Environmental Impacts of Transmission Lines

Introduction

This overview reviews the environmental issues and concerns raised by the construction and operation of electric transmission facilities. The first part provides a general summary of the types of analysis and the means to measure and identify environmental impacts.

The second part is an alphabetic list of potential impacts and the available methods to minimize or mitigate the impacts. This general information can be found on the following pages.

In the final section of this pamphlet, community involvement and the role of the Public Service Commission (PSC) is discussed. PSC regulates transmission line construction so that costs to consumers are minimized, Wisconsin has a safe and reliable electric supply, and environmental and social impacts are limited.

Measuring and Identifying Environmental Impacts

Quantifying Potential Impacts

The impact from the construction of a transmission line can be measured in several different ways. Useful measurements of impacts may be area (acreage), distance (miles or feet), or the number of transmission structures.

The effect of a new transmission line on an area may depend on the topography, land cover, and existing land uses. In forested areas for example, the entire right-of-way (ROW) width is cleared and maintained free of tall-growing trees for the life of the transmission line. The result is a permanent change to the ROW land cover. In agricultural areas, heavy construction vehicles traverse the ROW and temporarily suspend the use of the land for crop production. After construction ends and the fields are properly restored however, the land beneath the line can be cropped or pastured. For this reason, the area permanently affected by the line is usually much smaller than the area temporarily affected during construction. Where transmission lines are routed through areas that are valued for their scenic qualities, the visual impacts of the line (the area affected) may extend well beyond the ROW.

Determining the Degree of Potential Impacts

In general the degree of impact of a proposed transmission line is determined by the quality or uniqueness of the existing environment along the proposed route. The quality of the existing environment is influenced by several factors:

- **The degree of disturbance that already exists**
  The significance of prior disturbance can be evaluated by determining how close the place resembles pre-settlement conditions. Many areas have been substantially altered by logging, the installation of drain tiles, residential and commercial developments, or conversion to cropland.

- **The uniqueness of the resources**
  Proposed transmission routes are reviewed for species or community types that are uncommon or in decline in the region or state. The environmental review evaluates whether the resource possesses a feature that would make it unique, such as its size, species diversity, or whether the resource plays a special role in the surrounding landscape.

- **The threat of future disturbance**
  The resource is compared to surrounding land uses which may affect the quality of the resource over time. Whether the current and likely future land uses may threaten some aspect of the resource. Whether the resource is valued by the adjacent community and therefore, likely to be preserved.

Identifying the Duration of Potential Impacts

The construction of a transmission line involves both long-term and temporary impacts. Long-term impacts can exist as long as the line is in place and include land use restrictions and aesthetic impacts. Temporary impacts occur during construction or at infrequent intervals such as during line repair or ROW maintenance. Temporary impacts during construction can include noise and crop damage. Short-term impacts can become long-term impacts if not properly managed or mitigated.

Mitigating Potential Impacts

It may be possible to lessen or mitigate potential environmental, landowner, and community impacts by adjusting the proposed route, choosing a different type of pole structure, using different construction methods, or implementing any number of post-construction practices. The PSC can require the transmission construction applicants to incorporate specific mitigation methods into the project design, construction process, and/or maintenance procedures. Examples of common mitigation techniques are shown in the table below.

Table 1 Examples of Mitigation Strategies

Project Phase	Feature	Examples of Mitigation Methods
Design Phase	Transmission Structure	Choosing a different transmission pole with different construction requirements and aesthetic appeal. • H-frame structures have longer span widths which make it easier to cross rivers, wetlands, or other resources with fewer impacts (see Figure 1). • The darker color of oxidized steel structures may blend in better with forested backgrounds. • Low profile poles can be used near airports to avoid interference with flight approaches.
Construction Phase	Timing	• Constructing when the ground is frozen and vegetation is dormant to minimize impacts to wetland habitat. • Delaying construction in agricultural areas until after harvest to minimize crop damage.
Construction Phase	Erosion control	Installing and maintaining proper erosion controls during construction to minimize run-off of topsoil and disturbances to natural areas.
Post-Construction Phase	Invasive Species Management	Annual surveying for new populations of invasive species (*e.g.* purple loosestrife) caused by construction disturbances. Early detection of invasive species increases the likelihood of successful outcomes.
Post-Construction Phase	Restoration	• De-compacting agricultural soils so that impacts to crop yields are minimized (see Figure 2). • Re-vegetate ROWs in natural areas with DNR-approved seed mixes.

Replacing or Upgrading Existing Lines

One method to mitigate impacts during project design is replacing or double-circuiting an existing line rather than building a new line. The environmental advantages of double-circuiting an existing line are:

- Little or no additional ROW clearing, if the new line can be placed in the center of an existing ROW
- Land use patterns may have already adapted to the existing ROW
- Electric and magnetic fields (EMF) may be reduced because new structure designs place line conductors closer together resulting in lower EMF

There could also be disadvantages. Upgrading an existing transmission line from single-circuit to double-circuit can increase the cost by 130 percent or more, depending on the choice of structures and the size of the line. Using an existing transmission line ROW may also not be the best choice when:

- The existing ROW is in a poor location
- New residential areas have been built around the existing line
- Electricity use has grown more in other areas, so using the existing ROW reduces the efficiency of the new line and increases costs
- A wider ROW is needed because the size of the new line is much greater than the existing line

Figure 1 Typical Two-Pole, H-frame Structure

Figure 2 Typical Single-Pole, Double-Circuit Structure

Corridor Sharing

It is the policy of the state (Wis. Stat. § 1.12(6)) to site new transmission lines to the greatest extent feasible, utilizing existing corridors in the following order of priority: (a) existing utility corridors, (b) highway and railroad corridors, (c) recreational trails with limitations, and (d) new corridors. When properly evaluated as part of routing decisions, corridor sharing can be a useful method in mitigating environmental, property, and community impacts of a new transmission line. Transmission line ROWs can be shared in all or part with other electric transmission lines, roads or highways, gas or oil pipelines, and railroad corridors. ROW-sharing with some of these types of corridors has more advantages than others. The more the ROW overlaps an existing ROW, the more benefits are possible. Side by side placement of ROWs with no overlap has fewer benefits than true corridor sharing. Some types of corridor sharing, like building a high-voltage transmission line over a small distribution line right-of-way, are not beneficial in reducing impacts.

Sharing corridors with existing facilities may minimize impacts by:

- Reducing the amount of new ROW required.
- Concentrating linear land uses and reducing the number of new corridors that fragment the landscape.
- Creating an incremental, rather than a new impact.

Often, the most preferred type of corridor sharing is with an existing transmission line. An existing line may be double-circuited with a new transmission line and therefore require little or no expansion of the existing ROW. However, in some situations corridor sharing has drawbacks. Some examples of these disadvantages are described in Table 2.

Table 2 Examples of Possible Disadvantages of Corridor Sharing

Existing ROW	Examples of Corridor Sharing Drawbacks
Railroads	• Some railroad ROWs have long distances between road crossings and additional access roads would be needed for the construction of a transmission line. • Railroad corridors that pass through wetlands are generally berms that are too narrow to support transmission structures, resulting in additional impacts to wetlands.
Gas Pipelines	• Pipeline ROWs often run cross-country with little or no visual or agricultural effects. However, transmission lines constructed cross-country can interfere with farm operations and produce a negative visual impact. • For reasons of safety, gas pipelines often require a transmission line ROW to parallel the pipeline ROW with no or very minimal overlap. This minimizes any potential benefits of corridor sharing.
Rural Roads	• Along local roads, large trees may form a scenic canopy over the road. The construction of a transmission line ROW that overlaps the road ROW would require the clear cutting of these trees and negatively impact aesthetic views.
Existing Transmission Lines	• Locating a new transmission line ROW parallel with an existing line on separate structures can increase impacts to agricultural operations. • New double-circuited structures may be taller than the existing transmission structure and create increased hazards for bird or airport flyways.

Corridor-sharing with an existing utility may require some modification to the proposed transmission structures resulting in additional costs to the project. For example, corridor sharing with a railroad may require the installation of underground communication circuits for the railroad. Sharing a corridor with a gas pipeline may require the installation of cathodic protection to prevent pipeline corrosion caused by induced currents. Transmission structures located within a highway ROW must be moved at the ratepayers' expense, if the highway is modified.

One additional drawback to corridor sharing is that landowners who have agreed to an easement for one facility may be unfairly burdened by the addition of more facilities. Additional utility easements may further limit their rights and the use of their property. The property owner would then be responsible for negotiating a new easement contract in order to receive proper compensation from the utility.

Underground Electric Transmission Lines

It is a common practice in residential areas to place low-voltage distribution lines underground. However, placing high-voltage transmission lines underground is less common and can cost two to ten times more than building an overhead line. While this practice may reduce aesthetic and other impacts, it may increase others. High-voltage transmission lines differ from lower voltage lines in that significant aboveground facilities are necessary to support the underground cable. The PSC offers a separate brochure with more detailed information about underground transmission lines called ***"Underground Electric Transmission Lines"***.

Underground transmission lines can be a reasonable alternative:

- In urban areas where an overhead line cannot be installed with appropriate clearances
- When it allows for a significantly shorter route than overhead
- When aesthetic impacts would be significant

Underground transmission lines can have the following disadvantages:

- An increase in the area of environmental disturbance
- The complete removal of small trees and brush along the transmission ROW
- Increased construction and repair costs
- Increased operation and maintenance costs

Types of Impacts Associated with Transmission Lines

The following pages describe many of the usual environmental, landowner, and community impacts related to the construction and operation of transmission lines. The issues are listed in alphabetical order. This section is meant to provide general background information and not an all-encompassing list applicable to all construction projects.

Aesthetics

Potential Aesthetic Impacts

The overall aesthetic effect of a transmission line is likely to be negative to most people, especially where proposed lines would cross natural landscapes and private properties. The tall steel or wide H-frame structures may seem out of proportion and not compatible with agricultural landscapes or residential neighborhoods. Landowners who have chosen to bury their electric distribution lines on their property may find transmission lines bordering their property particularly disruptive to scenic views.

Some people however, do not notice transmission lines or do not find them objectionable from an aesthetic perspective. To some, the lines or other utilities may be viewed as part of the infrastructure necessary to sustain our everyday lives and activities.

Aesthetic impacts depend on:

- The physical relationship of the viewer and the transmission line (distance and sight line)
- The activity of the viewer (*e.g.*, living in the area, driving through, or sightseeing)
- The contrast between the transmission structures and the surrounding environment, such as whether the line stands out or blends in

A transmission line can affect aesthetics by:

- Removing a resource, such as clearing fencerows
- Degrading the surrounding environment (*e.g.*, intruding on the view of a landscape)
- Changing the context of the view shed (*e.g.*, evoking an image of development in a previously rural area)

Mitigation of Aesthetic Impacts

Electric transmission lines may be routed to avoid areas considered scenic. Routes can be chosen that pass through commercial/industrial areas or along land use boundaries.

The form, color, or texture of a line can be modified to somewhat minimize aesthetic impacts. There are some choices available in transmission structure color and/or construction material. Structures constructed of wood or of rust brown oxidized steel may blend better with wooded landscapes. Stronger conductors can minimize line sag and provide a sleeker profile.

ROW management can also mitigate visual impacts of transmission lines. Some of these techniques include planting vegetative screens to block views of the line, leaving the ROW in a natural state at road crossings, and placing or piling brush from the cleared ROW so that it provides wildlife habitat.

In the end, aesthetics are to great extent based on individual perceptions. Siting, design, construction materials, and ROW management can mitigate some of the adverse aesthetic effects of a line. It is in the interest of the applicant and the affected landowners to discuss these measures early in the planning and design process.

Agricultural Lands

Potential Impacts to Agricultural Land

Transmission lines can affect farm operations and increase costs for the farm operator. Potential impacts depend on the transmission line design and the type of farming. Transmission lines can affect field operations, irrigation, aerial spraying, wind breaks, and future land uses. For new transmission lines 100 kV or greater and longer than one mile, state law requires the utility to repair much of the damage that can occur during construction and/or provide monetary compensation (Wis. Stat. § 182.017(7)(c) to 182.017(7)(h)). The PSC offers a separate brochure with more detailed information about landowner rights called ***"Right-of-Way and Easements for Electric Facility Construction"***.

The placement of transmission structures can cause the following agricultural impacts:

- Create problems for turning field machinery and maintaining efficient fieldwork patterns
- Create opportunities for weed encroachment
- Compact soils and damage drain tiles
- Result in safety hazards due to pole and guy wire placement
- Hinder or prevent aerial activities by planes or helicopters
- Interfere with moving irrigation equipment
- Hinder future consolidation of farm fields or subdividing land for residential development

Placement of transmission lines along field edges or between fields where windbreaks have been planted can increase erosion of soils if the windbreaks must be removed.

In recent years there has been discussion about the potential for construction projects to spread farm pests and diseases or to otherwise affect the health of farming operations. Concerns have been raised about Johne's disease, soybean cyst nematode, the spreading of ginseng diseases to plots reserved for future ginseng production, and pesticide contamination of soils on organic farms. Issues of biosecurity can be a concern to many farm operators.

Soil mixing, erosion, rutting, and compaction are interrelated impacts commonly associated with transmission construction and can greatly affect future crop yields. Soils may be mixed during the excavation of pole foundations or during the undergrounding of electrical lines. The excavation depth for transmission structure foundations can vary greatly, but in some projects may be more than 50 feet deep. Excavated parent material or subsoils should not be mixed with topsoils and spread on the surface of the ROW. Significant rutting can occur when soils become saturated or in areas of sensitive soils (see Figure 3). This may impact agricultural lands by increasing the mixing of soils, erosion of topsoils during rain events, and compaction of soils. The degree that soils are compacted by heavy construction equipment again depends on the type of soil and its saturation level. Ineffective erosion controls may wash valuable topsoils downhill and impact wetlands and waterways. Agricultural soils that have been improperly protected or mitigated may suffer decreased yields for several years after the construction of the transmission line is completed.

Figure 3 Rutting in Agricultural Lands

Agricultural Impact Statement

An agricultural impact statement (AIS) is required when the builders of a public construction project have the power to condemn property (eminent domain) and will acquire more than five acres of land from any farm operation. Wis. Stat. § 32.035 specifies what the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) is required to include in an AIS. The AIS is prepared to help farmers determine appropriate compensation for their losses. Easement agreements should include a discussion of anticipated damages and mutually agreed-upon reparation.

Mitigation of Agricultural Impacts

The utility should work with agricultural landowners as early in the design process as is appropriate to help identify potential impacts, well in advance of construction. Landowners and utilities may work out solutions that include minor changes to pole heights, specific pole locations, construction timing, and other significant land use concerns. By incorporating these solutions in written agreements, agricultural impacts can be prevented and/or minimized. A utility working with landowners can:

- Avoid or minimize construction through sensitive farmland.
- Identify, address, and document concerns before construction begins.
- Find resolutions for anticipated impacts (*e.g.*, payments to temporarily suspend farming activities or the installation of a temporary fence).

Problems with pole placement can be mitigated to some extent if the utility works with farmers to determine optimal pole locations. The following approaches might be useful:

- Using single-pole structures instead of H-frame or other multiple-pole structures so that there is less interference with farm machinery, less land impacted, and weed encroachment issues may be minimized.
- Locating the line along fence lines, field lines, or adjacent to roads so as to minimize field impacts.
- Using transmission structures with longer spans to clear fields.
- Orienting the structures with the plowing pattern to make farm equipment less difficult to use.
- Minimizing the use of guy wires but where necessary, keeping the guy wires out of crop and hay lands and placing highly visible shield guards on the guy wires.
- Minimizing pole heights and installing markers on the shield wires above the conductors in areas where aerial spraying and seeding are common.
- Locating new transmission lines along existing transmission line corridors.
- Using special transmission designs to span existing irrigation systems or if necessary, reconfiguring the irrigation system at the utilities expense.

Problems with the spread of farm pests or diseases and contamination of soils can be reduced by:

- Having the farmer avoid spreading manure or pasturing livestock in the transmission line ROW prior to construction. (This is the most cost-effective method to prevent the spread of animal disease.)
- Avoiding access through, or construction in, areas that may contain manure.

- Learning about individual farm field activities, such as planting, tillage, and crop rotations so that construction methods and timing can be adapted to the timing of crop work.
- Installing exclusion fencing to keep livestock away from construction activities, or markers to identify where construction is occurring, in consultation with the farmer, so that field activities and construction do not overlap.
- Putting barriers between equipment and manure or disease-contaminated soil.
- Physically removing manure or contaminated soil from equipment in compliance with existing farm disease control efforts.

Protection of organic farm certifications requires critical communication with the farmer and a thorough understanding of the farmer's operations along the ROW.[1]

Mitigation of farm impacts includes prevention of mixing topsoils with sub soils and the underlying parent material. Wis. Stat. § 182.017(7)(c) requires utilities that construct transmission lines that are 100 kV or larger and longer than one mile to ensure that topsoil is stripped, piled, and replaced upon completion of the construction operation.

If construction activity occurs during wet conditions and soils are rutted, repairing the ruts as soon as possible can reduce the potential for impacts. However, if improperly timed, mitigation work on rutted soil could compound the damage already present. Allowing a short time for the soil to begin drying and then using a bulldozer to smooth and fill in the ruts is a common mitigation approach (see Figure 4). The Atterberg field test should be used to determine when the soil is friable enough to allow rutting to be remediated safely.

Figure 4 Smoothing Out Ruts by Backblading with a Dozer

[1] An organic farmer is also protected during ROW maintenance by the requirements in Wis. Stat. § 182.017(7)(c) through (h), particularly those related to soil management and pesticide use.

To minimize soil compaction during construction in low-lying areas, saturated soils, and/or sensitive soils, low-impact machinery with wide tracks can be used. DATCP has recommended that such machinery and tires also be used across agricultural land if it must be worked during wet conditions.

When construction of the line is complete, the soil in the ROW in fields that were accessed by heavy construction traffic should be checked for compaction with a soil penetrometer and compared to penetrometer readings on soils outside of the ROW. If compaction within the ROW is detected, appropriate equipment should be used to restore the soil tilth. A soil with good tilth has large pore spaces for adequate air infiltration and water movement. (Roots only grow where the soil tilth allows for adequate levels of soil oxygen.) DATCP can provide guidance on the best methods or equipment to be used.

Problems with potential damage to soil productivity due to soil mixing, soil compaction, and soil erosion can be lessened by:

- Identifying site-specific soil characteristics and concerns from the landowner and farm operator before construction begins.
- Avoiding areas where impacts might occur by altering access routes to the construction sites.
- Using existing roads or lanes utilized by the landowner.
- Using construction mats, ice roads, or low ground pressure or tracked equipment to minimize compaction, soil mixing, rutting, or damage to drainage systems.
- Segregating top soils or soil horizons during excavation and construction to minimize soil mixing.
- De-compacting soils following construction with appropriate equipment until the degree of soil compaction on the ROW is similar to soils off the ROW.
- Avoiding construction and maintenance activities during times when soils are saturated.
- Avoiding the removal of critical windbreaks and replanting windbreaks with lower growing woody species, to minimize soil erosion due to wind.

Wis. Stat. § 182.017(7)(c)

This statute describes a number of restoration practices that the utility must employ when building a high-voltage transmission line on private property. This statute includes requirements, such as: removing rock and all construction debris; restoring all disturbed slopes, terraces, and waterways to their original condition; repairing drainage tile lines and fences damaged by construction; and paying for crop damage. Unless landowners waive their rights in an easement agreement, the utility is required to implement these mitigation practices. If a route passes through primarily agricultural land, DATCP has recommended that, to aid enforcement of the statute requirements, detailed best management practices should be incorporated into the project construction plans and agricultural specialists should be available to consult with the environmental monitors employed to oversee the contractors and ensure that these protections are implemented.

USDA Conservation Reserve Program Lands

Some properties in Wisconsin are enrolled in USDA National Resource Conservation Service (NRCS) programs established to preserve wetlands, grasslands, and farmland. These federal easements may have restrictive land uses not consistent with the construction of a transmission line. In these situations, utilities can negotiate with representatives of the NRCS or avoid these properties and find alternative routes for the transmission line.

Airports and Airstrips

Transmission lines are a potential hazard to aircraft during takeoff and landing. To ensure safety, local ordinances and Federal Aviation Administration (FAA) guidelines limit the height of objects in the vicinity of the runways. Utilities can route transmission lines outside of the safety zone, use special low-profile structures, put a portion of the line underground, or place lights or other attention-getting devices on the conductors.

Large brightly colored balls or markers may be installed on overhead transmission line conductors to improve their visibility to pilots and lessen the risk of collision. These markers are often employed near airports or airstrips, in or near fields where aerial applications of pesticides or fertilizers occur, and in areas where tall machinery, such as cranes, are frequently operated.

Archeological and Historical Resources

Archeological and historical sites are protected resources. They are important and increasingly rare tools for learning about the past. They may also have religious significance. Transmission line construction and maintenance can damage sites by digging, crushing artifacts with heavy equipment, uprooting trees, exposing sites to erosion or the elements, or by making the sites more accessible to vandals. Impacts can occur wherever soils will be disturbed, at pole locations, or where heavy equipment is used.

The Wisconsin Historical Society (WHS) has the primary responsibility for protecting archeological/historical resources. WHS manages a database that contains the records of all known sites and is updated as new information becomes available. The database must be searched for any sites that might be located along any of the proposed transmission routes.

The PSC is required to notify the WHS, if the construction of a transmission line has the potential for encountering any archeological resource. Archeological surveys might be required in these areas. The results of the surveys are reported to the WHS. WHS will then make recommendations for avoiding and minimizing impacts to the sites. It is the responsibility of the PSC to ensure that the construction practices follow all WHS recommendations. Route changes are seldom necessary. Judicious transmission pole placement can often be used to span resources and avoid impacts to the sites.

If during construction an archeological site is encountered, the construction at the site is stopped and the WHS and PSC must be notified by the utility. The WHS then makes recommendations on how construction should proceed so that impacts to the resource are managed or minimizing.

Cultural Concerns

Protection of archeological and historic resources is often discussed in terms of "cultural resource" impacts. However, there are other cultural factors that occasionally surface during a transmission project review. A cultural concern can occur when an identifiable group or community has practices or values that may conflict with the presence of a new transmission line.

An example of a cultural concern that has been addressed in past transmission line cases is the routing of a proposed transmission line through an Amish community. Because the Amish do not use electric service, wish to remain non-confrontational, and tend not to become involved in government processes, a concerted effort was made to avoid impacts on this community.

Cultural impacts may also be related to property impacts and general social concerns such as fairness. These issues are discussed under the heading, "Property Owner Issues".

Electric and Magnetic Fields (EMF)

Potential Impacts of EMF

Health concerns over exposure to EMF are often raised when a new transmission line is proposed. Exposure to electric and magnetic fields caused by transmission lines has been studied since the late 1970s. These fields occur whenever electricity is used. A magnetic field is created when electric current flows through any device including the electric wiring in a home. Every day we are exposed to many sources of EMF from vacuum cleaners, microwaves, computers, and fluorescent lights.

The research to date has uncovered only weak and inconsistent associations between exposures and human health. To date the research has not been able to establish a cause and effect relationship between exposure to magnetic fields and human disease, nor a plausible biological mechanism by which exposure to EMF could cause disease. The magnetic fields produced by electricity do not have the energy necessary to break chemical bonds and cause DNA mutations. The PSC offers a separate brochure with more detail about electric and magnetic fields called, ***"Electric & Magnetic Fields (EMF)"***.

Reducing EMF Levels of Transmission Lines

Magnetic fields can be measured with a gauss meter. The magnitude of the magnetic field is related to current flow, not line voltage. A 69 kV line can have a higher magnetic field than a 345 kV line. Magnetic fields quickly dissipate with distance from the transmission line.

A common method to reduce EMF is to bring the lines closer together. This causes the fields created by each of the three conductors to interfere with each other and produce a reduced total magnetic field. Magnetic fields generated by double-circuit lines are less than those generated by single-circuit lines because the magnetic fields interact and produce a lower total magnetic field. In addition, double circuit poles are often taller resulting in less of a magnetic field at ground level.

Endangered/Threatened and Protected Species

Potential Impacts to Protected Species

Endangered species are species whose continued existence is in jeopardy. Threatened species are likely to become endangered. Species of special concern have some problems related to their abundance or distribution, although more study is required.

The DNR Bureau of Endangered Resources (BER) manages the Natural Heritage Inventory (NHI) which lists current and historical occurrences of rare plants, animals, and natural communities. The database includes the location and status of these resources. However, some areas of the state have not been surveyed extensively or recently, so the NHI database cannot be relied upon as a sole information source for rare species.

Construction and maintenance of transmission lines might destroy individual plants and animals or might alter their habitat so that it becomes unsuitable for them. For example, trees used by rare birds for nesting might be cut down or soil erosion may degrade rivers and wetlands that provide required habitat.

Mitigation of Impacts to Protected Species

If preliminary research and field assessments indicate that rare species or natural communities may be present in the project area, the utility should conduct DNR-approved surveys prior to construction. If a state-listed species is likely to be in the project area, impacts can usually be avoided or minimized by redesigning or relocating the transmission line, special construction techniques, or limiting the time of construction to specific seasons. The PSC has the authority to order transmission construction applicants to conduct surveys and implement mitigation measures.

In some limited cases, transmission line ROWs can be managed to provide habitat for endangered/threatened resources. An example includes osprey nesting platforms built on top of transmission poles. Close cooperation between the transmission provider, ROW maintenance staff, and the DNR is needed to develop an effective management plan.

Implantable Medical Devices and Pacemakers

Potential Impacts to Implantable Medical Devices

Implantable medical devices are becoming increasingly common. Two such devices, pacemakers and implantable cardioverter defibrillators (ICDs), have been associated with problems arising from interference caused by EMF. This is called electromagnetic interference or EMI.

EMI can cause inappropriate triggering of a device or inhibit the device from responding appropriately. Sources of EMI documented by medical personnel include radio-controlled model cars, slot machines, car engines, digital cellular phones, anti-theft security systems, radiation therapy, and high voltage electrical systems and devices. It has been estimated that up to 20 percent of all firings of ICDs are inappropriate, but only a very small percentage of those are caused by external EMI.

Manufacturers' recommended threshold for modulated magnetic fields is 1 gauss which is 5 to 10 times greater than the magnetic field likely to be produced by a high-voltage transmission line. Research shows a wide range of responses for the threshold at which ICDs and pacemakers responded to an external EMI source. The results for each unit depended on the make and model of the device, the patient height, build, and physical orientation with respect to the electric field.

Mitigation of EMI

Transmission lines are only one of a number of external EMI sources. All pacemaker and ICD patients are informed of potential problems associated with exposure to EMI and must adjust their behavior accordingly. Moving away from a source is a standard response to the effects of exposure to EMI. Patients can shield themselves from EMI with a car, a building, or the enclosed cab of a truck.

Invasive Species

Potential Impacts by Invasive Species

Non-native plants, animals, and microorganisms found outside of their natural range can become invasive. The majority of non-native species are harmless because they do not reproduce or spread abundantly in their new surroundings. Some non-native species have been introduced intentionally such as the Norway maple for landscaping and the ring-necked pheasants for hunting. However, a small percentage of non-native species are able to become quickly established, are highly tolerant of a wide range of conditions, and are easily dispersed. The diseases, predators, and parasites that kept their populations in check in their native range may not be present in their new locations. Over time, non-native, invasive species can overwhelm and eliminate native species, reducing biodiversity and negatively affecting both ecological communities and wildlife habitats.

Human actions are the primary means of invasive species introductions. Transmission line construction causes disturbance of ROW soils and vegetation through the movement of people and vehicles along the ROW, access roads, and laydown areas. These activities can contribute to the spread of invasive species. Parts of plants, seeds, and root stocks can contaminate construction equipment and essentially "seed" invasive species wherever the vehicle travels. Invasive species' infestations can also occur during periodic transmission ROW maintenance activities especially if these activities include mowing and clearing of vegetation. Once introduced, invasive species will likely spread and impact adjacent properties with the appropriate habitat.

Best Management Practices

To control invasive species, Wis. Admin. Code ch. NR 40 establishes a classification system for invasive species and prohibits activities that result in the spread of invasive species in certain categories. It also establishes preventive measures to help minimize their spread. Using the practices consistent with a Best Management Practices (BMP) manual will assist utilities in complying with "reasonable precaution" requirements of Chapter NR 40.

The BMP manual identifies many methods that can be used to limit the introduction and spread of invasives species during and post-construction. These measures include marking and avoidance of invasives, timing construction activities during periods that would minimize their spread, proper cleaning of equipment, and proper disposal of woody material removed from the ROW.

Because construction measures may not be completely effective in controlling the introduction and spread of invasives, post-construction activities are required. Sensitive areas such as wetlands and high quality forests and prairies should be surveyed for invasive species following restoration of the construction site. If new infestations are discovered, then measures should be taken to control the infestation. Each exotic or invasive species requires its own protocol for control or elimination. Techniques to control exotic/invasive species include the use of pesticides, biological agents, hand pulling, controlled burning, and cutting or mowing. The company should be consulting the DNR to determine the best methods for control of encountered invasive species.

Noise and Light Impacts

During Construction

During each phase of construction of the transmission line, noise will be generated by the construction equipment and activities. Initially, vegetation in the ROW is mowed or cut using mowers, whole tree processors, and/or chainsaws. Wood brush and logs may be chipped or burned in the ROW. Trucks are used to haul away material that can't be stockpiled or disposed on-site and to bring in necessary construction materials. Typical construction vehicles include bucket trucks, cranes or digger derricks, backhoes, pulling machines, pole trailers, or dumpsters. Transmission structures are constructed by first using a standard drill rig to bore a hole to the required depth. If water is encountered, pumps will be used to move the water to either adjacent upland areas or to waiting tanker trucks for proper disposal. When bedrock is close to the surface or when subsoils primarily consist of large boulders and large cobbles, blasting may be required. Concrete trucks carry concrete to the boreholes to construct the foundations of the transmission structures. Cranes then erect the towers on the foundations. Finally the wire is strung between the towers using large pulleys. After the construction is completed, the ROW is graded, agricultural soils are de-compacted, and the ROW cleaned up.

All of these operations produce noise that may impact adjacent landowners. However, normal work schedules and local ordinances usually restrict noise producing activities to daytime hours.

During Operation

Vibration or humming noise can be noticeable and is most often associated with older transmission lines. It is usually the result of conductor mounting hardware that has loosened slightly over the years and can be easily identified and repaired by the utility as part of line maintenance.

The other types of sounds that are caused by transmission lines are sizzles, crackles, or hissing noises that occur during periods of high humidity. These are usually associated with high-voltage transmission lines and are very weather dependent. They are caused by the ionization of electricity in the moist air near the wires. Though this noise is audible to those very close to the transmission lines, it quickly dissipates with distance and is easily drowned out by typical background noises.

Ionization in foggy conditions can also cause a corona, which is a luminous blue discharge of light usually where the wires connect to the insulators.

Additionally, residential properties located in close proximity to a substation could be impacted by the noise and light associated with the operation of a new or enlarged substation.

Property Owner Issues

ROW Easements

Property owner issues are often raised by individuals or communities along proposed transmission line routes. Two common issues are payers versus users and property owner rights versus public good.

There is often a feeling of unfairness between those that use electricity and those that bear the impacts of the facilities required to support that use. The money paid to landowners for ROW easements is meant to compensate them for having a transmission line cross their property. These easement payments are negotiated between the landowner and the utility. Some landowners do not regard the payments as sufficient to truly compensate for the aesthetic impacts and the loss of full rights to their own land. This is especially true if the landowner is not compensated for the "highest and best use" of the affected parcel. Also, property owners who live near the line, but not on the ROW, might be affected but are not compensated.

While not directly paid to property owners, compensation is paid to towns, municipalities, and counties through which a 345 kV or greater transmission line (high-voltage) is constructed via payment of one-time environmental and/or annual impact fees (Wis. Stat. § 196.491 (3g)(a)). The amount can be considerable and is proportional to the percentage of the line constructed within a specific political subdivision and the cost of the project.

Finally, the policy of corridor sharing favors the placement of new transmission lines within or next to existing infrastructure, causing some landowners to be burdened by multiple easements. These hardships must be balanced against the potential to reduce environmental impacts caused by the development of new transmission corridors.

Property Value Studies

The potential change in property values due to the proximity to a new transmission line has been studied since the 1950s by appraisers, utility consultants, and academic researchers. Data from these studies is often inconclusive and has not been able to provide a basis for specific predictions in other locations for other projects.

While the data from many of the studies reviewed are often inconclusive, some general conclusions among the studies have been made. In 2003, the Electric Power Research Institute (EPRI) conducted an assessment of the researched relationship between electric transmission facilities and property values.[2] Their conclusions do not differ substantially from previous analyses.

- The potential reduction in sale price for single-family homes in the U.S. may range from 0 to 14 percent. For states within the Midwest (Minnesota, Wisconsin, and the Upper Peninsula of Michigan), the average decrease appears to be between 4 and 7 percent. EPRI reported a potential overall decrease of 0 to 6.3 percent.
- Higher-end properties are more likely to experience a reduction in selling price than lower-end properties.
- Adverse effects on the sale price of smaller properties could be greater than effects on the sale price of larger properties.
- Amenities such as proximity to schools or jobs, lot size, square footage of a house, and neighborhood characteristics tend to have a much greater effect on sale price than the presence of a power line.
- The degree of opposition to an upgrade project may affect the size and duration of the sales-price effects. Furthermore, adverse effects on price and value appear to be greatest immediately after a new transmission line is built and appear to diminish over time and generations of property owners.
- Effects on sale price are most often observed for property crossed by or immediately adjacent to a power line, but effects have also been observed for properties farther away from a line. Homes not directly adjacent to the ROW or beyond 200 feet from the ROW, however, were affected to a much lesser degree than those abutting the line or ROW.[3] [4]
- Setback distance, ROW landscaping, shielding of visual and aural effects, and integration of the ROW into the neighborhood can significantly reduce or eliminate the impact of transmission structures on sales price.
- Although, appreciation of property does not appear to be affected, proximity to a transmission line can sometimes result in increased selling time.
- The value of agricultural property is likely to decrease if the power line structures are placed in an area that inhibits farm operations.

Radio and Television Reception

Transmission lines do not usually interfere with normal television and radio reception. In some cases, interference is possible at a location close to the ROW due to weak broadcast signals or poor receiving equipment. If interference occurs because of the transmission line, the electric utility is required to remedy problems so that reception is restored to its original quality.

Recreation Areas

Recreation areas include parks, trails, lakes, or other areas where recreational activities occur. Transmission lines can affect these areas by:

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[2] Goodrich-Mahoney, J. Transmission Line and Property Values: State of the Science. EPRI, November 2003.

[3] Kung, H. and C. Seagle, "Impact of Power Transmission Lines on Property Values: A Case Study," Appraisal Journal, July 1992.

[4] Hamilton, S. and G. Schwann. 1995. Electric Transmission Lines and Property Value. Land Economics 71(4):436-444.

- Limiting the location of buildings.
- Discouraging potential users of recreational areas whose activities depend on the aesthetics of natural surroundings (*e.g.*, backpackers, canoers, hikers).
- Altering the types of wildlife found in an area by creating more edge habitat or additional mortality risks to birds.
- Providing paths or better access to previously inaccessible areas for those who snowmobile, ski, bike, hike, or hunt.
- Posing potential safety risks by locating new poles or wires in the path of recreational vehicles such as snowmobiles and ATVs without adequate markings.

Some of these effects can be mitigated by locating lines along property edges, using pole designs that blend into the background and reduce aesthetic impacts, or designing recreation facilities to take advantage of cleared ROW.

Safety

Safety Standards

Transmission lines must meet the requirements of the Wisconsin State Electrical Code.[5] The code establishes design and operating standards, and sets minimum distances between wires, poles, the ground, and buildings. While the code represents the minimum standards for safety, the electric utility industry's construction standards are generally more stringent than the Wisconsin State Electrical Code requirements. Wis. Admin. Code § PSC 114.234A4 prohibits the construction of high voltage electric transmission lines over occupied residential dwellings or residential dwellings intended to be occupied. Although they may not be prohibited by code, building other structures within a transmission line ROW is strongly discouraged.

Contact with Transmission Lines

The most significant risk of injury from any power line is the danger of electrical contact between an object on the ground and an energized conductor. Generally, there is less risk of contact with higher voltage lines as opposed to low-voltage lines due to the height of the conductors. When working near transmission lines, electrical contact can occur, even if direct physical contact is not made, because electricity can arc across an air gap. As a general precaution, no one should be on an object or in contact with an object that is taller than 15 to 17 feet while under a high-voltage electric line. Individuals with specific concerns about whether it is safe to operate vehicles or farm equipment near transmission lines should contact their electric provider.

Fallen Lines

Transmission lines are designed to automatically trip out-of-service (become de-energized) if they fall or contact trees. This is not necessarily true of distribution lines. However, transmission lines are not likely to fall unless hit by a tornado or a vehicle.

[5] Wisconsin adopts the most recent edition of the National Electrical Safety Code with certain changes, deletions, and additions. Volume 1 of the Wisconsin Electrical Code is found in Wis. Admin. Code Ch. PSC 114. It is administered primarily by the Commission.

Lightning

New transmission lines are built with a grounded shield wire placed along the top of the poles, above the conductors. Typically, the shield wire is bonded to ground at each transmission structure. This protects the transmission line from lightning. Transmission poles, like trees or other tall objects are more likely to intercept lightning strikes, but do not attract lightening. Lightning is not more likely to strike houses or cars near the transmission line. Shorter objects under or very near a line may actually receive some protection from lightning strikes.

Induced Voltage

People or animals can receive a shock by touching a metal object located near a transmission line. The shock is similar to that received by touching a television after walking across a carpet. The magnitude and the strength of the charge will be related to the mass of the ungrounded metal object and its orientation to the transmission line.

Induced current can be prevented or corrected by grounding metal objects near the transmission line. Grounding chains can be installed on tractors. Metal fences can be connected to a simple ground rod with an insulated lead and wire clamp. Electric fences with proper grounding should continue functioning properly even when subject to induced voltage.

More information about working safely under and near transmission lines can be obtained from a brochures available online from the Bonneville Power Administration, *"Living and Working Safely around High-Voltage Power Lines"* (www.bpa.gov/corporate/pubs/public_service/livingandworking.pdf) and from the Midwest Rural Energy Council, *"Installation and Operation of Electric Fences, Cow Trainers and Crowd Gates"* (http://www.mrec.org/pubs.html).

Stray Voltage

Causes of Stray Voltage

Stray voltage and its impacts on livestock and other confined animals have been studied in detail by state and federal agencies, universities, electric utilities, and numerous scientists since the late 1970s. The PSC has opened investigations, encouraged the upgrade of rural distribution systems, established measurement protocols, and compiled a stray voltage database to track investigations, all in order to develop successful strategies for minimizing stray voltage in farm operations (http://psc.wi.gov/utilityinfo/electric/strayvoltage.htm). Over the decades, significant resources have been allocated to understand this issue.

Electrical systems, including farm systems and utility distribution systems, are grounded to the earth to ensure safety and reliability, as required by the National Electrical Safety Code and the National Electrical Code. Because of this, some current flows through the earth at each point where the electrical system is grounded and a small voltage develops. This voltage is called neutral-to-earth voltage (NEV). When NEV is measured between two objects that are simultaneously contacted by an animal, a current will flow through the animal and it is considered stray voltage. Animals may then receive a mild electrical shock that can cause a behavioral response. At low voltages, an animal may flinch with no other noticeable effect. At higher levels, avoidance or other negative behaviors may result. Stray voltage may not be noticeable to humans.

Low levels of AC voltage on the grounded conductors of a farm wiring system are a normal and unavoidable consequence of operating electrical farm equipment. In other words some levels of stray voltage will always be found on a farm. For example, a dairy cow may feel a small electric shock when it makes contact with an energized water trough. The issue of concern is stray voltage that occurs at a level that negatively affects an animal's behavior, health, and more specifically, milk production.

Stray voltage can be caused by a combination of on-farm and off-farm causes. One off-farm contributor to stray voltage is the operation of transmission lines in close proximity and parallel to a distribution line. As a means to minimize new transmission line impacts, new lines are often co-located near a distribution ROW or the distribution line is underbuilt on the new transmission poles. This configuration can contribute to stray voltage issues. To minimize the likelihood of stray voltage occurrences, utilities sometimes propose to relocate these paralleling distribution lines further away from the transmission line and/or burying the distribution line underground. Additionally, the PSC may require the utility to conduct pre-construction and post-construction testing of potentially impacted farms and lines.

Potential Impacts of Stray Voltage

Herd problems can be difficult to diagnose. There are many factors to consider such as the herd's environment, diet, and health. Dairy cow behaviors that may indicate the presence of stray voltage include nervousness at milking time, increased milking time, decreased milk production, increased defecation or urination during milking, hesitation in approaching waterers or feeders, or an eagerness to leave the barn. Some of these symptoms are interrelated. For example, a dairy cow that does not drink sufficient water due to shocks may have decreased milk production. However, these same symptoms can be caused by other factors that are unrelated to stray voltage such as increased mastitis or milk-withholding problems for farms with milking parlors or in barns with milk pipelines. If stray voltage is suspected to be the cause of herd problems, the farm should be tested.

In 1996, the PSC established a stray voltage "level of concern" of 2 milliamps (PSC docket 05-EI-115). The level of concern is not intended as a "damage" level but as a very conservative, below-the-injury level, below the point where moderate avoidance behavior is likely to occur, and well below where a cow's behavior or milk production would be affected. The PSC and DATCP consider that at this level of current, some form of mitigative action should be taken on the farmer's behalf.

The level of concern is further defined with respect to how it should be reduced. If a utility distribution system contributes one milliamp or more to stray voltage on a farm, the utility must take corrective action to reduce its contribution to below the one milliamp level. If the farm electrical system contributes more than one milliamp, the farmer may want to consider taking corrective measures to reduce the level below one milliamp.

Mitigation of Stray Voltage

When stray voltage is a concern, electrical measurement in confined livestock areas should be done using the established PSC-approved testing procedures with appropriate equipment. These testing protocols have been developed to collect a reasonable set of data useful in the analysis of the quantity and quality of stray voltage that may be present under a variety of conditions, and the source (including on-farm versus off-farm sources) of such stray voltage.

Field research shows that cow contact current is often dependent on both on- and off-farm electrical power systems. A common on-farm source of stray voltage is the inappropriate interconnection of equipment grounding conductors with the neutral conductors of the farm wiring system. Mitigation of stray voltage can be achieved through a variety of proven and acceptable methods, such as additional grounding or the installation of an equipotential plane.

Farm operators may receive additional technical assistance from the Wisconsin Rural Electric Power Services (REPS) program (as defined and authorized by Wis. Stat. §§ 93.41 and 196.857). The REPS program is jointly managed by the PSC and DATCP. DATCP (http://datcp.wi.gov/Farms/Wisconsin_Farm_Center/Farm_Rewiring/Stray_Voltage/index.aspx) provides an ombudsman, veterinarian, an energy technical advisor, and a program assistant to the REPS program. The REPS staff provides information about stray voltage and power quality issues; work to answer regulatory questions; conduct on-farm and distribution system investigations that can assist farmers in working with the utility or electrician to resolve a power quality concern; provide a format for dispute resolution; and continue to research electrical issues. The REPS staff also works with farmers, their veterinarians and nutritionists to resolve herd health and production problems.

Water Resources

Potential Impacts to Surface Waters

Surface waters in the form of creeks, streams, rivers, and lakes are abundant throughout Wisconsin. Many of these waters have been designated as special resources that have state, regional, or national significance. Construction and operation of a transmission line across these resources may have both short-term and long-term effects.

The DNR is responsible for regulating public waters, including any crossings of these waters. For certain protected areas the Army Corps of Engineers and/or the US Fish and Wildlife Service might require additional permits and approvals.

Water quality can be impacted not only by work within a lake or river but also by nearby clearing and construction activities. The removal of adjacent vegetation can cause water temperatures to rise and negatively affect aquatic habitats. It can also increase erosion of adjacent soils causing sediment to be deposited into the waterbody, especially during rain events. Construction often requires the building of temporary bridges across small channels, which if improperly installed may damage banks and cause erosion. Overhead transmission lines across major rivers, streams, or lakes may have a visual impact on the users and pose a potential collision hazard for waterfowl and other large birds, especially when located in a migratory corridor.

Areas of Special Natural Resource Interest

Certain waters of the state that possess significant scientific value are identified as Areas of Special Natural Resource Interest (ASNRI) for their protection (Wis. Admin. Code ch. NR 1.05). ANSRI-identified waters include:

- State natural areas (Wis. Stat. §§ 23.27 through 23.29)
- Trout streams (Wis. Admin. Code ch. NR 1.02(7))
- Outstanding resource waters or exceptional resource waters (Wis. Stat. § 281.15)
- Waters or portions of waters inhabited by an endangered, threatened, special concern species or unique ecological communities identified in the natural Heritage Inventory
- Wild rice waters as identified by the DNR and the Great Lakes Indian Fish and Wildlife Commission
- Waters in areas identified as special area management plan or special wetland inventory study (Wis. Admin. Code ch. NR 103.04)

- Waters in ecological significant coastal wetlands along lakes Michigan and Superior as identified in the coastal Wetlands of Wisconsin
- Federal or state waters designated as wild or scenic rivers (Wis. Stat. §§ 30.26 and 30.27)

There are approximately 100,000 miles of trout streams in Wisconsin categorized as Class I, II, or III. High-quality trout streams (Class I) have sufficient natural reproduction to sustain populations of wild trout, at or near carrying capacity. These streams are often small and may contain small or slow-growing trout, especially in the headwaters. Approximately 40 percent of the trout streams are Class I trout streams. Degradation of trout habitat is caused by siltation from erosion, decreased groundwater flow from irrigation, drained wetlands, and poor watershed management. High oxygen demand from organic pollution, channelization, cattle grazing, and increased temperatures from both man-made (*i.e.* stormwater discharges) and natural sources are other common causes of trout habitat deterioration. State laws protect trout streams from pollution and other harmful effects.

Outstanding resource waters (ORW) and exceptional resource waters (ERW) are characterized as being valuable or unique for various features including fisheries, hydrology, geology, and recreation. Regulations require that these shall not be lowered in quality without good justification. By assigning these classifications to specific streams, high quality waters receive additional protection from point source pollution. Of the some 42,000 stream/river miles in the state, over 3,000 stream miles or approximately 8 percent have been designated as ORW and more than 4,500 stream miles or approximately 11 percent have been designated as ERW.

Mitigation of Impacts to Surface Waters

Techniques for minimizing adverse effects of constructing transmission lines in river and stream environments, especially in ASNRI-designated waters include avoiding impacts, minimizing impacts, and/or effective remediation of the impacts. Impacts to surface waters can be avoided by rerouting the line away from the waterbody, adjusting pole placements to span the resource overhead, boring the line under the resource, or constructing temporary bridge structures across the resource. Methods to minimize impacts include avoiding pole placements adjacent to the resource, using DNR-approved erosion control methods, using alternative construction methods such as helicopter construction, landscaping to screen the poles from the view of river users, and maintaining shaded stream cover. After construction, some impacts can be remediated.

There are several methods and cable types for constructing a transmission line under a resource. Lower voltage and distribution lines are commonly directionally bored under the waterway. High voltage lines are rarely constructed underground due to the substantial engineering, costs, and operational hurdles that would need to be overcome for it to be a feasible alternative to overhead construction. Constructing a line underground will minimize construction and esthetic impacts to the resource. However, it does require potentially large construction entrance and exit pits on either side of the resource. There are also concerns about the potential for frac-outs which can release drilling fluids into the waterbody and subsurface environment.

The use of properly designed temporary bridge structures avoids the necessity of driving construction equipment through streams (Figure 5). Temporary bridges consist of timber mats that can allow heavy construction traffic to cross streams, creeks, and other drainage features without damaging the banks or increasing the potential for soil erosion. Temporary bridges should be located to avoid unique or sensitive portions of these waterways, i.e., riffles, pools, spawning beds, etc.

Figure 5 Temporary Bridge Structure Spanning a Waterway

Proper DNR-approved erosion control is necessary for all construction activities, especially those that may affect water resources. DNR Best Management Practices (BMP) should be employed before, during, and immediately after construction of the project to reduce the risk of excess siltation into streams. Erosion controls must be regularly inspected and maintained throughout the construction phase of a project until exposed soil has been stabilized.

Woodlands and shrub/scrub areas along streams are a valuable buffer between adjacent farm fields and corridors of natural habitats. The vegetation maintains soil moisture levels in stream banks, helps stabilize the banks, and encourages a diversity of vegetation and wildlife habitats. The removal of vegetative buffers from ASNRI-designated stream corridors could raise the temperature of the water temperature. Cool water temperatures are necessary for good trout stream habitat. Existing vegetative buffers should be left undisturbed or minimally disturbed, whenever possible. For areas where construction impacts cannot be avoided, low-growing native tree and shrub buffers along these streams should be allowed to regrow and/or should be replanted so as to maintain the pre-construction water quality in the streams (Figure 6).

Figure 6 Restored River Bank Following Construction

Wetlands

Potential Impacts to Wetlands

Wetlands occur in many different forms and serve vital functions including storing runoff, regenerating groundwater, filtering sediments and pollutants, and providing habitat for aquatic species and wildlife. The construction and maintenance of transmission lines can damage wetlands in the following ways:

- Heavy machinery can crush wetland vegetation and wetland soils.
- Wetland soils, especially very peaty soils can be easily compacted, increasing runoff, blocking flows, and greatly reducing the wetland's water holding capacity.
- The construction of access roads can change the quantity or direction of water flow, causing permanent damage to wetland soils and vegetation.
- Construction and maintenance equipment that crosses wetlands can stir up sediments, endangering fish and other aquatic life.
- Transmission lines can be collision obstacles for sandhill cranes, waterfowl and other large water birds.
- Clearing forested wetlands can expose the wetland to invasive and shrubby plants, thus removing habitat for species in the forest interior.
- Vehicles and construction equipment can introduce exotic plant species such as purple loosestrife. With few natural controls, these species may out-compete high-quality native vegetation, destroying valuable wildlife habitat.

Any of these activities can impair or limit wetland functions. Organic soils consist of layers of decomposed plant material that formed very slowly. Disturbed wetland soils are not easily repaired.

Severe soil disturbances may permanently alter wetland hydrology. A secondary effect of disturbance is the opportunistic spread of invasive weedy species such as purple loosestrife. These invasive species provide little food and habitat for wildlife.

Local, state, and federal laws regulate certain activities in wetlands. When fill material is proposed to be placed in a federal wetland, a permit is required from the U. S. Army Corps of Engineers (USACE) under the Clean Water Act (CWA), Section 404. When a CWA, Section 404 permit is required, DNR must determine if the proposed activity is in compliance with applicable state water quality standards (Wis. Admin. Code chs. NR 103 and 299). If the proposal is found to be in compliance with state standards, DNR provides a "water quality certification" to the applicant. In the event that fill material is proposed to be placed in non-federal wetlands (those without connections with navigable waters), DNR must determine if the activity is in compliance with the Wisconsin Nonfederal Wetlands Water Quality Certification General Permit. If the project would result in impacts to wetlands associated with waters of the state, then DNR may have primary authority under Wis Stat. ch. 30.

Mitigation of Impacts to Wetlands

To minimize the potential impacts to wetlands, the utility can:

- Avoid placing transmission lines through wetlands.
- Adjust pole placements to span wetlands or limit the number of poles located in wetlands, wherever possible.
- Limit construction to winter months when soil and water are more likely to be frozen and vegetation is dormant.
- Use mats (Figures 7 and 8) and wide-track vehicles to spread the distribution of equipment weight when crossing wetlands during the growing season or when wetlands are not frozen.
- Use alternative construction equipment such as helicopters or marsh buggies for construction within wetlands.
- Clean construction equipment after working in areas infested by purple loosestrife or other known invasive, exotic species.
- Place markers on the top (shield) wire to make the lines more visible to birds if the collision potential is high.

USDA Wetland Reserve Program Lands

Some properties in Wisconsin are enrolled in USDA National Resource Conservation Service (NRCS) programs established to preserve wetlands, grasslands, and farmland. These federal easements may have restrictive land uses not consistent with the construction of a transmission line. In these situations, utilities can negotiate with representatives of the NRCS or avoid these properties and find alternative routes for the transmission line.

Figure 7 Mats Used in a Wet Meadow

Figure 8 Mats Used in a Wooded Wetland

Woodlands

Potential Impacts to Woodlands

Wisconsin forests provide recreational opportunities, wildlife and plant habitats, and timber. Building a transmission line through woodlands requires that all trees and brush be cleared from the ROW. One mile of 100-foot ROW through a forest results in the loss of approximately 12 acres of trees. Transmission construction impacts can include forest fragmentation and the loss and degradation of wooded habitat, aesthetic enjoyment of the resource, and/or the loss of income.

Different machines and techniques are used to remove trees from the transmission ROW depending on whether woodlands consist of mature trees, have large quantities of understory trees, or are in sensitive environments such as a wooded wetland. These can range from large whole tree processors which can cause rutting and compaction of the forest floor to hand clearing with chainsaws in more sensitive environments. These activities are shown in Figures 9 and 10.

Wisconsin statutes (Wis. Stat. § 182.017(7)(e))state that all timber removed for construction of a high-voltage transmission line remains the property of the landowner. Thus, the landowner should discuss the disposition of all timber to be cut with the ROW agent at the time of the easement negotiation. Smaller diameter limbs and branches are often chipped or burned. According to the landowner's wishes, wood chips may be spread on the ROW, piled to allow transport by the landowner to specific locations, or chipped directly into a truck and hauled off the ROW.

Forest Fragmentation

A transmission line ROW can fragment a larger forest block into smaller tracts. Fragmentation makes interior forest species more vulnerable to predators, parasites, competition from edge species, and catastrophic events. The continued fragmentation of a forest can cause a permanent reduction in species diversity and suitable habitat.

This loss of forested habitat increases the number of common (edge) plants and animals that can encroach into what were the forest interiors. This encroachment can have impacts on the number, health, and survival of interior forest species, many of which are rare. Examples of edge species that can encroach into forest interiors via transmission ROWs include raccoons, cowbirds, crows, deer, and box elder trees. Interior forest species include songbirds, wolves, and hemlock trees.

Figure 9 Whole Tree Processor Clearing a Pine Plantation

Figure 10 Hand Clearing Along a Flood Channel

Invasive Plants

Construction vehicles may inadvertently bring into forest interiors invasive and/or non-native plant species. The opening of the forest floor to sunlight through tree clearing of the ROW can further encourage these aggressive, invasive species to proliferate. Examples of problematic invasive species are buckthorn, honeysuckle, and garlic mustard. Invasive species, once introduced, have few local natural controls on their reproduction and easily spread. Their spread can alter the ecology of a forest as they out-compete native species for sunlight and nutrients, further reducing suitable habitat and food sources for local wildlife.

Disease

A specific but common risk to Wisconsin forests is the potential for oak wilt disease. Disturbance in the ROW during transmission line construction or maintenance can contribute to its spread. Red oak, black oak, and Northern pin oak trees are especially susceptible and will often die within one year. The cause of the disease is a fungus which is carried by sap-feeding beetles or spread through common root systems. In the upper Midwest, pruning or removal of oaks should be avoided during late spring and early summer, when the fungus most commonly reproduces.

Other Impacts

A cleared ROW increases access into a forest which may lead to trespassing and vandalism. It can also provide recreation opportunities such as access for hunting, hiking, and snowmobiling.

Mitigation of Impacts to Woodlands

Impacts to woodlands can be minimized by:

- Avoiding routes that fragment major forest blocks.
- Adjusting pole placement and span length to minimize the need for tree removal and trimming along forest edges.
- Allowing tree and shrub species that reach heights of 12 to 15 feet to grow within the ROW.
- Following the DNR guidelines for preventing the spread of exotic invasive plant species and diseases such as oak wilt.

Community Planning

In prior decades, electric transmission lines were constructed from point A to point B in the most direct manner possible without too much regard for communities, crops, natural resources, or private property issues. As these older lines require improvements, they may now be rerouted to share corridors with roads, and to reduce or even avoid, where possible, community and natural resource impacts. At the same time, a continued growth in energy usage will require new electric substations and transmission lines to be sited and constructed. New and upgraded electric facilities will impact many communities and many property owners.

To meet future growth, communities often draft plans for sewers, roads, and development districts, but few cities, towns, or counties include transmission lines in their plans. Transmission lines are costly to build and difficult to site. Cities, towns, and counties can help reduce land use conflicts by:

- dedicating a strip of land along existing transmission corridors for potential future ROW expansions
- identifying future potential transmission corridors and substation sites in new developments
- defining set-backs or lot sizes for properties adjacent to transmission lines so that buildings don't constrain future use of the ROW

Being an active participant in the decision-making process will improve the ability of communities to manage future growth and protect their resources.

The Role of the Public Service Commission

The PSC of Wisconsin regulates Wisconsin's utilities. A three-member board (the Commission) is appointed by the governor to make decisions for the agency provided with analysis by a technical staff with a wide range of specialties.

The PSC staff analyzes transmission line applications to see if the transmission lines are needed and to determine their potential impacts. The size and complexity of the proposed project determines the PSC review process. The PSC considers alternative sources of supply and alternative locations or routes, as well as the need, engineering, economics, safety, reliability, potential for individual hardships, and environmental factors when reviewing a transmission project.

An applicant must receive a Certificate of Pubic Convenience and Necessity (CPCN) from the Commission for transmission line projects that are either:

- 345 kV or greater; or,
- Less than 345 kV but greater than or equal to 100 kV, over one mile in length, and needing some new ROW.

The CPCN review process includes a public hearing in the affected project area.

Projects less than 100 kV and/or less than one mile long must receive from the Commission a Certificate of Authority (CA) if the project's cost is above a certain percent of the utility's annual revenue. The CA review process does not automatically include a public hearing. However, for those cases in which hearings are held, members of the public are encouraged to testify to their views and concerns about the project.

The Commission is responsible for making the final decisions about proposed transmission lines. The Commission decides whether the line will be built, how it is to be designed, and where it will be located. If there is a hearing, the Commission reviews all hearing testimony from PSC staff, the applicant, DNR staff, full parties, and members of the public. The three Commissioners meet regularly in "open meetings" to decide cases before them. The public can observe any open meeting. At these open meetings, the Commission approves, denies, or modifies the proposed project. The Commission has the authority to order additional environmental protections or mitigation measures.

The Public Service Commission of Wisconsin is an independent state agency that oversees more than 1,100 Wisconsin public utilities that provide natural gas, electricity, heat, steam, water and telecommunication services.

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