SECTION H
Tab 2

Wood Pole Line Management Program
Executive Summary Report

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Background

Hydro maintains approximately 2400 km of wood pole transmission lines operating at 69, 138 and 230 kV. These lines consist of approximately 26,000 transmission size poles of varying ages, with the maximum age being 39 years. Almost two-thirds of transmission pole plant assets fall into two age categories; approximately 34% are at or over 30 years, and another 31% are 20 to 30 years old. The remaining asset age is less than 20 years old.

Historically, Hydro's pole inspection and maintenance practices followed the traditional utility approach of sounding inspections only. In 1998, Hydro decided to take core samples on selected poles to test for preservative retention levels and pole decay. The results of these tests raised concerns regarding the general preservative retention levels in wood poles. It is well known in the industry that poles become susceptible to fungi and/or insect attack as the preservative levels deplete.

Between 1998 and 2003, Hydro undertook additional coring and preservative testing. This testing confirmed that there were a significant number of poles, which had a preservative level below what was required to maintain the required design criteria. During this period, certain poles were replaced because the preservative level had lowered to the point that decay had advanced and the pole was no longer structurally sound. These inspections and the analysis of the data confirmed that a more rigorous wood pole line management program was required.

Hydro first initiated the Wood Pole Line Management program as a pilot study in 2003. This pilot, lead to the recommendation that the program continue as a long-term asset management and life extension program. The program was presented to the Board of Commissioners of Public Utilities in 2004 as part of Hydro's capital program and was titled "Replace Wood Poles – Transmission". The proposal was supported in the application by the Hydro internal report titled "Wood Pole Line management Using RCM Principles" by Dr. Asim Haldar, Ph.D, P.Eng.

The Board found that "This approach (by Hydro) is a more strategic method of managing wood poles and conductors and associated equipment and is persuaded that the new WPLM Program, based on RCM principles, will lead to an extension of the life of the assets, as well as a more reliable method of determining the residual life of each asset. One of the obvious benefits of RCM will be to defer the replacement of these assets thereby resulting in a direct benefit to the ratepayers".

The Board found that the project was justified and prudent and approved the expenditures as submitted in the 2005 Capital Budget. (Ref; Board Order P.U. 53(2004).

As part of its 2005 Capital Budget application process, Hydro committed to provide the Board with an update of the 2004 program work, a progress report of the 2005 work and a forecast of the program objectives for 2006 and beyond. This report would be provided with the 2006 Capital Budget Application.

The Program

The Wood Pole Line Management (WPLM) program is a condition-based program, which uses basic Reliability Centered Maintenance principles and strategies. Under the program, line inspection data in each year is analyzed and appropriate recommendations are made for necessary refurbishment and/or replacement of line components (poles/structures, hardware, conductor, etc) in the subsequent year. The inspection data and any refurbishment and/or replacement of assets are recorded in a centralized database for easy access and future tracking.

The program is aimed at early detection and treatment of the wood pole before the integrity of the structures is jeopardized. If the deterioration of the structure is not detected early enough then the reliability of the structure will affect the reliability of the line and the system as a whole. It may also create safety issues and hazards for the Hydro personnel and for the general public.

Update of 2004 Work

The first objective of the 2004 program was to inspect, test and treat at least 3200 poles and associated line components. The program is built on the strategy of focusing on the older lines first and working towards the newer lines. The following table summarizes the inspection accomplishments for 2004.

Regions	Line Name	Year In Service	Voltage Level	Target Number of Poles Inspected	Complete	Inspection rate (poles per week)
Eastern	TL 201	1966	230kV	283	80%	30
	TL 203	1965	230kV	437	100%	
Central	TL 222	1967	138kV	553	100%	51
	TL 223	1966	138kV	177	50%	
	TL 224	1968	138kV	151	100%	
Western	TL 233	1973	230kV	511	100%	36
	TL 245	1969	138kV	239	100%	
	TL 250	1987	138kV	110	9%	
Northern	TL 221	1970	69kV	250	100%	42
	TL 226	1970	69kV	250	50%	
	TL 227	1970	69kV	330	35%	
Total				3291		

The second objective of the 2004 program was to develop and implement an electronic data collection system to facilitate the field data collection and subsequent data analysis.

This objective was started by first developing a definition of the requirements of the electronic data collection system, and the storage database. The intent is to be able to archive the WPLM Inspection data in such a way that it can be easily retrieved and analyzed.

The basic requirements for the hardware were that it be ‘Windows’ compliant, compatible with a ‘ Pocket PC’ type device with a ‘portrait’ oriented input screen and allow for a minimum of one week’s worth of data storage.

For the software the general requirements were that it be configurable with the paper forms already in use, be uploadable from remote locations, provide import/export capabilities to other Microsoft products, allow for the tracking of data and corrective action histories and be connectable with Hydro’s JDE business applications.

ESRI Canada was chosen as the contractor to select the hardware and to develop the electronic data collection software. Some of the hardware units evaluated were Allegro by Juniper systems (currently in use by R Whitewoods Inc.), Panasonic CF-P1, Hewlett Packard Ipaq, and Dolphin 9500. The model selected that best met all these requirements was the Dolphin 9500. Therefore, four units, including spare battery and charger base unit, were purchased.

Once the data collection software was developed, a training session was held with the field personnel. The line crew and supervisors were given training on how to use the new software to collect the inspection data electronically. The training sessions included a field trip to TL 232 to provide hands on use of the program.

The second phase of the program was the development of an Access based database, which stores all of the electronic data for archival and query purposes. A database modeling workshop was held, in which it was determined that the primary requirement for the database is to extract relevant information for further analysis and to provide interaction with other external programs such as EXCEL. From this workshop, the database was created and subsequent training session on the ArcMap software was held. The software and database were installed on Hydro’s network. From this point, all electronic data collected were uploaded to the database. Also, all 2003 and 2004 inspection data, contained in an Excel spreadsheet, were imported to the database. Database query and reporting tools are currently under development.

The fourth objective of the 2004 work was to develop a methodology to assess the consequences of a specific failure mode with particular reference to strength deterioration with increasing line age.

Hydro engineering staff developed the reliability analysis methodology based on the premise that the strength as well as the effects of all loads on the line or on its components can be defined by their respective probabilistic distributions. The respective distribution is based on the sample test data set from Hydro systems or from published data of similar pole age groups and exposures.

The methodology is based on the concept of the transmission line studied as a "series" system where the failure likelihood is primarily controlled by the "weakest link" component. As the component's strength deteriorates over time the failure consequence must be evaluated by assessing individual failure mode. For example a suspension structure subjected to transverse wind load is likely to fail by pole bending below the cross brace point. Therefore it is important to have sufficient fiber strength and section modulus to withstand this load effect. Under vertical loading, the same pole will likely fail by buckling. Therefore it is necessary to ensure that sufficient material left in the cross sectional area to yield the adequate capacity.

Conclusion

In conclusion, the three major objectives for the 2004 program were fully achieved. This included collection of inspection data for 3200 poles and other associated line components, development of an electronic data collector system, and an electronic database to process the data and the development of a sound reliability based methodology to assess and analyze the pole inspection data.

The major thrust of the 2004 program was also to develop a full electronic data collection system as well as an electronic database to manage effectively 26000 poles as well as other line component information. The database is now operating successfully and engineering is analyzing the pole data for further reporting. It is envisaged that all 2005 data will be collected electronically, thus eliminating the paper forms.

A framework for systematically analyzing a large volume of wood pole transmission line inspection data has been developed using the reliability based analysis technique. The method uses a hybrid approach where the uncertainties in load and strength values and the strength deterioration due to aging are taken into account in combination with the condition rating of each pole. This information is then developed into a condition matrix table.

This matrix table provides four possible outcomes for future mitigations. The method is developed only for one failure mode "pole bending" at this time. It is equally applicable to other failure mode scenarios such as vertical failure mode of the cross arm or buckling failure mode of the angle and/or dead end structures. Work is underway in developing the reliability based methodology for these other failure modes and eventually all failure modes will be evaluated using the matrix table. Failure modes will be coordinated with the field inspection data to provide specific mitigation actions for each line component. The ultimate objective is that all failure modes will be evaluated using the "Condition Matrix" table. Figure 1 shows a typical plot for the reliability versus condition matrix for TL 209.

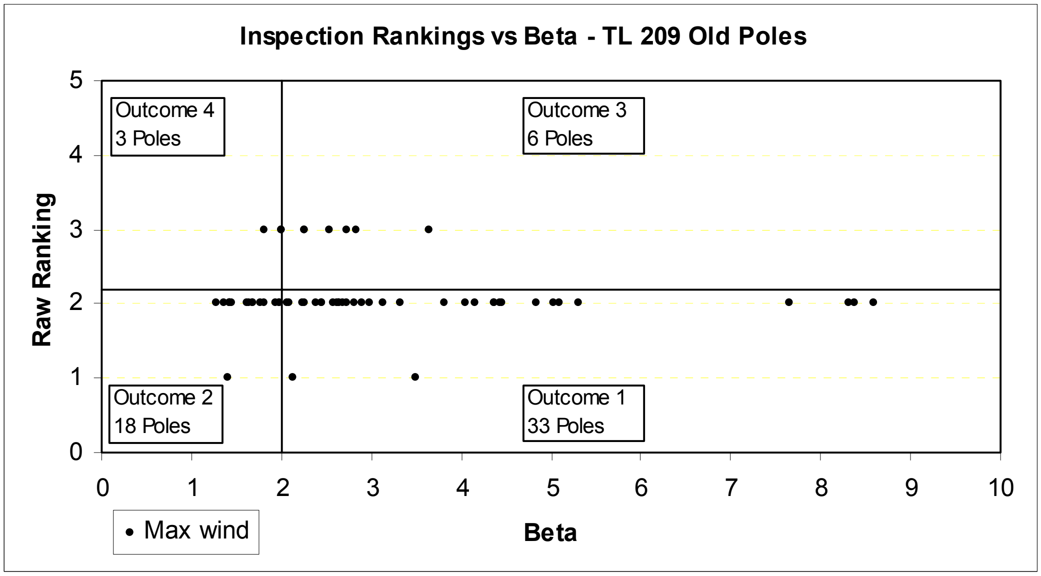

Fig. 1 Summary Plot For Suspension Structures (Pole Bending) –Beta Values Versus Condition Ranking

2005 Work Plans

The inspection and treatment work plan for 2005 is shown summarized in the following table.

Regions	Line Name	Year In Service	Voltage Levels	Number of Poles to be Inspected	Remarks
Eastern	TL 201	1966	230kV	158	
	TL 218	1983	230kV	223	
	TL 212	1866	138kV	156	
	TL 219	1990	138kV	263	
Central	TL 210	1969	138kV	455	
	TL 223	1966	138kV	88	
	TL 234	1981	230kV	245	
Western	TL 243	1978	138kV	159	
	TL 250	1987	138kV	578	
Northern	TL 226	1970	69kV	268	
	TL 227	1970	69kV	298	
	TL 239	1982	138kV	100	
	TL 241	1983	138kV	152	
Labrador	TL 240	1976	138kV	792	
Total				3935	

As well, in 2005, the corrective action work resulting form the analysis of the 2003/2004 inspection data is summarized in the table below.

Total Poles Inspected	Rejections after analysis	Poles to Monitor	Estimated Cost for all 2005 refurbishment
5284	**116**	**421**	**$1,300,000**

The estimated costs for the 2005 refurbishments are within 10% of what was forecasted in the 2005 Capital Budget. At the time of this report about 25% of this work has been completed. The majority of the refurbishments are on the eastern end of the system, and because of outage restrictions, these will be done in the fall of 2005. All refurbishments planned for 2005 will be completed in 2005.

The inspection and treatment plan for the years 2006 and beyond are shown in general terms in the table below. The total pole asset consists of 26000 poles approximately.

	2006	2007	2008	2009	2010
Number of poles	3600	3200	2500	1600	1600
Percent of asset	13.8%	12.3%	9.6%	6.2%	6.2%

This table summarizes the inspection and treatment plan for the years 2006 and beyond. This is stated in general terms only, and is based on the statistical information. Should the inspections reveal some unforeseen conditions, then this inspection and treatment plan may be adjusted. The overriding premise of the whole WPLM program is that it is 'condition based'. That is, the inspections, treatments and corrective actions are all executed on the condition of the equipment.

Attached, for additional general information is a sample inspection sheet for TL 223. This is presented here as a typical example of the type of information that is collected for each of the lines. It is provided to give an extra measure of information and understanding of the type and content of information that is being processed in this program.

SAMPLE INSPECTION SHEET

Inspection Report – TL 223

Report Coverage: 2004 inspection year

Report Issued April 25, 2005

General Line Description:

- Construction Type: Wood Pole H-Frame
- Operating Line Voltage: 138kV
- Geographic Location: Springdale Substation to Indian River Substation
- Year of Construction: 1966
- Line Length: 29.8km
- Basic Line Loading, Original Design:
    - 1" Radial Glaze
    - 110MPh Gust Wind
    - 0.5" Ice / 55MPh Wind

Construction Summary:

- Total Wood Poles: 351
- Pole Size: CL3 (100%)
- Suspension: 92%
- Angles and Deadends: 8%
- Species (based on inspection data)
    - Douglas Fir 0%
    - Southern Pine 98%
    - Western Red Cedar 2%

Pole Length Breakdown (Percent):

45'	50'	55'
31	59	10

Past Performance:

- Significant Line Failures:
    - No significant line failures recorded
- Line Upgrades:
    - No line upgrades recorded
- Previous Inspections:
    - Standard preventive maintenance inspections (20% annually) until 2002. No major pole replacements. Cross arm replacement has been an issue over the last few years with approximately 35 replaced in 2002/2003.

Current Inspection (covered by this report)

- 175 poles (50% of total) inspected
- 7 poles (4%) recorded as possible rejections by field crew
- 1 pole (0.5%) scheduled for replacement after analysis
- Major pole issue: checking
- Minor pole issues: shell separation
- Rotten cross arms are prominent on this line with 10 replacements (13%) in 2005, and 23 (30%) to monitor
- 12 poles after 2005 replacement program will require periodic monitoring
- Preservative retention: average 0.133pcf (minimum required 0.18pcf)

Future Work

- 2005
    - Replace 1 pole, 10 cross arms, and other noted defects in 2005 using existing WPLM CJC
    - Inspect another 90 poles in 2005
- After 2005
    - Periodically monitor 12 poles, cross arms and numerous other wood items
    - Schedule next major inspection for 2014