarry	Along pipeline	99.5-103
184	Delaware	Deposit	025.06.000019		DEL-187	Historic	Quarry	Along pipeline	99.5-103
185	Delaware	Deposit	02506.000020		DEL-189	Historic	quarry	adjacent	99.5-103
186	Delaware	Hancock	02506.000022		DEL-9826	Historic	foundation remains	1500' east	99.5-103
187	Delaware	Deposit	02506.000021		DEL-101	Historic	well, cairn	adjacent	99.5-103
188	Delaware	Deposit		3132	ACP Dela No#	Precontact	Camp	2500' SW	99.5-103
189	Delaware	Hancock		8407	ACP Dela No#	Precontact	Traces of occupation	1500' SW	106.107.5
190	Delaware	Hancock	02509.000065		Historic Quarry and Scatter, DEL-190	Historic	Quarry and scatter	500' west	106.107.5
191	Delaware	Hancock	02509.000063		Historic Springhouse, DEL-501	Historic	No Info.	700' SW	106.107.5
192	Delaware	Hancock	025.09.000064		DEL-500	Historic	Structural remains	1000' east of route (along pipeline)	106.107.5
193	Delaware	Hancock	02509.000003		B Gee Gristmill Barn	Historic	barn	2000' SW	107.5-110
194		Hancock		8031	Hancock?	Precontact	Camp	within and adjacent	107.5-110
195	Delaware	Hancock		8032	Hancock?	Precontact	Camp	1500' NE	107.5-110
196	Delaware	Hancock		8033	No Info.	Precontact	Camp	1500' east	107.5-110
197	Delaware	Hancock		8034	No Info.	Precontact	Camp	1500' south	107.5-110
198	Delaware	Hancock		8035	No information	Precontact	Camp	Shown covering large area along East Branch in Villlage of Hancock southwest of pipeline.	107.5-110
199	Delaware	Hancock	02509.000066		DEL-226	Historic	feature & scatter	adjacent	112-113
200	Delaware	Hancock	02509.000067		DEL-227	Historic	No Info.	adjacent	112-113
201	Delaware	Hancock	02509.000068		DEL-228	Historic	feature & scatter	1500' NW	112-113
203	Delaware	Hancock	025.09.000062		Historical Site D	Historic	19th-century mill foundation.	Just south of pipeline near Bouchoux Brook Road.	115
205	Sullivan	Fremont		8001	Basket?	Precontact	Camp	4700' west	121

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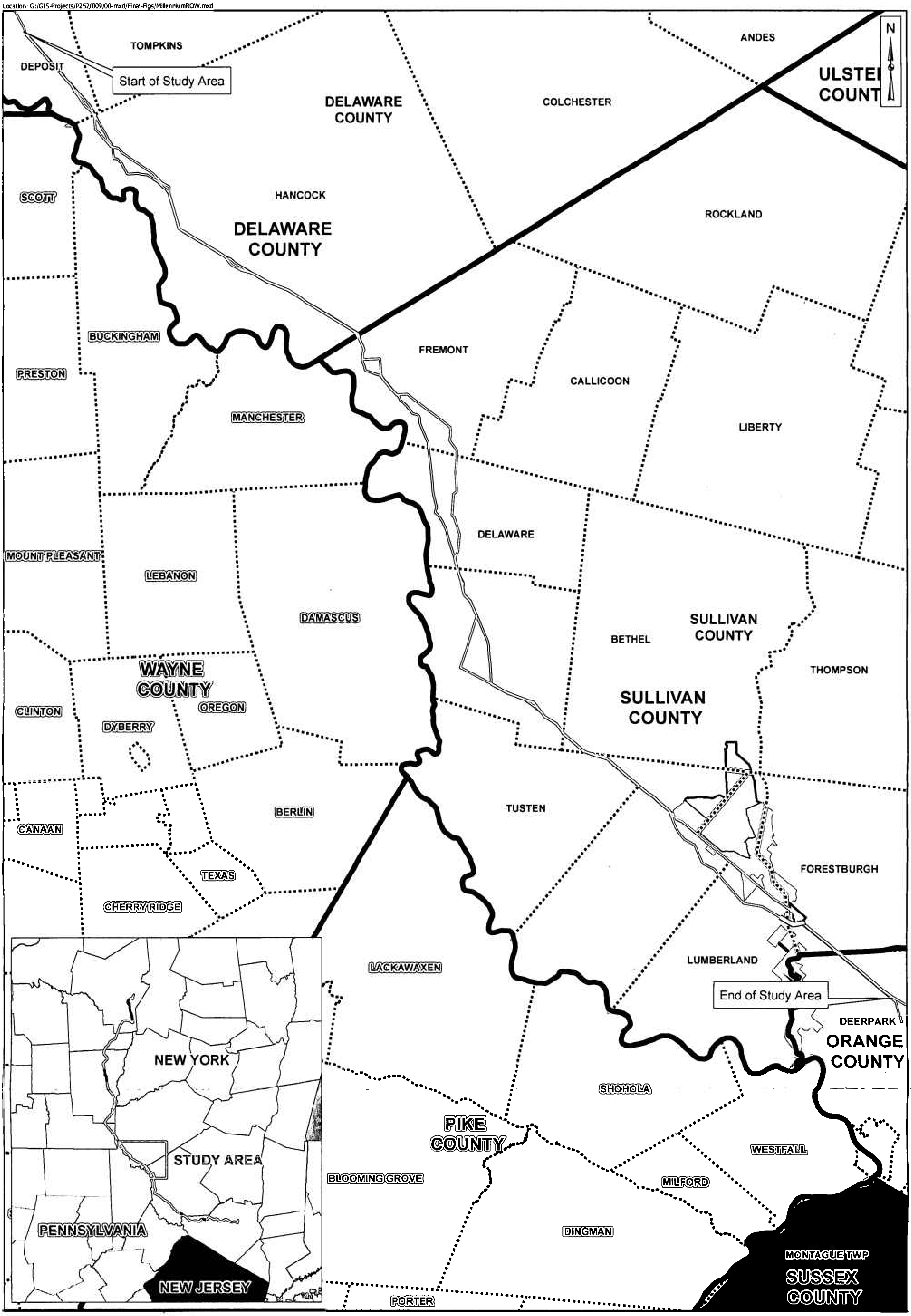
Site ID	County	Municipality	OPRHP Site #	NYSM #	Site Identifier	Cultural Affiliation	Description	Location	Milemarker
206	Sullivan	Fremont		8000	Basket?	Precontact	Camp	4500' west	121
214	Sullivan	Cochecton	105.03.000057		SUL-102	Historic	Well	Along pipeline.	133
216	Sullivan	Cochecton	105.03.000066		SUL-112	Historic	Complex	Along pipeline.	138
217	Sullivan	Delaware	10503.000067		SUL-101	Historic	foundation	adjacent	139
219	Sullivan	Bethel		4949	ACP Sulv no#	Precontact	Traces	Covers large area near Crystal Lake, nearest of which is 500' north of pipeline.	143-144
220	Sullivan	Highland	105.08.000035		SUL-9830	Historic	Sawmill complex	Along pipeline at Halfway Brook.	146

Location: G:/GIS-Projects/P252/009/00-mxd/Final-Figs/MillenniumROW.mxd



NYRI
New York Regional Interconnection

NEW YORK REGIONAL INTERCONNECTION
Project Location: New York

Scale: 1" = 20,000'
Date: October 26, 2007

Source: 1) Millennium Pipeline, 2005
2) ESS, Proposed Routes, 2007

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Legend

- NYRI Proposed-Overhead
- NYRI Proposed-Underground
- Millennium Pipeline
- County Boundaries
- Town Boundaries

Cumulative Impact Assessment Study Area

Figure 1

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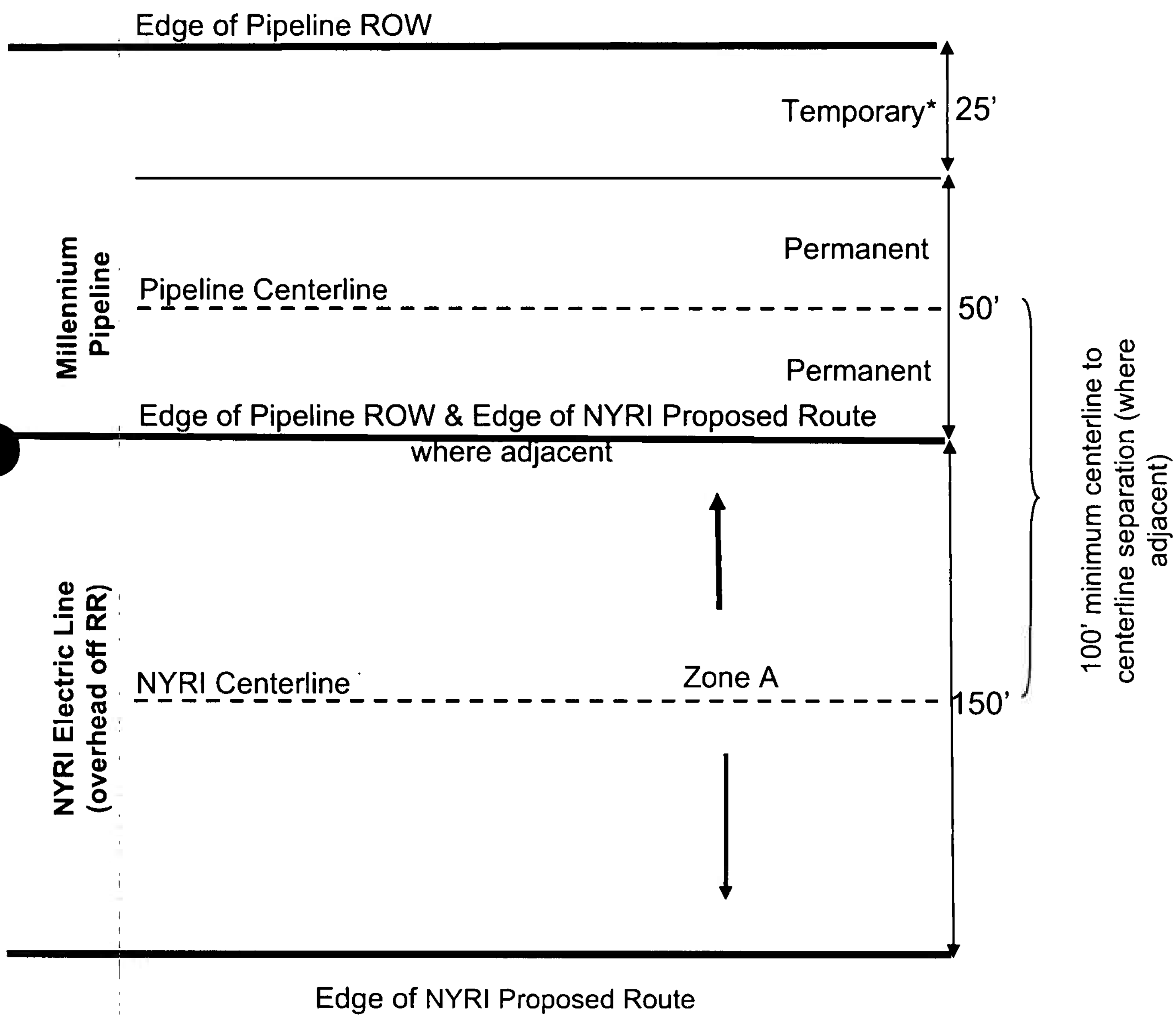
Figure 2
Comparison of Vegetative Clearing Along NYRI Proposed Route Transmission Corridor & Millennium Pipeline Right-of-Way (ROW)



*The Millennium Pipeline Alignment sheets show a wider (greater than 25 feet) clearing at streams, wetlands and road crossings. Vegetation clearing at these locations could increase from between 50 to 150 feet depending on site conditions.

**Within Zone A, vegetation will be cleared completely for construction and then vegetation maturing less than 24 feet in height will be allowed to regenerate and be maintained through herbicide application.

Figures (on CD)

Attachment A

Cumulative Impact Study Correspondence

NEW YORK INDEPENDENT SYSTEM OPERATOR
Building the Energy Markets of Tomorrow ... Today℠
10 Krey Boulevard · Rensselaer, NY 12144

May 29, 2007

Leonard H. Singer
Couch White, LLP
540 Broadway
P.O. Box 22222
Albany, New York 12201-2222

Subject: New York PSC Case No.: 06-T-0650 – Information request to the NYISO

Dear Mr. Singer:

Mark Lynch requested that I respond to your letter of April 18, 2007 asking the New York Independent System Operator (NYISO) or the New York State Reliability Council (NYSRC) to identify any rules or procedures regarding the proposed construction or operation of a transmission line adjacent to a natural gas pipeline right of way. The NYISO does not establish rules. Rather, it follows reliability rules established by the North American Electric Reliability Corporation (NERC), the Northeast Power Coordinating Council (NPCC) and the NYSRC. I understand that the NYSRC will be responding to your inquiry regarding their rules under separate cover. Nothing in the NYISO's agreements, tariffs or procedures address the construction or operation of a transmission line in a natural gas pipeline right of way. Please contact Carl Patka at (518) 356-6220, cpatka@nyiso.com if you have any questions or concerns.

Very truly yours,

Rick Gonzales

Rick T. Gonzales
Acting Vice President of Operations

xc: M. Lynch
C. Patka

LEBOEUF, LAMB, GREENE & MACRAE LLP

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July 11, 2007

Leonard H. Singer, Esq.
Couch White, LLP
540 Broadway
P.O. Box 22222
Albany, New York 12201-2222

Re: New York PSC Case No.: 06-T-0650 - Application of New York Regional Interconnect Inc. for a Certificate of Environmental Compatibility and Public Need Pursuant to Article VII for a High Voltage Direct Current Electric Transmission Line Running Between National Grid's Edic Substation in the Town of Marcy, and Central Hudson Gas & Electric's Rock Tavern Substation Located in the Town of New Windsor

Dear Mr. Singer:

This response to your letter to Mr. P. Donald Raymond is provided on behalf of the New York State Reliability Council (NYSRC).

The New York Independent System Operator (NYISO) is obligated to comply with the Reliability Rules established by the NYSRC. The NYISO, in turn, is obligated to secure compliance with the NYSRC Reliability Rules by all parties who interconnect with the New York State bulk power system or who participate in the NYISO's competitive markets. It also should be noted that the New York Public Service Commission has adopted all of the NYSRC's Reliability Rules as New York State reliability requirements.

With specific reference to the proposed construction and operation of the NYRI transmission line adjacent to the Millennium Pipeline Project right of way, certain provisions of the Reliability Rules appear to be relevant, including the following:

Section II, B. Transmission Capability - Planning

- Table A - Design Criteria Contingencies
  - f. Simultaneous permanent loss of both poles of a direct current bipolar HVDC facility without an ac fault.

- Table B - Extreme Contingencies
  - c. Loss of all transmission circuits on a common right-of-way.
  - i. Sudden loss of fuel delivery system to multiple plants (i.e., gas pipeline contingencies).

The NYSRC's Reliability Rules are available on its website: NYSRC.org, under Documents. For your convenience, I am enclosing a copy of Section II, B of the Reliability Rules.

Please contact me if you have any questions concerning this response.

Sincerely,

Paul L. Gioia

Paul L. Gioia
Counsel
New York State Reliability Council, L.L.C.

Enclosure/97648

B. TRANSMISSION CAPABILITY - PLANNING

Introduction

The *NYS Bulk Power System* must be planned with sufficient transmission capability to withstand the loss of specified, representative and reasonably foreseeable design criteria contingencies at projected customer *demand* and anticipated transfer levels. Application of these design criteria contingencies should not result in any criteria violations, or the loss of a major portion of the system, or unintentional separation of a major portion of the system. These design criteria contingencies are listed in Table A. Analysis of these contingencies should include thermal, voltage, and *stability* assessments as defined by the Reliability Rules. The Reliability Rules also apply after any critical generator, transmission circuit, transformer, series or shunt compensating device, or high voltage direct current ("HVDC") pole has already been lost, and after *generation* and power flows have been adjusted between outages by the use of *ten (10) minute operating reserve* and, where available, phase angle regulator control and HVDC control.

Loss of small portions of the *NYS Power System* (such as radial portions) may be tolerated provided they do not jeopardize the *reliability* of the overall *NYS Bulk Power System*.

Assessment of extreme contingencies recognizes that the *NYS Bulk Power System* may be subjected to events which exceed in severity the representative contingencies in Table A. These assessments measure the robustness of the transmission system, and should be evaluated for risks and consequences. One of the objectives of extreme *contingency* assessment is to determine, through planning studies, the effects of extreme contingencies on system performance. Extreme *contingency* assessments provide an indication of system strength, or to determine the extent of a widespread system *disturbance*, even though extreme contingencies do have low probabilities of occurrence. Extreme *contingency* assessments examine several specific contingencies which are listed in Table B. They are intended to serve as a means of identifying some of those particular situations that may result in a widespread *NYS Bulk Power System* shutdown.

Transmission owners may take actions to reduce the frequency of occurrence of extreme contingencies, or to mitigate the consequences that are indicated as the result of testing for such contingencies.

The ability of the *NYS Bulk Power System* to withstand representative and extreme contingencies must be determined by simulation testing of the system as prescribed by the Reliability Rules and all applicable *NYISO* policies, procedures and guidelines.

Section B also sets forth a Reliability Rule requiring *fault* duty levels to be within appropriate equipment ratings.

A *Special Protection System (SPS)* may be employed to provide protection for infrequent contingencies or for temporary conditions that may exist such as project delays, unusual combinations of system *demand* and equipment outages or unavailability, or specific equipment maintenance outages. An *SPS* may be applied to preserve system integrity in the event of severe facility outages and extreme contingencies. The decision to employ an *SPS* should take into account the complexity of the scheme and the consequence of correct or incorrect operation as well as benefits. An *SPS* should be used judiciously and when employed, should be installed consistent with good system design and operating policy.

This Reliability Rule section also specifies requirements for establishing and maintaining a list of *NYS Bulk Power System* facilities.

Table A Design Criteria Contingencies
a. A permanent three-phase *fault* on any generator, transmission circuit, transformer or bus section, with *normal fault clearing*.
b. Simultaneous permanent phase-to-ground *faults* on different phases of each of two adjacent transmission circuits on a multiple circuit tower, with *normal fault clearing*. If multiple circuit towers are used only for station entrance and exit purposes, and if they do not exceed five towers at each station, then this condition is not applicable.
c. A permanent phase-to-ground *fault* on any generator, transmission circuit, transformer or bus section, with *delayed fault clearing*.
d. Loss of any *element* without a *fault*.
e. A permanent phase-to-ground *fault* on a circuit breaker, with *normal fault clearing*. (*Normal fault clearing* time for this condition may not always be high speed.)
f. Simultaneous permanent loss of both poles of a direct current bipolar HVDC facility without an ac *fault*.
g. The failure of a circuit breaker to operate when initiated by a *special protection system ("SPS")* following: loss of any *element* without a *fault*; or a permanent phase-to-ground *fault*, with *normal fault clearing*, on any transmission circuit, transformer or bus section.

Table B Extreme Contingencies
a. Loss of the entire capability of a generating station.
b. Loss of all transmission circuits emanating from a generation station, switching station, d-c terminal, or substation.
c. Loss of all transmission circuits on a common right-of-way.
d. Permanent three-phase *fault* on any generator, transmission circuit, transformer, or bus section, with *delayed fault clearing* and *with due regard to reclosing*.
e. The sudden loss of a large *load* or major *load* center.
f. The effect of severe power swings arising from *disturbances* outside the *NYS Bulk Power System*.
g. Failure of a *SPS* to operate when required following the normal contingencies listed in Table A.
h. The operation or partial operation of a *SPS* for an event or condition for which it was not intended to operate.
i. Sudden loss of fuel delivery system to multiple plants (i.e. gas pipeline contingencies).

Reliability Rules

B-R1. Thermal Assessment

a. Pre-Contingency Thermal Criteria

1. For normal transfers, no transmission facility shall be loaded beyond its *normal rating*.

2. For *emergency* transfers, no transmission facility shall be loaded beyond its *normal rating*. However, a facility may be loaded to the *long-term emergency ("LTE") rating* pre-contingency, if the *short-term emergency ("STE") rating* is reduced accordingly.

b. Post-Contingency Thermal Criteria

1. For normal transfers, no facility shall be loaded beyond its *LTE rating* following the most severe of design criteria contingencies "a" through "g" specified in Table A.

   An underground cable circuit may be loaded to its *STE rating* following:
   Loss of *Generation* - provided *ten (10) minute operating reserve* and/or phase angle regulation is available to reduce the loading to its *LTE rating* within fifteen (15) minutes and not cause any other facility to be loaded beyond its *LTE rating*.

   Loss of Transmission Facilities - provided phase angle regulation is available to reduce the loading to its *LTE* *rating* within fifteen (15) minutes and not cause any other facility to be loaded beyond its *LTE rating*.

For design criteria contingencies "b", "c", "e", "f", and "g" in Table A that are not confined to the loss of a single *element*, *transmission owners* may request permission from the *NYISO* to design the system so that post-contingency flows up to the *STE ratings* on the remaining facilities can occur. This is permissible provided operating measures are available to reduce the loading to its *LTE rating* within fifteen (15) minutes and not cause any other facility to be loaded beyond its *LTE rating*.

Design exceptions should be well documented, including *NYISO* comments, and must be approved by the *NYSRC*.

2. For *emergency* transfers, no facility shall be loaded beyond its *STE rating* following the more severe of design criteria contingencies "a" or "d" listed in Table A. The *STE rating* is based on an assumed pre-loading equal to the *normal rating*. Therefore, if the limiting facility is loaded above its *normal rating* pre-contingency, the *STE rating* must be reduced accordingly.

B-R2. Voltage Assessment

Reactive power shall be maintained within the *NYS Bulk Power System* in order to maintain voltages within applicable pre-disturbance and post-disturbance limits for both normal and emergency transfers, consistent with the Reliability Rules and all applicable guidelines and procedures.

a. Pre-Contingency Voltage Criteria

For both normal and *emergency* transfers, no bus voltage shall be below its pre-contingency low *voltage limit* nor be above its pre-contingency high *voltage limit.*

b. Post-Contingency Voltage Criteria

No bus voltage shall fall below its post-contingency low *voltage limit* nor rise above its post-contingency high *voltage limit.* For normal transfers, design criteria contingencies "a" through "g" specified in Table A are applicable. For *emergency* transfers, design criteria contingencies "a" through "g" specified in Table A are applicable.

B-R3. Stability Assessment

Stability of the NYS Bulk Power System shall be maintained during and following the most severe of the design criteria contingencies "a" through "g" specified in Table A, with due regard to reclosing. For each of those design criteria contingencies that involves a fault, stability shall be maintained when the simulation is based on fault clearing initiated by the "system A" protection group and also shall be maintained when the simulation is based on fault clearing by the "system B" protection group.

a. System Stability

1. For normal transfers, *stability* of the *NYS Bulk Power System* shall be maintained during and after the most

severe of design criteria contingencies "a" through "g" specified in Table A. The *NYS Bulk Power System* must be stable if the faulted *element* is re-energized by *delayed reclosing* before any manual system adjustment, unless specific alternate procedures are documented.

2. For *emergency* transfers, *stability* of the *NYS Bulk Power System* shall be maintained during and after the more severe of design criteria contingencies "a" through "g" specified in Table A. The *NYS Bulk Power System* must also be stable if the faulted *element* is re-energized by *delayed reclosing* before any manual system adjustment. *Emergency* transfer levels may require *generation* adjustment before manually reclosing faulted *elements* not equipped with automatic reclosing or whose automatic reclosing capability has been rendered inoperative.

b. Generator Unit Stability

With all transmission facilities in service, generator unit *stability* shall be maintained on all facilities not directly involved in clearing the *fault* for design criteria contingencies "a" through "g" specified in Table A.

B-R4. Extreme Contingency Assessment

Assessment of the extreme contingencies listed in Table B shall examine post-contingency *steady state* conditions as well as overload cascading and voltage collapse. Pre-contingency *load* flows chosen for analysis should reflect reasonable power transfer conditions. The testing shall be conducted at megawatt ("MW") transfers at the expected average transfer level. This may be at or near the *normal transfer limit* for some *interfaces*. Analytical studies shall be performed to determine the effect of the extreme contingencies in Table B.

After due assessment of extreme contingencies, measures will be utilized where appropriate, to reduce the frequency of occurrence of such contingencies, or to mitigate the consequences that are indicated as a result of testing for such contingencies.

B-R5. Restoration

System expansion or reconfiguration plans shall include an assessment of their impact on the existing NYCA System Restoration Plan (NYCA SRP).

B-R6. List of NYS Bulk Power System Facilities

The *NYISO* shall develop, maintain, and keep current a list of *NYS Bulk Power System* facilities.

B-R7. Fault Current Assessment

***Fault duty* levels shall be within appropriate equipment ratings.**

Measurements

B-M1. The *NYISO* shall ensure that the thermal, voltage, short-circuit, and *stability* performance of the *NYS Bulk Power System*, as planned, is in accordance with *NYSRC* thermal, voltage, fault duty, and *stability* assessment criteria, and applicable NPCC Criteria. (B-R1 through B-R3 and B-R7)

B-M2. The *NYISO* shall assess the risks and system performance resulting from the extreme contingencies in Table B, and shall utilize measures, where appropriate, to reduce the frequency of occurrence of such contingencies, or to mitigate the consequences that are indicated as a result of testing for such contingencies. (B-R4)

B-M3. The NYISO shall develop, maintain, and execute procedures to evaluate system expansion or reconfiguration plans and identify their impact on the NYCA SRP. This process shall be performed every year as part of the NYISO annual transmission assessment. Any impacts identified shall be described in terms of how and where the SRP may need to be modified, and made available to the NYISO Operating Group and the operating function of the appropriate transmission owners for consideration in the annual review and update of NYISO and transmission owner restoration plans as required by Reliability Rule G-R1. (B-R5)

B-M4. The *NYISO* shall establish and maintain a procedure for developing a list of *NYS Bulk Power System* facilities. On request, the *NYISO* shall submit this procedure and list of *NYS Bulk Power System* facilities to the *NYSRC* for review. The *NYS Bulk Power System* facilities list shall be published in the annual *NYISO* "Load and Capacity Data Report" or other publication approved by the *NYSRC*. (B-R6)

Guidelines

NYISO Voltage Limit Guideline – Refer to Appendix E of the NYISO "Transmission Expansion and Interconnection Manual". This guideline should be used in transmission studies in accordance with Reliability Rule B-R2.

NYISO Stability Limit Guideline – Refer to Appendix F of the NYISO "Transmission Expansion and Interconnection Manual". This guideline should be used in transmission studies in accordance with Reliability Rule B-R3.

NYPP Tie Line Ratings Task Force Report – Refer to the Planning Reference Documents on the NYISO web site. This guideline should be used in transmission studies accordance with Reliability Rule B-R1.

NYISO Fault Current Assessment Guideline – Refer to the Planning Reference Documents on the NYISO web site. This guideline should be used in transmission studies in accordance with Reliability Rule B-R7.

The NYISO documents referenced above can be found on the NYISO web site, www.nyiso.com/services.

Thermal and voltage *ratings* for facilities to be included in transmission planning assessments are to be determined by the *transmission owner*, or operator pursuant to contractual arrangement, consistent with applicable *NYISO* guidelines. These *ratings* and limits will be used for all studies conducted by the *NYISO* and *transmission owners* and in the operation of the *NYS Bulk Power System*.

References

NPCC Document A-2; NERC TPL-001-0, TPL-002-0, TPL-003-0, TPL-004-0

Reliability Rules B-R1 through B-R7 are more specific or more stringent than the above NPCC and NERC Standards.

New York State Department of Environmental Conservation
Division of Environmental Permits, 4th Floor
625 Broadway, Albany, New York 12233-1750
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Website: www.dec.ny.gov

Alexander B. Grannis
Commissioner

August 20, 2007

Laura M. Ernst
Project Manager
ESS Group, Inc.
401 Wampanoag Trail, Suite 400
East Providence, RI 02915

Re: Case No.: 06-T-0650 - Application of New York Regional Interconnect Inc. for a Certificate of Environmental Compatibility and Public Need Pursuant to Article VII for a High Voltage Direct Current Electric Transmission Line Running Between National Grid's Edic Substation in the Town Of Marcy, and Central Hudson Gas & Electric's Rock Tavern Substation Located in the Town of New Windsor

Dear Ms. Ernst:

This letter follows up on discussions DEC Staff had with you on August 2 and August 7 concerning the analysis of cumulative impacts for the application of New York Regional Interconnect ("NYRI") and responds to NYRI's request for further input on the cumulative impact issue.

An application for a Certificate of Environmental Compatibility and Public Need Pursuant to Article VII of the Public Service Law functions as an environmental impact statement (EIS). In setting forth the potential environmental impacts of a proposed project, an EIS should include an evaluation of the expected future impacts of the project, including the reasonably related short-term and long-term effects, cumulative effects and other associated environmental effects. This approach is consistent with the objectives of the Public Service Law which are to ensure that the Public Service Commission consider the probable environmental impacts of a project and ensure the impacts are minimized.

If the NYRI project was built it would result in up to a 1500 foot wide clearing of land over an almost 200 mile corridor. A significant concern the Department has with this and other large projects - especially linear projects in areas with significant forest cover, is the resulting forest fragmentation and its associated impacts to wildlife, particularly some forest dwelling bird species. This concern is especially acute where the proposed project departs from using low lying railroad right-of-way, starting in Chenango County, and proceeds over steeper, often forested terrain, notably west and south of the Catskills. Numerous other linear projects have either been located (the New York Power Authority's Marcy South Line) or are being located (the Millennium Pipeline project over the previously existing Columbia Gas A-5 Line) in this area. And now it is foreseeable that additional transmission projects may be sited in this area if, as proposed by the U.S. Department of Energy, the National Interest Electric Transmission Corridor for the Mid-Atlantic area is finalized. The potential NYRI corridor becomes a logical location to site additional electric transmission facilities.

Forest Fragmentation

Forest fragmentation occurs when large, contiguous forests are divided into smaller blocks. It is described in various ways, such as: the breaking up of large, contiguous forested tracts into smaller or less contiguous tracts (Southern Research Station, U.S. Forest Service, www.srs.fs.usda.gov/sustain/data/authors/glossary.htm); the splitting of forest lands into smaller, detached areas as a result of road building, farming, suburban development, and other activities (School of Forest Resources and Conservation, University of Florida, www.sfrc.ufl.edu/Extension/ssfor11.htm); and the creation of "islands" of forest habitat that are disconnected from other forests by agricultural lands, transmission lines, roads, developments, etc. (Texas Cooperative Extension, texaspinestraw.tamu.edu/glossary.html).[1]

Forest fragmentation can isolate wildlife populations, and may result in forested areas too small to meet the habitat requirements of some species. It is of particular concern in New York because of the potential impacts to habitats of woodland birds. Such species may become more susceptible to predation and nest parasitism as a result of forest fragmentation. Some grassland bird species could benefit by the creation of grassland habitat, however, this cannot be determined absent a comprehensive evaluation. The stipulation NYRI entered into with the Department of Public Service Staff for cumulative impacts does not address the issue of forest fragmentation among the required scope of studies. This Department, however, believes that the NYRI application must evaluate the potential impact to forests from the construction and operation of the proposed transmission line in order for the Public Service Commission to make its required findings under Section 126 of the Public Service Law.

Study Objectives

You inquired how the Department wants NYRI to address the issue of forest fragmentation. As we indicated, the objectives of a cumulative impact analysis for the NYRI project should be to determine: (1) what data and information is currently known about the forest and bird resources in New York (see discussion below concerning the scope of study), including

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[1] *See e.g. Forest Fragmentation in Connecticut: What Do We Know and Where Are We Headed?*, James Hurd, Jason Parent and Daniel Civco Laboratory for Earth Resources Information Systems Center for Land use Education and Research Department of Natural Resources Management and Engineering University of Connecticut, Mary Tyrrell Yale School of Forestry and Environmental Studies Yale University; Brett Butler Forest Inventory & Analysis Program USDA Forest Service, Northern Research Station. Available at: http://research.yale.edu/gisf/assets/pdf/CT%20Forest%20Fragmentation%20White%20Paper%2031oct2006b.pdf.

an historical perspective; (2) how forests have been impacted over time by development, and (3) what further impacts to the forests and bird populations may occur as a result of the construction and operation of the NYRI project, and, therefore, future, similar projects.

The Connecticut study referenced in Footnote 1 provides a useful template for a cumulative impact study in terms of how to characterize the forest land, both existing and historic. For the purpose of NYRI's cumulative review we would look to patch sizes that have some correlation to bird species that utilize the forests. In addition to describing the forests, NYRI's study should also include an evaluation of the natural and wildlife resources, in particular the birds that utilize the forests. As we discussed, it will be necessary for NYRI to complete a breeding bird survey of the study area (see below). John Ozard, Nongame and Habitat Unit Leader in the Division of Fish, Wildlife and Marine Resources, discussed where NYRI could obtain available birding data that might be helpful in designing a study protocol and provided the names of Department Staff who could provide further assistance.

We also identified a number of previous projects which have evaluated the issue of forest fragmentation and could serve as a starting point for NYRI's cumulative impact analysis. Among them were two previous Article VII cases - the NYSEG Brothertown Road project and the original Iroquois Gas Transmission System pipeline project. Information for these should be available from the Department of Public Service. Another project that was not mentioned were plans for development of Sterling Forest in Orange County. Al Ciesluk in our Region 3 office in New Paltz (845.256.3014) can provide background on that.

The second concern is the geographic scope of the study. As we suggested you might want to consider starting at the Broome County border- Deposit area, and use as your northern boundary the combination of Routes 206, 17, and 17K, and use as your southern boundary the Delaware River/Pennsylvania border and the New Jersey border.

Study Resources

In addition to the good links we already provided you for the Cornell Lab of Ornithology (http://www.birds.cornell.edu/bfl/gen_instructions/fragmentation.html) and from Yale University (http://research.yale.edu/gisf/assets/pdf/CT%20Forest%20Fragmentation%20White%20Paper%2031oct2006b.pdf), the State University of New York College of Environmental Science and Forestry has programs in Forest Health, Forest Ecosystem Science and Forest Management that may be able to provide expertise and assistance.

Department Staff continue to be available if NYRI wants to further discuss this issue.

Sincerely,

Jeffrey Gregg

cc: Bob Malecki, NYRI
Lisa Wilkinson
William Little
Steven Blow, DPS
Jim De Waal Malefyt, DPS

Attachment B

Forest Fragmentation Study

Attachment B

Impact of Forest Fragmentation on Woodland Birds

NEW YORK REGIONAL INTERCONNECTION

PREPARED FOR

NYRI
New York Regional Interconnection

New York Regional Interconnect
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PREPARED BY

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Project No. P252-009.2

November 14, 2007

ESS Group, Inc.

IMPACT OF FOREST FRAGMENTATION ON WOODLAND BIRDS
New York Regional Interconnection

Prepared For:

New York Regional Interconnect
100 State Street, Suite 1033
Albany, New York 12207-1800

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November 14, 2007

ESS Group, Inc.

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ESS Group, Inc.

1.0 INTRODUCTION

As outlined in correspondence dated August 20, 2007 (see Attachment A), DEC requested NYRI to address potential impacts of forest fragmentation on woodland birds as a result of the cumulative impact of the NYRI and Millennium Pipeline projects. Forest fragmentation can have both negative and positive effects on bird species. Negative effects include the creation of isolated blocks of forest that are too small to serve as habitat for species that require larger, contiguous areas of undisturbed forest. Fragmented forests contain edge habitats that may benefit some species, but have negative effects on others as a result of increased predation and exposure to nest parasitism. Finally, when a population of a species is isolated within a smaller forest fragment, that population is more susceptible to being locally extirpated as a result of a disturbance.

In response to DEC's request, the following assessment was completed to address three objectives: 1) characterize existing forest and avian resources along those portions of the proposed NYRI route that are adjacent to the Millennium Pipeline, 2) discuss how forests in these areas have been impacted by development historically, and 3) determine whether further impacts to forest and avian resources may occur as a result of the construction and operation of the NYRI project.

This assessment focused on Greenfield areas along the Proposed Route Transmission Corridor that parallel the Millennium Pipeline and would require clearing. The full study area includes the parallel section that runs from NYRI station 100 to station 160 for a distance of approximately 60 miles.

For portions of the Proposed Route that will be along Greenfield areas, the Proposed Route Transmission Corridor width is 150 feet and a 150-foot clearing width will be required. As shown on Figure 4.4.2-1 in Section 4.4, Exhibit 4, there will be one clearing zone (Zone A) in Greenfield areas where vegetation will initially be cleared for construction, but vegetation maturing less than 24 feet in height will be allowed to regenerate. This analysis assumes that a 150 foot wide area will be cleared through forested Greenfield areas. Remaining portions of the route that both parallel and are adjacent to the Millennium Pipeline ROW will be widened. These areas were not included in the analysis because they have already been fragmented.

2.0 EXISTING CONDITIONS

At a regional scale, forest cover within the study area is comprised of eastern transitional and mixed deciduous forest. The predominant forest cover types along the route include oak-hickory and maple-beech-birch associations (Kingsley 1985). When looking at the broader region, the study area is near the Catskill State Park and Upper Delaware River Corridor. The region has a long history of human and natural disturbance in the landscape (DEC 1997).

2.1 Forest Communities - Proposed Route

The following information on the forest communities along the Proposed Route in this area was obtained from the New York State Natural Heritage Program (Edinger et al. 2002). The oak-hickory hardwood forest occurs primarily on dry, well-drained sites found on ridgetops, upper slopes, or south and west facing slopes. Loams and sandy loams are the predominant soil type within this forest community. According to the New York State Natural Heritage Program's element ranks, the oak-hickory forest occurs commonly in the state and is "apparently secure". The most dominant tree species within this broadly defined community include red oak (*Quercus rubra*), white oak (*Q. alba*), and black oak (*Q. veluntina*). Pignut hickory (*Carya glabra*), shagbark hickory (*C. ovata*) and sweet pignut (*C. ovalis*) are usually mixed in with oak at lower densities. Common associate species include white ash (*Fraxinus americana*), red maple (*Acer rubrum*), and Eastern hop hornbeam (*Ostrya virginiana*).

The subcanopy of the oak-hickory forest is generally comprised of small trees and tall shrubs including flowering dogwood (*Cornus florida*), witch hazel (*Hamamelis virginiana*), shadbush (*Amelanchier arborea*), and choke cherry (*Prunus virginiana*). The most common low shrubs include maple-leaf viburnum (*Viburnum acerifolium*), blueberries (*Vaccinium angustifolium*), red raspberry (*Rubus idaeus*), gray dogwood (*Cornus foemina*), and beaked hazelnut (*Corylus cornuta*).

Common groundcover species include wild sarsaparilla (*Aralia nudicaulis*), false Solomon's seal (*Smilacina racemosa*), Pennsylvania sedge (*Carex pensylvanica*), and tick-trefoil (*Desmodium glutinosum*).

Characteristic avian species within the oak-hickory forest include Red-bellied Woodpecker (*Melanerpes carolinus*), Whip-poor-will (*Caprimulgus vociferus*), and Wild Turkey (*Meleagris gallopavo*).

The maple-beech-birch hardwood forest community occurs primarily on moist, well-drained, usually acidic soils and includes many of the same species as the oak-hickory community (Edinger et al. 2002). This community is also ranked "apparently secure" according to the New York State Natural Heritage Program. Common associate tree species include white ash, Eastern hop hornbeam, and red maple.

The subcanopy and shrub layer is usually comprised of hobblebush (*Viburnum lantanoides*), American hornbeam (*Carpinus caroliniana*), striped maple (*Acer pensylvanicum*), witch hazel, and alternate-leaved dogwood (*Cornus alternifolia*).

The herbaceous groundcover layer is usually sparse within this forest community. However, some of the characteristic species include star flower (*Trientalis borealis*), common wood-sorrel (*Oxalis montana*), Canada mayflower (*Maianthemum canadense*), and intermediate wood fern (*Dryopteris intermedia*). Tree seedlings and saplings of dominant tree species are also commonly found within the herbaceous layer.

Characteristic birds found within the maple-beech-birch forest include American Redstart (*Setophaga ruticilla*), Red-eyed Vireo (*Vireo olivaceus*), Ovenbird (*Seiurus aurocapillus*), Black-throated Blue Warbler (*Dendroica caerulescens*), Least Flycatcher (*Empidonax minimus*), Acadian Flycatcher (*Empidonax virescens*), and Red-bellied Woodpecker.

2.2 Woodland Avian Communities - Proposed Route

The *New York State Breeding Bird Atlas 2000* (the *Atlas*) was used to compile a species list of birds that occur within the study area. Results of the compilation are presented in Table 1. The list includes both woodland and shrubland species that are likely to occur near the project.

The *Atlas* is a comprehensive, statewide survey that provides data on the current distribution of breeding birds in New York. The Atlas 2000 Project began in January 2000, with fieldwork completed in 2005. To compile the *Atlas*, the state was divided into ten regions, based upon the "Kingbird" reporting regions for the New York State Ornithological Association. One or two Regional Coordinators were responsible for seeing that all of the blocks in their region were surveyed. Each survey block measures five by five kilometers (three by three miles); there are 5,333 blocks in the entire state. Atlasers visited various habitats within their assigned block(s) and recorded evidence of breeding for the birds they observed, using defined breeding codes.

The avian species list was compiled by selecting Atlas blocks which overlapped with the Proposed Route Transmission Corridor that runs adjacent to the Millennium Pipeline. Table 1 includes all avian species found within these areas that utilize a variety of habitats which range from mature, mixed-forest to agricultural lands. Species of primary concern in the area that require large blocks of mature, mixed-forest are presented in Table 2 (New York State Breeding Bird Atlas 2000; Herkert et al. 1993).

2.2.1 Woodland Avian Species Forest Habitat Requirements

Research suggests that minimum habitat size requirements for forest interior birds is often species-specific and can range widely (Robbins et al. 1989; Sherry and Holmes 1997; Forman et al. 1976; Bushman and Therres 1988; Anderson and Bernstein 2003; Wiggins 2005; Robbins 1979; Blake and Karr 1984; Van Horn and Donovan 1994; Robinson 2000; Cimprich et al. 2000; Rosenberg et al. 1999). The studies reviewed used several different terms, including suggested minimum breeding area, breeding territory, as well as minimum habitat area, which may also explain the wide range in minimum habitat requirements cited. In addition to size, habitat characteristics such as food availability, presence of snags, foliage density, and percent canopy cover can also play a role in determining habitat size requirements. A small forest patch with ideal habitat characteristics may be suitable while a larger forest patch with less ideal habitat characteristics may not. The characteristics of the surrounding landscape matrix also play a role determining the minimum habitat size requirements of a species. A small forest patch within a wider landscape which contains large blocks of contiguous forest may provide suitable habitat, while a larger forest patch within a severely fragmented matrix may not be suitable. The minimum habitat size requirement may also vary by region (Rosenberg et al. 1999; Van Horn and Donovan 1994; Wiggins 2005). However, based on a review of existing literature, there appears to be a consensus that the larger forest patch, the greater the likelihood of the occurrence and breeding success of forest interior species (Robbins et al. 1989; Donovan and Flather 2002; Anderson and Bernstein 2003; Wiggins 2005; Rosenberg et al. 1999; Van Horn and Donovan 1994).

A five-year study (Robbins et al. 1989) which examined the relationship between forest area and the probability of occurrence of forest interior species was used to estimate minimum breeding area size requirements of these forest interior species. For those species found along the Proposed Route and included in the Robbins study, the estimated required minimum breeding area size ranged from six acres to 1,730 acres, depending on the species (Robbins et al. 1989). These results suggest that there is great variability in minimum breeding habitat size requirements and breeding habitat size requirements are species-specific. Other sources reviewed uncovered an even wider range of estimated minimum general habitat sizes with estimated areas greater than 9,884 acres required for some species (Sherry and Holmes 1997).

Specific general habitat requirements for individual species are discussed further in Section 4.1.

2.3 History of Disturbance

The eastern transitional and mixed deciduous forests, which are dominant in southern New York, have a long history of human disturbance. The vast majority of New York forests were cleared for agriculture starting with the arrival of the first European settlers. Since the time farm abandonment began with farmers moving west for more suitable lands, the state has become reforested. The state has gone from 20% to 25% forest cover in 1890 to about 62% cover today (NYSDEC 2007). In addition to forest clearing for agriculture, some of the forest in the region today has been fragmented through the construction of homes, roads, railroads, highways, utility lines, water reservoirs and other forms of development. Although large blocks of forest exist, the region is already fragmented by existing development to some degree.

The forest within this region also has a history of natural disturbance from several sources. Past fires have likely played a role in shaping the composition, age classes, and relative abundance of various tree species. Evidence of past fires, which often include a sparse understory and even-age stand of trees, may be found in sections of the forest within the study area. Insect pests such as gypsy moths (*Lymantria dispar*) have had a significant effect on the present forest cover (NYSDEC 1997). Since the early 1960s, oaks within this region have been defoliated by gypsy moths and future defoliations of oaks and other species are possible. It is not yet clear whether the hemlock wooly adelgid (*Adelges tsugae*), which has eliminated hemlock in most of Connecticut and the southern Hudson Valley of New York, will become a threat to forests in this region (NYSDEC 1997). Tree disease has not played as large a role in shaping the forest in this area as these insect pests. The last tree disease to play a significant role in shaping the forest in the region was the chestnut blight (*Endothia parasitica*) which eliminated chestnut from the eastern United States during the early 20th century.

3.0 FOREST FRAGMENT ANALYSIS

3.1 Methodology

Contiguous forest areas intersected by the Greenfield segments of the Proposed Route were hand-digitized using color infrared orthophotographs from NYS Office of Cyber Security and Critical Infrastructure Coordination, US Census Roads data, and the Proposed Route. Edges of the forests were defined by roads or changes in land cover (i.e. agriculture). Streams that bisected a forest were not considered fragmenting features. A recent study of forest fragmentation in Connecticut was reviewed to provide guidance for developing the fragmentation analysis methodology (Hurd et al, 2006).

Fragmented forest areas are divided by the Proposed Route Transmission Corridor into at least two sections. See Figure 1 for visual depictions of fragmented forested areas. The Proposed Route Transmission Corridor within the Study Area (150 foot-wide clearing) was overlaid onto the forest patches and areas of fragmented forest patches were calculated. At most, this resulted in dividing one forest patch into three sections of varying size. The resulting smaller areas of the original patch were labeled as A, B, and C, starting with the northernmost or easternmost patch (Table 3).

3.2 Forest Patch Metrics

Analyses were performed on forested lands intersected by the Proposed Route Transmission Corridor in Greenfield areas. The forest cover is a mix of deciduous and coniferous trees. The study area includes a total of 22,208 acres in 50 separate tracts, or 'patches' of forest that are intersected, by the Proposed Route. Of these 50 forest patches, 37 patches with a combined area of 14,298 acres, were affected by fragmentation. The remaining forest patches were only "perforated" by the Proposed Route Transmission Corridor. A forest was perforated in cases where a Greenfield section of the Proposed Route penetrated the forest, but did not bisect it. These areas largely remained intact and were not included in the fragmentation analysis.

The largest forested area fragmented is 1,911 acres in Sullivan County, between stations 120 and 121, and the smallest is 1.2 acres in Sullivan County, south of station 125. See Table 3 and Figure 2 for the results of the fragment analysis.

The two largest forest patches (1,365 acres and 1,911 acres) would be minimally affected by the Proposed Route crossing. The 1,365 acre forest patch will be fragmented into two smaller forest patches with sizes of 1,105 acres and 237 acres, while the 1,911 acre patch will be converted into two smaller patches with sizes of 1,902 acres and 6 acres (not including the cleared ROW area). The smallest patch of forested land (1.2 acres) will be reduced by more than half (to a 0.4 acre and 0.3 acre patch) after the ROW clearing.

There will be approximately 368 acres of land cleared along the 20.22 miles of Greenfield sections of the Proposed Route which includes existing forest, agricultural fields and scrub/shrub areas. Fragmentation will occur along 18.61 miles of the total Greenfield sections of the Proposed Route, with 37 patches of contiguous forest being converted into 84 smaller patches of forest. The change in the number of forest patches and size of these patches from existing to post-construction conditions is presented in Figure 2. Currently, the majority of forest patches have a size between 250 and 1,250 acres (n = 17). There are fewer numbers of smaller forest patches less than 25 acres (n = 6) and very large patches greater than 1,250 acres (n = 2). The patch size distribution generally displays a bell curve pattern, skewed towards larger size patches. After construction, there is a shift in the size distribution towards smaller patch sizes. The largest number of forest patches have a size less than 25 acres (n = 36) following construction. However, the number of large forest patches greater than 250 acres only decreases in count by four from existing conditions (n = 19) to post-construction (n = 15) conditions. Forest patches between 250 and 1,250 acres show a decrease in number from existing (n = 17) to post-construction conditions (n = 14). Existing forest patches between 250 and 1,250 acres will be subject to the greatest degree of fragmentation as a result of the project.

4.0 POTENTIAL IMPACTS OF FOREST FRAGMENTATION ON AVIAN SPECIES

Birds can provide an indication of the effects of forest fragmentation and vegetation maintenance within a ROW on the local ecosystem (Yahner et al. 2002a). A review of existing scientific studies that examines the impacts of forest fragmentation on birds and other wildlife yielded several conclusions (Confer and Pascoe 2003; Donovan and Flather 2002; Driscoll and Donovan 2004; Haskell 1995; Wilcove 1985; Terborgh 1989, 1992; Robinson et al. 1995; Yahner et al. 2002a; Yahner et al. 2003a). In general, the results of most of the studies suggest that fragmentation can have both positive and negative effects. Some species may benefit, while others may be negatively affected. The scale at which the studies occurred also needs to be taken into consideration when evaluating results. Although localized fragmentation may negatively impact some species, at a regional level it may provide an overall benefit to bird populations by creating greater habitat diversity. In addition, the composition of the surrounding landscape (either fragmented or contiguous), appears to play a role in determining the effects of fragmentation at a local level (Driscoll and Donovan 2004).

4.1 Potential Negative Effects

Forest fragmentation can have negative impacts on birds, especially on forest-interior species that require mature forest for habitat (Cornell Lab of Ornithology 2007). The increased likelihood of nest parasitism and predation as a result of forest fragmentation is a concern for forest interior avian species found within the study area (Table 2). Studies have demonstrated that as forest cover increases, the level of nest predation decreases (Robinson et al. 1995). The converse of this finding is that nest predation increases as the amount of forest cover decreases. Fragmentation can also lead to greater susceptibility to local extirpation as a result of natural or human disturbance.

The potential negative effects of fragmentation at a local level appear to be greater when the surrounding landscape, when viewed at a broader scale, is also fragmented. Results from studies of Wood Thrushes (*Hylocichla mustelina*) in New York suggest that negative edge effects on thrushes were stronger in fragmented landscapes than contiguous landscapes (Driscoll and Donovan 2004). These fragmented landscapes contain smaller patches with more exposed edges and other unfavorable forest patch characteristics which may lead to increased exposure to predators (Driscoll and Donovan 2004). The avian species that are most likely to be negatively impacted by forest fragmentation are discussed in Section 4.3.

4.1.1 American Crow and Brown-head Cowbird

Both the American crow (*Corvus brachyrhynchos*) and Brown-headed Cowbird (*Molothrus ater*) are two species that have been implicated as one of several factors causing the decline in forest interior nesting birds. These species have greater access to interior forest species nests as a result of fragmentation.

American crows "rob" nests and eat the eggs. Crows tend to thrive in open environments such as agricultural lands and developed areas where they can readily find food sources and avian nests. When forests are fragmented, more beneficial habitat is created for crows. Fragmentation opens up forests so that nest predators such as crows can more readily find and "rob" nests (Haskell 1995, Wilcove 1985, Terborgh 1989, 1992). The combination of fragmentation and subsequent increase in nest predators can have an impact on the abundance of forest interior nesting birds.

Brown-headed Cowbirds are brood parasites. They lay their eggs in other birds' nests. The "foster parents" or hosts usually raise the cowbird young at the expense of their own eggs or young (Petit 2006). A single female is capable of laying nearly one egg per day at the peak of the breeding season, and produces a total of 30 to 40 eggs over the two- to three-month breeding season (May to July). Female cowbirds usually lay only one egg in a host nest, which results in 30 to 40 nests being parasitized (usually several different species) per female in one season (Petit 2006). Cowbirds are prevalent in open areas and as land was cleared in the United States their numbers and original range have spread resulting in an impact to forest nesting birds. As more forests are fragmented, forest nesting birds are more susceptible to brood parasitism. Nest parasitism and predation may eventually reach levels at which the local population can no longer be sustained without the influx of new migrants, in effect becoming a "sink" population (Robinson et al. 1995). With continued fragmentation of a landscape, adjacent "source" populations may also be depleted, leading to an overall regional decline in the population of a given woodland bird species (Robinson et al. 1995).

Nest predation is a significant factor affecting nesting success in most songbird populations (Heske et al. 2001). Other nest predators in ROWs are snakes (Yahner et al. 2001a), white-footed mice (*Peromyscus leucopus*) and eastern chipmunks (*Tamias striatus*) (Bramble et al. 1992a; Yahner 2003a) and a variety of larger mammals (Yahner 1991, Yahner et al. 2001b). In a study over two years in an electric transmission ROW no nests (n = 59) were parasitized by the brood parasite, the Brown-headed Cowbird. Significant nest predation was caused by the eastern chipmunk (Yahner et al. 2004).

4.2 Potential Positive Effects

Although it may negatively affect some species, the creation of ROWs and "edge" areas within blocks of contiguous forest may benefit some species, especially those that depend on early successional plant communities for habitat. The "edge effect" is a long-accepted ecological principal that recognizes that the edge (or border) between different habitat types typically produces larger numbers and a greater diversity of wildlife than the adjacent habitats considered alone. The border between habitats is inhabited by species that specialize in utilizing edge habitats, as well as by species that primarily use the adjacent habitat types. This situation is common on ROWs in the northeastern United States, where the maintained old field/shrubland habitat of a ROW often borders a different habitat type (e.g., woodlands, agricultural lands, rural/suburban/urban developments). As a result, ROWs can support a diverse population of avian species (Confer and Pascoe 2003; Yahner et al. 2002a; Yahner et al. 2003a). The avian species that would most likely benefit from the forest fragmentation are discussed in Section 4.4.

4.3 Potential Impacts to Woodland Bird Species

Those species with the greatest sensitivity to forest fragmentation based on past research are presented in Table 2 (Herkert et al. 1993; Donovan and Flather 2002). These interior forest species require large blocks of mature, contiguous forest. They also represent non-game species that are protected under New York State law or are listed as a species of concern (See Note 2, Table 1). Minimum habitat size requirements for each species listed in Table 2 are discussed below. The studies reviewed used several different terms including minimum breeding area, breeding territory, and minimum habitat size which may account for the wide range in figures cited for some species. In each case, the largest, most conservative figure reviewed was used in this analysis.

American Redstart – The American Redstart may be one of the more area-sensitive species, which prefers large intact tracts of habitat greater than 9,884 acres (Sherry and Holmes 1997). There are no forest patches this large along the Proposed Route in the study area (Table 3). The largest forest patch (1,911 acres) in the study area will be minimally fragmented into a 1,902 acre patch and 6 acre patch by the creation of the Greenfield section of the Proposed Route (Table 3).

Black-and-white Warbler – The minimum breeding area size has been estimated at 545 acres (Robbins et al. 1989). Other research found that the Black-and-white Warbler was not observed in forest fragments smaller than 19 acres (Forman et al. 1976) and does not breed in forest patches smaller than 173 acres (Bushman and Therres 1988). The number of forest patches meeting the suggested minimum area for breeding (545 acres) will decrease from 8 to 7 forest patches following construction in the study area (Table 3).

Broad-winged Hawk – Based on a literature-derived mean from 25 breeding females, the territory of the Broad-winged Hawk is 569 acres (Anderson and Bernstein 2003). The number of existing forest patches with an area large enough to provide territory for breeding female Broad-winged Hawks based on this study will decrease from 8 to 7 (Table 3) as a result of project construction in the study area.

Brown Creeper – Existing research suggests that the minimum forest patch sized used by Brown Creepers varies by area (Wiggins 2005). Studies in Connecticut found minimum patch size of 124 acres, while in Wisconsin, the minimum patch size used by Brown Creepers was 247 acres (Wiggins 2005). Brown Creepers also appear to have specific habitat requirements which may play a larger role in determining whether they will occur in a given forest patch than the actual forest patch size itself. The local density of large snags and mature trees appear to be the most important factors in determining Brown Creeper abundance (Wiggins 2005). Using the more conservative estimate from Wisconsin, the number of forest patches with a minimum area of 247 acres will decrease from 19 to 15 following construction in the study area (Table 3).

Cerulean Warbler – The estimated minimum breeding area for the Cerulean Warbler is 1,730 acres based on the Robbins study (Robbins et al. 1989). However, another study (Anderson and Bernstein 2003) listed a much smaller breeding habitat size. Based on literature-derived mean for 25 females, the breeding territory of the Cerulean Warbler is 65 acres (26 ha) (Anderson and Bernstein 2003). Considering the more conservative, larger figure of 1,730 acres for breeding area, there will be no loss of forest patches this size or larger following construction in the study area (Table 3).

Hooded Warbler – Review of existing research uncovered a wide range of minimum habitat sizes for the Hooded Warbler. These sizes range from a low of 74 acres (30 ha) (Robbins 1979) to high of 1,480 acres (600 ha) (Blake and Karr 1984). Assuming that minimum habitat size is the more conservative 1,480 acres, there will be no decrease in the number of forest patches with this minimum size as a result of construction of the project in the study area (Table 3).

Ovenbird – For Ovenbirds, the minimum contiguous habitat area required for successful breeding ranges from 250 acres (100 ha) to 2,220 acres (885 ha) (Van Horn and Donovan 1994). Differences in regional requirements for the species may play a role in this wide range of minimum estimated habitat sizes (Van Horn and Donovan 1994). There are no existing forest patches greater than 2,220 acres that are fragmented within the study area.(Table 3). The largest forest patch (1,911 acres) in the study area will be minimally fragmented into a 1,902 acre patch and 6 acre patch by the creation of the Greenfield section of the Proposed Route (Table 3).

Pileated Woodpecker – Minimum breeding area according to Robbins et al. (1989) is 408 acres, while other studies cite 320 acres as the minimum area needed to meet the needs of the Pileated Woodpecker (Robinson 2000). Habitat quality factors, including log volume, stump volume, and canopy closure, play a large role in habitat size (Robinson 2000). There will be a net decrease of two forest patches that have an area greater than 400 acres as a result of construction in the study area (Table 3).

Red-eyed Vireo – There is little data available on minimum habitat size requirements for Red-eyed Vireos. However, in breeding grounds, they have been found in forest patches as small as 1.23 acres (Cimprich et al. 2000). Robbins et al. (1989) also lists a small minimum breeding area for the Red-eyed Vireo of 6 acres. There are 36 forest patches with a minimum size of 6 acres in the study area; following construction, there will be 67 forest patches with a minimum size of 6 acres (Table 3).

Scarlet Tanagers – Research suggests that Scarlet Tanagers require a minimum breeding area of 75 acres of contiguous forested habitat in the forested Northeast, and 175 to 300 acres in less forested Midwest and Atlantic Coastal areas (Rosenberg et al. 1999). An estimated minimum breeding area of 30 acres has also been cited in studies (Robbins et al. 1989). Using the minimum habitat size (75 acres) cited for the Northeast, the number of forest patches with this minimum area will increase from 27 to 39 forest patches following construction in the study area (Table 3).

Veery – According to Robbins et al. (1989), the minimum habitat for breeding is 50 acres for the Veery. Other sources cite larger minimum habitat sizes, including 67 acres in Illinois and areas greater than 250 acres in other regions (USFWS 2001). Using the most conservative estimate of 250 acres, the number of forest patches of this size or greater will decrease from 19 to 15 following construction in the study area (Table 3).

Yellow-throated Vireo – Based on a literature-derived mean for 25 females, breeding territory for Yellow-throated Vireos is 185 acres (Anderson and Bernstein 2003). The number of forest patches of at least 185 acres will increase from 21 to 23 following construction in the study area (Table 3).

Based on these findings, it appears that the impact of creating smaller forest patch sizes will vary by bird species because of the variation in their minimum habitat or breeding size requirements. The habitat quality and location of a given forest patch in relation to large blocks of forest within the broader landscape matrix will also play a role in determining potential impacts to interior bird species (Driscoll and Donovan 2004; Robinson 2000; Rosenberg et al. 1999; Wiggins 2005).

4.4 Potential Benefits to Woodland Bird Species

Recent declines in populations of shrubland birds in the Northeast are a growing concern among avian conservationists. The Project would have a long-term beneficial impact to wildlife and avian species which favor shrubland areas, as the amount of this habitat type would permanently increase as a result of construction and operation of the Project. Transmission ROW are linear corridors that often traverse contiguous forests, thereby making the ROW extremely valuable for bird species requiring early successional habitats (Bramble et al. 1992b, 1994; Yahner et al. 2002b; Yahner et al. 2003b). For a complete list of birds in the Study Area that feed, nest, or seek cover in shrubland, see Table 1.

Some studies (Confer and Pascoe 2003; Yahner et al. 2003a) suggest that ROWs are able to support greater diversity and number of birds than forested habitats. This is a result of increased shrubland habitat that is created by the ROWs. In addition to providing habitat for shrubland bird species, there is evidence which suggests that the ROWs may provide some benefits to forest interior species as well, thereby increasing overall avian diversity in the area. A long-term study of bird populations along a ROW in Pennsylvania found that the ROW not only provided food and habitat for early successional species, but also provided food and habitat for forest interior species (Yahner et al. 2002a). In addition, some of the forest interior species appeared to shift their home range to include a portion of the ROW (Yahner et al. 2002a). The ROW in Pennsylvania was managed to include a tree-free, forb-grass cover zone under the structures (termed the wire zone) and an area with taller shrub cover along the borders of the ROW. This maintenance technique will be similar to that used along the Proposed Route with a tree-free, permanently maintained ROW under the structures and a selective cut zone along the ROW edges. The wire/border zone maintenance method appears to support the greatest diversity of bird species by providing food and cover for early successional, edge, and woodland bird species and is the recommended approach for ROW maintenance (Yahner et al. 2003a).

Vegetative management, typical for a ROW, does not have a significant negative impact on avian populations that utilize the area for nesting, food, or cover (King and Byers 2002; Yahner et al. 2003a). A study of the bird populations along a ROW found little difference in the bird community after 15 years of vegetation management (Yahner et al. 2003a). In addition, the number of Cowbirds along the ROW remained relatively low, and did not appear to be having an impact on nest success in the area (Yahner et al. 2002a, Yahner et al. 2003a). Trends in the Northeast indicate that abandoned farmlands are increasingly converted into woodlands outside metropolitan areas (Saucier 2003), reducing the amount of stable shrubland. The vegetative management in a ROW typically provides the long-term, stable shrubland habitat needed for woodland birds and habitat diversity. The exchange of forested habitats for shrublands is interpreted as a net gain for regional biodiversity (Confer and Pascoe 2003).

When considering the landscape at a broader scale, the existence of large patches of contiguous forest at a regional level may mitigate negative effects of fragmentation at a local level. Species such as scarlet tanagers that generally nest in contiguous forest landscapes have actually experienced increases in regional populations although they may be sensitive to fragmentation at a local level (Donovan and Flather 2002). This finding may be explained by the concept of source-sink population structure in which sink populations in poorer habitat are maintained by the influx of migrants from source populations which occupy more suitable habitat (Donovan and Flather 2002).

Early successional habitat has become less common in the forests of the eastern United States in recent decades (Trani et al. 2001), and maintenance of a ROW creates early successional habitat for birds populations (Yahner et al. 2002b). Because bird species adapted to early successional habitat have experienced population declines over recent decades in northeastern United States (Robbins et al. 1989; James et al. 1996; Yahner 2000, Yahner 2003b; Askins 2001; Brawn et al. 2001) a maintained ROW can provide important nesting habitat for many bird species (Yahner et al. 2004).

5.0 CONCLUSIONS

Approximately 14,298 acres in a total of 37 forested areas will be fragmented by a Greenfield section of the Proposed Route. The two largest forest patches (1,365 acres and 1,911 acres) would be minimally affected by the proposed route crossing. The 1,364 acre forest patch will fragmented into two smaller forest patches with sizes of 1,105 acres and 237 acres, while the 1,911 acre patch will be converted into two smaller patches with sizes of 1,902 acres and 6 acres (not including the cleared ROW area. The majority of patches which will be fragmented currently have a size which ranges from 251 to 1,250 acres. Forest fragmentation will occur along 18.61 miles of Greenfield sections of the Proposed Routes. However, the majority of those portions of the Proposed Route which are adjacent to Millennium will not contribute to forest fragmentation. These adjacent areas will only involve widening existing ROWs which will not fragment any new forested areas.

The creation of edge habitat as a result of forest fragmentation during the construction of a transmission line through Greenfield sections of the Proposed Route appears to have both positive and negative effects on bird populations, wildlife, and local ecosystems. Whether the effect is positive or negative is species specific. Those species that favor earlier successional, shrubland habitats will likely experience positive effects as a result of the project. Forest interior species that require contiguous blocks of forest for habitat may only experience temporary negative impacts as they are able to move to nearby suitable habitat. The quality of the existing forest habitat along the route will also play a role in determining the effects on interior forest bird species. If suitable habitat exists, it will likely still support a variety of bird species. If forest habitat is marginal, there may be more negative effects on species. However, when determining whether forest fragmentation will result in a net positive or negative benefit to wildlife, the key factor appears to be the characteristics of the wider landscape in which the transmission line will be constructed. If the wider regional landscape is primarily fragmented, the overall effect may be negative. However, if the wider landscape still contains large blocks of contiguous forest, the overall effect may be positive by providing a greater diversity of habitat in the region. Areas that are impacted by fragmentation may be re-colonized by birds from source populations from larger blocks of adjacent forest.

Because the majority of the Proposed Route from station 100 to station 160 passes through a broader landscape which still contains large blocks of contiguous forested habitat, it is unlikely that the fragmentation which will result from the project will have any long-term negative impacts on woodland bird species. Approximately 66% of the land cover within 2,400 feet of the centerline for the entire 189-mile proposed route is classified as either deciduous forest, evergreen forest, or mixed forest shrubland (National Land Cover Data Set 1992). Although this finding does not provide insight into the degree to which the landscape is fragmented, it does suggest that there are likely to be at least some large intact blocks of forest along the route. Any local, negative impacts should be mitigated by the presence of the larger forest patches in the region. As long as these larger forest blocks remain intact, populations of woodland bird species should not be negatively impacted at a regional level. In addition, the creation of early successional shrub habitat within the ROW may provide a benefit to species that forage and nest in this type of community, including some threatened and endangered species and species of concern under New York State law.

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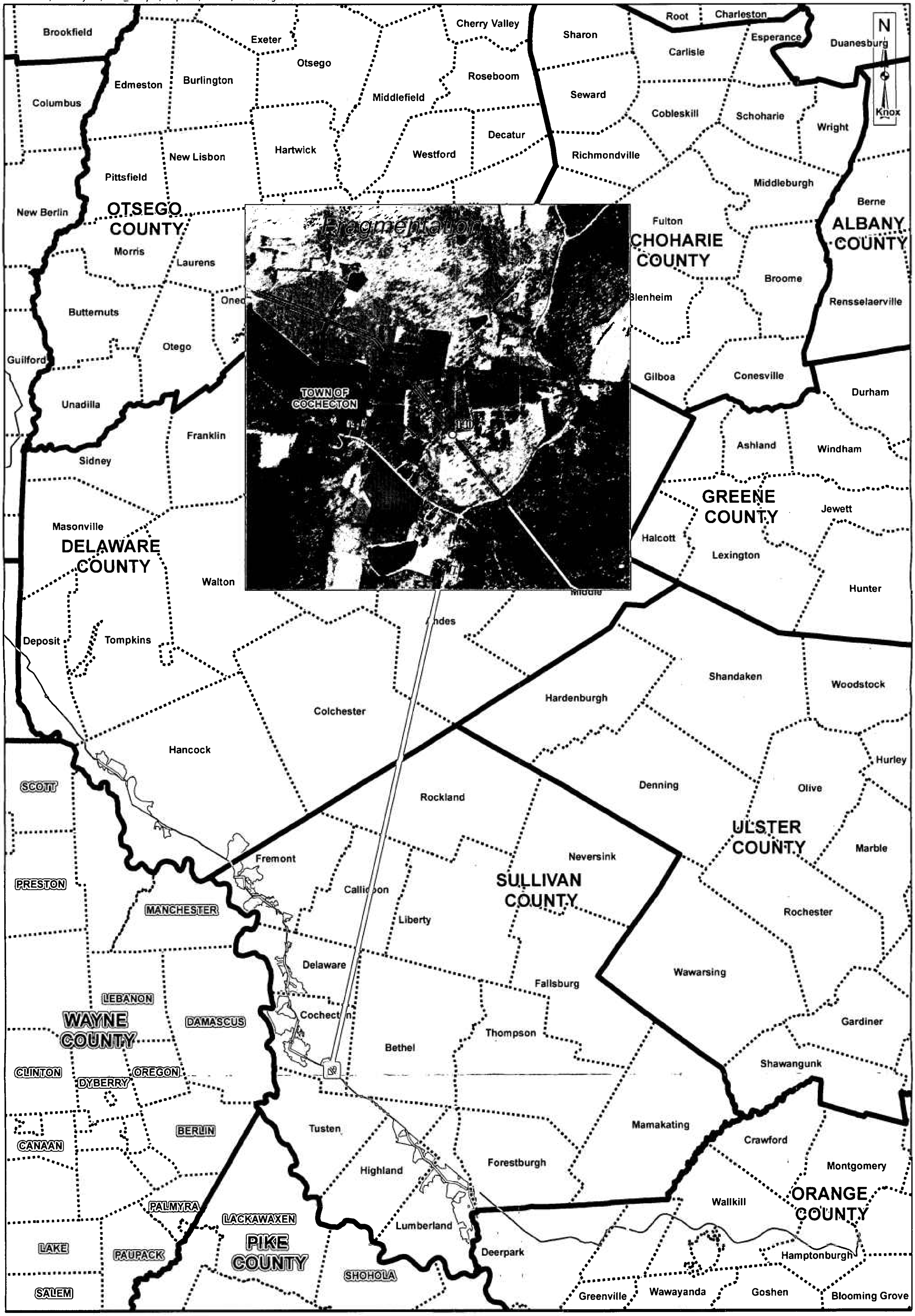
Location: G:/GIS-Projects/P252_Analysis/Proposed/00-mxd/ForestFrag.mxd



NYRI New York Regional Interconnection

NEW YORK REGIONAL INTERCONNECTION
Project Location: New York

Legend
Proposed Route Station Numbers
Proposed Route
Greenfields
Forest Patch

Forest Fragmentation

Basemap Scale: 1" = 36,000'

Source: 1) ESS Propsoed Route UG8
2) NYS Office of Cyber Security and Critical Infrastructure Coordination, 2002
3) NYS Office of Cyber Security and Critical Infrastructure Coordination, 2005
4) US Census, 2000

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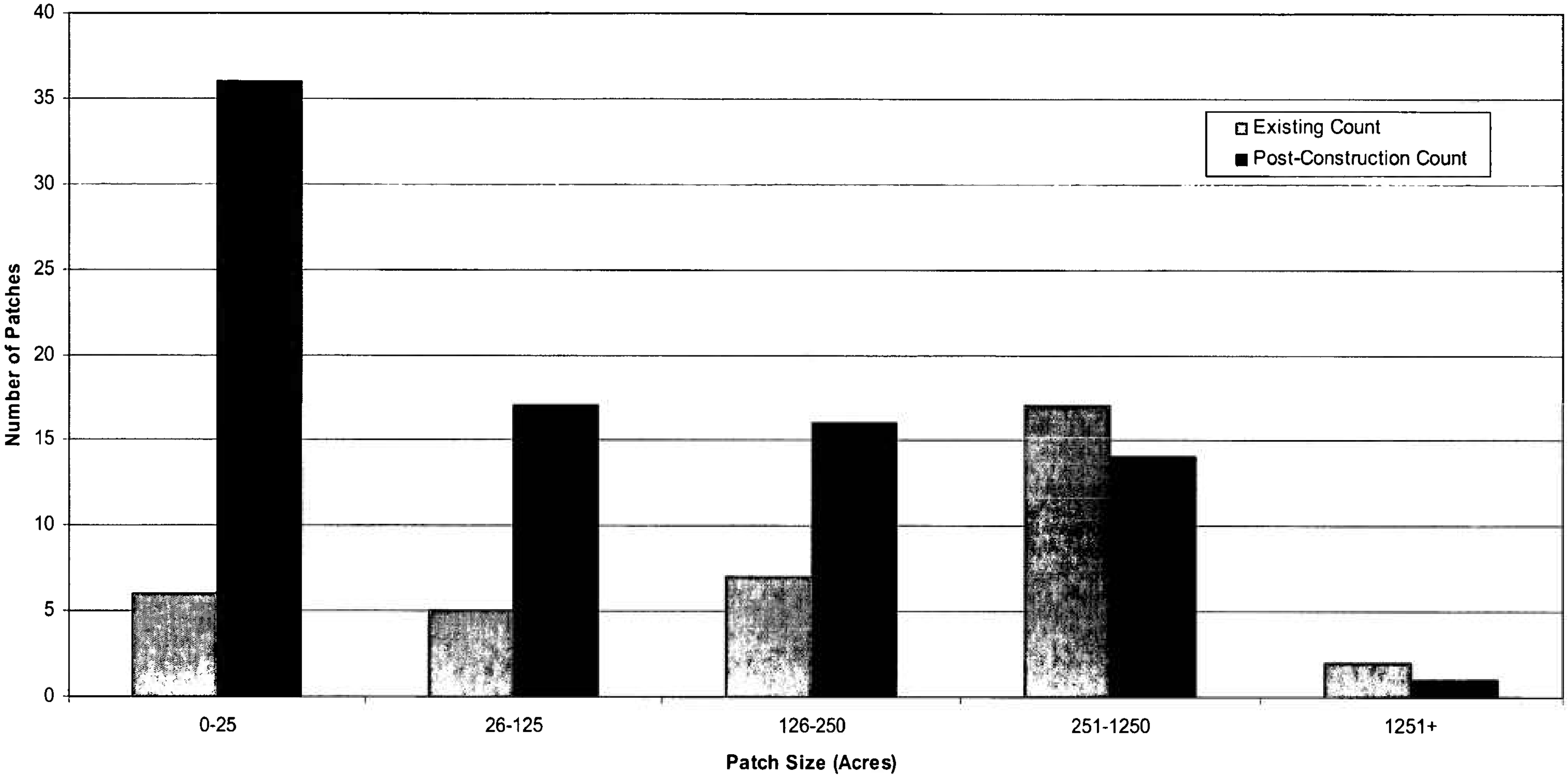
Figure
1

NYRI Proposed Route - Greenfield Sections Between Stations 100 - 160, Change in Forest Patch Size, Existing to Post-Construction



ESS Group, Inc.
Engineers
Scientists
Consultants

New York Regional Interconnection
New York State

Forest Fragmentation Study

Figure 2

Figures (on CD)

Tables

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Table 1. Bird Species by Potential Habitats Found along Greenfield Sections of the Proposed Route (Stations 100 to 160) Based on the New York Breeding Bird Atlas

Common Name[1]	Scientific Name	NY Legal Status[2]	Habitat Type[3]							
			OF	MF	WW	SS	EM	OW	AG	RES/UR
Great Blue Heron	*Ardea herodias*	P			N,F,C	F,C	F,C	N,F,C		
Green Heron	*Butorides virescens*	P			N,F,C	F,C	F,C	F,C		
American Bittern (E)	*Botaurus lentiginosus*	C				F,C	N,F,C	F,C		
Mute Swan	*Cygnus olor*	P						F,C		
Canada Goose	*Branta canadensis*	G					N,F,C	F,C		
Wood Duck	*Aix sponsa*	G			N,F,C	F,C	F,C	F,C		
American Black Duck	*Anas rubripes*	G	C	C	F,C	F,C	N,F,C	F,C		
Mallard	*Anas platyrhynchos*	G	C	C	F,C	F,C	N,F,C	F,C	N,C	
Common Merganser	*Mergus merganser*	G			N			F, C		
Turkey Vulture	*Cathartes aura*	P	N,F	N,C	C				F	F
Osprey	*Pandion haliaetus*	C						N,F		
Sharp-shinned Hawk (E)	*Accipiter striatus*	C		N,F,C	N,F,C				F	
Cooper's Hawk (T)	*Accipiter cooperii*	C		N,F,C	N,F,C				F	
Northern Goshawk	*Accipiter gentilis*	C		N,F,C	N,F,C					
Red-shouldered Hawk (SC)	*Buteo lineatus*	C	F	N,F,C	N,F,C	F	F	F	F	
Broad-winged Hawk	*Buteo platypterus*	P	F	N,F,C	N,F,C	F	F	F,C	F	
Red-tailed Hawk	*Buteo jamaicensis*	P	F	N,F,C	N,F,C	F	F	F	N,F	N,F
American Kestrel (SC)	*Falco sparverius*	P	N,F,C	N,F,C					N,F	
Ring-necked Pheasant	*Phasianus colchicus*	G	N,F,C						N,F,C	
Ruffed Grouse	*Bonasa umbellus*	G	F,C	N,F,C					F,C	
Wild Turkey	*Meleagris gallopavo*	G	F,C	N,F,C					F,C	
Northern Bobwhite	*Colinus virginianus*	G	N,F,C						N,F,C	
Killdeer	*Charadrius vociferus*	P	N,F,C						N,F,C	N,F,C
Spotted Sandpiper	*Actitis macularia*	P	N,C			N,C	N,F,C	F,C	N,C	
Wilson's Snipe	*Gallinago delicate*	G			N,F,C	N,F,C	N,F,C			
American Woodcock	*Scalopax minor*	G	N,F,C		F,C	N,F,C	F,C		N,F,C	
Rock Dove (Pigeon)	*Columba livia*	U	F,C						N,F,C	N,F,C
Mourning Dove	*Zenaida macroura*	P	N,F,C						N,F,C	N,F,C
Black-billed Cuckoo	*Coccyzus erythropthalmus*	P	N,F,C	N,F,C	N,F,C	N,F,C			N,F,C	
Yellow-billed Cuckoo	*Coccyzus americanus*	P	N,F,C		N,F,C	N,F,C			N,F,C	
Eastern Screech-Owl	*Otus asio*	P	N,F,C	N,F,C	N,F,C				N,F,C	N,F,C
Great Horned Owl	*Bubo virginianus*	P	F,C	N,F,C	N,F,C	F,C	F,C			
Barred Owl	*Strix varia*	P		N,F,C	N,F,C					
Northern Saw-whet Owl	*Aegolius acadicus*	P		N,F,C	N,F,C					

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Table 1. Bird Species by Potential Habitats Found along Greenfield Sections of the Proposed Route (Stations 100 to 160) Based on the New York Breeding Bird Atlas

Common Name[1]	Scientific Name	NY Legal Status[2]	Habitat Type[3]							
			OF	MF	WW	SS	EM	OW	AG	RES/UR
Common Nighthawk (T)	*Chordeiles minor*	C	N,F,C						N,F,C	N,F,C
Chimney Swift	*Chaetura pelagica*	P	N,F,C	N,F,C	N,F,C	F,C	F,C	F,C	F,C	N,F,C
Ruby-throated Hummingbird	*Archilochus colubris*	P	F,C	N,F,C	N,F,C				N,F,C	N,F,C
Belted Kingfisher	*Ceryle alcyon*	P						N,F,C		
Yellow-bellied Sapsucker	*Sphyrapicus varius*	P		N,F,C	N,F,C					
Red-bellied Woodpecker	*Melanerpes carolinus*	P		N,F,C	N,F,C					N,F,C
Downy Woodpecker	*Picoides pubescens*	P	N,F,C	N,F,C	N,F,C	N,F,C			N,F,C	N,F,C
Hairy Woodpecker	*Picoides villosus*	P	N,F,C	N,F,C	N,F,C	N,F,C			N,F,C	F,C
Northern Flicker	*Colaptes auratus*	P		N,F,C	N,F,C				N,F,C	F,C
Pileated Woodpecker	*Dryocopus pileatus*	P		N,F,C	N,F,C					
Eastern Wood-Pewee	*Contopus virens*	P	F,C	N,F,C	N,F,C					
Alder Flycatcher (SC)	*Empidonax alnorum*	P				N,F,C	F,C	F,C		
Willow Flycatcher	*Empidonax traillii*	P				N,F,C	F,C	F,C		
Least Flycatcher	*Empidonax minimus*	P	N,F,C	F,C	F,C	N,F,C	F,C	F,C		N,F,C
Eastern Phoebe	*Sayornis phoebe*	P	N,F,C	N,F,C	N,F,C	F,C	F,C	F,C	N,F,C	N,F,C
Eastern Kingbird	*Tyrannus tyrannus*	P	F,C	N,F,C	N,F,C	F,C	F,C	F,C	F,C	N,F,C
Great Crested Flycatcher	*Myiarchus crinitus*	P	N,F,C	N,F,C	N,F,C				N,F,C	N,F,C
Purple Martin (T)	*Progne subis*	P	N,F,C						F,C	N,F,C
Tree Swallow	*Tachycineta bicolor*	P	F,C		N,F,C	F,C	F,C	F,C	F,C	N,F,C
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	P			N	F,C	F,C	N,F,C		N,F,C
Bank Swallow	*Riparia riparia*	P				F,C	F,C	N,F,C		N,F,C
Cliff Swallow	*Hirundo pyrrhonota*	P				F,C	F,C	N,F,C	N,F,C	N,F,C
Barn Swallow	*Hirundo rustica*	P	F,C			F,C	F,C	F,C	N,F,C	N,F,C
Blue Jay	*Cyanocitta cristata*	P	F,C	N,F,C	N,F,C				N,F,C	N,F,C
American Crow	*Corvus brachyrhynchos*	G	F,C	N,F,C	N,F,C				N,F,C	F,C
Fish Crow	*Corvus ossifragus*	P			N,C	N,F,C	F,C	F		
Common Raven	*Corvus corax*	P		N,F,C						
Black-capped Chickadee	*Parus atricapillus*	P	F,C	N,F,C	N,F,C	F,C			F,C	F,C
Tufted Titmouse	*Parus bicolor*	P	F,C	N,F,C	N,F,C	F,C	F,C		F	N,F,C
Red-breasted Nuthatch	*Sitta canadensis*	P		N,F,C	N,F,C					
White-breasted Nuthatch	*Sitta carolinensis*	P		N,F,C	N,F,C					
Brown Creeper	*Certhia americana*	P		N,F,C	N,F,C					
Winter Wren	*Troglodytes troglodytes*	P	N,F,C	N,F,C	N,F,C					
Carolina Wren	*Thryothorus ludovicianus*	P	N,F,C	N,C	N,C	F,C	F,C			

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Table 1. Bird Species by Potential Habitats Found along Greenfield Sections of the Proposed Route (Stations 100 to 160) Based on the New York Breeding Bird Atlas

Common Name[1]	Scientific Name	NY Legal Status[2]	Habitat Type[3]							
			OF	MF	WW	SS	EM	OW	AG	RES/UR
House Wren	*Troglodytes aedon*	P	N,F,C	N,C	N,C	N,F,C			N,F,C	N,F,C
Golden-crowned Kinglet	*Regulus satrapa*	P		N,F,C	N,F,C					
Blue-gray Gnatcatcher	*Polioptila caerulea*	P	N,F,C	N,F,C	N,F,C	N,F,C	F,C		N,F,C	N,F,C
Eastern Bluebird	*Sialia sialis*	P	F,C	N,C	N,C	F,C			N,F,C	N,F,C
Veery	*Catharus fuscescens*	P		N,F,C	N,F,C					
Hermit Thrush	*Catharus guttatus*	P	N,F,C	N,F,C	N,F,C					
Wood Thrush	*Hylocichla mustelina*	P		N,F,C	N,F,C					
Swainson's Thrush	*Catharus ustulatus*	P		N,F,C	N,F,C				N,F,C	
American Robin	*Turdus migratorius*	P	N,F,C	N,F,C	N,F,C	N,F,C			N,F,C	N,F,C
Gray Catbird	*Dumetella carolinensis*	P	N,F,C			N,F,C	F,C		N,F,C	N,F,C
Brown Thrasher (SC)	*Toxostoma rufum*	P	N,F,C			N,F,C			N,F,C	N,F,C
Cedar Waxwing	Bombycilla cedrorum	P	F,C	N,F,C	N,F,C					N,F,C
European Starling	*Sturnus vulgaris*	U	N,F,C			N,F,C	F,C		N,F,C	N,F,C
Yellow-throated Vireo	*Vireo flavifrons*	P	F,C	N,F,C						N,F,C
Warbling Vireo	*Vireo gilvus*	P	F,C	N,F,C	N,F,C	F,C	F,C			
Red-eyed Vireo	*Vireo olivaceus*	P		N,F,C	N,F,C					N,F,C
Blue-winged Warbler	*Vermivora pinus*	P	N,F,C			N,F,C	F,C			
Golden-winged Warbler (T)	*Vermivora chrysoptera*	C	N,F,C		N,F,C	N,F,C	F,C		N,F,C	
Nashville Warbler	*Vermivora ruficapilla*	P	N,F,C		N,F,C	N,F,C				
Northern Parula (SC)	*Parula americana*	P		N,F,C	N,F,C					
Yellow Warbler	*Dendroica petechia*				N,F,C	N,F,C	F,C			N,F,C
Chestnut-sided Warbler	*Dendroica pensylvanica*	P	N,F,C		N,F,C					
Magnolia Warbler	*Dendroica magnolia*	P		N,F,C						
Black-throated Blue Warbler	*Dendroica caerulescens*	P		N,F,C						
Yellow-rumped Warbler	*Dendroica coronata*	P	F,C	N,F,C						
Black-throated Green Warbler	*Dendroica virens*	P		N,F,C		N,F,C				
Blackburnian Warbler	*Dendroica fusca*	P		N,F,C						
Pine Warbler	*Dendroica pinus*	P		N,F,C						
Prairie Warbler	*Dendroica discolor*	P	N,F,C	F,C						
Cerulean Warbler	*Dendroica cerulea*	C		N,F,C						
Black-and-white Warbler	*Mniotilta varia*	P		N,F,C						
American Redstart	*Setophaga ruticilla*	P	N,F,C	N,F,C	N,F,C	N,F,C				
Ovenbird	*Seiurus aurocapillus*	P		N,F,C						
Common Yellowthroat	*Geothlypis trichas*	P	N,F,C			N,F,C	N,F,C			

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Table 1. Bird Species by Potential Habitats Found along Greenfield Sections of the Proposed Route (Stations 100 to 160) Based on the New York Breeding Bird Atlas

Common Name[1]	Scientific Name	NY Legal Status[2]	Habitat Type[3]							
			OF	MF	WW	SS	EM	OW	AG	RES/UR
Northern Waterthrush	*Seiurus noveboracensis*	P			N,F,C	F,C	N,F,C	F		
Louisiana Waterthrush	*Seiurus motacilla*	P			N,F,C	N,F,C	F,C	F		
Hooded Warbler	*Wilsonia citrina*	P		N,F,C	N,F,C					
Canada Warbler	*Wilsonia canadensis*	P		N,F,C	N,F,C					
Scarlet Tanager	*Piranga olivacea*	P		N,F,C						
Northern Cardinal	*Cardinalis cardinalis*	P	N,F,C			N,F,C			N,F,C	N,F,C
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	P	N,F,C	N,F,C	N,F,C					
Indigo Bunting	*Passerina cyanea*	P	N,F,C			N,F,C			N,F,C	
Eastern Towhee	*Pipilo erythrophthalmus*	P	N,F,C	N,F,C						
Chipping Sparrow	*Spizella passerina*	P	N,F,C	N,C					N,F,C	
Field Sparrow	*Spizella pusilla*	P	N,F,C							
Vesper Sparrow (E)	*Pooecetes gramineus*	C	N,F,C							
Savannah Sparrow (SC)	*Passerculus sandwichensis*	P	N,F,C				N,F,C		N,F,C	
Song Sparrow	*Melospiza melodia*	P	N,F,C			N,F,C			N,F,C	N,F,C
Swamp Sparrow	*Melospiza georgiana*	P			N,F,C	N,F,C	N,F,C	F		
White-throated Sparrow	*Zonotrichia albicollis*	P	N,F,C	N,F,C						F,C
Dark-eyed Junco	*Junco hyemalis*	P	N,F,C	N,F,C						N,F,C
Bobolink	*Dolichonyx oryzivorus*	P	N,F,C			F,C	N,F,C		N,F,C	
Red-winged Blackbird	*Agelaius phoniceus*	P				N,F,C	N,F,C	F	N,F,C	N,F,C
Eastern Meadowlark (SC)	*Sturnella magna*	P	N,F,C						N,F,C	
Common Grackle	*Quiscalus quiscala*	P	N,F,C	N,F,C					N,F,C	N,F,C
Brown-headed Cowbird	*Molothrus ater*	P	N,F,C	N,F,C						
Purple Finch	*Carpodacus purpureus*	P		N,F,C						
House Finch	*Carpodacus mexicanus*	P	N,F,C						N,F,C	N,F,C
American Goldfinch	*Carduelis tristis*	P	N,F,C		N,F,C	N,F,C	F,C		N,F,C	N,F,C
Evening Grosbeak	*Coccothraustes vespertinus*	P		N,F,C						
House Sparrow	*Passer domesticus*	U							N,F,C	N,F,C
Bald Eagle	*Haliaeetus leucocephalus*	T		N,F,C	N,F,C			F		
Baltimore Oriole	*Icterus galbula*	P	N,F,C	N,F,C	N,F,C					F,C
Barn Owl	*Tyto alba*	P	F,C	N,C			F,C		N,F,C	
Black Vulture	*Coragyps atratus*	P	N,F,C						N,F,C	N,F,C
Blue-headed Vireo	*Vireo solitarius*	P		N,F,C						
Brewster's Warbler	*Vermivora pinus x V. chrysoptera*	P	N,F,C			N,F,C				

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Table 1. Bird Species by Potential Habitats Found along Greenfield Sections of the Proposed Route (Stations 100 to 160) Based on the New York Breeding Bird Atlas

Legend:

1. E = Endangered; T = Threatened; SC = Special Concern
2. New York State Legal Status: P= Protected; C = Concern; G=Game Species; T=Threatened; U=Unprotected
3. OF = Old Field/Shrubland
   MF = Mature Mixed Forest
   WW = Wooded Wetland
   SS = Shrub Swamp
   EM = Emergent Marsh
   OW = Open Water
   AG = Agricultural
   RES = Residential
   UR = Urban

For each species listed, habitat types marked with an "N" indicate that species may utilize that habitat type for nesting, an "F" indicates the species may forage in that habitat, and a "C" indicates the species may utilize that habitat for cover, resting, or roosting. Blank boxes indicate the species is not typically found in that habitat type, except as occasional transients.

Source: *The New York State Breeding Bird Atlas, 2000.*

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Table 2. Forest Fragmentation Study - Species of Greatest Concern

Common Name	Scientific Name
American Redstart	*Setophaga ruticilla*
Black-and-white Warbler	*Mniotilta varia*
Broad-winged Hawk	*Buteo platypterus*
Brown Creeper	*Certhia americana*
Cerulean Warbler	*Dendroica cerulea*
Hooded Warbler	*Wilsonia citrina*
Ovenbird	*Seiurus aurocapillus*
Pileated Woodpecker	*Dryocopus pileatus*
Red-eyed Vireo	*Vireo olivaceus*
Scarlet Tanager	*Piranga olivacea*
Veery	*Catharus fuscescens*
Yellow-throated Vireo	*Vireo flavifrons*

Based on two sources:

1) Herkert, James R., Robert E Szafoni, Vernon M. Kleen, and John E. Schwegman. 1993. *Habitat establishment, enhancement and management for forest and grassland birds in Illinois*. Division of Natural Heritage, Illinois Department of Conservation, Natural Heritage Technical Publication #1.

2) Donovan T.M. and C.H. Flather. 2002. *Relationships Among North American Songbird Trends, Habitat Fragmentation, and Landscape Occupancy*. Ecological Applications, Vol. 12, No. 2, pp. 364-374.

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Table 3. Results of Forest Fragmentation Analysis, Greenfield Areas along NYRI Proposed Route Stations 100 - 160.

Parcel #	Original Contiguous Acres	Length of Greenfield (ft)	*Resulting Patch (acres)		
			A	B	C
0	1.2	140	0.4	0.3	
1	5.6	251	3.5	1.0	
2	17.1	1,252	10.2	3.1	
3	18.0	1,002	7.8	7.0	
4	18.3	138	17.8	0.0	
5	20.2	894	9.7	7.4	
6	29.3	1,254	17.6	5.9	1.7
7	30.2	806	24.2	3.2	
8	35.2	270	26.0	8.2	
9	38.2	367	36.1	0.8	
10	85.9	904	75.0	7.4	0.5
11	139.8	3,238	87.3	39.2	2.8
12	159.6	1,036	155.1	0.9	0.2
13	164.9	2,783	129.3	26.3	0.1
14	172.2	652	159.7	10.2	
15	180.6	498	167.2	11.6	0.1
16	209.7	3,861	98.8	97.6	
17	229.1	3,519	145.4	58.5	13.1
18	255.0	3,963	190.4	51.0	
19	275.8	3,009	232.7	32.8	
20	280.5	2,053	219.9	53.6	
21	357.2	4,563	181.0	160.5	
22	357.2	634	349.7	5.3	
23	367.5	3,841	226.4	127.8	0.1
24	406.4	3,328	283.8	95.1	15.9
25	433.0	3,646	393.2	27.6	
26	485.0	5,719	379.2	86.3	
27	543.5	1,761	527.0	10.5	
28	544.2	5,177	413.7	112.7	
29	571.7	3,611	430.9	120.0	8.4
30	655.5	2,404	624.4	22.8	
31	863.6	5,383	612.0	233.1	
32	954.2	8,236	767.2	158.6	
33	1,010.1	4,288	782.6	212.7	
34	1,107.1	6,232	661.0	424.8	
35	1,364.5	6,669	1105.1	236.6	
36	1,911.3	890	1902.2	6.0	

*Note: Resulting patch acreage, A, B & C, represents the acreage of all the smaller patches created as a result of Greenfield Area ROW clearing

Attachment C (on CD)

Orthophotographs of the NYRI and Millennium Pipeline Route Alignments

Attachment D

Exponent Pipeline Report

Exponent Engineering P.C.

New York Regional Interconnection Study: Regional Pipeline Compatibility

New York Regional Interconnection Study: Regional Pipeline Compatibility

Prepared for

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Prepared by

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This report was prepared under the supervision of Thomas G. Livernois, Ph.D., P.E.

Thomas G. Livernois

Thomas G. Livernois
State of New York PE License No. 084688

November 2007

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Notice

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Acronyms and Abbreviations

A	Ampere
AC, ac	Alternating Current
dB	Decibel
dB(A)	Decibel A-weighted
DC, dc	Direct Current
EMI	Electromagnetic Interference
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
GE	General Electric
H	Henry, unit of inductance
Hz	Hertz, cycles per second
IEEE	Institute of Electrical and Electronics Engineers
kHz	kilo-Hertz, 1,000 Hertz
km	kilometer
kV	kilo-volt, 1,000 Volt
MFL	Magnetic Flux Leakage
mho	unit of conductance, Ohm^{-1}
MHz	mega-Hertz, 10^6 Hz
mV	milli-volt, 0.001 Volt
MW	mega-watt, 10^6 Watt
NACE	National Association of Corrosion Engineers
ROW	Right of Way
RF	Radio Frequency
RMS	Root Mean Squared
S	unit of conductance, Ohm^{-1}
TIF	Telephone Influence Factor
V	Volt, Voltage
VHF	Very High Frequency
UHF	Ultra High Frequency
Ω	Ohm
W	Watt
WIN	Weighted Induced Noise

Executive Summary

Exponent Engineering P.C. (Exponent) evaluated the potential effects of the New York Regional Interconnect's (NYRI) proposed ~190 mile direct current (dc) transmission line for effects on the adjacent Millennium pipeline project and pipeline cathodic protection and integrity and monitoring systems. The potential effects of dc electric and magnetic fields and corona phenomena from the NYRI transmission line on the cathodic protection of pipelines and communication systems were also evaluated.

The dc magnetic field from the overhead section of the proposed dc transmission line was too weak to produce any detrimental effect on the pipeline protection and monitoring systems. The dc electric field was at or below limits set forth in relevant suggested and cited guidelines.

The design of the NYRI dc transmission system includes a metallic return conductor. This design results in any ground current being reduced to a negligible amount. The leakage current to ground through the insulator strings and the ion flux from conductor corona was determined also to be negligible. Inductive coupling between the dc transmission and pipeline was also considered in detail, using the mutual inductances between the dc transmission line conductors and the pipeline. The study indicated that the traverse-induced voltages along the pipeline were too weak to interfere with the operation of pipeline cathodic protection and monitoring systems. The interference magnitude was also shown to be a function of the ac and dc filter designs of the proposed dc system. These designs were not planned to be available until the final converter station design; however, the results shown in this report are based on projected design parameters and final results are not expected to be materially different.

Interference with the telephone system was also investigated and been shown to be of negligible magnitude.

Exemplar pipeline monitoring equipment was reviewed and in the unlikely event of interference, potential mitigation techniques will be presented.

1 Introduction

New York Regional Interconnect, Inc. (NYRI) has proposed to construct an approximately 190 mile, single circuit ± 400 kV dc transmission line between the town of Marcy, New York and the Town of New Windsor, New York. The line would parallel existing transmission lines or gas pipelines for approximately 75 miles (of which approximately 3.3 miles would be underground) and railroad lines for approximately 73 miles (of which approximately 16 miles would be underground). A new right-of-way (ROW) would be required for about 22% of the route (approximately 42 miles of which about 2.3 miles would be underground). The positive (+) and negative (–) conductors and shield wires would be suspended from steel pole or latticework structures except for about 21.6 miles where the line would be placed underground.

In New York State, the transmission system transports electricity as alternating current (ac) that oscillates at a frequency of 60 Hertz (Hz) on three phase conductors. For electricity transported as dc power it must converted from ac power to dc power at a converter station; carried over a two-conductor transmission line (three conductors for a bipolar system if a dedicated neutral conductor is included; or two conductors with earth ground return if ground electrodes are provided to handle neutral return current when necessary), and then converted back to ac power at the terminal end of the line. In conceptual terms the process as embodied in the proposed project is illustrated below in Figure 1.

The Northern Converter Station will receive ac power from National Grid's Edic Substation over a very short single circuit 345-kV tie line. After conversion to dc power, electricity will be carried for approximately 190 miles down to the Southern Converter Station. After converting dc power back to ac power, the power will flow over two very short 345kV tie lines to the adjacent Rock Tavern Substation operated by Central Hudson Gas & Electric[1].

[1] While the predominate direction of power flow is expected to be from north to south, as described above, the dc link can be designed to enable power flow from south to north if needed.

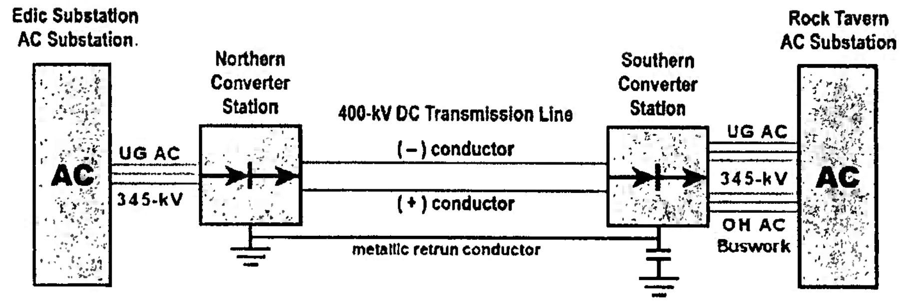


Figure 1. Schematic representation of the dc transmission line and ac/dc converter stations.

2 Relevant Aspects of DC Transmission Systems

2.1 DC Transmission Line Basics

In North America, electric power is primarily generated and transported as 60 Hz ac power but dc transmission lines are also utilized where ac transmission lines are not technically feasible or economical. DC transmission is a viable method for transporting a large quantity of power at high voltages or for connection between ac systems that are not operated synchronously. To do this, ac power must be converted to dc power at a source converter station, carried over a transmission line (typically two sets of conductors [called poles] instead of the three sets of conductors [called phases] needed for ac transmission), and then converted back to ac power at a terminal converter station. The simplest design is shown in Figure 2, diagram (a). This design is known as a monopolar link, with the earth being used as one of the conductors providing the ground return. A second design, known as a bipolar link, shown in Figure 2, diagram (b), has two sets of conductors – one positive, the other negative. In a bipolar link design, the current carrying path for any imbalance of the currents between the two poles (polarities) is typically the earth or, as shown in Figure 2, diagram (b) it can be a dedicated metallic return conductor[2]. As discussed later, NYRI has proposed a bipolar link with a metallic return conductor for both the overhead and the underground sections. In a bipolar link, each converter normally has the same power rating and is arranged such that the direct current in the neutral cancels so its current is normally close to zero. The neutral point between the two converters is typically connected to the ground via a grounding electrode at each end of the line. If a metallic neutral conductor were used, one end of the neutral conductor would be connected to the ground typically in or close to one of the two converter stations. By connecting the two neutral points, as shown in Figure 2, diagram (b), each converter station (positive and negative) can operate independently. If the two converters operate at equal current, then no current flows between the neutral points (or in the dedicated metallic return conductor). If either the positive or negative conductor is unable to provide service due to maintenance or a fault condition, or during

[2] A metallic conductor is a conductor fabricated from a metal for the purpose of conducting electricity, i.e., not conducting through the earth (IEEE Standard Dictionary, 2000).

maintenance of one converter, the other converter can carry current up to the current limit of the converter and conductors using the remaining pole conductor and the dedicated neutral return conductor.

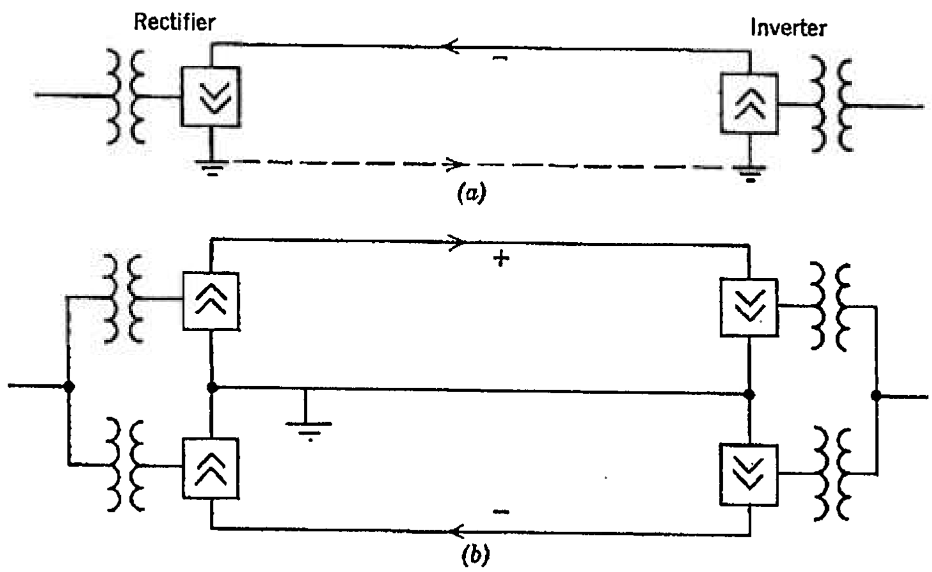
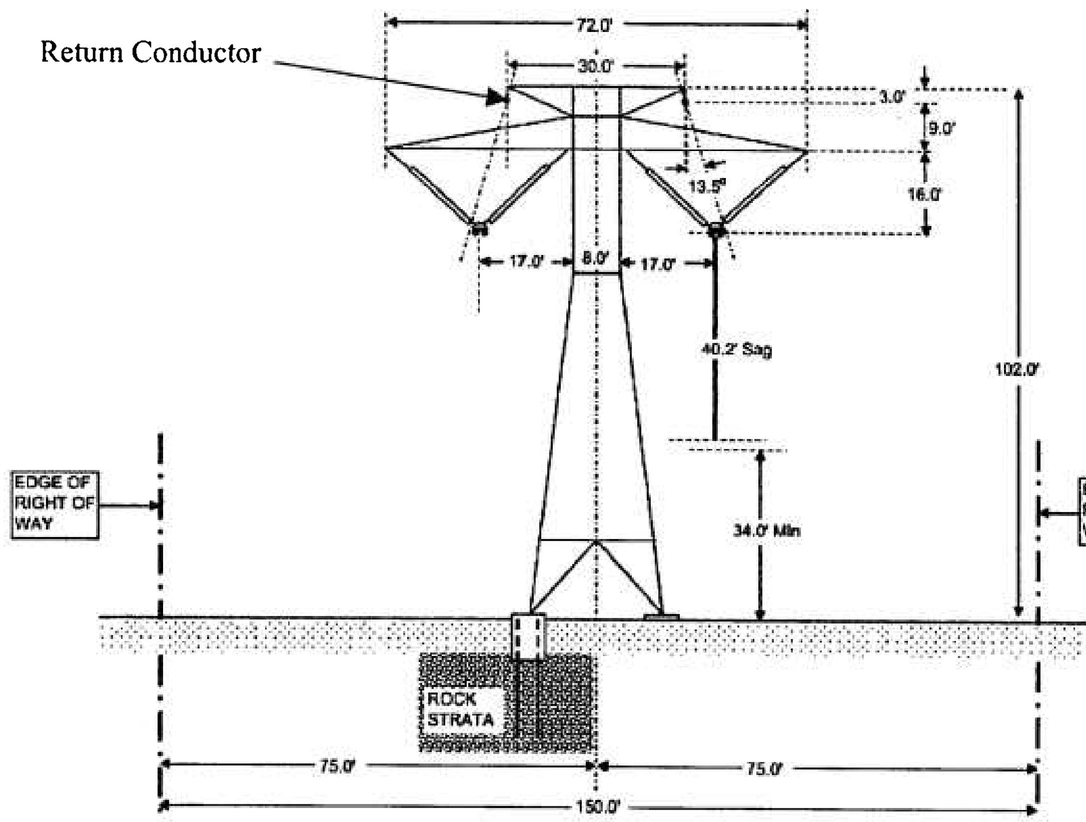


Figure 2. Monopolar and bipolar dc links

2.2 Equipment Interaction

The NYRI dc transmission design is a bipolar link with a dedicated metallic return conductor. The design includes two sets (poles) of dc conductors and one metallic return conductor, as shown in Figure 3. The metallic return conductor, if connected to a ground at only one point, provides a distinct path for return currents and prevents the dc return current from flowing through the earth. This thereby eliminates the possibility for the dc neutral current to be transferred through the earth into other systems such as pipeline protection and monitoring systems. In designs where the return current flows through the earth, the unbalanced neutral current potentially could interfere with the cathodic protection of buried objects reducing the effectiveness of installed cathodic protection systems. This is normally carefully studied in cases where such interference might pose a problem. With the design proposed by NYRI, the electrical isolation of the return current through the use of a dedicated metallic return conductor essentially eliminates the steady state ground return currents. The residual source of ground current is from leakage current through the suspension insulator strings and the ion flux from conductor corona. This leakage current is analyzed and discussed later in this report and was found to be of negligible magnitude.



TYPICAL +/- 400 kV DC TANGENT LATTICE TOWER
(1000' SPAN)

Figure 3. DC tower with metallic return conductor

The conversion process by which ac power is converted to dc power and vice versa can produce a byproduct of ac voltages and currents at multiples (orders) of the fundamental frequency, 60 Hz, which are termed harmonics. Harmonic voltages and currents are generated on both the ac and dc sides of the converters. A 12-pulse converter typically used in each pole of a bipolar link generates harmonics principally of orders $12q$ on the dc side of the converters and $12q\pm1$ on the ac side of the converters, where q is an integer[3]. These are called the characteristic harmonics.

[3] Kimbark 1971.

Small amounts of non-characteristic harmonics (typically odd harmonics of the ac fundamental frequency on the ac side and even harmonics of the fundamental frequency on the dc side) can also be present. The magnitudes of the harmonic voltages and currents are not constant and vary with the converter's operating conditions. These are a function of the load on the line and electric system conditions. Filters are installed to reduce the harmonics injected into the ac transmission lines connected to the ac side of the converters. AC filters serve the dual purpose of reducing ac harmonics and supplying reactive power to the interconnected transmission grid at the fundamental frequency. On the dc side of the converter, a dc reactor combined with a dc filter, connected between the poles and the ground or the dedicated neutral conductor, reduces to an acceptable level the harmonics that might otherwise be carried on the dc transmission line. The NYRI converter station design, as described in Exhibit E-2 of the Application, specifies that both ac and dc filters will be installed. A harmonic study will be performed during the final design to establish the design values criteria for the ac and dc filters.

The dominant harmonic voltage on the dc side of the converter is typically the 12th order harmonic at 720 Hz. Figure 4 illustrates the relative magnitude of the 12th order harmonic present at the output of a 12-pulse converter before the smoothing reactor and the dc filter for different operating conditions assuming a perfectly smooth dc current. The harmonic voltages generated by operating the converters, result in harmonic currents being injected into the dc transmission line conductors, but the harmonic currents are typically effectively reduced to a negligible magnitude by means of the smoothing reactor and the dc filter. The residual harmonic currents are superimposed on the main dc current, and establish an ac magnetic field around the dc conductors. This ac magnetic field, if of sufficient magnitude, may interact with adjacent objects and circuits such as a pipeline or its monitoring or cathodic protection systems. The inductive coupling between the dc transmission system and the pipeline system could induce harmonic voltages, which might interfere with the pipeline's monitoring and cathodic protection systems if the harmonic filtering is inadequate. Therefore it is important that an in-depth study to determine the extent of the potential interference as a result of dc transmission line be conducted when system details such as converter design, ac/dc filter specifications, surge capacitor, ac system specification, and communication system details are finalized.

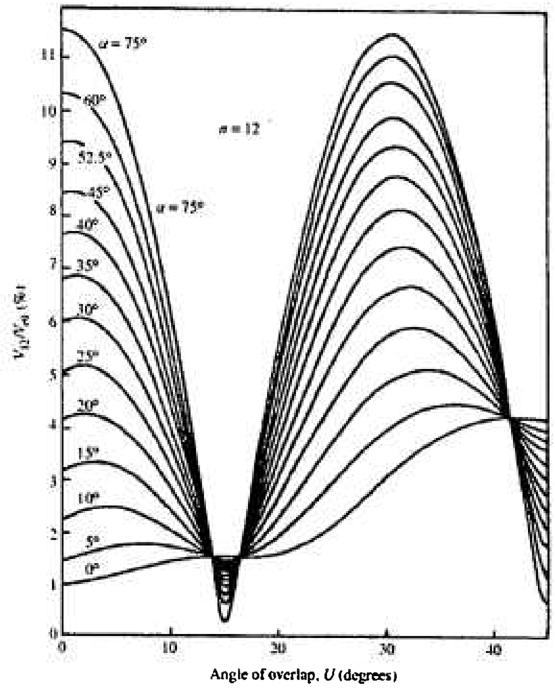


Figure 4. Harmonic spectrum of the voltage at the output of a 12-pulse converter[4]

The static electric and magnetic fields and corona-related radio-frequency fields associated with the proposed dc transmission line discussed in the companion report[5] were also considered in the present evaluation of potential effects on the pipeline system, including monitoring and cathodic protection systems in this context.

2.3 Monopolar and Fault Operations

In this section, the effect of rare events that might trigger the proposed dc transmission line to operate in emergency and fault operating conditions are discussed. The NYRI dc transmission line is a bipolar link design as presented in Figure 2. As stated earlier, the bipolar link transmission design can operate as a monopolar link during converter maintenance or fault on one of the conductors used for the dc transmission line. Monopolar link operation is typically

[4] V_{co} is the maximum average dc voltage, α is the converter firing angle.

[5] Exponent "New York Regional Interconnection – Electric and Magnetic Fields, Ions, Audible Noise, and Radio Noise," November, 2007.

associated with higher uncompensated harmonics on the dc transmission line and increased noise interference in the audible telephone frequency range of 100-3,000 Hz. The effect of increased harmonics during monopolar link operation is studied in this context. Since a detailed harmonic spectrum of the NYRI dc transmission line as a monopolar link (i.e., bipolar link under monopolar link fault or contingency conditions) or bipolar link will not be available until the detailed final design phase of the project, this study was conducted using published data on comparable dc transmission designs in operation.

A fault on the dc transmission line results in flow of dc current through the ground and back to the converters. In the proposed NYRI system, the fault currents would flow back to the grounded neutral before flowing back through the converters. Unlike ac current, dc current has no zero crossing for protective equipment such as a circuit breaker to clear the fault current. The controls on the converter limit the magnitude of the fault current through the phase control of the converters and clear the dc transmission line fault currents by reversing the rectifier converter voltage. This stops the current flow from the rectifier into the line. Since dc transmission line fault clearing does not involve any mechanical action, it can be significantly faster than clearing ac transmission line faults. Although, the dc fault current is quickly interrupted, its impact on any adjacent circuits and systems such as pipeline systems needs to be closely investigated. The fault currents associated with a dc line to a ground fault are typically significantly lower than for ac systems and the interactions are not expected to cause any adverse effects.

Broken conductors are very rare, but are a known failure mode of transmission lines. In this case, the Millennium pipeline is buried and the NYRI dc transmission line is proposed to be located 100 feet away from the pipeline.[6] Therefore, any adverse effect from a broken conductor will probably not be any different than a short circuit from a pole to a ground. Similar fault studies would also be conducted for ac transmission systems, though dc systems are inherently benign compared to ac systems. Figure 5 depicts a simplified conduction of the

[6] Based on email from NYRI, 10/10/2007, the Millennium pipeline is a 30-inch diameter coated pipeline. It will be located 100 feet away from the dc transmission centerline, and 36 inches below the ground surface. A second looping pipeline may be installed in the future and may be located at the edge of the pipeline ROW or about 75 feet from the tower centerline shown in Figure 3.

fault current through the earth and the pipeline. When a gas pipeline is provided with cathodic protection, the pipeline cathodic protection design team is required[7] to consider the need for lightning and fault current protection and isolating devices should also be considered. Cable connections from isolating devices to arresters should be short, direct, and of a size suitable for short term high current loading.

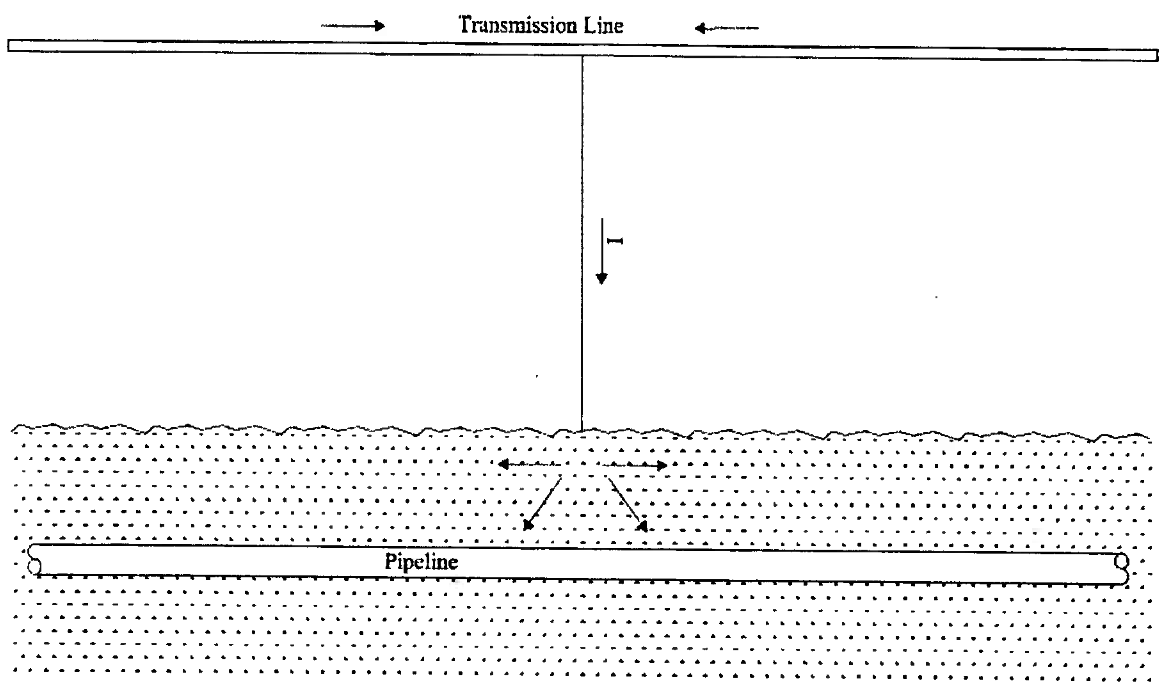


Figure 5. Conductive coupling during fault

2.4 Metallic Return Failure Mode Analysis

In a dc system with electrode lines or with neutral conductors grounded at one end of the line, loss of the neutral/electrode line by having a broken conductor or a ground fault on the neutral/electrode line has to be considered. First, in the bipolar mode, there is almost no unbalance of the current flowing in the neutral, so there is no voltage drop between the two ends of the conductor. In this case, it is very difficult to detect a broken conductor or a failed neutral

[7] NACE Standard RP0169-2002.

conductor insulator. If the neutral current is assumed to be measurable, however, there might be a detectable effect on the voltage balance between the two poles if the neutral conductor is broken. If it is grounded, the current will be split between the neutral and the ground but the current in the grounding conductor might be less than the leakage current flowing back from insulator leakage and corona currents. So, a ground fault might not be detectable by just measuring the current flow at the ground point.

In monopolar operation with one pole out of service, a broken neutral conductor would result in failure of the pole to operate if the neutral conductor is not connected to the ground in such a way that the circuit is closed. This would be detectable by monitoring the current in the grounding conductor or by seeing an unbalance between the pole and neutral conductor currents. A failed insulator making contact with a tower might be detectable in a similar way if the grounding point is close to the end of the neutral that is farthest away from the grounded terminal. If however, the failed insulator is close to the grounded end, the current flowing through the fault is not easily detectable because most of the current would flow in the neutral conductor and very little would flow in the ground. There is probably a point at which the fault will not be detectable. This should be studied to ensure that insulator failures would be detected and not lead to permanent ground faults on the neutral conductor.

Lightning surges or ground faults on one pole of the line will cause over-voltages that will lead to flashover of the neutral conductor's insulators. In a bipolar operation, this is probably not a real problem because the voltage from the neutral conductor to the ground at the point of the flashover should be low and will not sustain the arc. In monopolar operation without the use of the second dc conductor, however, the voltage drop from the neutral conductor to the ground can be substantial at higher dc current levels. In this case, if lighting hits the line, the neutral insulator can be expected to flash over and an arc between the neutral and the tower will be struck. The voltage from the neutral to the ground will be highest at the terminal away from the grounded terminal. Magnetic forces acting on the arc will make the arc grow longer and eventually, the voltage of the arc will be such that the current probably will have commutated back into the neutral. If the insulator (the gap length) is sufficient, this should be the end of the arcing. If the arc path is too short, however, the arc may re-strike or not be extinguished. The way to assure then that the arc will self extinguish is to have insulator strings that are sufficiently long to facilitate commutation of the current back into the neutral conductor. The insulator design parameters will be established during the final design phase of the dc transmission line to ensure a neutral conductor path.

3 Review of Cathodic Protection

This section covers a brief review of several types of pipeline cathodic protection circuits and its operating principles[8]. This background is important for the understanding of potential interactions of the proposed dc transmission line with cathodic protection systems.

3.1 Cathodic Protection[9]

Cathodic protection is a method that is used to minimize the amount of corrosion on a metal object, such as a pipeline buried underground. Cathodic protection is an electrochemical means of corrosion control similar to what happens to the cathode in a battery. In cathodic protection the pipeline is made to be the cathode (negative terminal) in this electrochemical cell. The soil is the electrolyte and the anode (positive terminal) is either a less noble metal such as zinc or magnesium (sacrificial anode) or corrosion resistant materials (impressed current anode)[10]. Sir Humphrey Davy first suggested cathodic protection in the 1820s as a means of controlling corrosion on British naval ships. Three alternative methods are mainly used to protect underground structures that may be subjected to corrosion:

1. The impressed current method of cathodic protection uses a dc source, such as a battery, dc generator, or rectifier. The most common power source for impressed current protection is the transformer rectifier. There are also solid-state rectifiers that perform similar functions, without the use of transformers. Rectifiers can be provided with constant voltage, constant current, or structure-to-electrolyte potential control[11]. The structure to be protected is connected to the negative terminal of the dc power source. In areas where electrical power is not readily available, solar power and wind driven generators coupled with storage batteries are used. Common uses of impressed current include long transmission pipelines. For long pipelines, many kilometers in length, the

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[8] This section is reproduced from AREMA (2003).

[9] Kimbark 1971, p. 434-437.

[10] NACE Standard RP0169-2002.

[11] Fitzgerald 2000.

attenuation or reduction of protection falls off with distance from the anode bed. On larger-diameter (30- to 36-inch diameter) pipelines the corrosion can be controlled on 33 to 66 km (20 to 40 miles) of pipeline, assuming a reasonably satisfactory dielectric coating is in place[12].

2. In galvanic-anode drainage, anodes are made of zinc, aluminum, or magnesium, which are more chemically active with respect to buried metal objects, normally iron. The soil with its salts and moisture forms the electrolyte (conductive path), which is between the protected object (cathode) and the more active material (the anode), and provides the electrical contact between cathode and anode. No external power supply is required. The protection current from the anode through the soil to the pipeline comes from the electrochemical cell created by the connection of the anode material to the more noble or electropositive material in the structure, i.e. the pipeline.

3. In bus drainage, used principally to protect pipes near electric railways, the pipe is bonded to the most negative point available, which may be the ground bus at the rectifier substation or the negative terminal of a negative feeder booster.

Impressed current or forced drainage is the only method used for protecting long[13] pipelines. Rectifiers usually provide the necessary electro-motive force if ac power is available.

Three arrangements of anodes are shown in Figure 6.

[12] Sigfried, Corrosion of Pipelines.

[13] For a typical soil resistivity of 1000 Ω.m, long pipeline is considered to be longer than one mile.

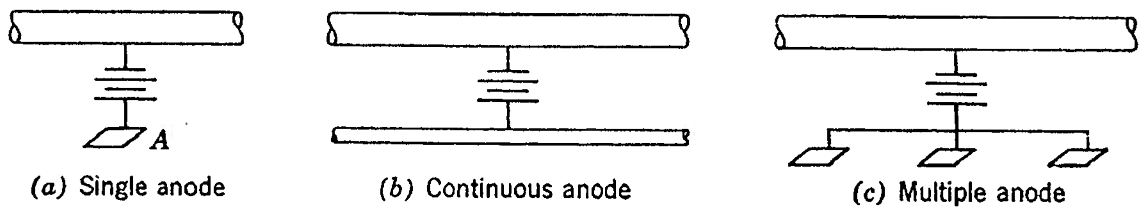

Figure 6. Three arrangements of anodes for cathodic protection

The single anode is applicable only to compact structures. Multiple anodes or continuous anodes are suitable to extended objects, such as cables or pipelines. Continuous anodes are made of old rails or abandoned pipelines buried parallel to the pipeline to be protected. Multiple anodes are generally more practical than continuous ones. The spacing between elements of the anode can be increased if their distance from the protected pipeline is increased. The greater the distance, however, the higher the resistance between the anode system and the protected pipe and the greater the possibility of damage to other structures, especially in congested areas. Practically, anodes are placed in order to get a reasonably uniform leakage current entering the protected pipe per unit of length. Sometimes the anodes are buried deep below the pipeline, principally for reducing ROW requirements.

3.2 Pipeline Coating

Pipelines with anodic protection are usually coated with insulating materials. The best coatings are made of polyvinyl chloride tapes. Other coatings used are concrete, cement mortar, and bituminous materials such as asphalt, coal-tar enamel, and mastic. Coatings significantly decrease the amount of current needed to protect a given surface of pipeline. A coating's performance depends on high resistivity, low permeability to water, good bonding between the coating and the metal, and absence of holes and cracks. Coating defects are normally called *holidays*. Uncoated portions of pipelines are most likely to cause corrosion and are known as *hot spots*[14]. Most coatings deteriorate with age but still have considerable value. The spacing

[14] Parker 1999.

between rectifiers may be as low as 500 feet on bare or poorly coated pipes and as great as 50 miles on pipes with good thermoplastic coatings. Typical values of leakage conductance of a 12-inch pipe are given in Table 1.

Table 1- Typical values of leakage conductance of buried 12-inch pipe[15]

	G/l	
	mho/1,000 ft	**mho/km**
Bare pipe in water (ρ=1.4 Ω.m)	100	300
Bare pipe in soil of low resistivity (ρ=14 Ω.m)	10	30
Bare pipe in soil of medium resistivity (ρ=140 Ω.m)	1	3
Bare pipe in soil of high resistivity (ρ=1,400 Ω.m) or Pipe with normal coating	0.1	0.3
Pipe with very good coating	0.01	0.03

Assuming the average potential of the pipe with respect to the soil to be –1.0 V, the leakage current in amperes per unit length is numerically equal to the conductance in mhos per unit length. With the passage of time, polarization effects reduce the leakage conductance, especially on coated pipes.

The National Association of Corrosion Engineers (NACE) guidelines for fault conditions state that limiting the coating stress voltage should be a mitigation objective. Expected threshold values for coatings differ with type and are generally considered to be in the range of up to 2 kV for tape wraps and coal tar enamels and 3 to 5 kV for fusion-bonded epoxy (FBE) and polyethylene coatings for a short duration fault[16].

3.2.1 Permissible Range of Potential Difference Between Coated Pipe and Soil[17]

The potential of a pipeline with respect to the adjacent soil, for the avoidance of corrosion, should be negative by at least 0.85 V as measured with a copper-copper sulfate half-cell. Good

[15] Uhlig 1948, p. 1188.

[16] NACE SP0177-2007.

[17] Kimbark 1971, p. 436.

insulating coatings can stand up to 10 V or more with no adverse effect on the pipe or coating. Inferior coatings that are perforated, are permeable to water, or have high leakage conductance should not be subjected to such high voltages. High voltages tend to form hydrogen on the surface of the iron at holes in the coating, degrading the bond between the pipe and the coating. Electro-osmosis[18] drives water into permeable coatings, thereby increasing the leakage conductance.

For gas pipeline in the United States, 49 Code of Federal Regulations (CFR) Part 192 regulates the minimum federal safety standards with respect to cathodic protection of pipelines[19]. Paragraph § 192.463 "External corrosion control: Cathodic protection" warns operators that:

> (c) The amount of cathodic protection must be controlled so as not to damage the protective coating or the pipe.

In appendix D to Part 192—Criteria for Cathodic Protection and Determination of Measurements, the following warning about over protection is included:

> A voltage in excess of 1.20 volts may not be used unless previous test results indicate no appreciable corrosion will occur in the particular environment. For oil pipeline in the United States, 49 CFR Part 195 regulates the minimum federal safety standards.

Paragraph § 195.571 requires:

> Cathodic protection required by this subpart must comply with one or more of the applicable criteria and other considerations for cathodic protection contained in paragraphs 6.2 and 6.3 of NACE Standard RP 0169 NACE Standard RP0169 applies to the DOT requirements for interstate gas transmission pipelines. This standard advises against using polarized potentials less negative than -850 mV for cathodic protection of pipelines when operating pressures and conditions are conducive to stress corrosion

[18] The movement of fluids through diaphragms that is as a result of the application of an electric current (IEEE, Standard Dictionary 2000).

[19] Klechka 2007.

In addition RP0169 states that:

> Regardless of separation, consideration should always be given to lightning and fault current protection of pipeline(s) and personnel safety (see NACE Standard RP0177).

3.2.2 Transmission Line Interaction with Cathodic Protection

Pipelines with active cathodic protection deliver up to -50 V dc at the source to keep potentials of at least -1 V. The pipelines are normally insulated with various coatings, but these coatings will infrequently contain small holes, called holidays, that allow some fraction of the current to leak into the ground. With their overhead metallic shield wires, transmission lines tend to be the path of least resistance for cathodic protection dc currents. The NYRI dc metallic return conductor in the vertical configuration tower[20] is to be attached to the tower using a suspension insulator (rated for 25 kV to 50 kV) and thus does not provide a suitable path for the pipeline cathodic dc currents. If the shield wires are used on the dc line, however, they would provide a path of least resistance for the cathodic protection dc current. This effect can be minimized if needed by attaching the shield wire to the tower using an insulator (rated approximately 15 kV) where the dc transmission line is adjacent to the pipeline, which would prevent a suitable path for the pipeline cathodic dc currents.

[20] Exhibit E-1.

4 Electromagnetic Interference (EMI) Study

There are four categories of electromagnetic coupling paths between systems: conduction, electric induction, magnetic induction and radiation of electromagnetic energy. Radio-frequency (RF) interaction is radiated energy, which is also discussed in this report.

- Conduction may occur when conducting paths, whether deliberate through wires, or through the earth or poor insulation, allow current to flow between the source and the receptor.

- Induction results from the electric and magnetic fields associated with the source coupling receptor objects that are in close physical proximity.

- Propagation of RF fields (arising from corona activity on conductors) to receptors is a far-field effect and occurs for more widely spaced objects.

4.1 Conduction

There are many possible conduction paths between the power system and the ground, where current can enter the earth and find its way into nearby pipelines and associated systems. These provide paths for earth currents from a power system to enter a pipeline. When power and pipeline facilities share a ROW, there can be numerous grounds in close proximity, providing a number of possible conducting paths for current between systems. It is important to consider conductive interference that may occur both during normal operation of the dc system and during faults when large currents can enter the earth. It is essential to preserve proper operation of pipeline facilities during normal power system operation. It is also essential to prevent damage to equipment or injury to personnel as a result of elevated voltages and currents during power system faults. It should be emphasized that worker injury cannot be entirely prevented by taking precautionary measures solely on the dc line. Protection of workers has to be a part of work procedures when working on the pipeline. The specific designs of both the power system and the pipeline greatly affect the potential for, and level of, any interference. A discussion for conductive interference between the NYRI dc transmission line and the adjoining pipelines can be found in sections 3.1 and 4.8.

4.2 Electric Field Induction

Electric field capacitive coupling between a source circuit and a receptor circuit can result in voltages on the receptor circuit. The receptor circuit may include objects such as motor vehicles, people, sheds, long trains or pole mounted communication wires. The magnitude of the coupled voltage depends on geometrical characteristics of the source and the receptor. Capacitive coupling occurs as a result of a change in the voltage over time (dV/dt) or by having a change in the capacitance over time (dC/dt). No net charge will result from the presence of the static charge on the dc line. Because of the small capacitance between the transmission line and pipeline object, and the location of the pipeline underground, electric field coupling between the NYRI dc transmission line, and pipelines will be negligible and thus interference is not expected.

4.3 Magnetic Field Induction

Magnetic field inductive coupling is significant for conductive objects that are located parallel to a power line for a significant distance, such as pipelines. Magnetic field induced voltage is expressed in volts per unit length along the parallel conductor, and is called the longitudinal electromotive force. It is important to consider magnetic field induction under normal operation of the power system and during power system faults, where the dc line current is significantly above rated values. It is also necessary to give special attention to harmonic currents when dealing with magnetic field induction. Because magnetic induction is proportional to frequency, one ampere current at 180 Hz induces three times the voltage that it would induce at 60 Hz. Commutation processes within the dc converters and operation-dependent harmonics generate harmonics typically in the range below the 50th harmonic but some radio frequency interference from corona sources must also be considered. The use of filters and reactors as planned by

NYRI will reduce harmonics on connecting ac and dc transmission lines to industry acceptable levels.

4.4 Radio-Frequency Field Interactions

Commutation processes within dc transmission converters generate harmonics in the kilo-Hertz (kHz) to mega-Hertz (MHz) ranges of the RF spectrum. Because of the short RF wavelength, they interact with distant objects at many multiples of their wavelengths, i.e., in the far field, but there are also near field interactions that must be considered. It is essential to distinguish between radiation and electric and magnetic field coupling. Figure 7 illustrates the types of interference that may occur at different frequencies. For example, ac harmonics can result in telephone interference, while corona results in ionic flux and radio interference.

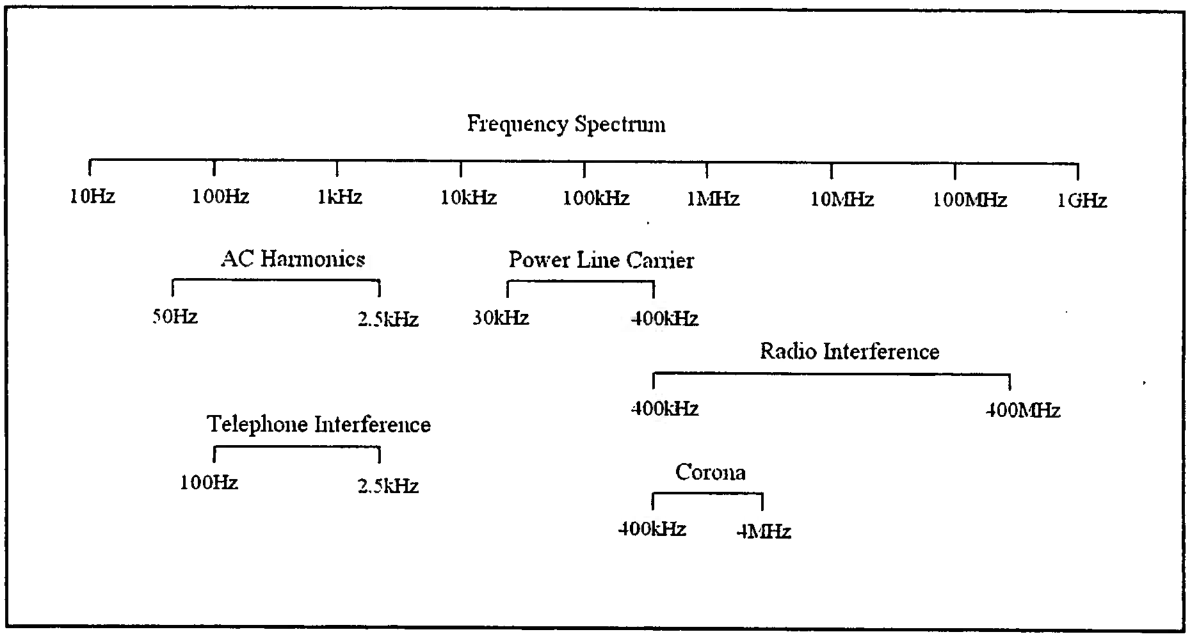

Figure 7. Various interference band

In order to investigate dc transmission interference into the pipeline's communication and signaling systems two general categories, radio interference and telephone interference, are studied as follows.

4.5 Radio Interference

Radio interference sources inject parasitic currents into the overhead conductors, causing radio noise fields. The electromagnetic field associated with such injected electric power in the transmission lines occurs predominately at frequencies less than 30 MHz. At frequencies above 30 MHz the line attenuation is so great that the noise fields produced as a result of direct (aerial) radiation from the interference source predominate.

Current commutation and voltage jumps in the dc converter operation generate parasitic electromagnetic emission. The metallic converter station building is designed to attenuate the RF generated inside the converter's valve hall.[21] RF fields measured outside the converter hall are found to be less than 40 dB (μV/m) across the broadcast frequency range of 400 kHz to 400 MHz[22]. Consequently, no or insignificant radio or TV interference originates from inside the converter's valve hall; however, interference can be coupled through the ac and dc conductors that penetrate the walls of the valve hall, so this has to be considered in the design of the converter stations. The interference field strength decreases monotonically with increasing frequency,[23] and this is the reason why there have been no reports of interference in the television frequency range. Such interference is of concern especially for pipeline diagnostic equipment, such as smart pigs, where video equipment might be used for inspection purposes.

Corona effects on the surface of high voltage overhead power transmission lines are the principal source of radiated noise. The conductor's corona process depends on the magnitude of the electric field strength at the surface of the conductors, the effective diameter of the

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[21] The building normally contains a conductive steel cage structure designed to act as a Faraday cage to reduce electromagnetic radiation (Arrillaga 1988, p. 142).

[22] Scmidt 1996, p. 204-210.

[23] Uhlmann 1975, p. 352.

conductor or conductor bundle, their surface characteristics and weather conditions. Appropriate design measures can minimize corona. Corona effects similar to those around overhead conductors can be also observed in the proximity of a conductor's hardware fittings. Compared with the conductor corona, however, these hardware fittings produce little or no radiated noise. Another potential source of noise is the radio interference caused by discharges around insulators, which are mostly a result of corona discharges along the insulator's surface. The level of radiated noise depends to a large extent on the degree of pollution, e.g., dust, insects, etc. on the insulator and on the voltage gradient along the surface of the insulator.

RF noise levels for the dc transmission line configuration planned by NYRI for use along the pipeline, shown in Figure 3, are expected to be near ~65 dB (1 μV/m) at a frequency of 1 MHz at ground level under the conductors and attenuates as the distance from the conductors increases. Noise levels decrease for higher frequencies and also decrease with distance from the line. The levels of radio noise are below 1 μV/m within the dc line transmission ROW for frequencies above 500 MHz.

In order to provide a practical insight into this issue, test results from a similar system are presented. This system was not equipped with a dedicated metallic return conductor and therefore interference effects are higher than those expected for the proposed NYRI HVDC system. Nevertheless the results provide a point of reference to compare the results of this study. The result of field test studies conducted by National Research Council of Canada and Manitoba Hydro on the Nelson River dc bipolar link[24] indicated that the RF interference generated at the converter station and propagated along the dc transmission lines has the following characteristics.

a) It has a high level of line-to-ground mode radiated interference near the station but this mode attenuates rapidly and becomes negligible within 15 km.

b) It has a line-to-line mode, which propagates for hundreds of kilometers.

[24] Morris et al. 1979, p. 1924-1946.

The Nelson River dc bipolar link studied above does not have a metallic return conductor (shield wire is not known to be continuous), and considering that line-to-ground mode radiated interference attenuates rapidly within 15 km of the converter stations, this mode does not pose any harm to pipeline system radio communication. The line-to-line mode is not expected to affect the pipeline systems because it is approximately 2 mV/m under the line at ground level and attenuates with increased distance from the line. It is below levels generated by other radiated sources such as from broadcast stations.

4.6 Telephone Interference

Telephone communication systems have been used in communication and signaling systems for pipelines. In addition, some electrical communication means used in the pipeline system closely resemble a basic telephone system. Therefore, a telephone interference study of the pipeline communication and signaling system is necessary.

A dc converter approximates a constant-voltage harmonic source on the dc side of the converter, and a constant-current harmonic source on the ac side of the converter. The harmonic currents flowing on both sides of a dc converter station are generated by the switching operations in the switching devices (thyristor or IGBT). These harmonic currents will induce potentials in neighboring parallel conducting objects as a result of magnetic induction. The magnetic coupling may be expressed as mutual impedance, i.e., as the voltage induced in the telephone circuit per ampere of current in the power circuit.

The magnetic coupling between the communication circuit and a high-voltage power line is a result of the ac magnetic flux linkage between the two systems. Therefore, harmonic current in a high-voltage dc transmission line induces a voltage in a wire running parallel to it with a magnitude that is determined by the mutual impedance. The coupling between parallel circuits is directly proportional to the common length, known as length of exposure. It is also dependent on the frequency and distance between the parallel circuits. The degree of coupling increases with frequency unless a dissipative media such as a ground is present between the two conductors in which case, the coupling is more complex and can be expected to be reduced for higher frequencies.

In order to assess the potential for telephone interference from ac harmonics, it is important to take into account the harmonic currents induced in the earth. The currents in the earth are modeled using an equivalent ground conductor.[25] The equivalent ground conductor substitutes the distributed currents through the earth and is modeled using an image conductor buried at an equivalent depth[26] below the earth's surface. Therefore a dc bipolar link with a metallic return conductor has significantly closer spacing between its conductors compared to the same bipolar link using an earth return. As a consequence of the distribution of current between a metallic return conductor and the earth, a metallic return conductor decreases the earth's currents and reduces the potential for interference accordingly.

The neutral current of a dc bipolar link, as stated earlier, is composed of a potential current mismatch, due to independent operation of the two converters, and their harmonic currents. In general this current, also known as residual current, is the primary contributor to telephone interference. Under monopolar operation, the harmonic currents on the neutral return conductor also contributed to the telephone interface.

The sensitivity of the human ear, the response of the telephone receiver, and the coupling between power and telephone circuits all vary with frequency. These variations are taken into account by appropriate weighting factors. Two systems of weighting factor are in wide use to determine the telephone interference in the U.S.: the Bell Telephone Systems (BTS) and Edison Electric Institute (EEI) weight factors. The weights in these systems have been revised from time to time to reflect increasing bandwidth and higher quality of telephone transmission. The weighting factors for each system, based on the sensitivity of the ear and the response of the telephone equipment, apply only to currents and voltages on the telephone circuit. This is called

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[25] Also known as Carson conductor.

[26] This depth is a function of ground resistivity. For a detailed derivation see Uhlmann 1975, p. 228-229.

C-message weighting. Kimbark[27] compiled a detailed description of these factors and outlined the interference calculation process.

The $I{\cdot}T$ product is defined as a root sum square of weighted harmonic currents as shown below.

$I \cdot T = \sqrt{\sum \{T_f I_f\}^2}$ where T_f is the *TIF* (Telephone Influence Factor) weighting factor.

The $I{\cdot}T$ product approximately relates to the effect of the harmonic currents flowing in the power circuit on the telephone lines. This is often defined on a station basis, i.e., for the total harmonic current flowing out of the converter bus into the ac system but not for the harmonic currents flowing in each line connected to the converter bus. This is an approximate measure of the amount of noise induced on a telephone circuit due to power-line currents.

To determine the noise induced in a communication circuit, the current in each power-line conductor is determined at each harmonic frequency. The current is then multiplied by the respective coupling impedance between each conductor and the communication circuit.[28] As a means of simplification, the concept of equivalent disturbing current (I_{eq}) is applied. I_{eq} is a weighted combination of harmonic currents in all conductors established to recognize existing and anticipated telephone circuits. Specifically, I_{eq} is a single-frequency current flowing in a theoretical single conductor located geometrically between the power conductors, which produces the same weighted noise in a nearby communication circuit. I_{eq} can be determined using the following equation,

$$I_{eq} = \sqrt{\sum \left[\{K_r(f) I_r(f)\}^2 + \{K_b(f) I_b(f)\}^2 + \{K_3(f) I_3(f)\}^2\right]}$$

where I_r is the residual component of current, I_b is the balanced component of current, and I_3 is the current in metallic return conductor or electrode line. K_r, K_b and K_3 are frequency dependent weightings.

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27 Kimbark 1971, p. 327-331.

28 Wilhelm 1994.

Interference from an alternating electric field can be suppressed by using shielded cables. The interference caused by harmonic currents can be reduced with the aid of ac and dc filter circuits and smoothing reactors. The filter circuits have to be custom-made according to the requirements of each specific system. Telecommunication systems can also be protected against interference by installing the appropriate protection such as isolation transformers or grounding reactors.

Based on the design proposed by NYRI, tuned dc filters at the 12^{th} and 24^{th} harmonics will limit the harmonic current superimposed on the dc side of the converter to 0.5 A-RMS under balanced bipolar link operation and to 1 A-RMS under monopolar link operation. The NYRI dc concept has not reached the analytical detailed design stage at this time, and these numbers are provided as the performance criteria.

The current harmonic level of 1 A-RMS is relatively low compared to similar dc transmission lines already in service. In order to provide a context for this value, the results of harmonic measurement of a comparable dc transmission line are presented.[29] Phase I of the New England dc bipolar inter-tie has a capacity of 690 MW with a nominal voltage of ±450 kV dc and is equipped with an overhead metallic return conductor. The accepted performance criterion under a bipolar link operation is 53 mV/km, and 260 mV/km. These performance measures were based on a one-kilometer line parallel to the dc transmission line with a one-kilometer separation. The dc transmission line current spectrum during bipolar link operation at rated power of 690 MW is shown in Figure 8. The RMS values for different harmonics are shown in Figure 8. The 6^{th} and 12^{th} harmonics have magnitudes of 0.9 A and 1.4 A respectively. The dominant harmonic appears to be the 3^{rd} order harmonic for the New England Phase I dc bipolar inter-tie[30].

[29] Garrity 1989, p. 779-786.

[30] The test results together with the fact that the 3-pulse harmonics are characteristic of a 3-pulse or half-bridge converter indicate that imbalances within the twelve-pulse converter are the cause of the 3-pulse harmonic. The conventional model described which was used to model the converter power circuits for this installation cannot reproduce the measured 3-pulse harmonics.

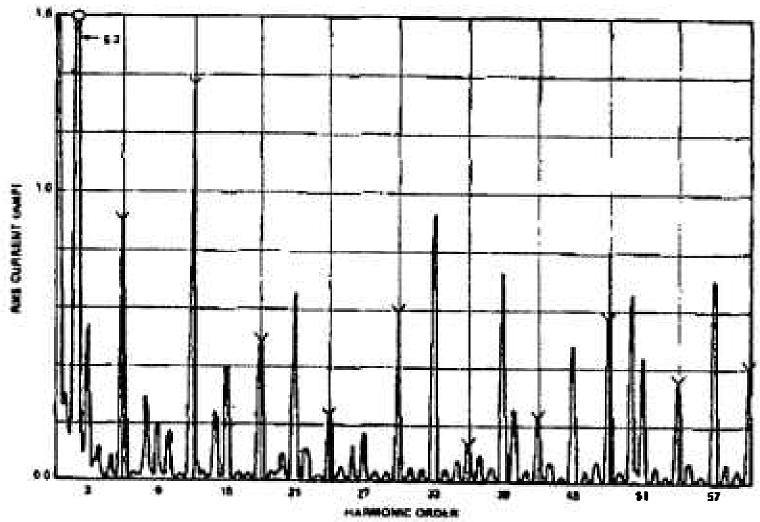

Figure 8. DC side current magnitude spectrum of rms current measured at harmonic frequencies

In order to provide an estimated value for the $I{\cdot}T$ factor based on the proposed performance criteria for the NYRI dc transmission line, it was assumed that the NYRI proposed dc side of the converter current spectrum resembles the New-England spectrum, except for the 3rd order harmonic which was unusually high in the New England system and later reduced[28]. Table 2 contains the harmonic current data used to calculate the *TIF* factor.

Table 2 - DC side current harmonics and *TIF* values[31]

h	TIF	I_{RMS} A	$(TIF.I)^2$	h	TIF	I_{RMS} A	$(TIF.I)^2$
3	30	0.00	0.00	39	9840	0.12	1,452,680
6	400	0.16	3,968	40	10090	0.04	194,826
12	2760	0.28	597,093	42	10480	0.04	210,178
15	4350	0.07	92,701	45	10480	0.09	840,710
18	5400	0.09	223,209	48	10210	0.10	1,149,047
21	6050	0.12	549,150	50	9670	0.11	1,209,660
24	6650	0.04	84,627	51	9230	0.08	528,217
27	6970	0.03	59,499	54	8410	0.06	265,285
30	7570	0.10	631,652	57	7470	0.12	837,184
33	8330	0.16	1,720,913	60	6460	0.07	204,441

$I{\cdot}T = 3{,}300$

The calculated $I{\cdot}T$ factor for the proposed NYRI dc transmission line based on the performance criterion $I_{RMS} = 0.5$ A is an order of magnitude smaller than the corresponding reported performance index values,[32] such as 25,000 for the Eel-River 230 kV, 320 MW Hydro-Quebec dc link. The calculated $I{\cdot}T$ factor would be approximately doubled under monopolar link operation with $I_{RMS} = 1$ A. It may therefore be prudent to reconsider the specified $I{\cdot}T$ factor to reduce the cost of harmonic filters for the NYRI system since these other systems operate without any known harmonic interference problems.

The measured values of harmonic currents were used to calculate the C-message-weighted induced noise (WIN) in a one-kilometer line parallel to the New England dc transmission line with a one-kilometer separation[33].

[31] The harmonic current magnitudes are calculated based on $I_{RMS} = 0.5$ A. Current magnitudes are RMS ampere.

[32] Wilhelm 1994, table 13.2.3.

[33] Garrity 1989, p. 779-786.

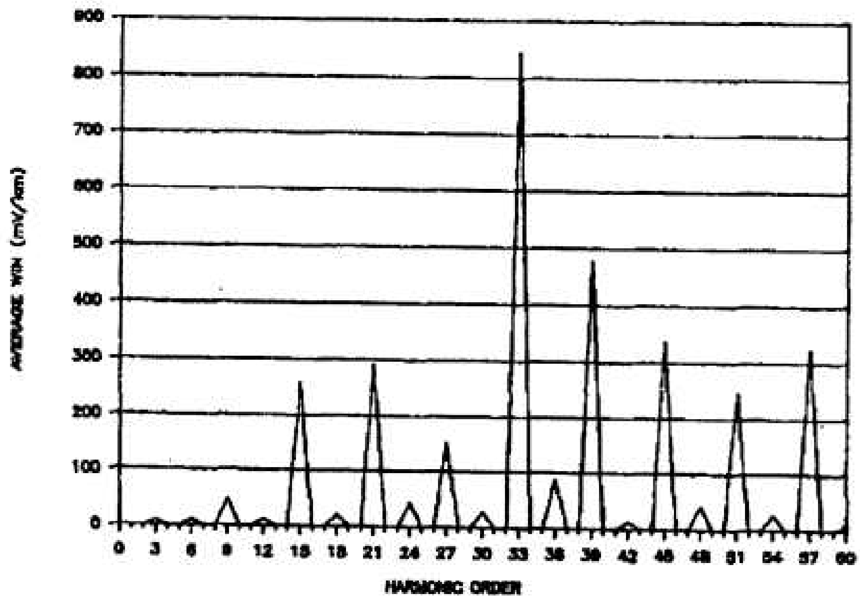

Figure 9. Average weighted induced noise spectrum

The WIN – using residual components of the measured harmonic currents – becomes 1,187 mV/km when the New England dc transmission line is operating at 690 MW. The test results indicated that the WIN values substantially exceeded the established performance levels. The results also indicated that the WIN was substantially reduced when the pole filters were disconnected, the neutral reactor bypassed, and the converter neutral points were grounded locally. As a result, the utilities agreed to permanently bypass the neutral reactor as an interim mitigating measure[34].

4.7 Inductive Interactions

Induction from ac harmonic currents on a high-voltage dc transmission line and a pipeline system results in voltages in the pipeline at harmonic frequencies that have been generated as a result of dc converter operation. In order to calculate the magnitude of the induced voltage in the pipeline, information on the dc transmission line harmonic magnitude and the mutual

[34] Garrity 1989, p. 779-786.

inductance values between the dc transmission line conductors and the pipeline systems are needed. The calculation process closely resembles the telephone interference calculation as discussed in the previous section. The calculation process also requires information on the return current distribution between the metallic return conductor and the earth and the resistivity of the earth.

As discussed in this report, the proposed dc transmission line design includes a metallic return conductor. Although the metallic return conductor effectively isolates the dc return current from flowing through the earth, it is less effective in restraining harmonic current from flowing through the earth. Therefore, the effect of the earth return path is considered in order to determine the induced harmonic voltages.

The harmonic return current is divided between the equivalent metallic return conductor and the earth. The impedance of the metallic return conductor and earth paths determine the distribution of harmonic return current between the two. As shown in Figure 10 the harmonic return current, equal to the sum of the two harmonic currents I_1 and I_2, is divided between the metallic return conductor *n* and earth return path shown symbolically as *e*. The subscripts *1* and *2* stand for the high-voltage main dc conductors installed on the transmission tower, *n* stands for the equivalent metallic return conductor, and *P* stands for the pipeline. The transmission tower is not shown in this figure for simplicity.

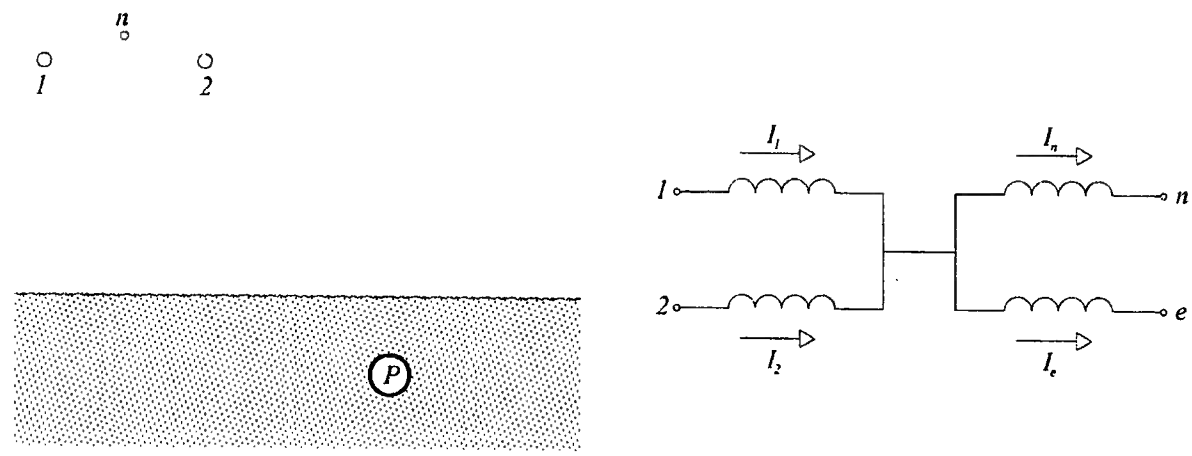

Figure 10. Simplified dc transmission conductors and return current inductances

As a first order calculation, the traverse induced noise in the pipeline caused by ac harmonics in a parallel power circuit can be approximated by using the mutual coupling between the pipeline and the dc transmission line conductors. Assuming the pipeline as conductor *P*, the mutual impedance, Z_{maP}, between conductor *a* and pipeline *P* with common earth return path can be determined using the following formula,[35] known as Carson's equation.

$$Z_{maP} = 0.00159f + j0.004657f \log\left(\frac{2160\sqrt{\rho/f}}{d_{aP}}\right) \quad \frac{\Omega}{\text{mile}}$$

where ρ is the earth resistivity Ω.m, f is the frequency in Hz, and d_{aP} is the distance between conductor *a* and pipeline *P*. Carson's equation determines the induced voltage between the pipeline *P* and the earth for a unit current in *a* and earth return. The h^{th} order induced harmonic voltage in pipeline *P* can be determined from:[36]

$$V_{Ph} = \ell\left(I_{h1}Z_{m1P} + I_{h2}Z_{m2P} + I_{hn}Z_{mnP}\right)$$

where ℓ is the length of exposure and I_h is the harmonic current of order *h* in power line.

[35] McMichael 1950.

[36] IEEE Std-1124-2003.

The following table summarizes the assumed the distances between the pipeline and the high-voltage conductors using the dimensions provided by Figure 3. Calculations assume the pipeline is located at the edge of the pipeline ROW and buried 36 inches below the ground level. The levels would be lower for larger distances between the dc transmission line and pipeline.

Table 3 - Pipeline distance from the dc transmission line conductors

$d_{P,1}$	*102.883'*	$d_{P,2}$	*65.460'*	$d_{P,n}$	*129.034'*

The harmonic current spectrum of the dc transmission line and its distribution between the metallic return conductor and the earth determines magnetic field intensity and therefore determines the induced voltage in a coupled circuit, including the pipeline. Similar to the approach adopted in the previous section, the harmonic current spectrum for the NYRI dc transmission line is assumed to be proportional to the New-England harmonic dc transmission line spectrum, which is produced in Table 2. The New-England residual current spectrum is also used for calculating the metallic return current, as exhibited in Table 4. These assumptions provide an initial approximation. More in-depth analysis requires further system details that will not be available until the final design.

Table 4 - Residual current harmonic content

h	9	15	21	27	33	39	45	51	57
I_{RMS} *A*	0.1	0.2	0.2	0.1	0.5	0.3	0.3	0.2	0.2

The induced voltage per mile for the pipeline is calculated assuming uniform ground conductivity (including the pipeline coating) of 1,000 Ω.m, which includes the pipeline coating. The mutual impedance between the pipeline and the dc power line at various frequencies, per

Table 2 and Table 4, were calculated using Carson's formula. The screening effect of conductors is not considered at this stage. Table 2 provides the harmonic current amplitudes for dc conductors at different frequencies. Since the harmonic current in the metallic return conductor opposes the dc conductor harmonic direction, the amplitudes of these harmonics are assumed to be negative of the Table 4 entries. The induced voltage in pipeline *P* per mile; i.e. V_P, is calculated and tabulated in Table 5. All the voltages are calculated for one mile of the pipeline parallel to the transmission line as illustrated in Figure 3.

Table 5 - Calculated induced voltages per mile in pipeline (NYRI case)

h	V_P V	h	V_P V
6	0.9	39	0.278
9	0.352	40	1.142
12	2.873	42	1.189
15	0.216	45	1.193
18	1.308	48	3.322
21	0.558	50	3.781
24	0.742	51	0.224
27	0.269	54	2.198
30	2.241	57	3.236
33	1.332	60	2.798

The calculated induced voltages are relatively small. Since the line height was considered at maximum sag (closest distance to the pipeline) instead of average line height along the span, the actual voltage levels will be less than listed. The maximum induced voltages occur at frequencies 720, 1,080, 1,800, 1,980, 2,880 Hz. Table 5 provides the spectrum of the induced ac voltages along the pipeline at different frequencies. Since the effect of line attenuation and the earth surrounding the pipeline are not considered in the above calculation, the induced voltage effect rises at higher frequencies. More accurate results require system details that will not be available until the final design phase of the project.

A minimum dc potential of -2 volts needs to be maintained between the pipeline and the earth for cathodic protection purposes. The largest induced harmonic voltages in the pipeline have a magnitude of ~ 4 volts. An ac voltage of this magnitude has a direct impact on the cathodic protection voltage profile along the pipeline, by forcing the pipeline to earth dc potential to drop below the minimum required amount. The effect of the dc transmission induced ac harmonic voltages into the pipeline is to annul the protection provided by the pipeline cathodic protection system. A practical remedy to this issue is to raise the cathodic protection source voltage to the effect that the attenuated voltage along the pipeline remains above 2 volts.

The above analysis assumes steady state (fixed loading) operation. While an analysis of dynamic conditions suggests potentially greater induction, the impact was determined to be negligible.

4.8 Conducted DC Current

The NYRI dc metallic return conductor minimizes the dc current flow through the earth, and thus reduces the dc transmission line interference into pipeline cathodic protection to a negligible level.

A source of residual dc current is the leakage current through contaminated dc suspension insulators. The suspension insulators are typically a string of insulator disks that meet the mechanical and the electrical insulation design requirements. A proposed insulator design for one of the towers is reproduced in Figure 11.

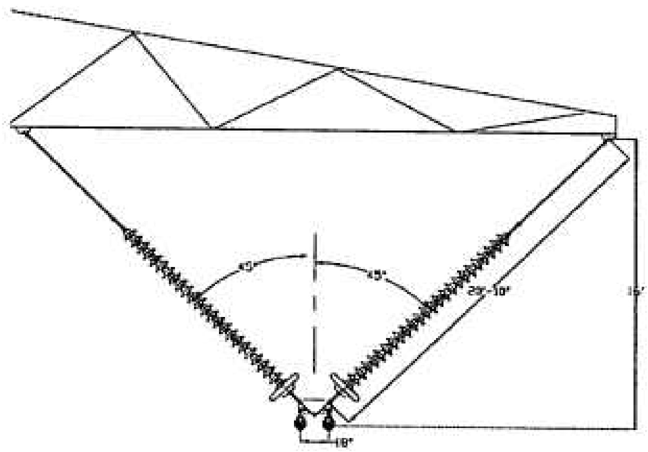

Figure 11. Suspension assembly detail

The distance between two consecutive dc transmission towers along the pipeline segments will vary from approximately 700 to 1,100 feet. Assuming a worst-case scenario with eight towers per mile and 660 feet between two towers, there are a total of 32 insulator strings for each mile of the dc transmission line. The maximum leakage current for a dc insulator with no arcing is below 0.5 mA[37]. The same number has also been suggested as the maximum value for the insulator strings by Washington Group.[38] Therefore, the maximum stray dc leakage current per mile per polarity (pole) would be + or - 16 mA. These leakage currents would tend to neutralize at the towers and any other adjacent towers joined by a bonded shield wire and only a small portion would flow back to the converter station. The portion of the leakage current flowing to the converter station would thus partially flow through the earth and partially through the pipeline. Coated pipeline is typically insulated from the earth, except for the hotspots along the pipeline. Thus a negligible portion of the leakage current would actually flow through the pipeline. The stray dc current from insulator leakage is in the milli-ampere per mile range under even worst-case conditions and therefore is negligible.

The result of the Pipeline Research Council International indicated that the ground-return currents from a dc system might have some effect on a pipeline even if the line is separated 100

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[37] Sörqvist and Vlastós 1997, p.1041-1048.

[38] Email correspondence from NYRI 9/20/07.

miles or more from the nearest electrode for a dc system with an earth return[39]. Currents induced in the ground and currents from adjacent cathodic protection systems will also have some effect on pipelines. The NYRI dc metallic return conductor practically isolates the dc transmission line from the earth and does not effect the pipeline

4.9 Pipeline Shielding

Varying magnetic fields induce current flows in conductive materials. This current, called eddy current,[40] tends to oppose the external magnetic field inside the conducting object producing a lower net field.[41] The eddy currents tend to stay on the surface of the conducting object. This occurs because the reactance at the conductor surface is smaller than the reactance of other possible paths within the conducting object. The skin depth, δ, measures exponential damping of the electromagnetic interference as it travels through the conducting object.[42] The skin depth for a flat conducting plate is:

$$\delta = \left(\sqrt{\pi f \mu \sigma}\right)^{-1} \approx 503\left(\sqrt{f \mu_r \sigma}\right)^{-1} \text{ meter}$$

where f is the frequency, μ and σ are the permeability and conductivity of the conductor respectively. This equation shows that the skin depth decreases as the frequency increases. Figure 13 depicts the comparative values for the skin depth for common metals.

Pipelines are typically made of iron, which is a conductive material. The skin depth for a flat iron plate at 60 Hz (σ = 1.02e7 $(\Omega.\text{m})^{-1}$, μ_r ~1000, μ ~1.26e-3 H/m) is 0.64 mm. The shielding effectiveness of solid conduit, in this case pipeline, is the same as that of a solid sheet of the same thickness and material.[43] Therefore the pipeline interior is effectively shielded from

[39] PRCI 1970, p. 91.

[40] Current that circulates in a metallic material as a result of electromotive forces induced by a variation of magnetic flux (IEEE Dictionary, 2000).

[41] Kipp 1969, p. 315.

[42] The external electromagnetic field drops to 5 percent of its magnitude at the surface of conductor once it travels 3.δ into the conductor (Kipp, 1969, p. 612).

[43] MIL-HDBK-419A, p. 8-60.

external electromagnetic fields. Thus the dc transmission line's ac electromagnetic field does not interfere with the pipeline monitoring and internal integrity inspection tools of the system such as smart pigs.

Magnetic flux leakage (MFL) tools, such as smart pigs, apply the principles of flux leakage inside a pressurized, flowing gas-transmission pipeline. A magnetizing system applies a magnetic field along a length of pipe as the tool moves through the line. Defects distort this applied field, producing flux leakage. Sensors measure flux leakage, and a recording system stores the measurements. Finally, the measurements are analyzed to estimate the defect geometry and severity[44]. MFL tools use energy density magnetic fields for accuracy, which are significantly larger than the dc transmission system EMI. Thus the dc transmission system EMI does not affect inspection accuracy of the MFL tools.

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[44] Nestleroth and Bubenik 1999.

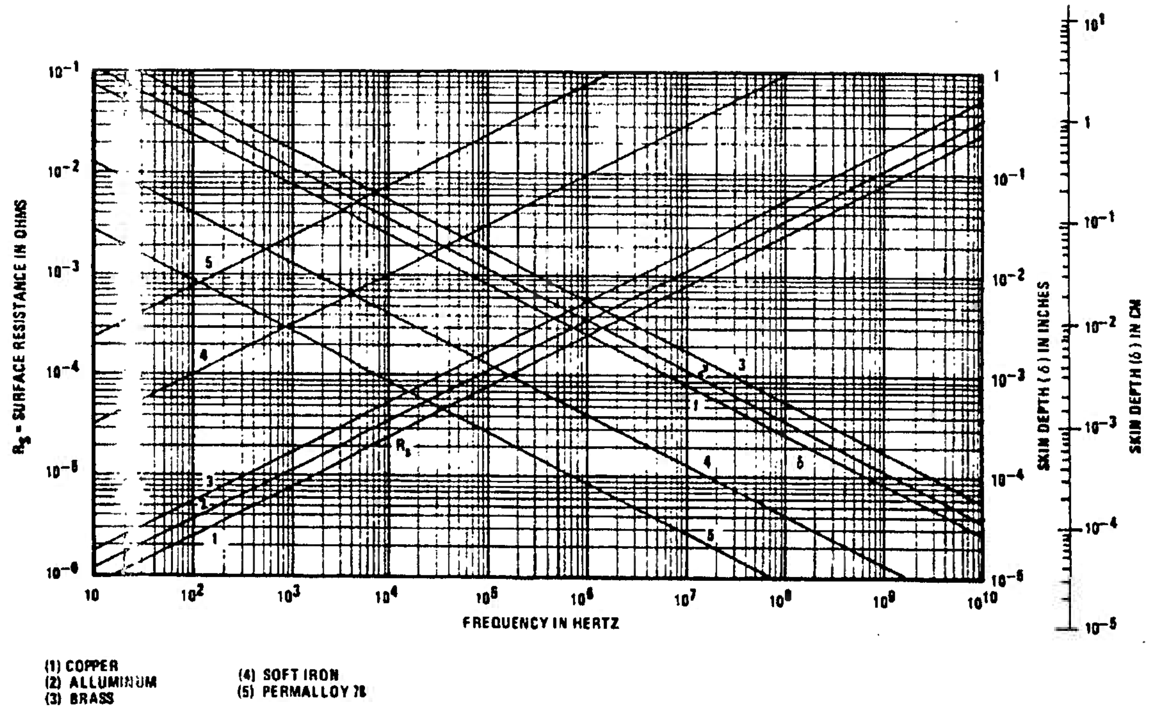

Figure 12. Skin depth for common metals

4.10 Conclusion

The effects of the conductive and inductive voltages and currents have been investigated. It has been shown that the conductive currents in the earth are normally negligible except during system transients such as faults. The associated fault voltages and currents for a dc line are less than for a comparable ac line or for lightning strikes. The normal conductive currents are of negligible magnitude and are too weak to affect the pipeline cathodic protection and control and monitoring systems. DC transmission ground fault can raise the momentary ground potential along the pipeline, which can overwhelm the pipeline cathodic protection, and communication and monitoring circuits but these effects will be less severe than for a typical ac line. Pipeline systems, including cathodic protection, should be inspected periodically especially in proximity to a fault location. This inspection can be based on the recommended procedure or maintenance guideline enforced for a lightning strike to the pipeline.

The effects of the EMI on the radio and telephone communication systems have also been investigated, and it was shown that the EMI effect is within industry acceptable limits. More detailed analysis, however, is required once further system design parameters are determined.

The harmonic induced voltages into the pipeline could have magnitudes in the range of the electric potential required for pipeline cathodic protection. The effect of these induced voltages depends on the ac impedance of the cathodic protection systems. If the ac output impedance of the cathodic protection systems is low, the voltages will be essentially short-circuited to the ground and should then not have any effect.

5 Exemplar Pipeline Equipment

The data on causes of gas transmission pipeline accidents (i.e., threats to the pipeline) show that between 1990 and 1999, there were a total of 777 reported accidents. The data indicates that the two greatest threats to a pipeline are from outside force damage (41%), and corrosion (22%)[45]. Pipelines are guarded against corrosion by coating and cathodic protection. It has been established that the NYRI dc transmission line with a dedicated metallic return conductor will have a negligible effect on the pipeline's cathodic protection systems. The pipeline is typically protected against outside forces by structural barriers or an impact monitoring system. No exemplar protection or monitoring system for the pipeline is identified at this time; however, a cursory review of commercially available equipment indicates that such equipment, such as GE ThreatScan,[46] is acoustic equipment. Such systems provide acoustic monitoring for accurate location and immediate risk assessment of impact events to pipelines, both underground and above ground. Considering that the audible noise of the NYRI dc transmission line is below common environmental noise levels,[47] the dc transmission line audible noise is not expected to interfere with such a monitoring system.

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[45] Federal Register / Vol. 68, No. 18 / Tuesday, January 28, 2003 / Proposed Rules, page 2486.

[46] GE Gas & Oil, 2007.

[47] The NYRI dc transmission audible noise is 10 dB(A) below the EPA guideline (Exponent, 2007).

6 Mitigation Techniques

6.1 Review

Potential interference issues can be minimized or obviated, by routing transmission lines as far away as possible from other facilities[48]. Prevailing regulatory and environmental factors, however, often force the electric and other utilities to share common corridors rather than follow separate routes. Hence, there is not much regulatory flexibility for achieving separate ROWs. This can be mitigated in part by installing filters at dc converter stations of appropriate design and size to attenuate sources of harmonic interference to acceptable levels. Despite the great care and effort expended during planning, design, construction, and commissioning of dc projects, many factors contribute to uncertainty that could potentially result in interference conditions between the power system and the pipeline system. Thus, consideration of mitigation is a logical and economic course of action to resolve localized interference issues, if they occur.

The following four general steps can be followed to achieve successful mitigation, if necessary:

1. Characterize the type and level of potential interference and the level of mitigation required.

2. Identify the locations of potential interference.

3. Identify the type of mitigation device to be used at each location.

4. Schedule the implementation of mitigation devices.

[48] IEEE Std. 1124-2003.

Although it is the conversion of an ac electromagnetic field from a transmission line into conducted interference (in the pipeline) that usually results in operational issues, the level of conducted interference that such a field could normally produce is still far below the level needed to cause permanent damage to the equipment.[49] The only significant exception to this generalization is, of course, that of a short circuit of a dc pole to the ground; however, even in this case the impact of the fault would be less than that associated with an ac line.

6.2 Interference Mitigation

Once harmonic interference issues have been identified, there are many different techniques available to electric utilities and pipeline companies to mitigate circuit interference. Several mitigation techniques are also discussed in IEEE Standard 1137. Some applicable techniques are as follows:

- Modify dc filters,
- Active dc filters,
- Improve loop balance,
- Replace open-wire circuits with cables,
- Improve cable shield grounding,
- Verify cable shield continuity,
- Apply noise chokes,
- Apply induction neutralizing transformers, and
- Use optical fibers.

While the application and benefits of most of the above items are obvious and self evident, the dc filters and loop balance are less obvious and are discussed below.

[49] Cramer 2004, p. 6-3.

6.2.1 DC Filter Modification

Earlier in this report, it was shown that harmonics on the dc side of the converters could be a potential source of telephone noise[50]. The analysis indicated that these harmonic effects are negligible; however the results were based on limited system details and assumptions based on existing dc transmission lines. Additional calculations should be conducted once further system detail becomes available. With detailed models based on final system design for calculating harmonic generation, it will be possible to compute higher order non-characteristic harmonics more accurately. This should determine the degree of filtering required on the dc side of the converter. Hence, any unpredicted interference due to higher order non-characteristic harmonics is less likely and so is the need to modify the dc filter later. If such calculations indicate a greater potential for interference than indicated by this analysis, then the design of the dc filters can be updated to eliminate the noise. An example of modification of a 12th order harmonic filter to provide 12th order and high-pass filtering and their filtering characteristics are shown in Figure 13. This modification reduced noise-metallic voltage by about 10 dB.[51]

[50] Telephone noise is considered as a general term for noise into pipeline communication and signaling systems.
[51] Hancock et al. 1979.

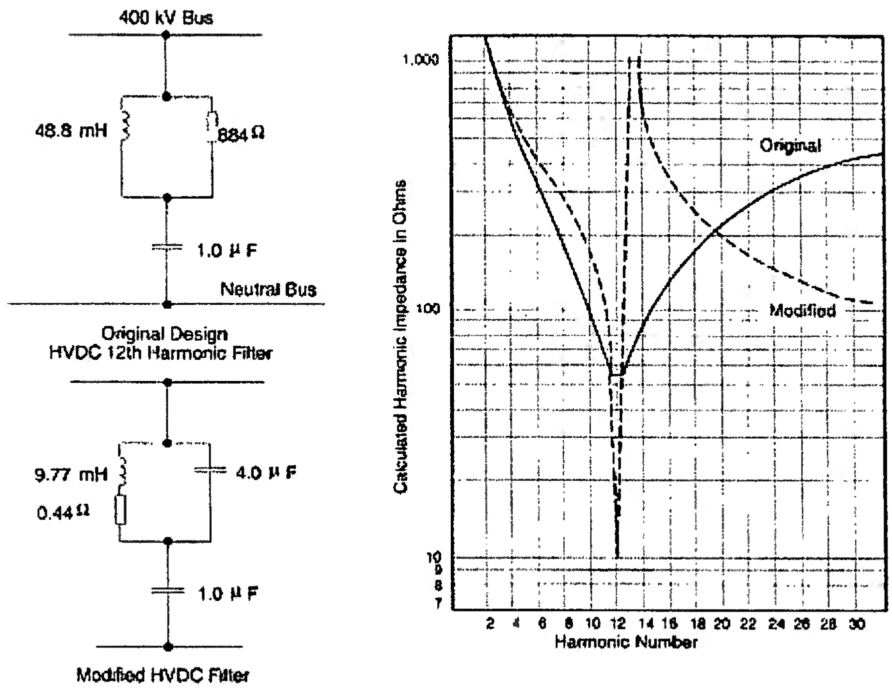

Figure 13. DC filter modification

6.2.2 Balance of Loops and Equipment

The induced voltage is of noise to ground type, whereas actual noise perceived by a circuit is metallic noise[52] or circuit noise. The difference is called balance voltage, similar to rail-to-rail induced voltage. Improvement in balance of loops results in reduction of metallic noise. The improvement will not only result in a reduction of induced noise but also will improve the overall quality of signaling service. Monopolar operation needs also to be considered in this study.

[52] Metallic noise is the weighted noise current in a metallic circuit at a given point when the circuit is terminated at that point in the nominal characteristic impedance of the circuit (IEEE, 2000).

7 Findings and Conclusions

The effect of the NYRI dc transmission line on a parallel pipeline, and the pipeline protection and monitoring systems have been evaluated in this report. The following are the findings and conclusions:

1. The flow of dc current in the earth and interference to any adjoining facilities, including those of pipelines, is essentially eliminated by the provision of the metallic return conductor. The dc leakage current, through the suspension insulators is negligible and will not be a source of interference. Only a dc fault current that arises from infrequent, short circuits from one pole to the ground would be large enough to potentially interfere with the pipeline. The fault current and any interference produced, however, are of extremely short duration.

2. The proposed dc transmission line will be designed to reduce harmonic currents. In addition, the inductive coupling between these harmonics on the dc transmission line and the pipeline should not result in interference into pipeline cathodic protection. The induced ac voltage into the pipeline might be in range of cathodic protection drainage potential.

3. Internal monitoring devices, such as smart pigs, are shielded by the pipeline metallic structure from fields of the dc transmission line. DC transmission line audible noise would not have any impact on typical acoustic based monitoring equipment.

4. Because the proposed dc transmission line will be designed to minimize harmonic currents, magnetic field coupling to the pipeline signal and communication systems and circuits should not be an issue.

5. Shield wires could provide a low resistance path for the pipeline protective dc current.

This report was based, in part, on certain design assumptions and industry guidelines. As part of the final design, the design team will study system harmonics. That study will build on and amplify the analyses provided in this report and support additional design criteria, if necessary.

8 Limitations

Exponent investigated specific issues relevant to the objectives of this stage of the project. Therefore, the scope of services performed during this investigation may not adequately address the needs of other users, and any reuse of this report or the findings, conclusions, or recommendations presented herein is at the sole risk of the user.

Preliminary conceptual designs were evaluated to assess the potential likelihood and severity of the operation of the proposed transmission line and to identify the need for mitigation of electrical effects that might adversely affect adjacent pipeline functions. During the final design stage of the project these issues will be reviewed again and addressed in the converter design, ac/dc filter specifications, surge capacitor, ac system specification, and communication system details.

The conclusions and recommendations presented herein are based on the work performed as described in this report. Exponent reserves the right to revise these conclusions and recommendations if and when additional information becomes available.

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