DETAILED PROJECT DESCRIPTION 2012



2012 Proposed Asset Management Plan

Category Code	Proj Code	Project Description/Scope	CGAAP BUDGET	IFRS BUDGET	Cash Flow (based on IFRS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Cash Flow Total
A Substation Rebuilds																	
A	12A1	T1-L Switch Replacements	110,000	109,000				27,000	27,000					27,500	27,500		109,000
A	12A2	Relay Replacements	25,000	25,000									10,000	15,000			25,000
A	12A3	Battery Bank Replacements	30,000	30,000	2,000	5,000	10,000	13,000									30,000
A	12A4	SF6 Switchgear Modifications	25,000	25,000								5,000	10,000	10,000			25,000
A	12A5	Sub 97 Voltage Conversion Phase II	60,000	60,000				20,000	20,000	20,000							60,000
A Substation Rebuilds Total			**250,000**	**249,000**	**2,000**	**5,000**	**10,000**	**60,000**	**47,000**	**20,000**	**-**	**5,000**	**20,000**	**52,500**	**27,500**	**-**	**249,000**
B Subdivision Rebuilds																	
B	12B1	Silicone Injection of Underground Cable	1,074,000	1,059,000	59,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000		1,059,000
B	12B2	Subdivision Conversions / Rebuilds with Silicone Injection	3,250,000	3,194,000	119,000	200,000	200,000	250,000	315,000	315,000	300,000	300,000	315,000	315,000	315,000	250,000	3,194,000
B	12B3	Replacement of Air Insulated Sectionalizing Enclosures	505,000	486,000	2,000	2,000	30,000	50,000	59,000	109,000		117,000		117,000			486,000
B	12B4	Fully Depreciated and Leaking Transformer Replacements	1,080,000	1,039,000	81,000	88,000	87,000	84,000	83,000	84,000	82,000	93,000	97,000	98,000	92,000	70,000	1,039,000
B	12B5	Residential Secondary Pedestal Replacements	25,000	25,000				5,000	5,000	5,000	5,000	5,000					25,000
B	12B6	Vault Transformer Replacements	255,000	247,000	5,000	50,000	50,000	43,000		2,000		49,000	48,000				247,000
B	12B7	Installation of Underground Backup Supply	65,000	64,000	1,000	2,000			30,000			31,000					64,000
B	12B8	Installation of Fault Indication on Padmounted Transformers	15,000	15,000	1,000	14,000											15,000
B	12B9	Sub 1, 2 & 28 Underground Conversion	192,000	188,000	2,000	2,500	2,500			38,000	38,000	38,000	38,000	29,000			188,000
B Subdivision Rebuilds Total			**6,461,000**	**6,317,000**	**270,000**	**458,500**	**469,500**	**532,000**	**592,000**	**653,000**	**525,000**	**733,000**	**598,000**	**659,000**	**507,000**	**320,000**	**6,317,000**
C Main Feeders																	
C	12C1	Wellington and Glanworth extension	400,000	390,000	2,000	2,000	97,000	97,000	96,000	96,000							390,000
C	12C2	Main Feeder Reinforcements	300,000	295,000	10,000	10,000	10,000	10,000	51,000	51,000	51,000	51,000	51,000				295,000
C	12C3	26M43 Feeder Construction Phase 1	120,000	118,000	59,000	59,000											118,000
C Main Feeder Total			**820,000**	**803,000**	**71,000**	**71,000**	**107,000**	**107,000**	**147,000**	**147,000**	**51,000**	**51,000**	**51,000**	**-**	**-**	**-**	**803,000**
D City Works																	
D	12D1	City of London (Road Authority) Relocations	1,797,000	1,765,000	150,000	150,000	150,000	150,000	200,000	200,000	200,000	200,000	200,000	109,000	56,000		1,765,000
D City Works Total			**1,797,000**	**1,765,000**	**150,000**	**150,000**	**150,000**	**150,000**	**200,000**	**200,000**	**200,000**	**200,000**	**200,000**	**109,000**	**56,000**	**-**	**1,765,000**
E Developer Projects																	
E	12E1	Developer Driven Distribution Circuits Expansions and Relocations	620,000	604,000	60,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	19,000				604,000
E	12E2	Residential Secondary Service Upgrades	325,000	321,000	20,000	20,000	20,000	20,000	35,000	35,000	30,000	30,000	30,000	30,000	30,000	21,000	321,000
E	12E3	New Single Family Residential Underground Distribution	1,550,000	1,496,000	85,000	85,000	85,000	135,000	135,000	135,000	135,000	135,000	135,000	160,000	170,000	101,000	1,496,000
E	12E4	New Multi-Housing Underground Distribution	650,000	630,000	35,000	50,000	50,000	60,000	60,000	31,000	60,000	60,000	60,000	60,000	60,000	44,000	630,000
E	12E5	New Commercial Distribution Services	2,100,000	2,025,000	125,000	125,000	125,000	125,000	175,000	175,000	175,000	280,000	190,000	190,000	190,000	150,000	2,025,000
E Developer Projects Total			**5,245,000**	**5,076,000**	**325,000**	**355,000**	**355,000**	**415,000**	**480,000**	**451,000**	**475,000**	**580,000**	**434,000**	**440,000**	**450,000**	**316,000**	**5,076,000**
F Network																	
F	12F1	Replacement of Network Vaults / Manholes / Transformers	1,075,000	1,047,000			15,000	50,000	170,000	100,000	170,000	100,000	170,000	150,000	100,000	22,000	1,047,000
F	12F2	Replacement of Primary & Secondary Cables	350,000	341,000	25,000	26,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	20,000	341,000
F	12F3	Elimination of the East End Network Phase 3	275,000	270,000			15,000	55,000	55,000	25,000		10,000	55,000	55,000			270,000
F	12F4	Manhole Cable Rebuilds	150,000	147,000				27,000	45,000				30,000	45,000			147,000
F Network Total			**1,850,000**	**1,805,000**	**25,000**	**26,000**	**60,000**	**162,000**	**300,000**	**155,000**	**200,000**	**140,000**	**285,000**	**280,000**	**130,000**	**42,000**	**1,805,000**
G Overhead Line																	
G	12G1	Replacement of Fully Depreciated Poles	300,000	292,000		2,000	2,000	2,000	60,000	60,000	60,000	54,000	52,000				292,000
G	12G2	Replacement of Poles Susceptible to Pole Fires	520,000	506,000	2,000	4,000	100,000	100,000	100,000	100,000			100,000				506,000
G	12G3	Rebuild of Fully Depreciated Overhead Areas	1,810,000	1,770,000	50,000	150,000	150,000	200,000	100,000	200,000	200,000	200,000	200,000	200,000	120,000		1,770,000
G	12G4	Sub 1, 2 & 28 Overhead Conversion	859,000	841,000	100,000	100,000	100,000	100,000	69,000				100,000	100,000	100,000	72,000	841,000
G	12G5	Porcelain Arresters Replacement Program	100,000	98,000		2,000	35,000	35,000	26,000								98,000
G	12G6	Removals & Restoration of Overhead Plant	30,000	30,000						5,000	5,000	5,000	5,000	5,000	5,000		30,000
G Overhead Line Total			**3,619,000**	**3,537,000**	**152,000**	**258,000**	**387,000**	**437,000**	**355,000**	**365,000**	**265,000**	**259,000**	**457,000**	**305,000**	**225,000**	**72,000**	**3,537,000**
H Automation																	
H	12H1	Recloser Installations	195,000	187,000									63,000	70,000	54,000		187,000
H	12H2	Network Temperature Monitoring Devices	10,000	10,000										5,000	5,000		10,000
H	12H3	RTU Replacement Program	50,000	49,000									24,000	25,000			49,000
H	12H4	Control Room New Monitors	50,000	50,000								25,000	25,000				50,000
H Automation Total			**305,000**	**296,000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**25,000**	**112,000**	**100,000**	**59,000**	**-**	**296,000**
Total E&O Capital Budget			**20,347,000**	**19,848,000**	**995,000**	**1,323,500**	**1,538,500**	**1,863,000**	**2,121,000**	**1,991,000**	**1,716,000**	**1,993,000**	**2,157,000**	**1,945,500**	**1,454,500**	**750,000**	**19,848,000**

2012 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	12A1
Project Name:	T1-L Switch Replacements
Project Driver:	REL

Project Title:	T1-L Switch Replacements
Project Manager:	Cole Tavener
Project Tech.:	Rolf Reiners
Supporting Reference Material	2008 Substation Deficiency Report

Description/Justification

As part of London Hydro's continuous substation assessment process, a number of T1-L switches were found with considerable amounts of rust and even holes. Previous measures to protect the metal structure's surface have prolonged the in-service life of these devices, but have not provided a permanent solution.

The purpose of this capital plan is to continue a phased replacement of the identified depreciated T1-L switches based on a priotized sequence.

COST ESTIMATE

Section - 110	**$109,000**

Prepared By:	Cole Tavener, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

T1-L Switch Replacements

Project 12A1

T1-L is the designation provided to primary side substation transformer switches. London Hydro, through its continuous substation assessment process has determined that a particular style of T1-L switch (S&C) is susceptible to considerable amounts of rust, holes, and/or collecting water. These defects pose potential safety and reliability issues that must be addressed. The problem with the identified switches is a ledge design on the incoming chamber. Newer London Hydro T1-L switches do not contain a ledge and therefore should not suffer from the above mentioned defects. Below are two pictures: one illustrating the defective T1-L switches with an incoming ledge chamber design (1) and the second showing the latest London Hydro standard T1-L switch.

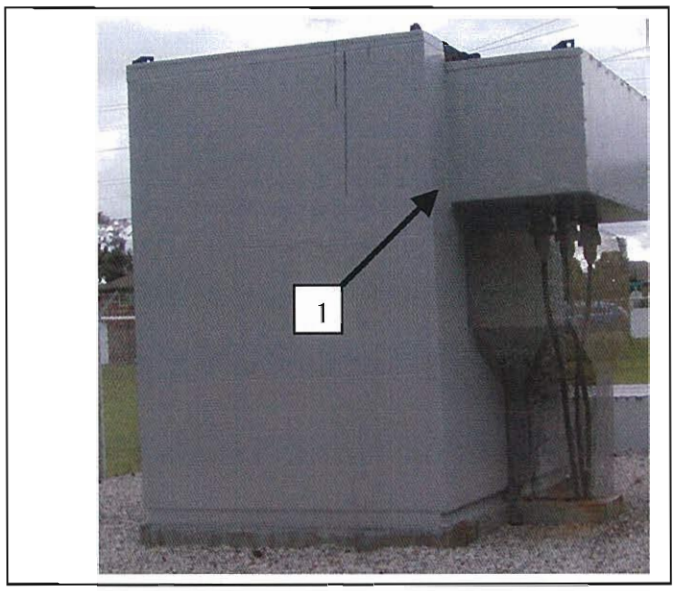


Figure 1 – Identified Defective T1-L Switch



Figure 2 – Replacement T1-L Switch

2012 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	12A2
Project Name:	Relays
Project Driver:	REL

Project Title:	Relay Replacement Program
Project Manager:	Cole Tavener
Project Tech.:	Rolf Reiners
Supporting Reference Material	2008 Substation Deficiency Report, 4kV Aging Infrastructure System Planning Report - 2011

Description/Justification

Relays are used to monitor system conditions and trip circuit breakers during a fault. London Hydro has a population of 60 electromechanical relays, devices that are nearing end-of-life due to technical obsolescence. In co-ordination with the 4kV system plan, a program will be executed to replace electromechanical relays with digital relays. In 2013, the electromechanical relays at Substation 25 will be replaced.

COST ESTIMATE

Section - 110	**$25,000**

Prepared By:	Cole Tavener, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Relay Replacement Program
Project 12A2

The protection relays at many of London Hydro's substations are nearing end-of-life due to technical obsolescence. To address this situation a program for relay replacements has been developed in co-ordination with the 4kV System Plan. Aged electromechanical relay will be replaced with modern digital relays. The digital relays will enhance protection reliability and provide additional information to the control room during faults.



Figure 1: Substation 25 Electromechanical Relays



Figure 2: Substation 96 Digital Relays

2012 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	12A3
Project Name:	Battery Banks
Project Driver:	REL

Project Title: Battery Bank Replacement Program

Project Manager:	Cole Tavener	**Project Tech.:**	Rolf Reiners

Supporting Reference Material: 2008 Substation Deficiency Report

Description/Justification

Battery Banks supply the DC power required to operate circuit breakers and relays during power failures.

The 48V SAFT-NITE battery bank at Substation 37, installed in 1997, will be replaced in 2012.

COST ESTIMATE

Section - 110	**$30,000**

Prepared By:	Cole Tavener, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Battery Bank Replacement Program
Project 12A3

Battery banks installed in substations provide DC power to enable the operation of circuit breakers and relays during a power failure. The batteries are inspected annually and tested once every four years. Battery banks are replaced based on age and condition.



Figure 1: Battery Charger

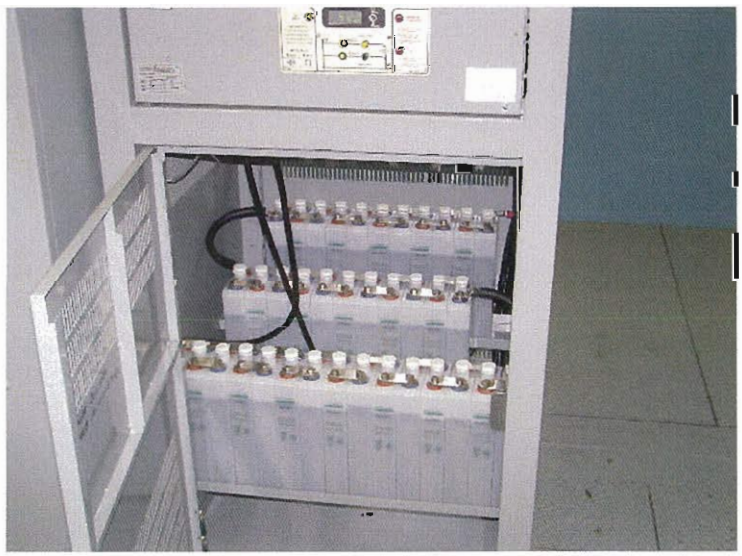


Figure 2: Batteries

2011 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	12A4
Project Name:	SF6 Switchgear
Project Driver:	REL

Project Title:	SF6 Switchgear Modifications

Project Manager:	Cole Tavener	**Project Tech.:**	Rolf Reiners

Supporting Reference Material	Downtown SF6 Switchgear Failure Investigation

Description/Justification

This project will address the **development** of a new control system for the four SF6 switches installed on the 27.6kV downtown loop.

1) Decade Developments
2) Old Oak Properties
3) Galleria
4) One London Place

COST ESTIMATE

Section - 110	**$25,000**

Prepared By:	Cole Tavener, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

SF6 Switchgear Modifications
Project 12A4

The original 27.6kV supply to downtown London was provided using a ringed underground cable. To allow the ring to be sectionalized four SF6 insulated switches were installed. The switches are remotely operable to enable expedient restoration of the downtown load in the event of a fault. In 2011, the switch controllers used to enable remote operation experienced multiple failures. Subsequent investigation by the manufacturer revealed that the controllers, now over 15 years old, are no longer supported. This project will address the **development** of a new controller required to maintain the current level of reliability for the 27.6kV downtown load.

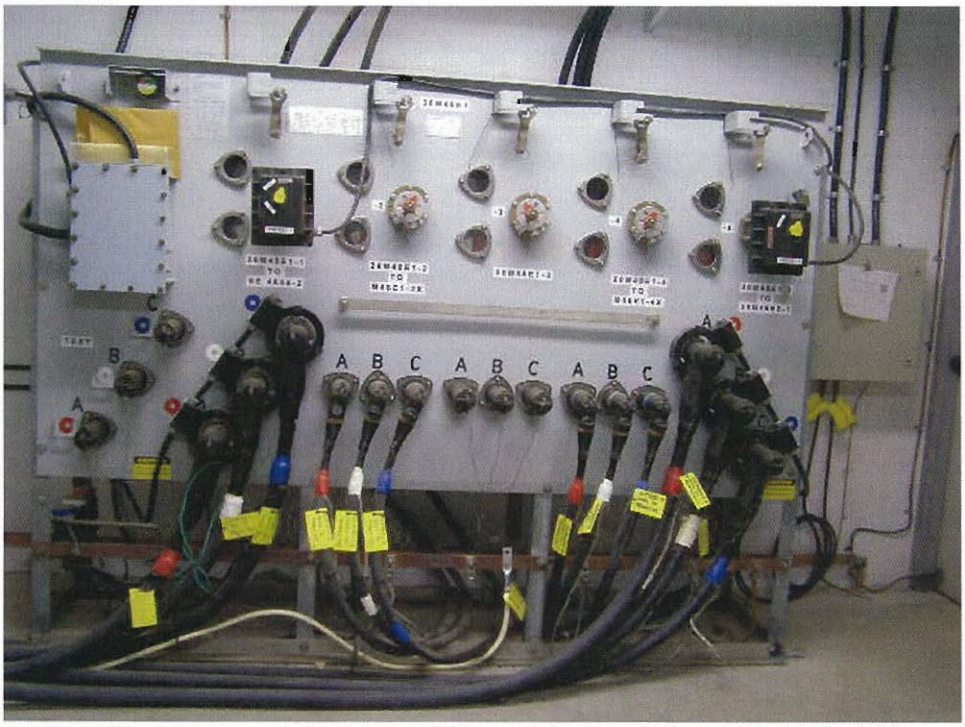


Figure 1: Old Oak SF6 Switch



Figure 2: SF6 Switch Controller

2011 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	12A5
Project Name:	Substation 97
Project Driver:	REL

Project Title:	Substation 97 Voltage Conversion
Project Manager:	Rod Doyle
Project Tech.:	
Supporting Reference Material	2008 Substation Deficiency Report

Description/Justification

The 2008 Substation Deficiency Report identified Substation 97 as the most deficient substation owned by London Hydro. Work completed in 2010 and 2011 has converted more than half of the substation's 8.32kV load to the 27.6kV system. In 2012, further conversions will occur and new 27.6/8.32kV transformation capable of supplying the remaining load will be installed.

COST ESTIMATE

Section - 110	**$60,000**

Prepared By:	Cole Tavener, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Substation 97 Voltage Conversion
Project 12A5

Two of Substation 97's three 8.32kV feeders in the rural area south of the 401 were rebuilt at 27.6kV in 2010. The station was reconfigured to provide a simpler and more efficient supply in 2011. In 2012, further load transfers to the 27.6kV system will occur and a bank of 27.6/8.32kV step-down transformers will be installed to provide back-up for the remaining load supplied by Substation 97.



Figure 1 – Substation 97



Figure 2 – Substation 97 Overhead Bus

2012 ASSET MANAGEMENT PLAN
Project Sheet

Project Number:	12B1
Project Name:	Cable Silicone Injection
Project Driver:	REL

Project Title: Silicone Injection of Underground Cable

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Scott Lasseter/Dane Kirilovic

Supporting Reference Material

Engineering Report Update 2010, **Rehabilitation of Aging Underground Residential Distribution Systems** (2012 addendum)
Asset Sustainment Plan, 2012-2026 Report

Description

This item covers the rehabilitation of underground cable by means of silicone injection in three subdivisions. The total length to be injected is estimated at 20 km of polymeric cable (25+ years old). These three areas were selected using the SPOORE analysis (modeled in the GIS based software Geo Media), which ranks the subdivisions' performance using a five-year history of failures on cables and transformers, as well as a visual representation of leaking transformers from the annual OEB inspections.

Silicone injection technology increases the lifespan of polymeric cable, adding up to another 40 years of service. In 2011, London Hydro addressed approximately 50 km of old cable.

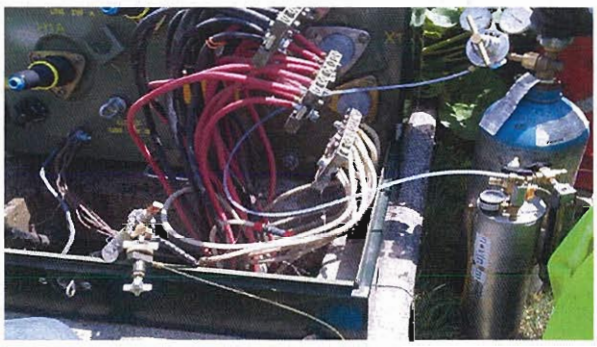
The rehabilitation will include replacement of transformers that are deteriorated or leaking, which also improves the customers' downtime by allowing more effective switching. The new transformers are equipped with dual load break switches that allow flexible open points.

It is estimated that at this rate of cable rehabilitation work, the existing population of cable that has passed its lifetime could be addressed over six years. Eventually, a consistent multi-year plan of rehabilitation could bring London Hydro to a complete renewal of all the underground plant that should be retired; Accordance to the 15 year Asset Sustainment Plan, 50 km of cable rehabilitation work per year is an adequate yearly target for replacement.

Subdivisions: Whiteoaks North, Hazelden Park, and Ronark

COST ESTIMATE

Section - 145	**$1,059,000**



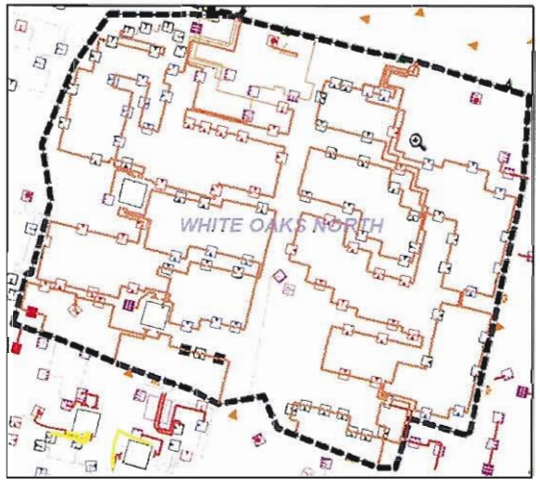
Prepared By: Hassan El Madhoun, E.I.T.
Assistant Distribution Engineer

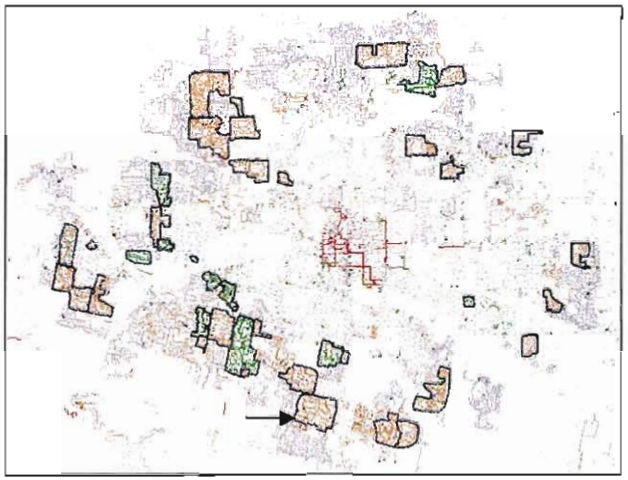
Approved By: Ken Walsh, P.Eng.
Chief Engineer &
V.P. of Operations

1. *White Oaks Park North (27.6 kV Supply)*

This subdivision occupies an area of approximately 1.1 sq km and has 15.8 km of underground primary cable. White Oaks supplies over 1,600 customers in an area located at the south of the city, between Bradley Ave and Southdale Rd, west of Wellington St. The cable in general is over 35 years old and two cable failures occurred on this stretch of cable in the course of five years. Adding to that, customers experienced sustained power interruptions due to multiple transformer failures and leaking transformers.

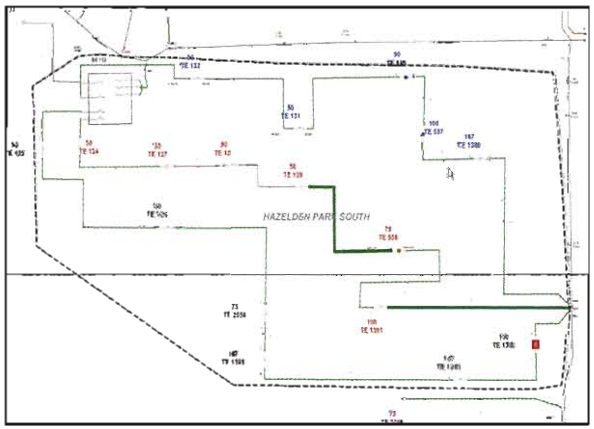
This work will include the rehabilitation of up to 16 km of cable by means of cable silicon injection. Almost 20% of the transformers will be changed out as part of this project scope. The SPOORE analysis identifies this subdivision as the second most unreliable based on outage data from the past five years.

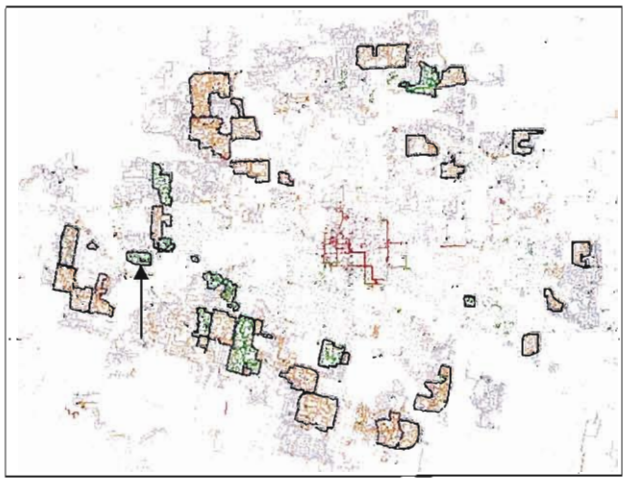




2. *Hazelden Subdivision (4.16 kV Supply)*

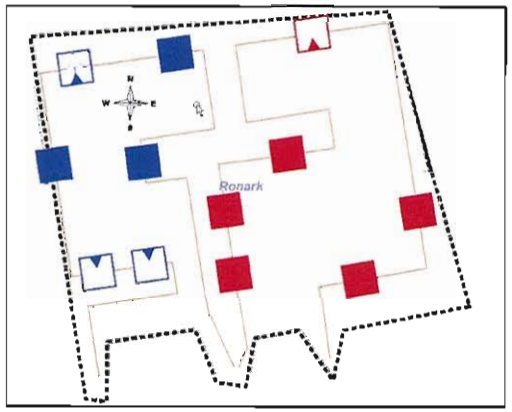
Based on the 2010 SPOORE results, Hazelden subdivision was ranked the 5th worst reliable subdivision. There are approximately 159 customers fed via 17 transformers and 3.5 km of primary distribution cable. The scope of work is to complete the rehabilitation of this underground subdivision by injecting 2.6 km of cable and replacing 7 transformers. Hazelden subdivision will remain supplied by SUB-44.

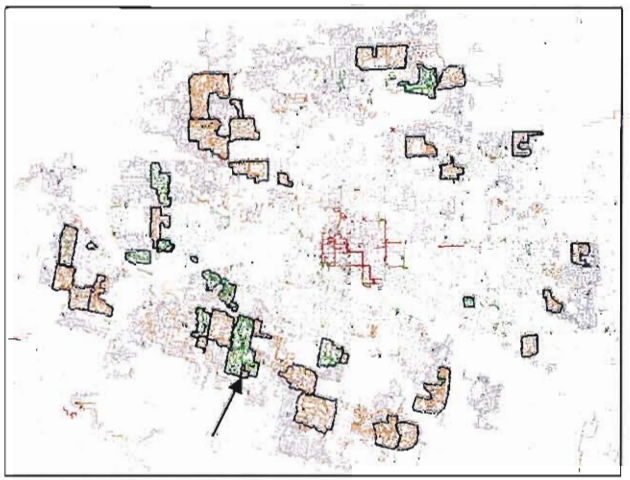




3. Ronark (27.6 kV Supply)

In 2010 this subdivision experienced multiple cable faults and transformer failures. All the cable in this subdivision is over 35 years old. Theer are 8 live front transformers that are depreciated. Customers in this relatively small subdivision experienced outages as a direct result of a cable failure. This subdivision has a higher density of customers/km of cable in comparison to other subdivisions. The entire length of cable in this subdivision will be treated by silicon injection; all the live front transformers will be replaced with mini-pads.





2012 ASSET MANAGEMENT PLAN
Project Sheet

London Hydro

Project Number:	12B2
Project Name:	Subdivision Rehabilitation
Project Driver:	REL

Project Title: Subdivisions Conversions / Rebuilds / Silicone Injection

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Jamie Macpherson

Supporting Reference Material

Engineering Report Update 2010, **Rehabilitation of Aging Underground Residential Distribution Systems** (2012 addendum)
Asset Sustainment Plan, 2012-2026 Report

Description

This budget item covers a complete rehabilitation by voltage conversion of two underground residential subdivisions currently supplied at 4.16 kV. Subdivisions proposed for voltage conversion in 2012 experienced anywhere between 1-3 cable failures and up to 5 transformer failures per subdivision. The subdivision selection is based on a comprehensive SPOORE analysis which at the least considers reliability, safety, risk and aging of underground cable; the results of this is based a 5-year performance window.

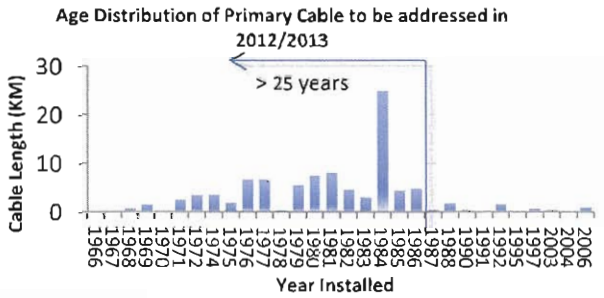
Silicone injection technology increases the lifespan of polymeric cable (XLPE), adding up to another 40 years of useful life to the cable. All depreciated cable will be refurbished by means of cable silicone injection except when the cable is only rated for 15 kV and 5 kV. Approximately 27 km of cable is 28 kV rated and is planned for silicone injection. In addition, 1.5 km of new XLPE cable will be installed where cable injection is not a viable option or when system reconfiguration is necessary.

With the conversion to 27.6 kV, all transformers will be replaced; this will also address many depreciated live front and pozitek type transformers still in the system. Furthermore, six depreciated switching enclosures will be addressed as part of this underground residential subdivision rehabilitation effort.

Subdivisions: Lockwood Park (4kV), Norton Estates II (4kV)

COST ESTIMATE

Section - 145	**$3,194,000**

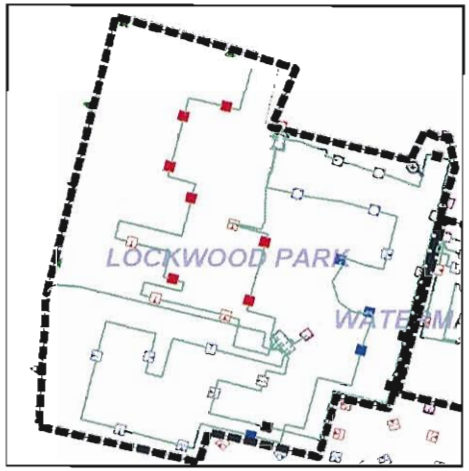


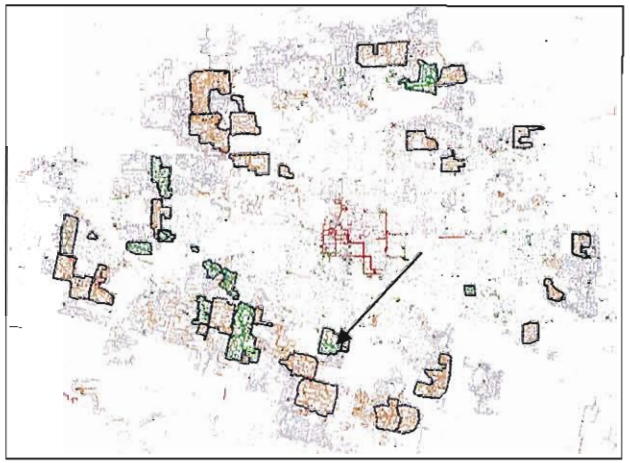
Prepared By:	Hassan El Madhoun, E.I.T. Assistant Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

1. ***Lockwood (4.16 kV Supply)***

Lockwood is a relatively small subdivision generally located at the south area of the city. A total of approximately 400 customers in an area of 0.5 sq km are supplied via 6 km of underground primary cable. Almost all the cable in this subdivision is 25+ years old. On average, the 36 pad mounted transformers in Lockwood Park have been in service for 30 years, some of which are live front and pozitek. In recent years, customers in this subdivision experienced multiple sustained power interruptions due to three cable failures and a transformer failure.

Not all the primary cable in this subdivision is rated for 27.6kV supply. For that reason approximately 1 km of cable will need to be replaced to accommodate the conversion. The remaining 5 km of existing cable, which is rated for 28kV, will be silicon injected. An additional 2.1 km of cable will be installed to close loops for improved reliability and operability during unplanned outages. The scope of the Lockwood conversion plans also includes the replacement of all transformers as well as one switching enclosure.

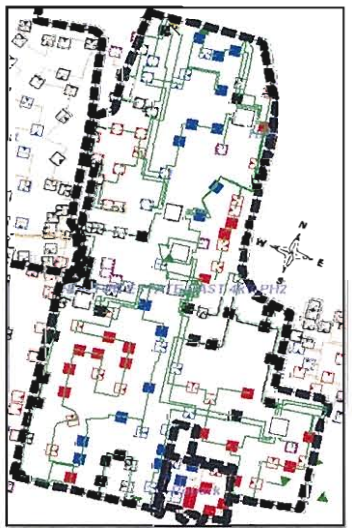


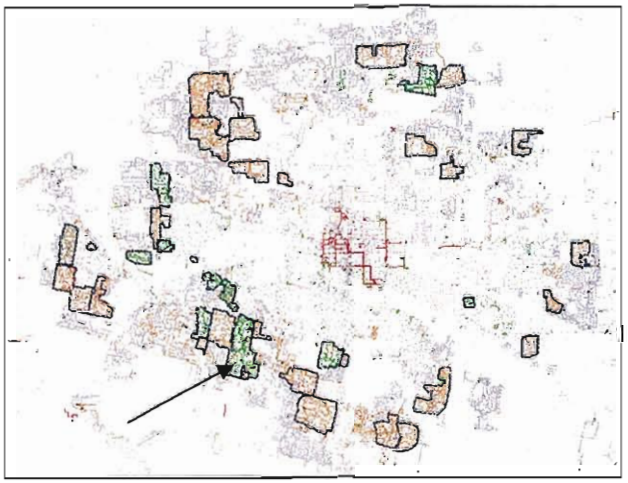


2. ***Norton Estate (4.16 kV Supply)***

Norton Estates located in the south-west area of the city, near Wharncliff Rd and Southdale Rd, is the largest subdivision in area and in length of primary cable. A total of 22.5 km of primary cable supply 1,250 customers via 119 transformers. Virtually all the cable is 25+ years old. This subdivision has experienced one cable fault and over five outages due to failures of aging transformers. The average age of transformers is approximately 32 years.

The scope of this work is to silicon inject 22 km of cable, replace 0.5 km where cable cannot be injected, and install an additional 2-3 km of cable for system re-configuration. Norton Estate subdivision has 6 air insulated switching enclosures that have been in service for over 40 years. Four are underutilized and will be removed by reconfiguring the system and the other two will be replaced with standard 200A LC switchgear. All transformers will be replaced to accommodate the 4 kV to 27.6 kV conversion plans.





2012 ASSET MANAGEMENT PLAN

London Hydro

E&O Department

Project Number:	12B3
Project Name:	Replacement of SE's
Project Driver:	REL

Project Title: Replacement of Air Insulated Sectionalizing Enclosures

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Jamie Macpherson

Supporting Reference Material

Asset Sustainment Plan-2012-2026 Report,
Distribution Reliability Report: ***Performance Review and a New Perspective for In-service 27.6 kV Three-Phase Air Insulated Sectionalizing Enclosures,*** May 2006

Description/Justification

Year 2012 will be the seventh year into this long-term project intended to eliminate air-insulated switchgear from the 27.6 kV distribution system.

To date, over 71 units have been addressed since the start of this multiyear program. It is anticipated that 8 more units (such as the one below) will be addressed in 2012; at this rate, it will take another 7-8 years to complete the total 151 SE's identified at the start of the program.

COST ESTIMATE

Section - 145	**$486,000**

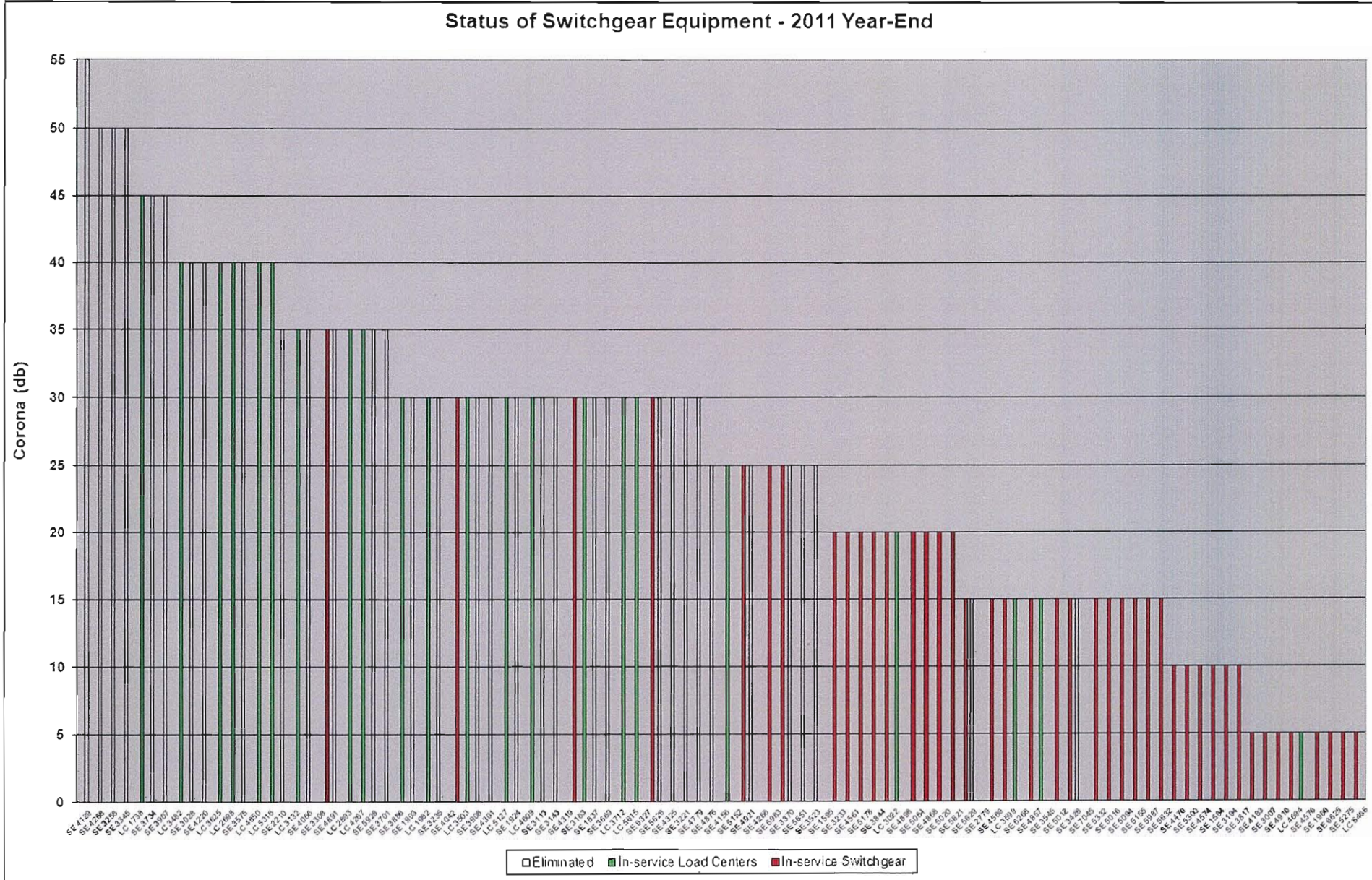


Prepared By: Hassan El Madhoun, E.I.T.
Assistant Distribution Engineer

Approved By: Ken Walsh, P.Eng.
Chief Engineer &
V.P. of Operations

Replacement of Air-Insulated Sectionalizing Enclosures Project 12B3

Earlier research and analysis into the failures of air-insulated switching enclosures on the 27.6 kV system led to the internal publication of an in-depth report at London Hydro in 2006. The findings and recommendations have helped with targeting the most prone-to-failure units which were eliminated without delay. The work conducted over the past six years shows a remarkable, positive impact in performance. From the time the higher-risk units started to be changed out (2006) to-date, almost half of the total number of units have now been addressed. The chart further illustrates that of the equipment that was found at some risk, the majority have been dealt with either by replacement (green bars), or by system reconfiguration (transparent bars). The existing units (red bars) that remain in service will be addressed in the following years as part of this multi-year program.



2012 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	12B4
Project Name:	Leaking Transformers
Project Driver:	SAF

Project Title:	Fully Depreciated and Leaking Transformer Replacement

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Steve Lavell

Supporting Reference Material

OEB Audits conducted by field staff

Description/Justification

London Hydro field staff conduct annual audits of padmounted transformers in accordance with the requirements of the Ontario Energy Board. These audits are meant to identify defective/end of life transformers and transformers which may be weeping oil around the primary and secondary bushings. These matters are usually caused by transformer aging and the degradation of the sealing gaskets.

This project covers the cost to identify and replace the fully depreciated and leaking transformers. This budget item also includes funding for the replacement of transformers that have failed in the field and require replacement.

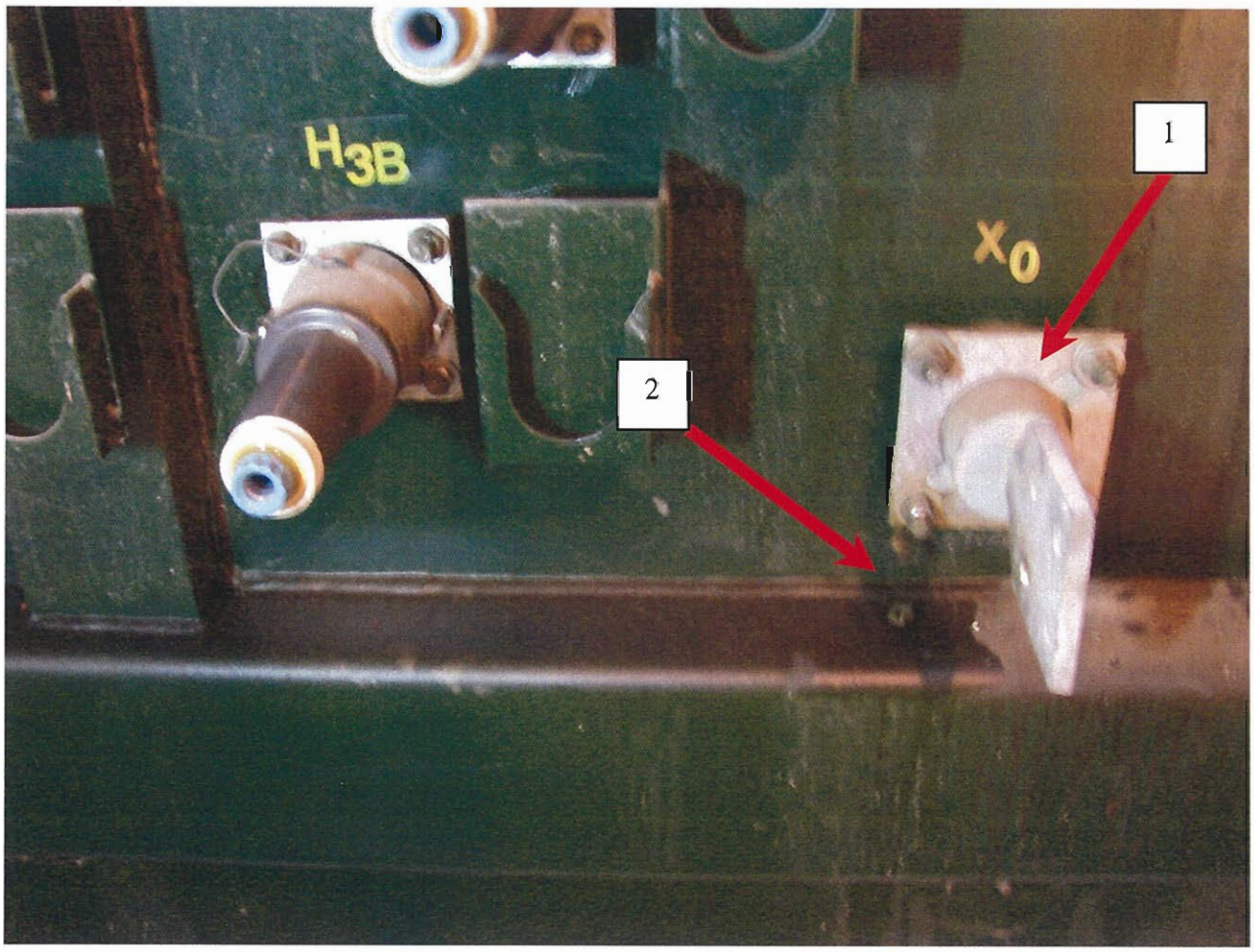
COST ESTIMATE

Section - 145	**$1,039,000**

Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Fully Depreciated and Leaking Transformer Replacement
Project 12B4

London Hydro performs OEB audits on the condition of the padmounted transformers in our system. These audits help us identify potentially defective/end of life transformers for replacement. London Hydro takes its environmental responsibilities seriously and as such continues to invest capital dollars into the identification and removal of these suspect transformers. This budget item also includes funding for the replacement of transformers that have failed in the field and require replacement. The cost to replace a typical suspect transformer ranges between $7,500 - $15,000 depending on transformer type. The allocated amount for this project is $1,039,000.



1) Neutral Bushing
2) Oil Leak

2012 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	12B5
Project Name:	Secondary Pedestal Replacement
Project Driver:	REL

Project Title:	Residential Secondary Pedestal Replacement

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Scott Lasseter

Supporting Reference Material

Asset Sustainment Plan, 2012-2026 Report
OEB Audits conducted by field staff

Description/Justification

London Hydro has a large number of single phase low voltage junction pedestals active in our system. These units are typically used in residential areas. They allow one common bus cable to be divided into several service cables to feed multiple meters. As per the Asset Sustainment Plan report some of these units are at the end of life; they are in excess of 30 years old and the enclosures are starting to corrode. It has also been found that the connections and barriers within the existing units are beginning to fail.

This budget targets the replacement of these existing units with our new non-metalic units shown below. The replacements will be prioritized based on the findings from our OEB audits conducted by field staff and address areas where problems have been experienced in the past in compliance with the Asset Sustainment Plan report.

COST ESTIMATE

Section - 145	**$25,000**

New replacement unit shown to right



Prepared By:	Jagoda Borovickic Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

2012 ASSET MANAGEMENT PLAN
Project Sheet

London Hydro

Project Number:	12B6
Project Name:	Vault Rebuilds
Project Driver:	SAF

Project Title: Vault Transformer Replacements

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Jamie Macpherson

Supporting Reference Material

4 kV Aging Infrastructure System Planning Report - 2011
Asset Sustainment Plan, 2016-2026 Report
OEB Audits conducted by field staff

Description

The Asset Sustainment report identified various indoor transformer vaults as being in poor condition. These vaults were also inspected by London Hydro staff. The following vaults have been identified to be replaced in 2012:

Wilton Grove Public School (TV 1981)

This public school vault contains oil filled transformer (non-PCB). This transformer will be replaced with padmount transformer located outside the vault. This budget item will also allow for the installation and termination of the primary cables from the new transformation to the new riser location and secondary cables from the new transformation to the disconnects inside the vault.

Craig Street (TV 630, TV 631, TV 632 & TV 625)

The 4 kV Aging Infrastructure System Planning Report identified various parts of the system fed out of SUB 1 as being in poor condition. The area will be converted from the 4.16 kV distribution system to the 27.6 kV distribution system. The underground systems and dry-type transformer vaults in these areas are approximately 50 years old and in poor condition. This budget item will allow for the replacement of these dry-type transformers with padmount or pole mount transformers located outside the vaults. It will also allow for the installation and termination of secondary cables from the new transformation to the new disconnects inside the vaults.

All transformer vaults proposed for replacement in 2012 meet the replacement criteria identified in the Asset Sustainment Plan.

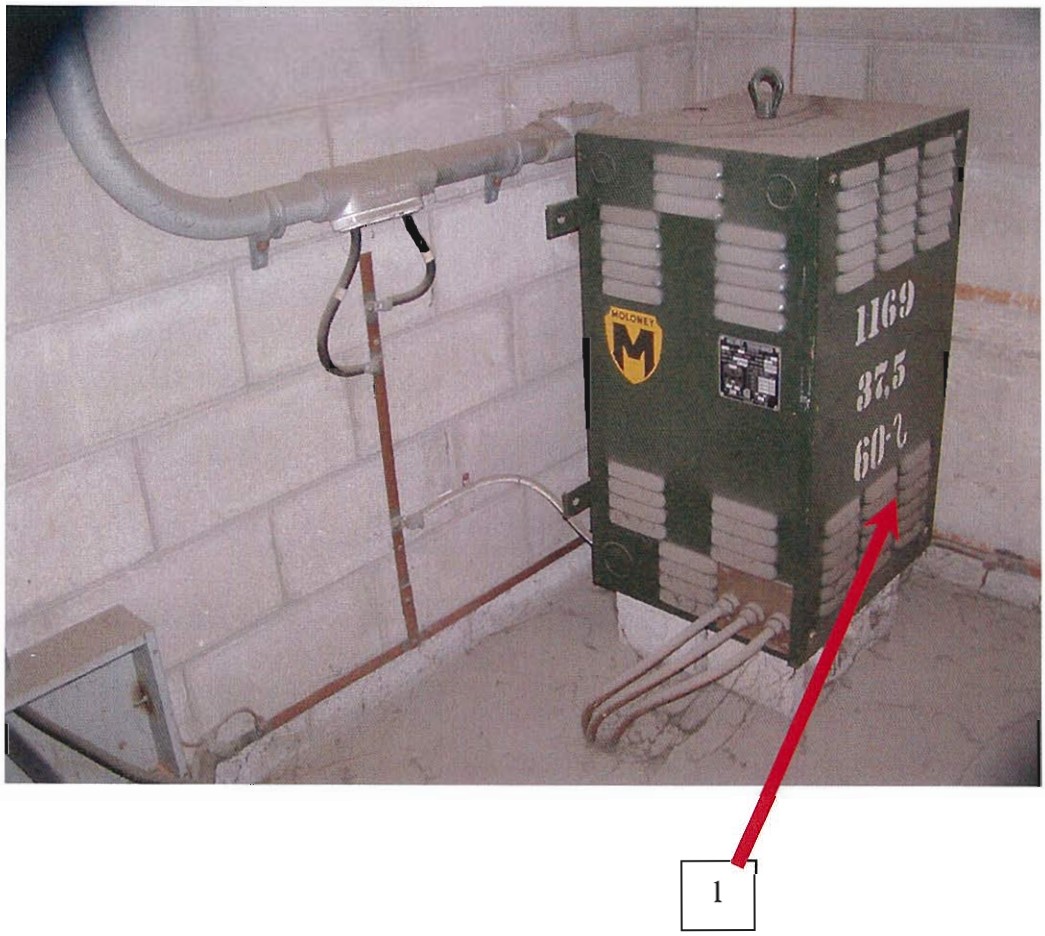
COST ESTIMATE

Section - 145	**$247,000**

Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Apartment Vault Replacements
Project 12B6

20 Craig Street



1) Dry Type transformer

2012 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	12B7
Project Name:	Backup Supply Installation
Project Driver:	REL

Project Title: Installation of Underground Backup Supply

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Dane Kirilovic

Supporting Reference Material

Description/Justification

London Hydro has started to experience outages in the residential underground subdivisions that were serviced approximately 30 years ago with a radial underground system. This configuration leaves London Hydro's control room operators with no options to restore power quickly during outages resulting from equipment failure.

This budget item provides for two additional radial supplies in those subdivisions to be "looped" thereby providing our operators with an alternate source from which they can restore power. This work will greatly improve the speed that power can be restored to these areas and enhance the reliability of supply.

COST ESTIMATE

Section - 145	**$64,000**

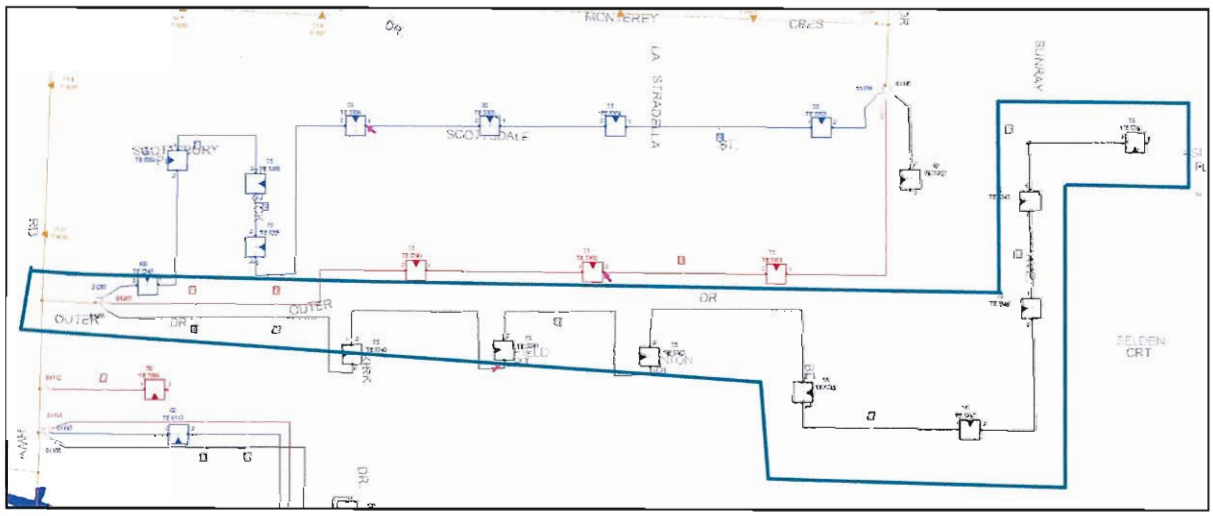
Estimated Completion Date:	June, 2012
Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Installation of Underground Backup Supply
Project 12B7

London Hydro has started to experience outages in the underground areas that were installed approximately 30 years ago without a looped supply arrangement. As a result, cable faults within these radially supplied systems lead to prolonged outages due to the absence of switching or reconfiguration options. This budget item will correct the situation by completing the loop and providing an alternate source of supply to two subdivisions:

- to the area highlighted below that is located in Lambeth Park Estate Subdivision
- to one more radial that will be selected on a priority basis.

3) Lambeth Park Estate



2012 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	12B8
Project Name:	Fault Indicator Installations
Project Driver:	REL

Project Title: Installation of Fault Indication on Padmounted Transformers

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Steve Lavell

Supporting Reference Material

Description/Justification

Fault locating of long underground systems can lead to extended outages in the absence of strategically placed fault indicators. In areas without fault indicators, our crews must open each transformer and test the cable in order to determine the location of the fault. Fault indication technology allows for fault assessment from outside of the transformer allowing our crews to quickly locate the fault, isolate the faulted cable and return power to the affected customers quickly.

This item includes the installation of fault indicators in areas with complex or lengthy underground distribution systems.

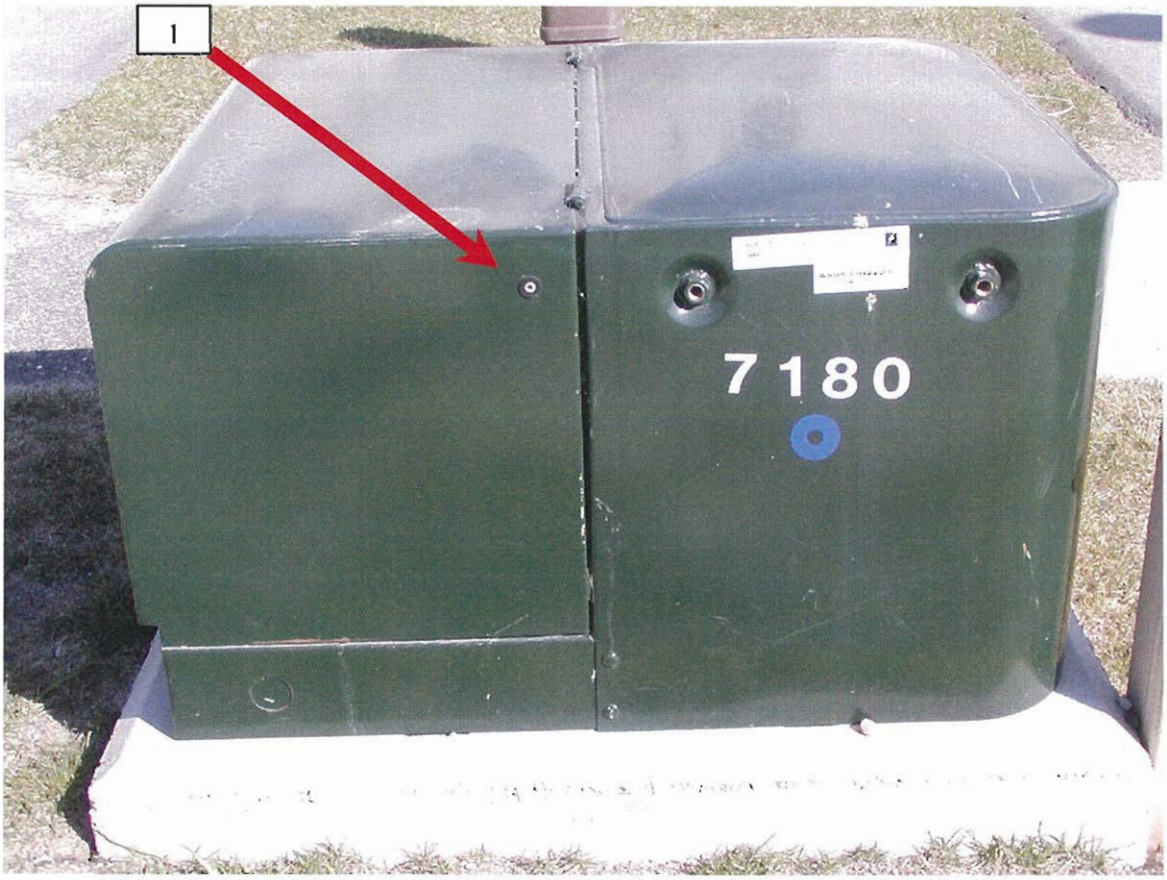
COST ESTIMATE

Section - 145	**$15,000**

Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Installation of Fault Indication on Padmounted Transformers
Project 12B8

As was mentioned prior, the installation of fault indication in areas with lengthy and complex circuit arrangements has the ability to decrease both outage duration and cost of repair. The average underground subdivision contains 16 transformers on a feeder loop. These loops are segmented into two radial sections of 8 transformers to minimize the effects of an outage. Through the installation of fault indication it was found that the average time required to locate a faulted section of cable could be reduced by 1.25 hours. This translates into a savings of roughly 9600 customer minutes per outage.



1) Fault Indicator – Led lights red when transformer has witnessed fault current.

2012 ASSET MANAGEMENT PLAN
Project Sheet

London Hydro

Project Number:	12B9
Project Name:	Zone 'A' Underground Conversion
Project Driver:	SAF, REL

Project Title: Rebuild and Conversion of Sub 1, 2 & 28 Vault Areas (Zone 'A')

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Jamie Macpherson

Supporting Reference Material

4kV Aging Infrastructure System Planning Report - 2011
Asset Sustainment Plan, 2012 - 2026 Report

Description

The *Asset Sustainment Plan Report* identified various parts of the system in this area as being in poor condition. The deficiencies related to the age of the equipment may adversely impact the reliability of supply as well as public and employee safety. The poles and associated hardware are approximately 50 years old. As well, the underground systems and dry-type transformer vaults in these areas are in poor condition. The area will be converted from the 4.16kV distribution system to the 27.6kV distribution system, as per the directive outlined in the *4kV Aging Infrastructure System Planning Report*. This budget item will allow for the replacement of these dry-type transformers with padmount or pole mount transformers located outside the vaults. It will also allow for the installation and termination of secondary cables from the new transformation to the new disconnects inside the vaults.

The following vaults have been identified to be replaced in 2012:
- 186 Elmwood Avenue – TV 1913
- 111 Waterloo Street – TV 628
- 279 Horton Street – TV 809

COST ESTIMATE

Section - 145	**$188,000**

Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Zone 'A' Underground Vault Conversion
Project 12B9

The initiatives outlined in the *4kV Aging Infrastructure System Planning Report* require converting all 4.16kV within Zone 'A', with Zone 'A' being the service territories for Substations 1, 2 and 28. In addition, the proposed voltage conversion area requires rebuilding and converting depreciated transformer vaults; thus, meeting the criteria outlined in the *Asset Sustainment Plan, 2012 - 2026 Report*. The deficiencies related to the age of the equipment may adversely impact the reliability of supply as well as public and employee safety since these vaults are located in confined spaces within the customer's building.

The following vaults have been identified to be replaced in 2012:

- 186 Elmwood Ave – TV 1913
- 111 Waterloo St – TV 628
- 279 Horton St – TV 809



Dry Type transformer

2012 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	12C1
Project Name:	Wellington Rd. S. Extension
Project Driver:	RNF, REL

Project Title: Wellington Road and Glanworth Drive 27.6kV Extension

Project Manager:	Rod Doyle	**Project Tech.:**	Hank Bonnar

Supporting Reference Material: System Planning initiative to correct low voltage and eliminate single contingency

Description/Justification

This project involves extending 27.6kV supply from the 19M22 feeder along Wellington Road South from Scotland Drive to Glanworth Drive. This build will facilitate the conversion of the older 8.32kV pole line along Wellington Road resulting in reduced losses, better voltage support and increased capacity. Step-down transformers will be utilized to offload the 97F2 feeder at Manning Drive and at Glanworth Drive.

Also, a small expansion on Tempo Road along with the installation of step-down transformers at strategic locations will assist with further offloading of the 97F2 feeder. The project will include changing various transformer phase connections on the 8.32kV system to provide balanced loading. This work order will coordinate with Project Number 12A5 to offload the remainder of the 97F2 feeder from Substation 97.

COST ESTIMATE

Section - 140	**$390,000**

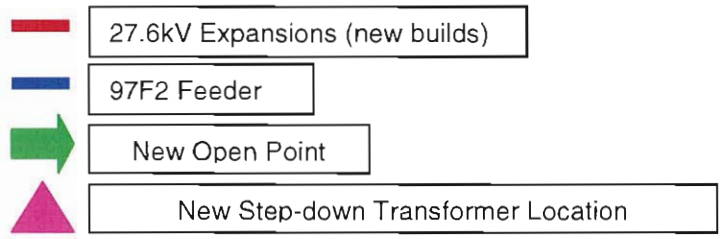
Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

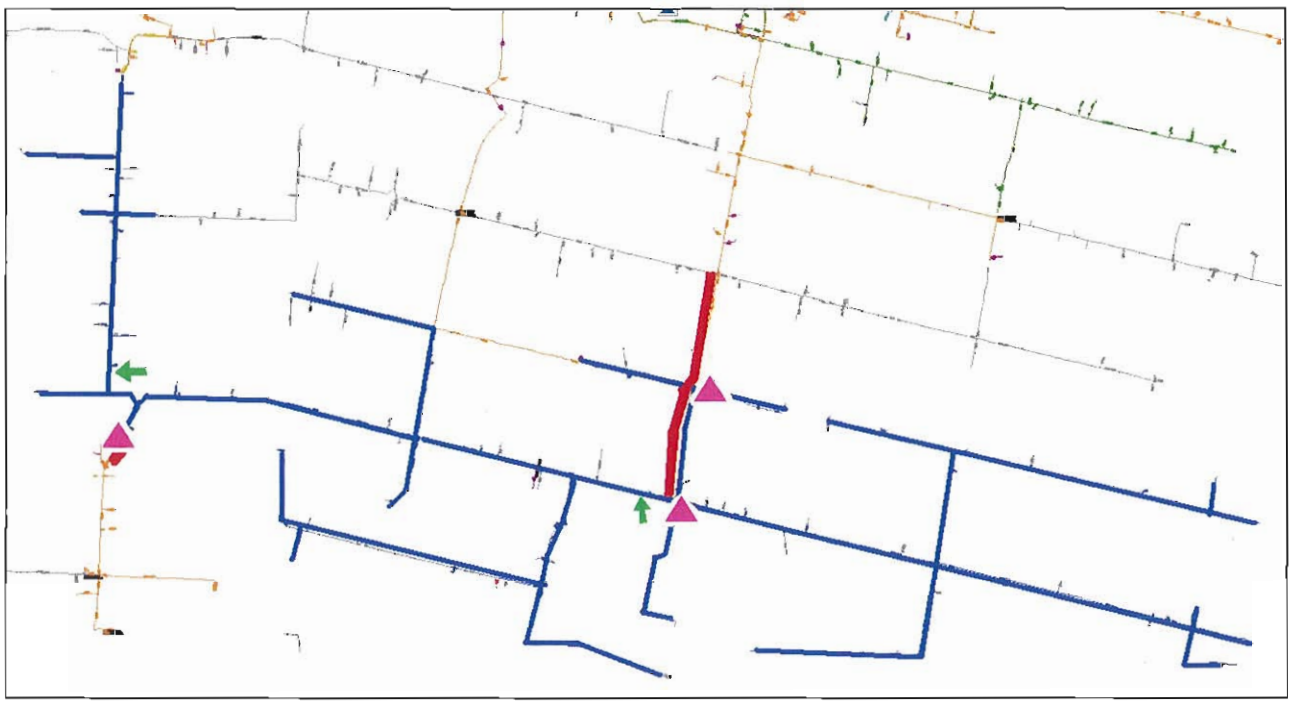
Wellington Road and Glanworth Drive 27.6kV Extension
Project 12C1

Previously, voltage regulators were installed on the 97F2 feeder to assist with low-voltage problems; however, this corrective measure's limitations have been surpassed with increasing load; therefore, System Planning Department has identified the need to provide load relief for the 97F2 feeder. The 97F2 feeder is a 8.32kV feeder with no backup to other feeders and any new commercial load will cause the 97F2 feeder to experience low-voltage problems during peak operating times. Furthermore, the substation that the 97F2 feeder is supplied from does not have any backup. The 97F2 feeder covers a large supply area of approximately 40 km^2.

This project involves extending 27.6kV supply from the 19M22 feeder along Wellington Road South from Scotland Drive to Glanworth Drive. This build will facilitate the conversion of the older 8.32kV pole line along Wellington Road reducing losses and increasing capacity. Step-down transformers will be utilized to offload the 97F2 feeder at Manning Drive and at Glanworth Drive.

Also, a small expansion on Tempo Road along with the installation of step-down transformers at strategic locations will assist with further offloading the 97F2 feeder. The project will include changing various transformer phase connections on the 8.32kV system to balance loading. This work order will coordinate with Project Number 12A5 to offload the remainder of the 97F2 feeder from Substation 97.





Feeder Expansion to offload 97F2

2012 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	12C2
Project Name:	Main Feeder Reinforcements
Project Driver:	RNF

Project Title:	Main Feeder Reinforcements		
Project Manager:	Rod Doyle	**Project Tech.:**	Hank Bonnar, Jim Soetemans

Supporting Reference Material

4kV Aging Infrastructure System Planning Report - 2011
Asset Sustainment Plan, 2012 - 2026 Report
(System Planning Department initiative)

Description/Justification

This budget section is to reinforce main feeders throughout the city by a number of means such as increasing the amount of circuit ties to improve system operability and reliability, increase conductor size to improve load transfer capability, rebuild existing main feeders due to depreciation to maintain existing levels of service or to build new feeders to meet new load growth. London Hydro may undertake these initiatives in conjunction with road authority relocations along main feeder routes.

Feeder One:

Rebuild the pole line along Horton Street from Maitland Street to Colborne Street. Coordinates with road authority relocations under Project Number 12D1. The existing 4.16kV will be converted to 27.6kV as per the directives outlined in the *4kV Aging Infrastructure System Planning Report*. This feeder build positions London Hydro for a future feeder tie between central and southwest London.

Feeder Two:

Rebuild the pole line along Hill Street from Colborne Street to Waterloo Street. Extend 1000kcmil underground cable across Wellington Road bridge to High Street. This feeder reinforcement will be built to 27.6kV standards but energized at 4.16kV to maintain substation ties severed by Feeder One's construction through the course of 2012. Constructing this feeder in 2012 will also put London Hydro in a position to convert the remaining areas under Project Numbers 13B9 and 13G5 starting early in 2013 when this feeder is re-energized to 27.6kV. This feeder build will improve operability and reinforce ties between central and southwest London.

The above feeder work will also assist with the Zone 'A' voltage conversions under Project Numbers 12B9 and 12G6.

COST ESTIMATE

Section - 140	**$295,000**

Prepared By:	Rod Doyle. P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

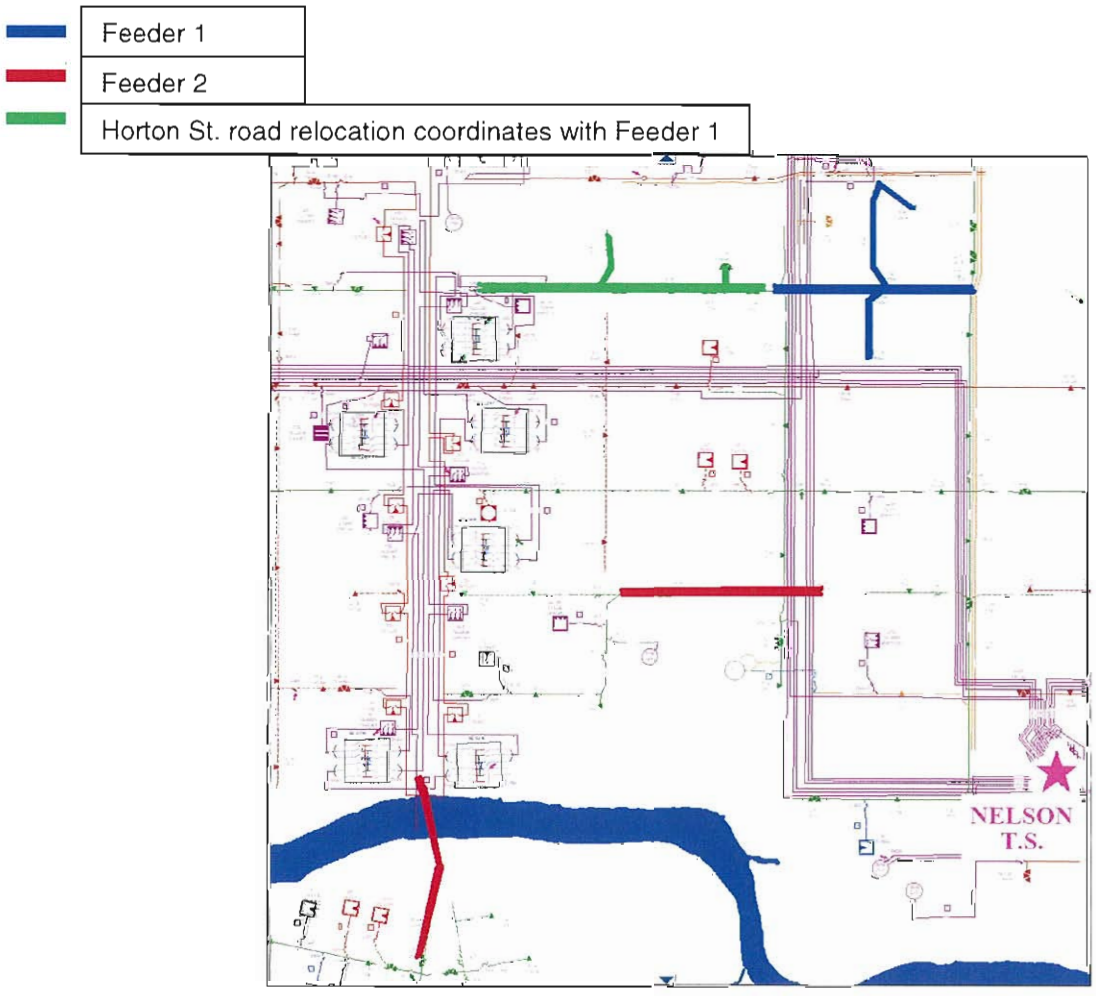
Main Feeder Reinforcements
Project 12C2

This budget section is to reinforce main feeders throughout the city by a number of means such as increasing the amount of circuit ties to improve system operability and reliability, increase conductor size to improve load transfer capability, rebuild existing main feeders due to depreciation to maintain existing levels of service or to build new feeders to meet new load growth. London Hydro may undertake these initiatives in conjunction with road authority relocations along main feeder routes and/or position London Hydro for future feeder re-configurations in anticipation of a new transformer station.

The initiatives outlined in the *4kV Aging Infrastructure System Planning Report* require converting all 4.16 kV within Zone 'A', with Zone 'A' being the service territories for Substations 1, 2 and 28. In addition, the City of London is undertaking road improvements within Zone 'A' along Horton Street between Wellington Road to Burwell Street. Due to the overlapping areas of these projects and System Planning Department identifying the need for more 27.6 kV feeder ties across central London Hydro in anticipation of a future transformer station warrants London Hydro to build these main feeder reinforcements. In addition, the proposed works under this Project Number replaces depreciated infrastructure meeting the criteria outlined in the *Asset Sustainment Plan, 2012 - 2026 Report*.

Feeder One:
The 4.16 kV tie along Horton Street between Wellington Road to Colborne Street will be rebuilt and converted. This section of pole line coordinates with City of London road relocations in Project Number 12D1. This work will sever the 28F1 feeder tie to the 1F2 feeder through switching enclosure SE 6220 and sever the tie between the 28F1 and 1F4 feeders through switching enclosure SE 6221. SE 6220 will remain at 4.16 kV. The severed 4.16 kV feeder ties will be re-established through Feeder Two construction. Feeder One build will position London Hydro for a future feeder tie between central and southwest London. Feeder One construction will continue in 2013.

Feeder Two:
Rebuild the pole line along Hill Street from Colborne Street to Waterloo Street and extend 1000kcmil underground cable across Wellington Road bridge to High Street. This feeder will be built to 27.6 kV standards but energized at 4.16 kV to re-establish the 28F1 - 1F2 4.16 kV feeder tie through switching enclosures SE 6221 and SE 6220 and re-establish the 28F1 tie to 1F4 through switching enclosure SE 6221. Create a 21F3 & 28F1 4.16kV feeder tie by connecting the 1000kmcil cable the 21F3 feeder. This connection will aid with continuation of Zone 'A' conversion in 2013 when this feeder is energized at 27.6 kV. Feeder Two build will position London Hydro for a future feeder tie between central and southwest London. Feeder Two construction will continue in 2013.



Main Feeder Reinforcements

2012 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	12C3
Project Name:	26M43 Phase 1
Project Driver:	RNF

Project Title: 26M43 Feeder Construction Phase 1

Project Manager:	Rod Doyle	**Project Tech.:**	Hank Bonnar

Supporting Reference Material

New Supply Capacity for London - 2006 to 2010
2008 Addendum to New Supply Capacity for London 2006-2010

Description/Justification

This project was scheduled for completion in 2011 but due to delays with The City of London completing construction on a new bridge along this same section of road, London Hydro was only able to complete a portion of this feeder project. This project will complete the 26M43 Feeder (Phase 1) that was started late 2011.

Due to the growing load in the northwest section of the City, London Hydro requires increased load transfer capability in this region.

London Hydro has inadequate conductor size along Hyde Park Road between Sarnia Road to Fanshawe Park Road limiting transfer capabilty from Oxford Street to Fanshawe Park Road. Constructing an improved circuit along Hyde Park Road is not feasible at this time until the City of London widens Hyde Park Road starting in 2015.

An alternative to resolve the transfer capability in this area is to build part of the future 26M43 feeder that was identified in the *New Supply Capacity for London* 2006 - 2010 reports. The construction of this partial feeder is along Sarnia Road between Wonderland Road and Hyde Park Road. This will create a new feeder tie between the 26M55 and the 26M54 and improve the load transfer capability along Hyde Park Road.

The CN rail crossing will be framed for a future feeder that was also identified in the *New Supply Capacity for London 2006 - 2010* reports.

COST ESTIMATE

Section - 131	**$118,000**

Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

26M43 Feeder Construction Phase 1

Project 12C3

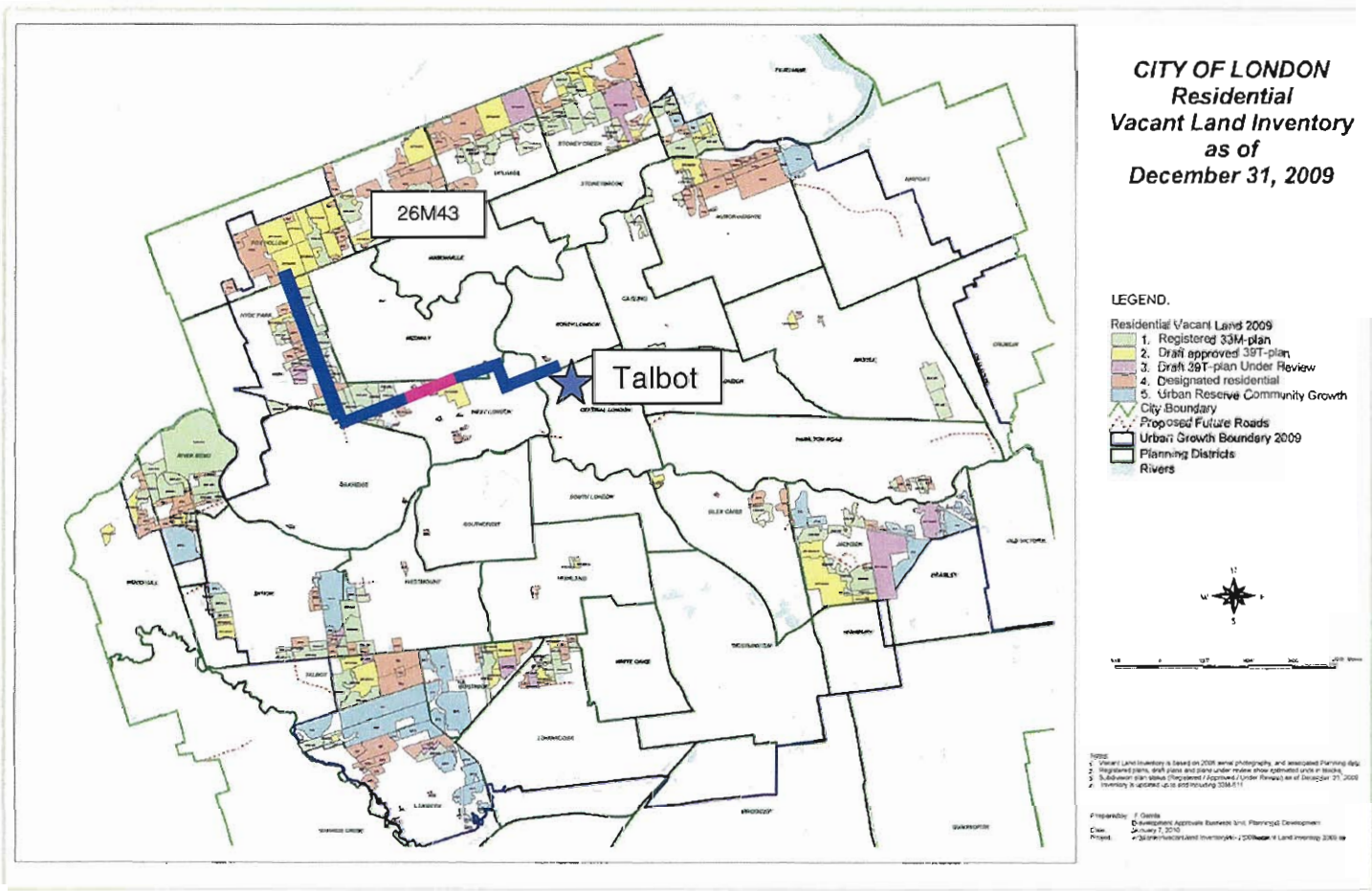
This project was scheduled for completion in 2011 but due to delays with The City of London completing construction on a new bridge along this same section of road, London Hydro was only able to complete a portion of this feeder project. This project will complete the 26M43 Feeder (Phase 1) that was started late 2011.

The scope of the work involves extending the pole line on Sarnia Road between Aldersbrook Road, over the CN rail right-of-way to Oakcrossing Gate. This construction will create a new feeder tie between the 26M55 and 26M54.

The remaining phases of 26M43 will be constructed when it is required due to load growth. The completion of the 26M43 feeder will supply the northwest corner of the city.

26M43 Feeder – Phase 1

26M43 Feeder



Feeder Route for the 26M43 Feeder

2012 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	12D1
Project Name:	City Requested Relocations
Project Driver:	COL

Project Title: City of London (Road Authority) Relocations

Project Manager:	Rod Doyle	**Project Tech.:**	Hank Bonnar & Jim Soetemans

Supporting Reference Material

Description/Justification

This project comprises of the relocation of London Hydro Infrastructure located on the road allowance. These relocations are initiated by the Road Authority (City of London) and are necessary in order to accommodate planned modifications to the roadway.

The terms and conditions under which these relocations occur are specified in the Public Service Works on Highways Act enacted by the Provincial Government. The Act gives a Road Authority the power to ensure that all operating corporations entitled to the use of the road allowance cooperate with the Road Authority to execute any required modifications to the profile of the road allowance in a timely manner. The Act states that an Operating Corporation (London Hydro Inc) must modify or relocate their plant on the road allowance to accommodate the Road Authority's improvements or alterations within a specified time period. The Act also outlines the mechanism for the apportionment of costs for these required works. Typically the Operating Corporation is permitted to recover 50% of the labour and vehicle costs from the Road Authority.

Some of the known relocation projects for 2012 include:
- Horton Street between Wellington Road and Burwell Street
- Wonderland Road North between Fanshawe Park Road West and Eagletrace Drive
- Southdale Road West between Wharncliffe Road South and Singleton Avenue
- Oxford Sreet.West between Hyde Park Road and Sanatorium Road
- Hamilton Road, Commissioners Road East & Old Victoria Road intersection round-about
- various manhole chimneys, rings and covers adjustments due to repaving
- various other locations

COST ESTIMATE

Section - 133	**$1,765,000**

Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

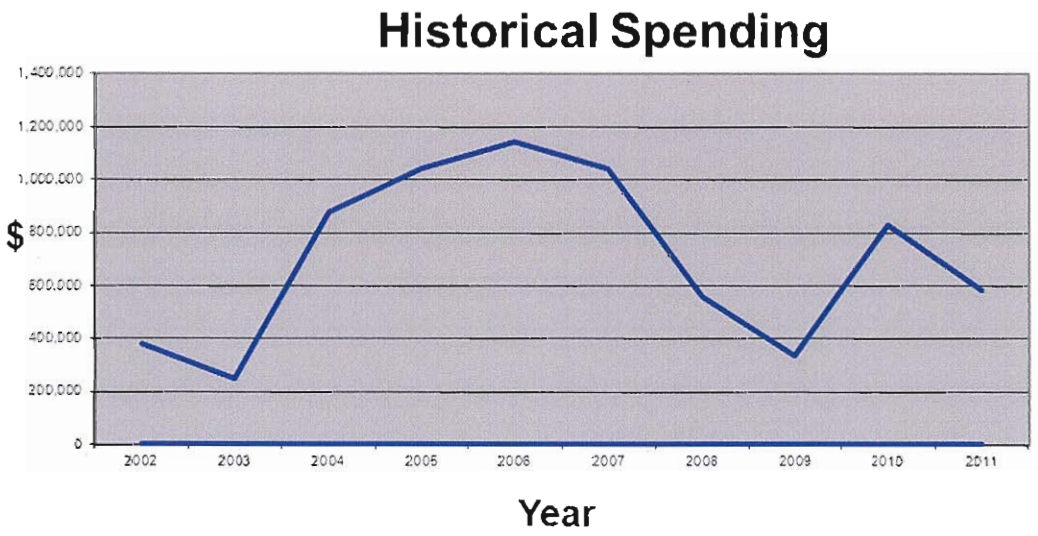
City of London (Road Authority) Relocations
Project 12D1

London Hydro works closely with the City of London to try to determine which of their projects will affect London Hydro's infrastructure. Unfortunately, the City has not defined all their projects for 2012; therefore, the annual expenditures are estimated based on a combination of known projects and base historical spending. Spending in this area has ranged from $249,000 to $1,140,000 in the last several years depending on the projects that were identified by the City of London as being required. However, the projects that the City of London has identified for 2012 are large in scope; thus, resulting in an increase expenditure in this project section.

The City of London has identified the following projects of significance for London Hydro to relocate its plant in 2012:

- Horton Street between Wellington Road and Burwell Street
- Wonderland Road North between Fanshawe Park Road West and Eagletrace Drive
- Southdale Road West between Wharncliffe Road South and Singleton Avenue
- Oxford Street West between Hyde Park Road and Sanatorium Road
- Hamilton Road, Commissioners Road East & Old Victoria Road intersection reconstruction to a round-about

This budget section also covers various manhole chimney rings and covers adjustments due to repaving and other various relocations.



2012 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	12E1
Project Name:	Expansions and Relocations
Project Driver:	DEV

Project Title:	Developer Driven Distribution Circuit Expansions and Relocations

Project Manager:	Jagoda Borovickic/Rod Doyle	**Project Tech.:**	Hank Bonnar

Supporting Reference Material

Description/Justification

This budget item includes extension of the existing high voltage overhead or underground distribution system in order to accommodate new customer developments as they are added to London's service area. This budget item includes all costs associated with the construction of these extensions.

Some of the major expansion and relocation projects anticipated for 2012 include:

- Wharncliffe Rd. S. overhead expansion to Westbury Subdivision
- Commissioners Rd. east of Wellington Rd. pole relocation for new hospital entrance.
- Talbot St. & Carling St. underground 27.6kV expansion

This item also includes the relocation of existing London Hydro plant for accommodating new developments within the city limits. These relocations are required when items such as new proposed driveways and turn lanes for new developments are in conflict with the existing hydro plant. This budget item includes all costs associated with the relocation.

COST ESTIMATE

Section - 131	**$604,000**

Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

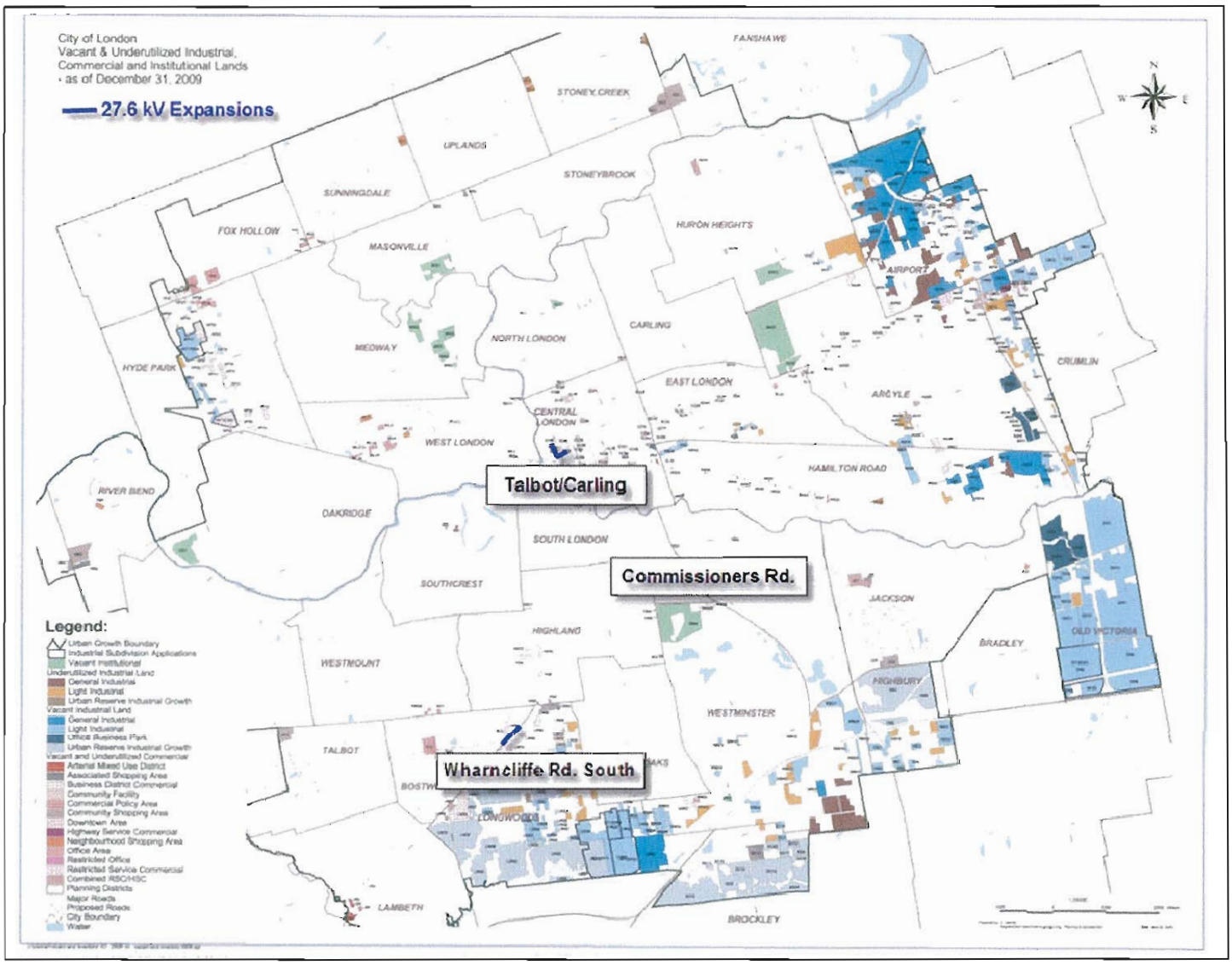
Developer Driven Distribution Circuit Expansions and Relocations
Project 12E1

This project comprises the installation and/or modification of electrical equipment that is used in supplying customers' installations. It also includes the work associated with upgrading existing installations.

The London Hydro Conditions of Service Document details how capital contributions are assessed for these installations.

From a budgeting perspective, the annual expenditures are estimated based on a number of factors including: City of London development forecasts and customer inquiries.

The two expansions that are proposed for 2012 include Wharncliffe Road South overhead expansion for accommodating servicing of a new residential subdivision and Talbot Street and Carling Street expansions for providing back up supply to the new development at the northwest corner of Richmond Street and Carling Street, and a relocation on Commissioners Road to accommodate a new hospital entrance. These expansions are illustrated on the map below. These three projects account for $320,000. The remaining $300,000 allocated for expansions and relocations is yet to be determined by various developers.



2012 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	12E2
Project Name:	Secondary Service Upgrades
Project Driver:	DEV

Project Title: Residential Secondary Service Upgrades

Project Manager:	Rod Doyle	**Project Tech.:**	Jim Soetemans

Supporting Reference Material

Description/Justification

This budget item includes replacement of the existing low voltage conductors with conductors of increased size from the overhead transformer to the customers' electrical service stacks. These upgrades are often required when customers increase their electrical demands. This item involves all costs associated with these upgrades.

COST ESTIMATE

Section - 131	**$321,000**

Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

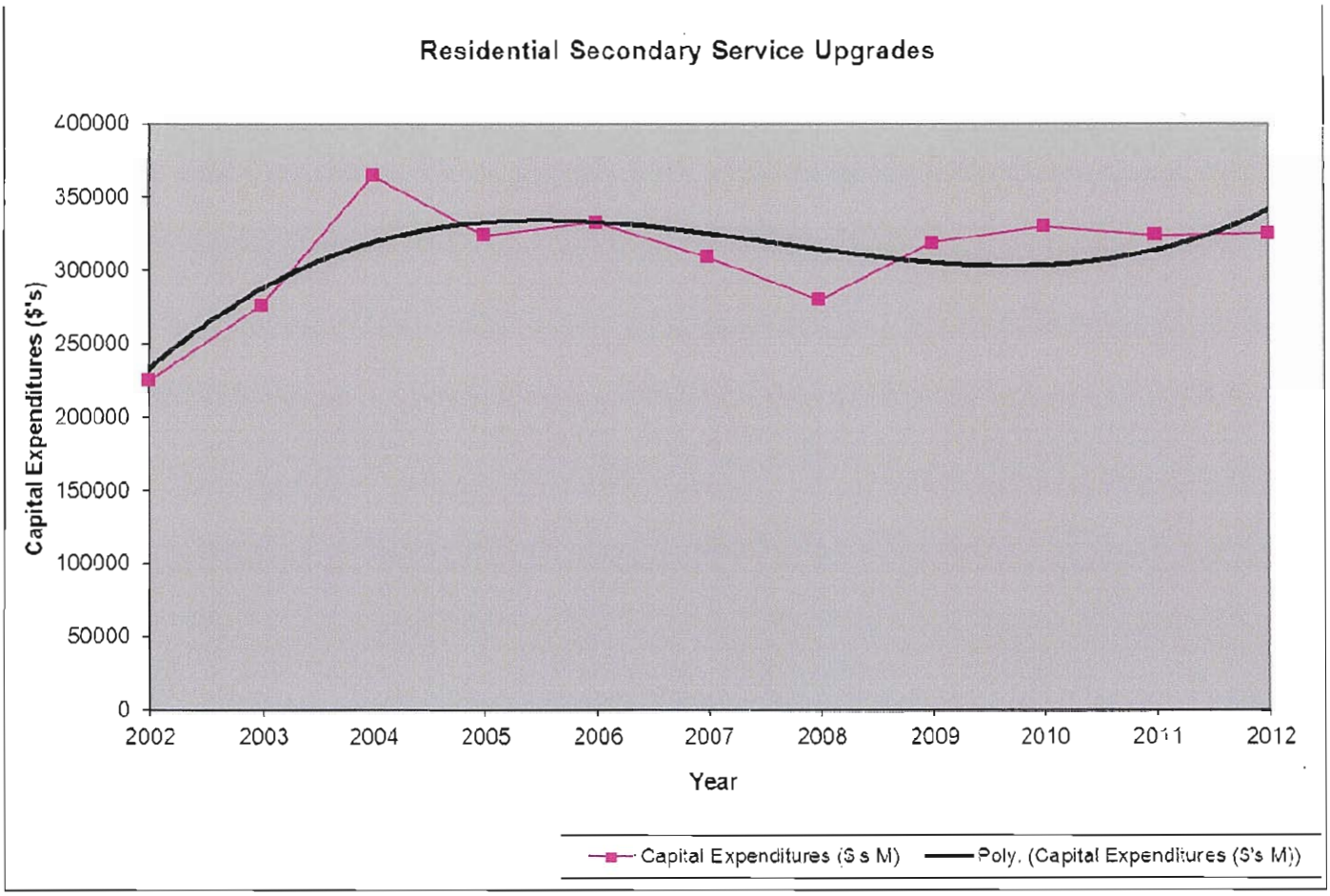
Residential Secondary Service Upgrades

Project 12E2

This project comprises the replacement of overhead low voltage electrical services to residential dwellings. There is no charge to customers for these upgrades as they are part of London Hydro's basic connection for overhead residential customers as defined in the Distribution System Code.

These upgrades are initiated by customers that require an increase to their electrical service size. These requests may be due to issues such as the addition of new load in their home or due to requirements of an insurance company that requires the service to be upgraded to a minimal size and configuration.

From a budgeting perspective, the annual expenditures are estimated based on past history. A graph has been provided below and illustrates the level of required expenditures within London Hydro's service territory.



2012 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	12E3
Project Name:	Residential Underground
Project Driver:	DEV

Project Title: New Single Family Residential Underground Distribution

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Jamie Macpherson

Supporting Reference Material

Description/Justification

This item involves the installation of single family residential underground distribution systems to provide service as needed to developers. We are budgeting $1,496,000 for 2012 based on a number of factors including the past history spending and the forecast by the Canada Mortgage and Housing Corporation.

It is noted that market conditions can create large fluctuations in expenditures from year to year. This item is solely dependent on market conditions. This section will contain several different projects of varying magnitude depending on customer requirements.

COST ESTIMATE

Section - 142	**$1,496,000**

Prepared By:	Jagoda Borovickic, P.Eng Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

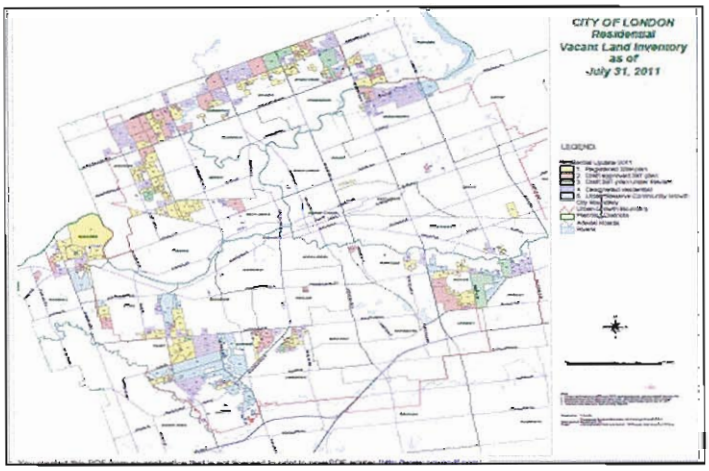
Residential Underground
Project 12E3

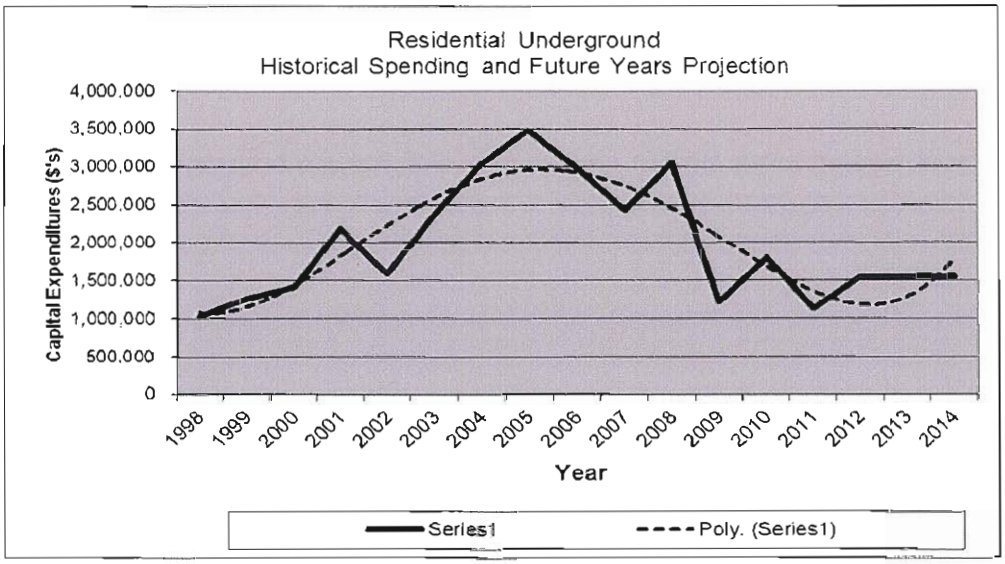
This project involves the installation of single family residential underground distribution systems to provide service as needed to developers.

The London Hydro Conditions of Service Document details how capital contributions are assessed for these installations.

From a budgeting perspective, the annual expenditures are estimated based on a number of factors including: past history, City of London development forecasts, market reviews including Canada Mortgage and Housing Corporation, and customer inquiries. Examples of the various documents created and reviewed are shown. This information is updated each year and the forecasts and budgets are adjusted accordingly.

This collection of information is part of a larger library that is used in the preparation of the 25 year load forecast.





Housing Market Outlook - Ontario Region Highlights - Date Released: Third Quarter 2011

Ontario Region Housing Forecast - New Construction

	Housing Starts	2010	2011(F)*	% chg (2010/2011)	2012(F)*	% chg (2011/2012)	YTD 2011*	YTD 2010*	% chg (2010/2011)
London	Single-Detached	1,461	1,100	-24.7	1,200	9.1	563	802	-29.8
	Multiple	618	520	-15.9	620	19.2	266	490	-45.7
	Total	2,079	1,620	-22.1	1,820	12.3	829	1,292	-35.8

Canada Mortgage and Housing Corporation 6

Housing Starts in London

Apartment development is included in Multihousing at CMHC, however is included in 12E5 Commercial at London Hydro.

2012 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	12E4
Project Name:	Multi-Housing Servicing
Project Driver:	DEV

Project Title: New Multi-Housing Underground Distribution

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Jamie Macpherson

Supporting Reference Material

Description/Justification

This item is for the installation of multi-housing (primarily townhouses and condominiums) underground distribution systems to provide service as needed to developers. We have budgeted $630,000 for 2012 based on a number of factors including the past history spending and the forecast by the Canada Mortgage and Housing Corporation.

This item is solely dependent on market conditions. This section will contain several different projects of varying magnitude depending on customer requirements.

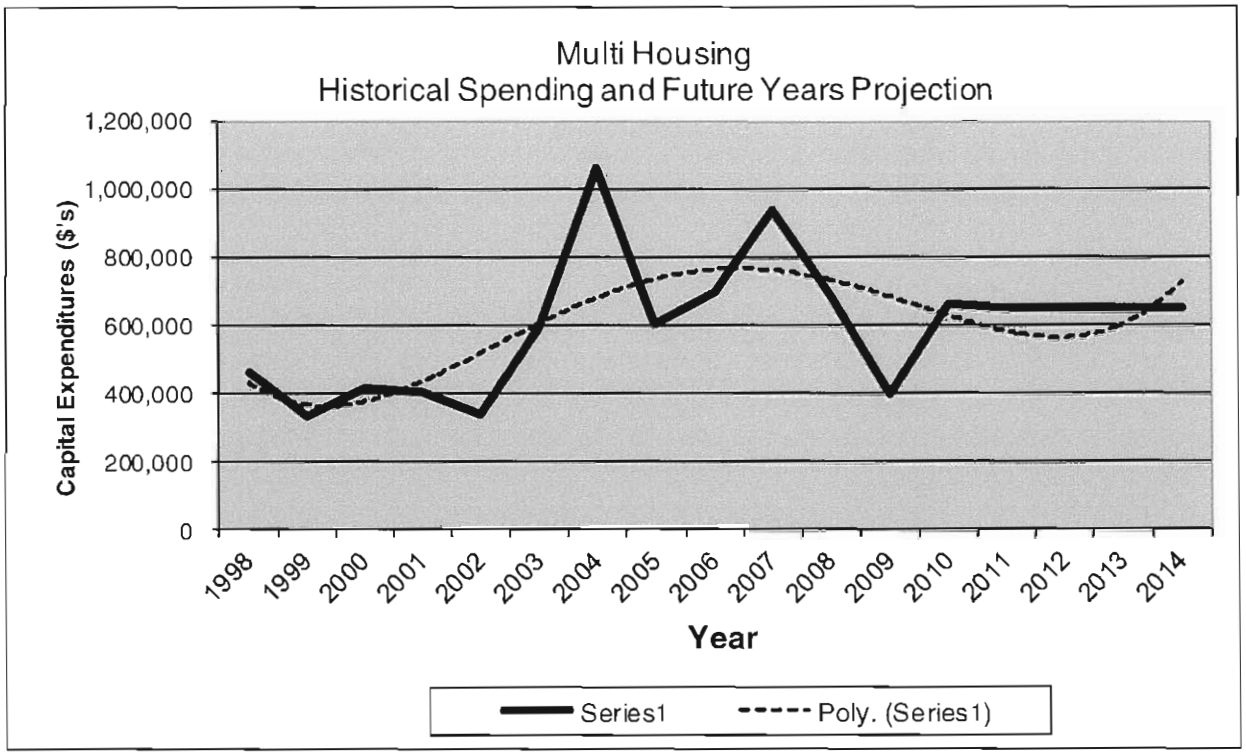
COST ESTIMATE

Section - 143	**$630,000**

Prepared By:	Jagoda Borovickic, P.Eng Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Multi-Housing Underground
Project 12E4

This project involves the installation of multi housing underground distribution systems to provide service as needed to developers.



The London Hydro Conditions of Service Document details how capital contributions are assessed for these installations.

From a budgeting perspective, the annual expenditures are estimated based on a number of factors including: past history, City of London development forecasts, market reviews including Canada Mortgage and Housing Corporation, and customer inquiries. Examples of the various documents created and reviewed are shown. This information is updated each year and the forecasts and budgets are adjusted accordingly.

This collection of information is part of a larger library that is used in the preparation of the 25 year load forecast.

Housing Market Outlook - Ontario Region Highlights - Date Released: Third Quarter 2011

Ontario Region Housing Forecast - New Construction

	Housing Starts	2010	2011(F)*	% chg (2010/2011)	2012(F)*	% chg (2011/2012)	YTD 2011*	YTD 2010*	% chg (2010/2011)
London	Single-Detached	1,468	1,100	-24.7	1,200	9.1	563	802	-29.8
	Multiple	618	520	-15.9	620	19.2	266	490	-45.7
	Totali	2,079	1,620	-22.1	1,820	12.3	829	1,292	-35.8

Canada Mortgage and Housing Corporation 6

Housing Starts in London

Apartment development is included in Multihousing at CMHC, however is included in 12E5 Commercial at London Hydro.

2012 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	12E5
Project Name:	Commercial Distribution
Project Criver:	DEV

Project Title: New Commercial Distribution Services

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Albert Kanters/Scott Lasseter

Supporting Reference Material

Description/Justification

This item is for the installation of commercial overhead and underground distribution systems to provide service as needed to customers. We have budgeted $2,025,000 for 2012. This item is solely based on market conditions.

This budget is based on past historical expenditure patterns and past history, City of London development forecasts, market reviews, and customer inquiries.

COST ESTIMATE

Section - 144	**$2,025,000**

Prepared By: Jagoda Borovickic, P.Eng
Distribution Engineer

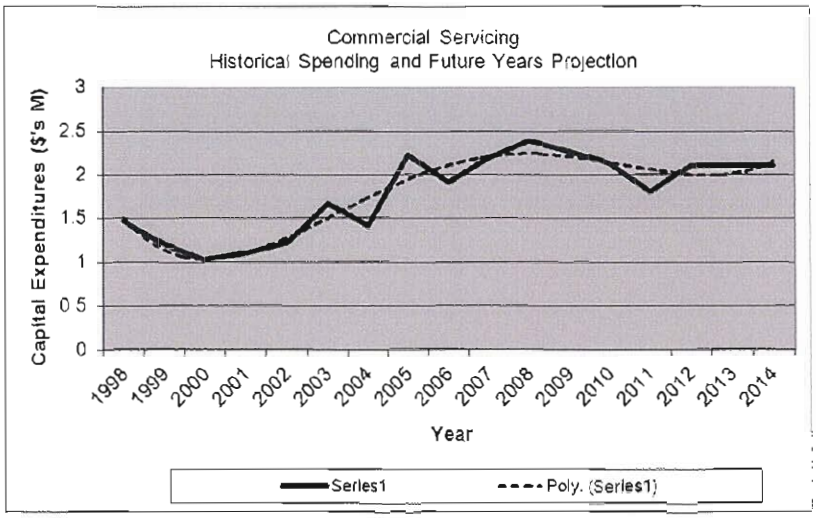
Approved By: Ken Walsh, P.Eng.
Chief Engineer &
V.P. of Operations

Commercial Distribution
Project 12E5

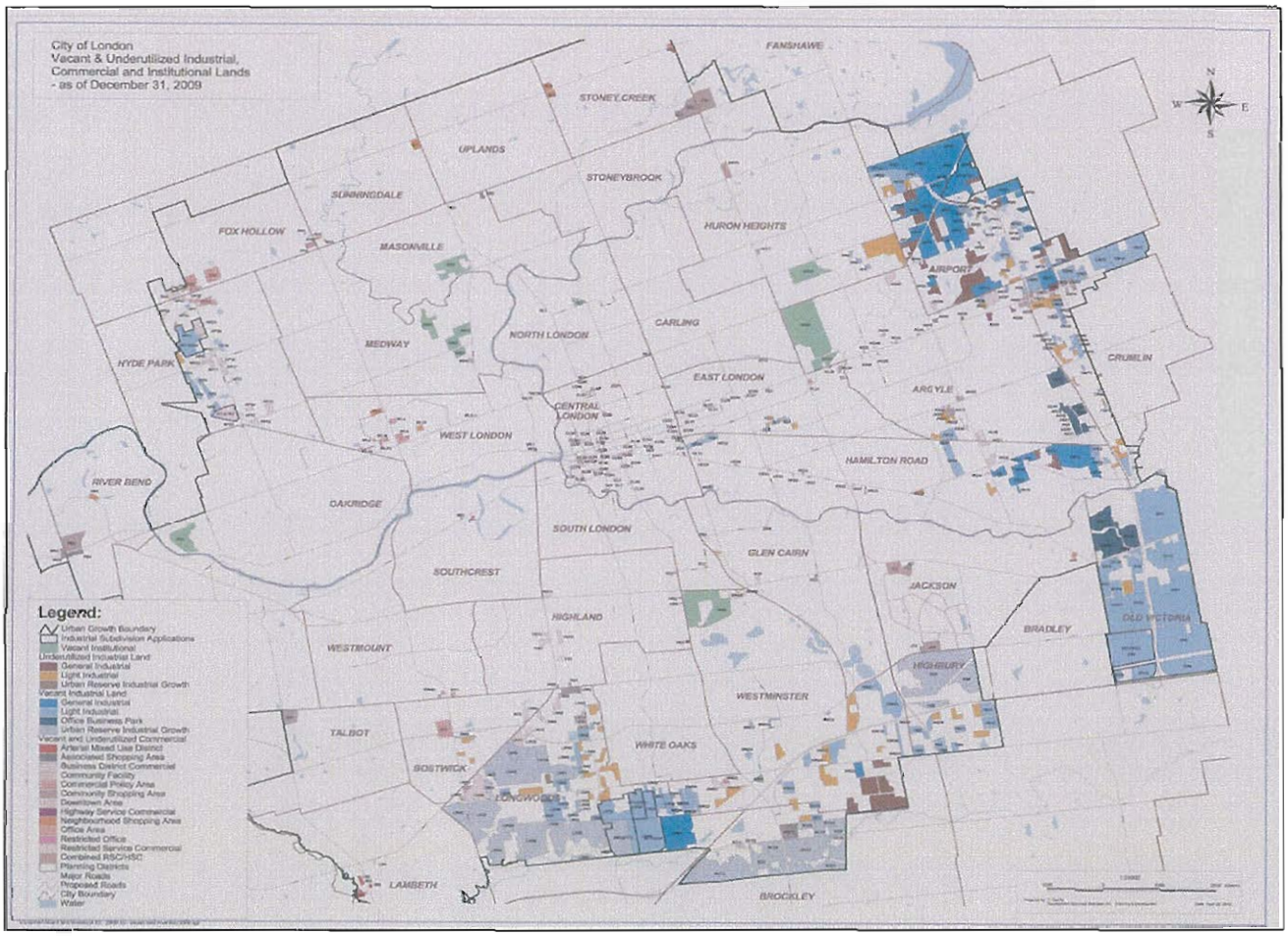
This project comprises the installation and/or modification of electrical equipment that is used in supplying commercial (including apartments) and industrial customers' installations. It also includes the work associated with upgrading existing installations.

The London Hydro Conditions of Service Document details how capital contributions are assessed for these installations.

From a budgeting perspective, the annual expenditures are estimated based on a number of factors including: past history, City of London development forecasts, market reviews, and customer inquiries. Examples of the various documents created and reviewed are shown. This information is updated each year and the forecasts and budgets are adjusted accordingly.



This collection of information is part of a larger library that is used in the preparation of the 25 year load forecast.



2012 ASSET MANAGEMENT PLAN

London Hydro

E&O Department

Project Number:	12F1
Project Name:	Network Vault/Manhole/Tx Replacements
Project Driver:	SAF

Project Title:	Replacement of Network Vaults/Manholes/Transformers

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Dane Kirilovic

Supporting Reference Material

Asset Sustainment Plan, 2012 - 2026 Report
Structural Inspection Reports

Description/Justification

This item involves the design and installation of structural entities such as concrete manholes, vaults, roof slabs and steel vault grating as well as replacement of network transformers and protectors at various locations.

The condition of the above items is monitored through inspections by a structural engineer based on the Asset Sustainment Plan and observations by our operations staff. This item is used to resolve all safety and reliability issues resulting from these inspections and in compliance with the Asset Sustainment Plan.

COST and TIMING ESTIMATES

Section - 141	**$1,047,000**

Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operation

Replacement of Network Vault/Manhole/Transformers
Project 12F1

Each year, London Hydro's operations staff conduct inspections of the London Hydro subsurface chambers on a scheduled basis. These inspections are carried out in compliance with the requirements of the Distribution System Code. During the course of these inspections, notes are made to identify the structures that require additional assessment by a Professional Structural Engineer. Additional structures for assessment are identified by the Asset Sustainment Plan report. The structural engineer then provides direction on the appropriate course of action that is required (if any) to maintain the structural integrity and safety of the installation.

The structural engineer's findings are documented and then implemented within the timelines that are specified. Typical findings involve delamination of concrete roof slabs and walls. This can be due to numerous factors including aggregate composition, salt contamination, age and method of construction used at the time. The picture below illustrates a deteriorated wall of a network transformer vault.



Sample of a Network Transformer Vault wall deterioration that needs to be repaired

2012 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	12F2
Project Name:	Primary/Secondary Cable Replacements
Project Driver:	REL

Project Title: Replacement of Primary and Secondary Cables

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Scott Lasseter

Supporting Reference Material

Description/Justification

Over the years some of the cables in our distribution system have deteriorated and their dielectric strength has been compromised. This is partially due to age, the environment in which they are installed and loading conditions. These sections are often hard to detect until the quality of power is compromised. The degree of the problems can range from low voltage problems to power outages.

When these cables are identified, they are replaced with cables that meet our present day specifications and standards.

This budget item will include the replacement of primary and secondary cables which have reached failure or are approaching the end of their useful service life.

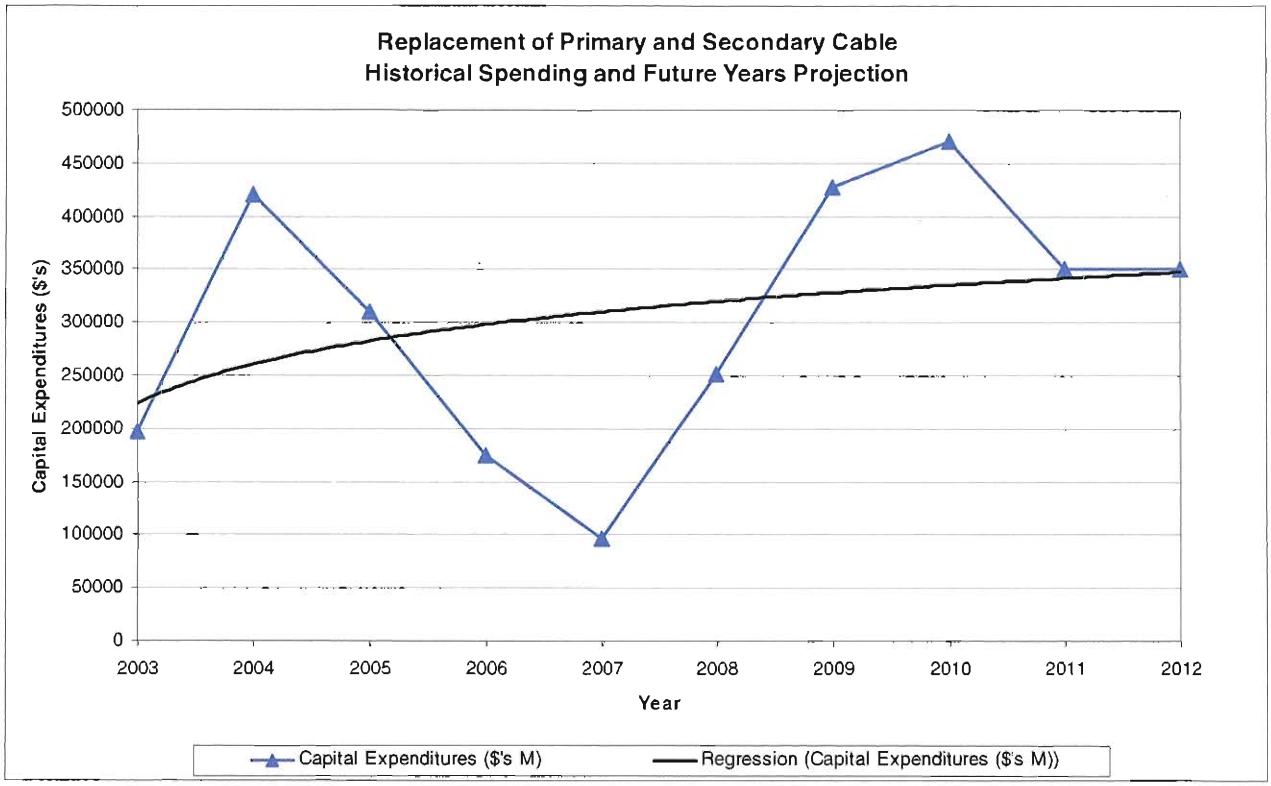
COST ESTIMATE

Section - 150	**$341,000**

Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Replacement of Primary and Secondary Cables
Project 12F2

London Hydro has approximately 1700 km of primary cable in our distribution system and 25 km of low voltage main secondary cable in our downtown core. Although London Hydro is continuously assessing and replacing these cables through identified capital projects, some cables fail unexpectedly and require replacement. This budget item provides for replacement of these cables. Due to the fact that these failures are unplanned, a historical trend is used to estimate the required level funding for the replacements. The graph below illustrates that expenditures have been as high as $470,000 and as low as $100,000.



2012 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	12F3
Project Name:	Eliminate East Network Ph 1&2
Project Driver:	REL

Project Title: Eliminate East End Network Phase 3- Dundas Street east of Rectory Street.

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Jamie Macpherson

Supporting Reference Material

Description/Justification

This project represents one phase of the long term plan of eliminating the East End Network and connecting the customers in the area to 27.6 kV system. This budget item includes conversion of customer owned substation SUB 278 to the 27.6 kV system by installing a new padmount transformer on the customer's property and connecting customer's low voltage switchgear to the new transformation. This project is preparation for the last phase of the East End Network Elimination project that is scheduled for 2013.

COST ESTIMATE

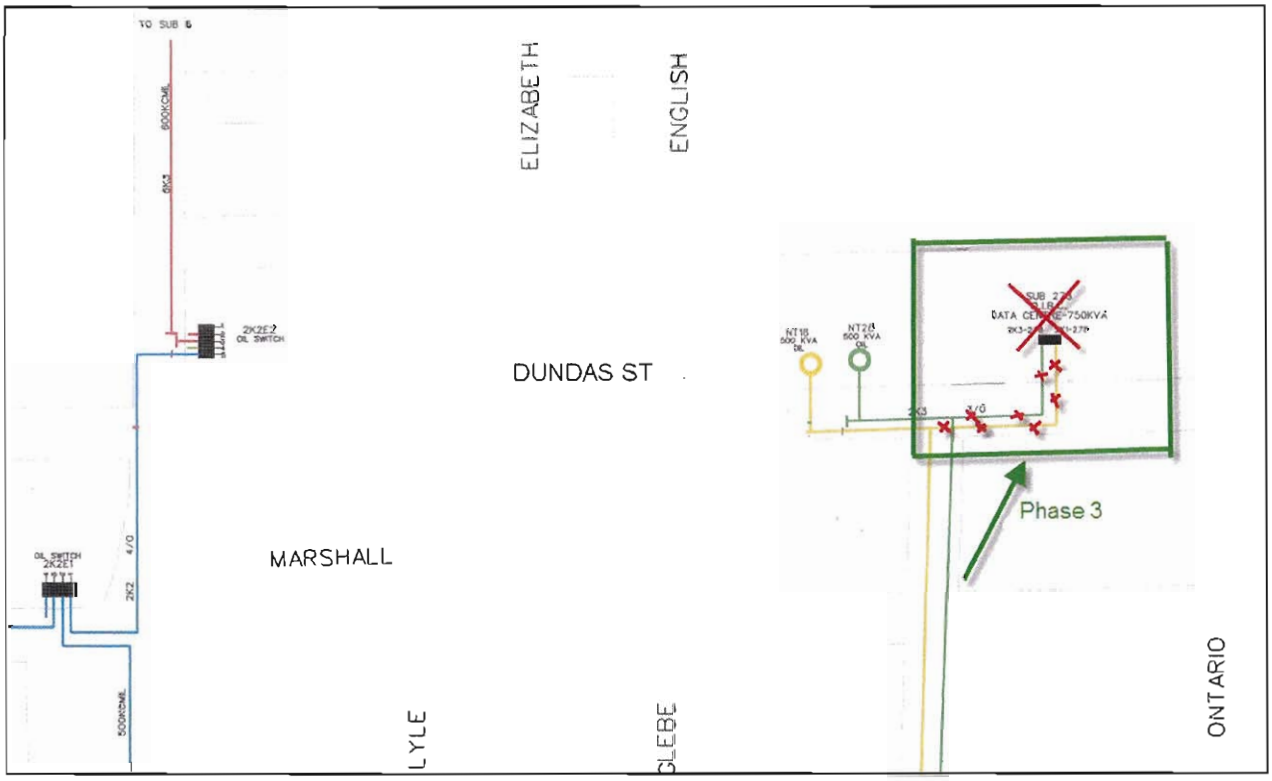
Section - 150	**$270,000**

Prepared By:	Allan Van Damme, P.Eng. Director of Engineering
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Eliminate East End Network – Dundas St. East of Rectory Street
Project 12F3

This is the third phase of a multi-phase program to eliminate the east end network. The elimination of this network will provide a simpler and safer distribution system. The existing plant is approaching the end of its useful life. The plan will integrate with the significant redevelopment that is occurring in the area bordered by Adelaide and Rectory Streets along Dundas Street. All load will be converted from the 13.8 kV distribution system to the 27.6 kV distribution system in line with our long term plans for a new TS. The third phase will address the area of Dundas Street between Rectory Street and Ontario Street as shown below.

Area Affected by Phase 3 of the East End Network Elimination



2012 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	12F4
Project Name:	Manhole Cable Rebuilds
Project Driver:	SAF

Project Title:	Manhole Cable Rebuilds
Project Manager:	Jagoda Borovickic
Project Tech.:	Dane Kirilovic

Supporting Reference Material

Description/Justification

The City of London's downtown core is largely supplied from the network system by an extensive low voltage network grid. The network is supplied by 13.8 kV PILC (paper insulated lead cable). The primary cables and the low voltage network grid cables are installed in the common duct and manhole system that became very crowded over the past fifty years. This item includes replacement of lead primary cables with new EPR flat strap cables, replacement of secondary cables, and reconfiguration of cables within crowded manholes that are difficult to work in.

In addition, this budget will cover installation of cable protecting fuses in the mains of the low voltage grid. High fault energies, that can lead to detrimental failures, are predominant characteristic of the low voltage network grid These fuse elements limit the fault energy during the failure of the downstream device and decrease probability of the detrimental failures.

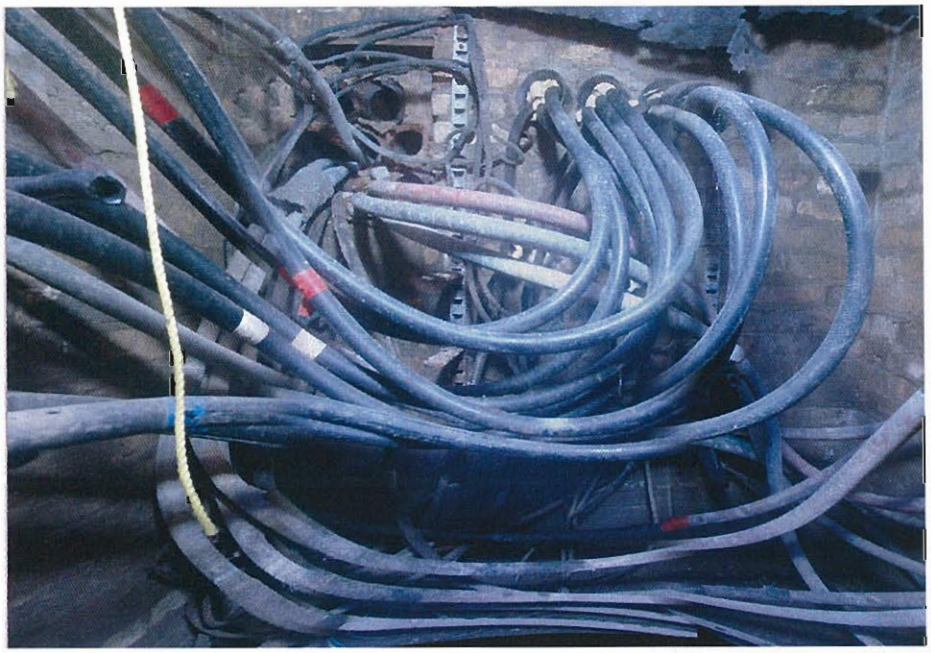
COST ESTIMATE

Section - 150	**$147,000**

Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Manhole Cable Rebuilds
Project 12F4

The City of London's downtown core is largely supplied from the network system. The network is supplied by 13.8 kV PILC (paper insulated lead cable). Some of these cables are very old cables installed more than fifty years ago. The primary cables and the low voltage network grid cables are installed in the common duct and manhole system that has become very crowded over the past fifty years. This item includes replacement of lead primary and secondary cables, and removal and reconfiguration of cables within crowded manholes that are difficult to work in. Where possible, the existing lead primary cables are being replaced with a lead free alternative cable. By doing this work we will eliminate unused cables, clear up hazards and make space available for future cable installations. The picture below is a good illustration of a crowded manhole in London's downtown core.



Manhole 693 – Dundas St. east of Richmond St

The City of London's downtown low voltage network grid consists of approximately 22 km of copper secondary mains that are routed through the downtown duct and manhole system. London Hydro has installed approximately 3000 cable protecting fuses on this system over the last five years to address the safety issues that are inherent for a system of this design.



Low Voltage Cable Protecting Fuse used on Secondary Network

2012 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	12G1
Project Name:	Replacement of Rotten Poles
Project Driver:	SAF

Project Title: Replacement of Fully Depreciated Poles

Project Manager:	Rod Doyle	**Project Tech.:**	Jim Soetemans

Supporting Reference Material

Pole Test Records
Asset Sustainment Plan, 2012 - 2026 Report

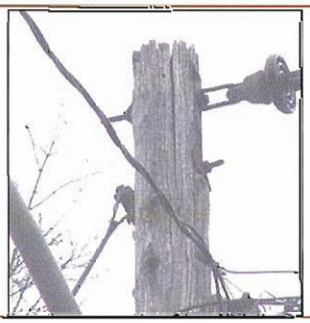
Description/Justification

In the last several years, London Hydro tested over 16,000 wood poles as part of our proactive maintenance approach. We have completed testing of all poles identified as being in poor and fair condition and poles identified in service for over 20 years. Also, approximately half of these poles are retested within the last 5 years as recommended in the previous year's test results. The testing involves performing a visual check of the pole and its equipment, sounding the pole, obtaining a core sample from the base of the pole when required and recording all relevant information.

This budget item will replace the approximately 30 to 40 poles that are anticipated as being fully depreciated and requiring immediate replacement based upon the 2011 pole testing program finding.

COST ESTIMATE

Section - 132	**$292,000**



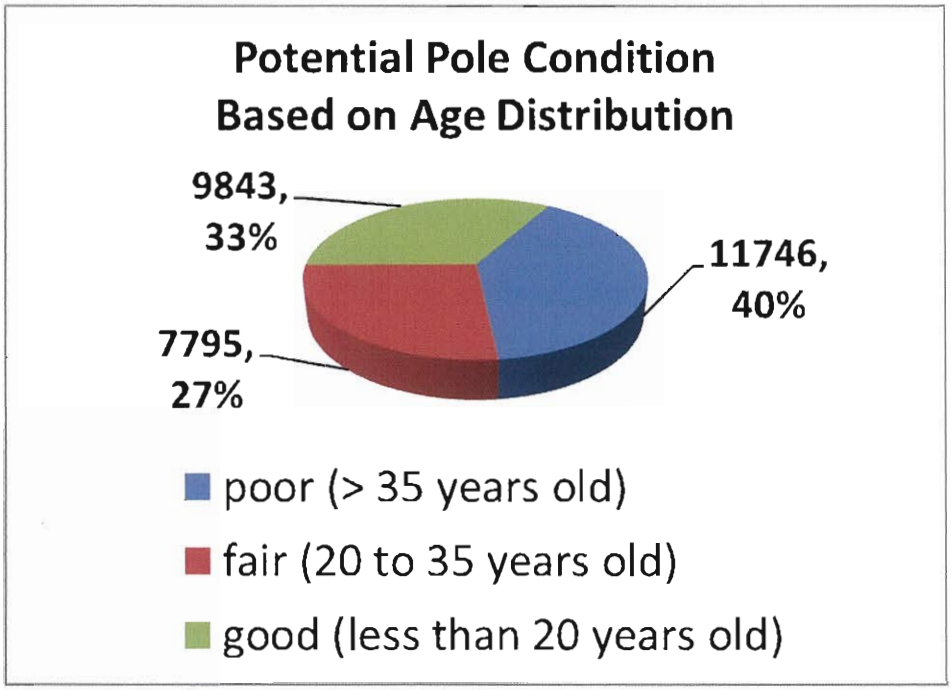
Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Replacement of Fully Depreciated Poles
Project 12G1

This project involves replacement of the fully depreciated wooden poles that were tested and recommended for replacement.

London Hydro's system contains over 29,000 poles. Approximately 98% of the poles on London Hydro's system are made of wood. In 1998 London Hydro introduced the pole testing program as part of our condition based assessment. The testing was based on the results of the infrastructure audit conducted on London Hydro's overhead system in the same year. Since then, London Hydro tested all poles identified as being in poor or fair condition during the infrastructure audit, poles that supposedly migrated from good to fair condition since the audit, and all poles that were recommended to be revisited in the previous testings. Also, poles that are older than 20 years are tested every 5 years. Pole testing is done on annually basis and capital expenditures are based on the results of the inspections.

A graph showing the overall pole age on London Hydro's system is shown below. Poles greater than 35 years in service have the potential to be in poor condition. It's estimated that 5,390 poles (18%) in our system are over 50 years of age.



Potential Condition of Poles (29,384 Poles in Total) based on age.
The pole age is based on the current GIS data. Some pole ages have been estimated.

The table below summarized the condition of 8,500 poles inspected between the years 2007-2010. Based on past testing results, it's estimated that about 13% of the poles tested are due for replacement within 5 years.

Scale	Condition	% of total pole test population
Replace in 0-2 years	Major Wear	5 %
Re-inspect in 2-4 years	Moderate Wear	5 %
Re-Inspect in 4-5 years	Minor Wear	3 %
Re-Inspect in 10 years	Good Condition	87 %

2012 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	12G2
Project Name:	Replacement of Pole Fire Poles
Project Driver:	REL

Project Title: Replacement of Poles Susceptible to Pole Fires

Project Manager:	Rod Doyle	**Project Tech.:**	Jim Soetemans

Supporting Reference Material

Mitigating Pole Fires on London Hydro's Distribution System Report
Asset Sustainment Plan, 2012 - 2026 Report

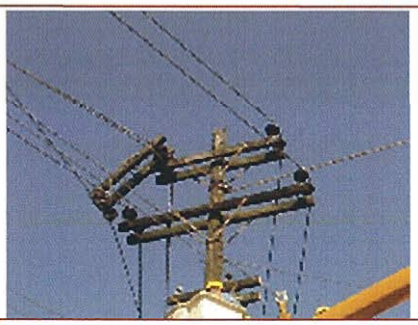
Description/Justification

The areas designated for replacement consists of the plant built more that 40 years ago and is identified in the above reports as requiring replacement. This plant consists of outdated and aged materials and construction techniques that are more prone to failure than those used today.

This budget item will replace the pole line along Highbury Avenue between Dundas St. and Oxford Street East.

COST ESTIMATE

Section - 132	**$506,000**



Prepared By: Rod Doyle, P.Eng.
Distribution Engineer

Approved By: Ken Walsh, P.Eng.
Chief Engineer &
V.P. of Operations

Replacement of Poles Susceptible to Pole Fires

Project 12G2

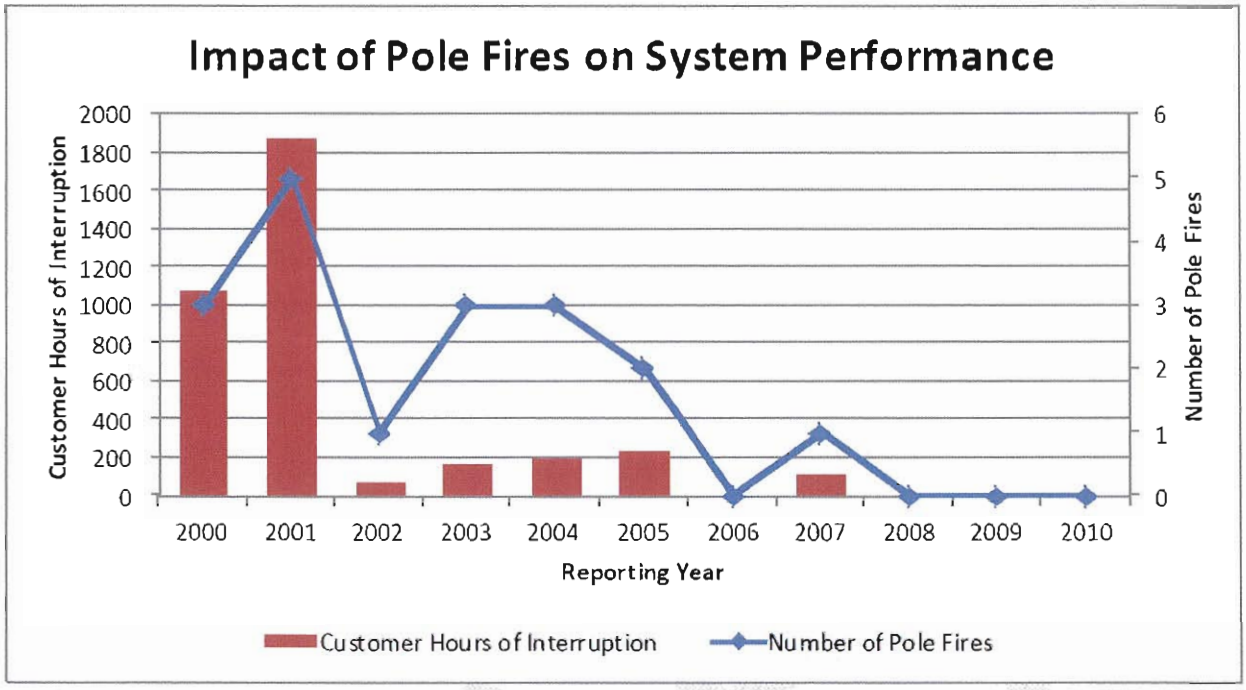
The only project scheduled for 2012 involves replacement of 28 poles susceptible to pole fires and reframing a few adjacent poles along Highbury Avenue North between Oxford Street East and Dundas Street.

Due to the pole line rebuilds and voltage conversions under Project Number 12G3 in the First Street and Second Street areas, the need for the 4.16kV circuit tie along this section of Highbury Avenue North is no longer required. Therefore, the 4.16kV load along this section of Highbury Avenue North will be converted to 27.6kV. Converting the loads along this section are consistent with the requirements under the *Asset Sustainment Plan* and *4kV Aging Infrastructure System Planning Report*.

Pole fires occur in specific older types of overhead construction with wood crossarms and pin type insulators. In these types of construction, leakage current tracks over deteriorated insulators and becomes concentrated in places where bolts and steel brackets interface with the wood resulting in fires.

Several years ago London Hydro instituted the pole fire replacement program and to-date has completed 78% of the projects. This resulted in the significant improvement in the system performance as illustrated on the graph below. The replacement program will continue on an annual basis until the time that all pole fire prone poles are replaced.

After completing this pole-fire project scheduled for 2012, 80% of the pole-fire projects will be completed.



Impact of Pole Fires on System Reliability

2012 ASSET MANAGEMENT PLAN

London Hydro

E&O Department

Project Number:	12G3
Project Name:	Rebuild Depreciated Areas
Project Driver:	REL

Project Title: Rebuild of Fully Depreciated Overhead Areas

Project Manager:	Rod Doyle	**Project Tech.:**	Hank Bonnar & Jim Soetemans

Supporting Reference Material

Asset Sustainment Plan, 2012 - 2026 Report
4kV Aging Infrastructure System Planning Report - 2011

Description/Justification

The above reports have identified various parts of the system in this area as being in poor condition. The deficiencies related to the age of the equipment may adversely impact the reliability of supply as well as public and employee safety. The poles and associated hardware are approximately 50 years old. Many of the transformers in the area are operating in excess of their capacity due to load which has been added by customers over the years (i.e. air-conditioning and other appliances). These reports confirm we must continue to replace aging plant.

In 2010 a city wide audit focusing on depreciated areas was completed and yielded the following areas as priority for replacement:

1. Old East - Phase 2 of 2. This area bounded by Elias Street, Dundas Street, Ontario Street and Burbrook Place was deemed the worst depreciated area in terms of overall condition. Phase 1 last year completed everything west of Quebec Street. Phase 2 will complete everything east of Quebec Street.

2 Pond Mills - Phase 2 of 2. This area on the southwest corner of Commissioners Road East and Pond Mills Road was deemed the second worst depreciated area. Converting this area will also assist with offloading Sub 15, which experienced a failed transformer last year. Phase 1 last year completed the 3-phase loop section. Phase 2 will complete the 1-phase loop sections.

3. First / Second Street area - Phase 2 of 2. This area bounded by Oxford Street East, Spanner Street, First Street and Second Street was deemed fourth worst depreciated area. Phase 1 last year completed First Street and its radial streets. Phase 2 will complete Second Street and its radial streets.

COST ESTIMATE

Section - 132	**$1,770,000**

Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

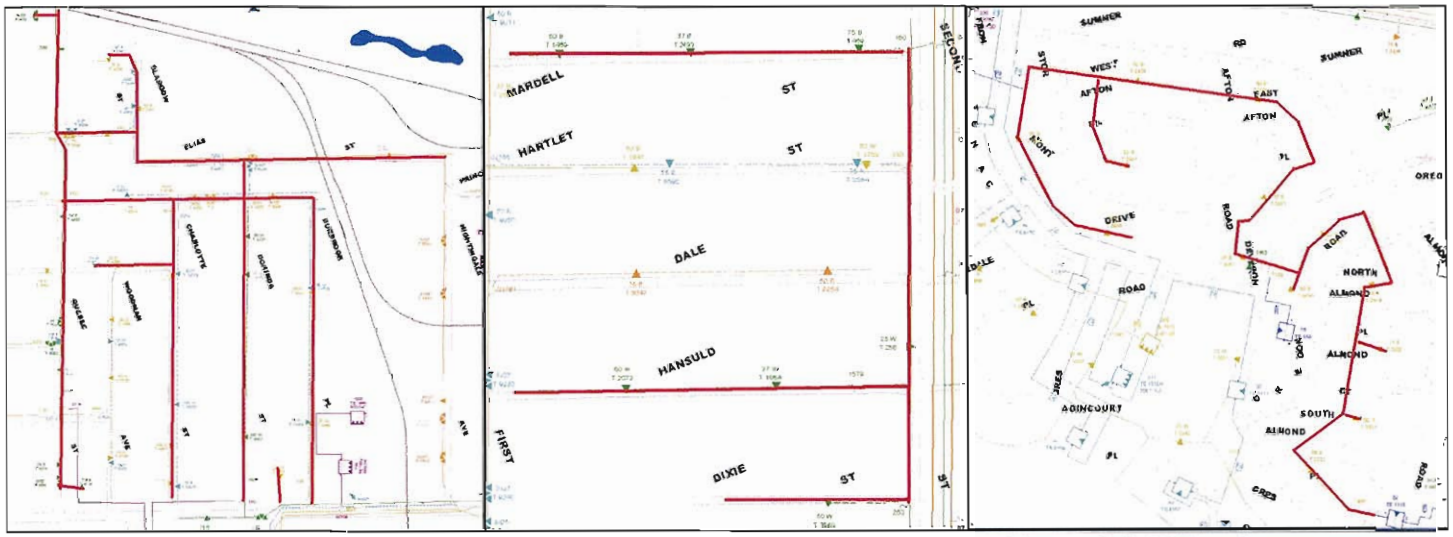
Replacement of Fully Depreciated Overhead Areas
Project 12G3

London Hydro has established a set of criteria to be used when prioritizing which fully depreciated overhead areas are to be rebuilt. These include: results from the visual audit conducted on the overhead system in 1998, OEB infrastructure audit results, pole testing results, safety issues, system performance, accessibility and reliability.

London Hydro completed an audit of its most depreciated overhead areas. Twenty-seven areas were evaluated based on a number of factors, such as:

- overall condition, which included pole, wood crossarms, transformers and conductors
- safety conditions, which included adequate anchoring, #6 Copper, grounds, non-standard framing, encroachments
- environment, which included leaking transformers
- accessibility and operability

Some areas are in extremely poor condition and require complete rebuilds. Most of the poorest conditioned areas are at the vintage 4.16kV distribution system. Conversion of this voltage system will be implemented to benefit other system requirements such as offloading substations and improve system efficiency (reduce system losses). Conversion of these depreciated 4.16kV areas are supported in the *4kV Aging Infrastructure System Planning Report – 2011* and must be completed prior to undertaking the rebuilding and converting Zone 'A' in the report.



East London Area **First/Second St. Area** **Pond Mills Area**

The above three areas were started in 2011 and will be completed in 2012. The overhead plant in these areas were fully depreciated and qualify for replacement under the *Asset Sustainment Plan, 2012 - 2026 Report*

1. Old East - Phase 2 of 2. This area bounded by Elias Street, Dundas Street, Ontario Street and Burbrook Place was deemed the worst depreciated area in terms of overall condition. Phase 1 last year completed everything west of Quebec Street. Phase 2 will complete everything east of Quebec Street.

2. Pond Mills - Phase 2 of 2. This area on the southwest corner of Commissioners Road East and Pond Mills Road was deemed the second worst depreciated area. Converting this area will also assist with offloading Sub 15, which experienced a failed transformer last year. Phase 1 last year completed the 3-phase loop section. Phase 2 will complete the 1-phase loop sections.

3. First / Second Street area - Phase 2 of 2. This area bounded by Oxford Street East, Spanner Street, First Street and Second Street was deemed fourth worst depreciated area. Phase 1 last year completed First Street and its radial streets. Phase 2 will complete Second Street and its radial streets.

2012 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	12G4
Project Name:	Zone 'A' Overhead Conversion
Project Driver:	REL

Project Title: Rebuild and Conversion of Subs 1, 2 & 28 Overhead Areas (Zone 'A')

Project Manager:	Rod Doyle	**Project Tech.:**	Hank Bonnar & Jim Soetemans

Supporting Reference Material

4kV Aging Infrastructure System Planning Report - 2011
Asset Sustainment Plan, 2012 - 2026 Report

Description/Justification

The initiatives outlined in the *4kV Aging Infrastructure System Planning Report* require converting all 4.16kV within Zone 'A', with Zone 'A' being the service territories for Substations 1, 2 and 28. In addition, the proposed rebuilds replace depreciated infrastructure meeting the criteria outlined in the Asset Sustainment Plan, 2012 - 2026 Report.

This budget section is the first phase over the next few years to convert Zone 'A'. This budget section must coordinate closely with the Zone 'A' vault conversion under Project Numbers 12B6 and 12B9.

COST ESTIMATE

Section - 132	**$841,000**

Prepared By: Rod Doyle, P.Eng.
Distribution Engineer

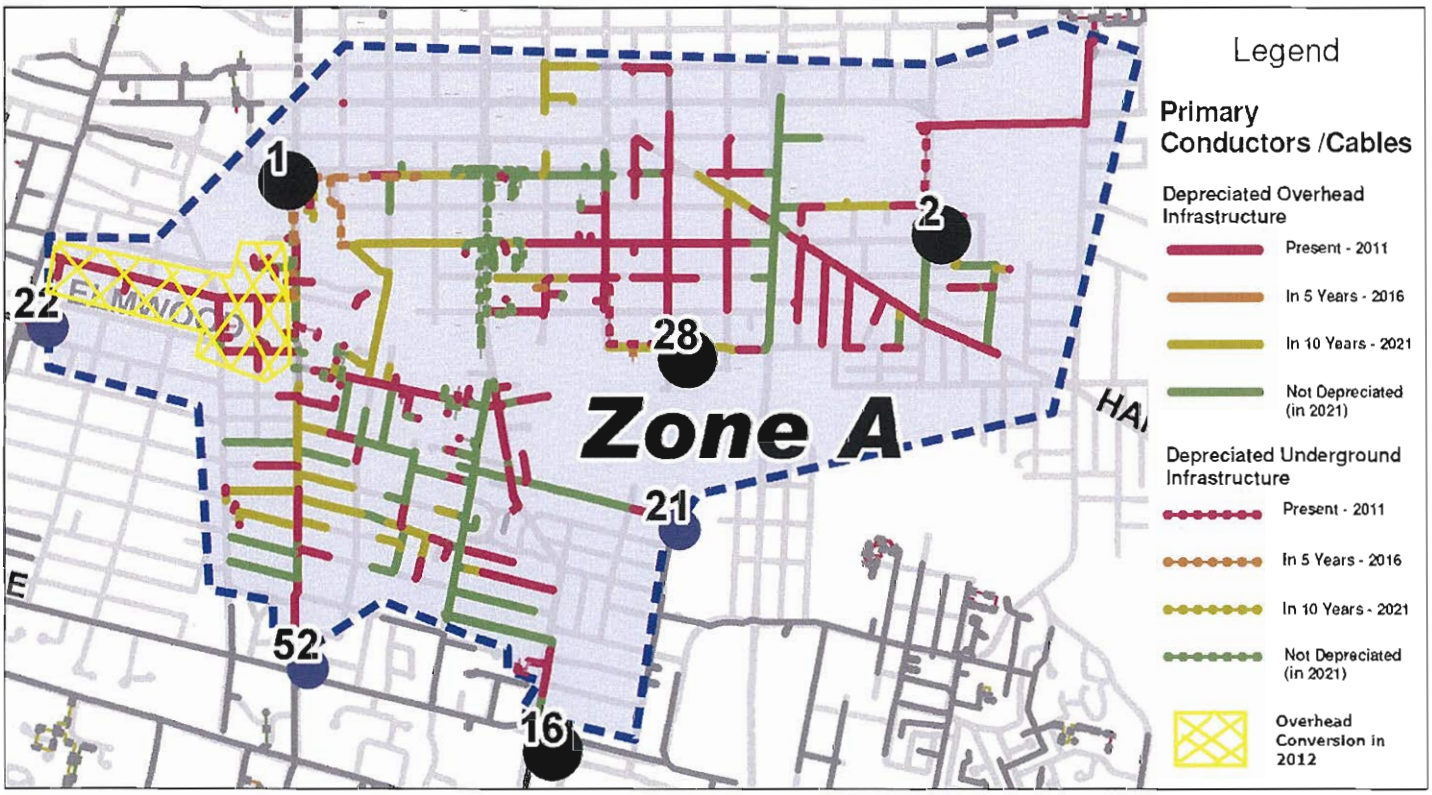
Approved By: Ken Walsh, P.Eng.
Chief Engineer &
V.P. of Operations

Zone 'A' Overhead Conversions
Project 12G4

The initiatives outlined in the *4kV Aging Infrastructure System Planning Report* require converting all 4.16kV within Zone 'A', with Zone 'A' being the service territories for Substations 1, 2 and 28. In addition, the proposed rebuilds replace depreciated infrastructure meeting the criteria outlined in the *Asset Sustainment Plan, 2012 - 2026 Report*.

This budget section is the first phase over the next few years to convert Zone 'A'. This year will convert the following areas:

- Bruce Street, between Wharncliffe Road and Ridout Street
- Wortley Road, between Bruce Street and Elmwood Avenue
- Craig Street, between Wortley Road and Ridout Street
- Marley Place, between Bruce Street and Duchess Avenue
- Edward Street, Brighton Street and Teresa Street all between Bruce Street and Elmwood Avenue



Zone 'A' Area

The above work must coordinate closely with the Zone 'A' vault conversion under Project Numbers 12B6 and 12B9.

2012 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	12G5
Project Name:	Porcelain Arrester Replacement
Project Driver:	SAF

Project Title:	Porcelain Arrester Replacement Program

Project Manager:	Hassan El-Madhoun	**Project Tech.:**	Sherri Bechtel

Supporting Reference Material

March 2011 Reliability Incident Summary Report

Description/Justification

This budget item is for the replacement of Porcelain Distribution Class Arresters. This is the first year of a multi-year program intended to target and eliminate all known locations of porcelain arresters and replace them with polymer style arrester.

COST ESTIMATE

Section - 132	**$98,000**



Prepared By:	Hassan El Madhoun, E.I.T. Assisstant Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Porcelain Arrester Replacement Program
Project 12G5

Porcelain arresters are known to have a poor seal, thereby letting in moisture. Moisture ingress can reduce the Maximum Continuous Operating Voltage (MCOV) and the porcelain arrester can overheat and fail, sometimes violently, causing a safety concern.

Based on the best known date of when London Hydro stopped purchasing Porcelain Arresters, an initial estimated number of locations was identified: 275 risers are still likely equipped with porcelain arresters and approximately 1400 transformers may be equipped with porcelain style arresters. A full audit of our system will be conducted over the 2011 to 2013 period; the plan is to begin spending $98,000 in 2012 and 2013; the full scope of work will not be defined until the audit is completed.



Fig 1. Arresters at risers

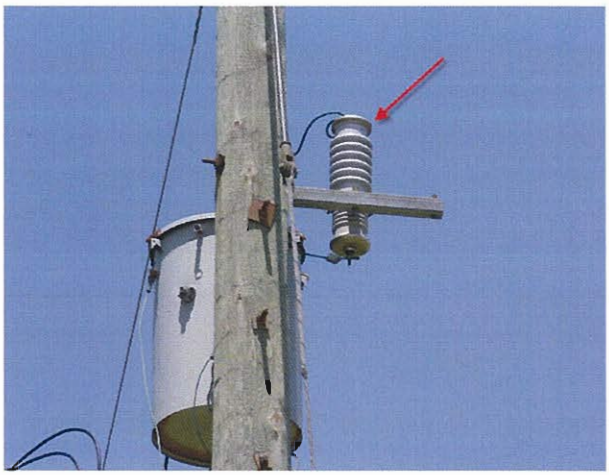


Fig 2. Transformer arrester

2012 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	12G6
Project Name:	Removal and Restoration
Project Driver:	REL

Project Title: Removal and Restoration of Overhead Plant

Project Manager:	Rod Doyle	**Project Tech.:**	Hank Bonnar & Jim Soetemans

Supporting Reference Material

Description/Justification

In 2012, London Hydro will be completing overhead pole line rebuilds in various areas within the city. These rebuilds involve many pole hole excavations and pole removals. This budget will be used to complete restoration in these areas. It is noted that these removals must be coordinated with our joint use partners such as Bell & Rogers and thus timing is dependent on external parties.

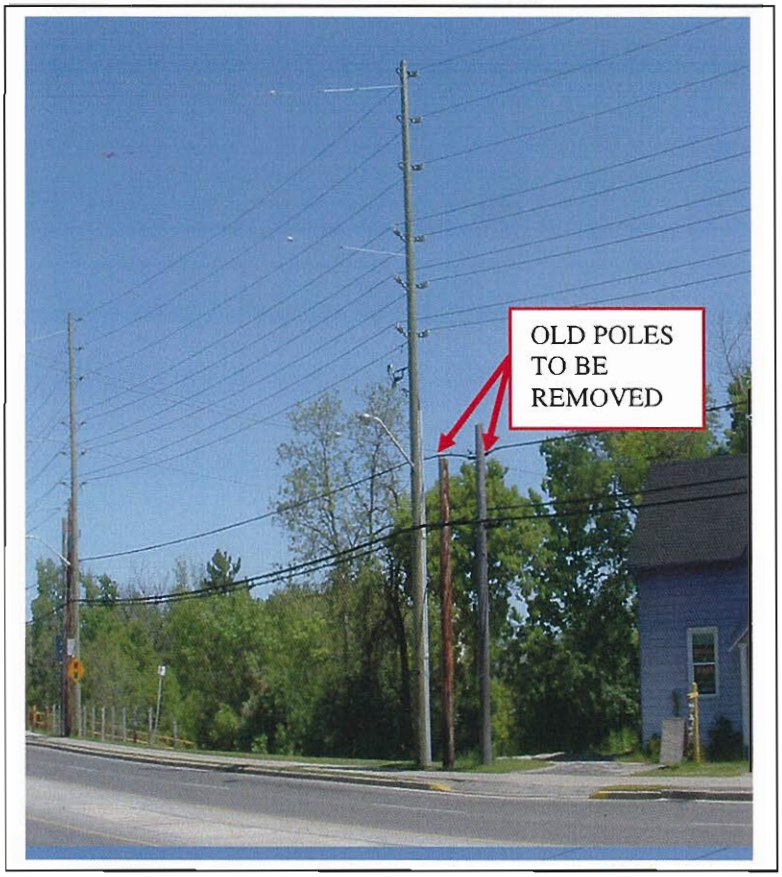
COST ESTIMATE

Section - 132	**$30,000**

Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Removal and Restoration
Project 12G6

The picture below is an example of new hydro pole construction, where the old structure is still supporting 3rd party attachments. The final phase of construction involves the removal of this structure, but must be co-ordinated with the 3rd party utilities (i.e. Rogers Cable, Bell) still attached to our poles.



2012 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	12H1
Project Name:	Recloser Installations
Project Driver:	REL

Project Title: Automation on Feeders - Recloser Installations

Project Manager:	Rod Doyle	**Project Tech.:**	Jim Soetemans

Supporting Reference Material: Quality of Supply Report 2010

Description/Justification

This project has been budgeted to install 3 reclosers to facilitate SCADA switching, fault isolation and restoration. Installation of these devices has resulted in significant improvements in reliability. The reclosers will be installed at the following locations:

1) Between SW 01514 & SW 02307 (in place of SW 01252) on Fanshawe Park Road East just west of North Centre Road.

2) In place of loadbreak switch N52-7 on Southdale Road East just east of White Oak Road. This is an open point between the 32M7 and 32M4 feeders.

3) In place of loadbreak switch S49-8 on Windermere Road west of Adelaide Street North. This will aid in sectionalizing the 26M11 feeder.

COST ESTIMATE

Section - 250	**$187,000**

Prepared By:	Rod Doyle Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Recloser Installations
Project 12H1

The installation of automated switches or reclosers on major feeders has a positive impact on the duration and frequency of outages. London Hydro now has over 100 automated devices in the field and plans to continue installing reclosers until there is an average of 2.5 reclosers per 27.6 kV feeder; thus, sectionalizing each feeder to approximately 1000 customers between reclosers.

The installation of reclosers is a very cost effective way of improving SAIFI reliability (System Average Interruption Frequency Index). A report was developed into an industry paper entitled "Use of Reclosers on London Hydro's Electrical System" (included in abstract) that examined various methods for evaluating the cost effectiveness of reliability improvement programs.

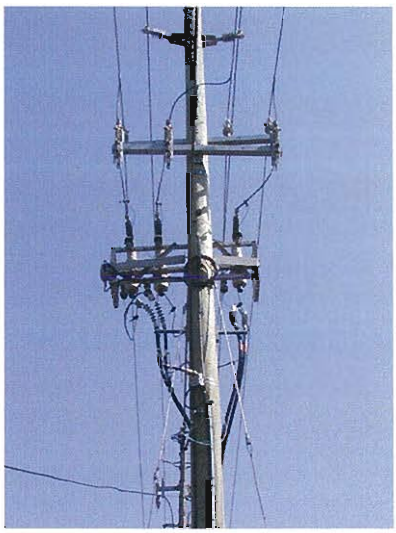


Figure 1 – Horizontal Recloser Installation

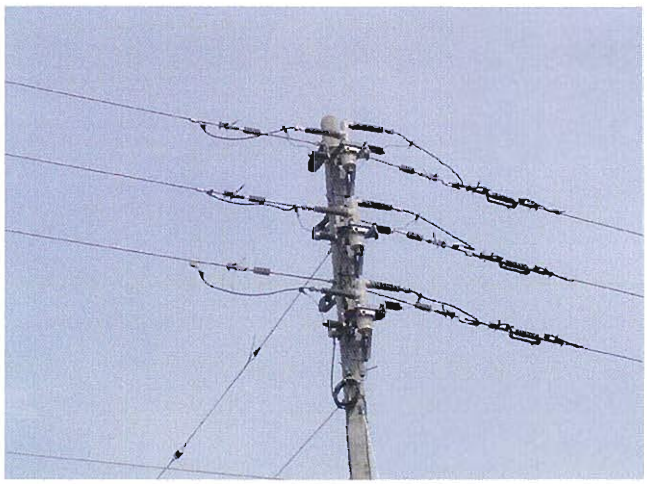


Figure 2 – Vertical Recloser Installation

2012 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	12H2
Project Name:	Network Temperature Monitoring
Project Driver:	REL

Project Title: Installation of Network Temperature Monitoring Devices

Project Manager:	Ed Jambor	**Project Tech.:**	Kim Franklin

Supporting Reference Material

Description/Justification

When network transformers or cables are taken out of service, network loads will shift in ways that are difficult to predict. Although we do our best to model the system and to provide reinforcements where required, parts of the system can still get overloaded during contingency conditions. Exactly how many cable half sections can be out of service without causing overheating of the remaining parts of the network is an ongoing question.

We experimented with a low cost temperature monitor in 2009 that has done a good job of keeping track of cable and mole surface temperatures. If enough of these are installed in key locations it will give us better information on how network loads shift during planned and emergency outages. This will allow us to provide reinforcements to help prevent future cable failures and network fires.

The money provided will allow for dozens of temperature monitors to be installed in key locations.

COST ESTIMATE

Section - 150	**$10,000**

Prepared By:	Ed Jambor, P. Eng. Director of Operations
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Network Temperature Monitoring
Project 12H2

The temperature monitoring devices are a USB style and sized device that has a thermocouple attachment. The USB device can be programmed to store temperatures every few minutes, hourly, daily, etc. The devices are very low in cost, taped onto a cable in a manhole and must be visited periodically to download the data into an Excel spreadsheet. If enough of these devices can be installed we will learn more about the behaviour of the network as loads shift (and temperatures increase) during partial outages. As technology improves and costs come down, we may eventually be able to communicate with similar devices in real time, but for now, the information from these devices is retrieved manually as required.

2012 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	12H3
Project Name:	RTU Replacement Program
Project Driver:	REL

Project Title:	Remote Terminal Unit (RTU) Replacement Program

Project Manager:	Cole Tavener	**Project Tech.:**	Rolf Reiners

Supporting Reference Material	Asset Sustainment Plan - Electrical Distribution System: 2012 - 2026

Description/Justification

The purpose of this project is to implement the standard remote terminal unit (RTU) design developed in 2011. It is part of a program to address the replacement of up to 20 RTUs between 2012 and 2017.

COST ESTIMATE

Section - 250	**$49,000**

Prepared By:	Cole Tavener, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Remote Terminal Unit (RTU) Replacement Program
Project 12H3

RTUs provide the interface between substation devices and the SCADA master computer. In addition to remote control, these devices enable remote observation of the system's configuration and load flows. The ability to observe the system remotely is critical to system reliability, specifically System Average Interruption Duration Index (SAIDI).

London Hydro currently utilizes 45 RTUs to monitor its substations. Over half the asset population is no longer supported by the manufacturer and the oldest units have exceeded their expected useful life by nearly a decade. One third of the asset population consists of piloted equipment that was found to be inadequate. To maintain system observation and control capabilities, a RTU replacement program is required.

Manufacturer	Type	Quantity	Earliest Installation
Cat Com Systems	Rantech	24	1983
GE Multilin	DART	5	1995
SEL	2032	4	2007
SEL	RTAC	3	2011
Natis Communications	RTU3200	3	2008
G&W	ATC	3	2000
GE Multilin	Ibox	2	2003
GE Multilin	D20	2	2002

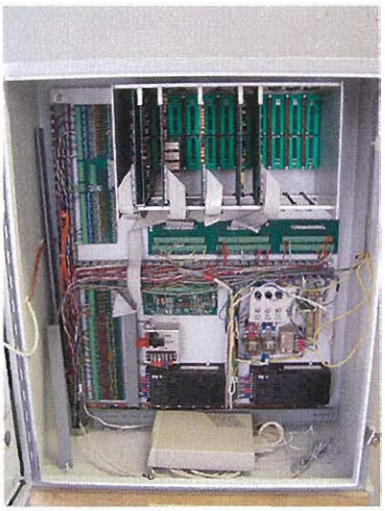


Figure 1 – Rantech RTU



Figure 2 – SEL 2032 RTU

2012 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	12H4
Project Name:	Control Room New Monitors
Project Driver:	REL

Project Title: Installation of New Control Room Computer Monitors

Project Manager:	Ed Jambor	**Project Tech.:**	Al Popovich

Supporting Reference Material

Description/Justification

The computer monitors in the control room were installed with the original SCADA system and it's anticipated that the new OMS system planned for 2012 and 2013 will require additional monitors that are larger in size at the System Operator's workstations.

The larger monitors will work in tandem with the wallboard to allow viewing and operating of the electrical network. Paper maps are currently being used to keep track of the real time state of the network's open points but with the introduction of the OMS system, open points need to be kept up to date using computer screens.

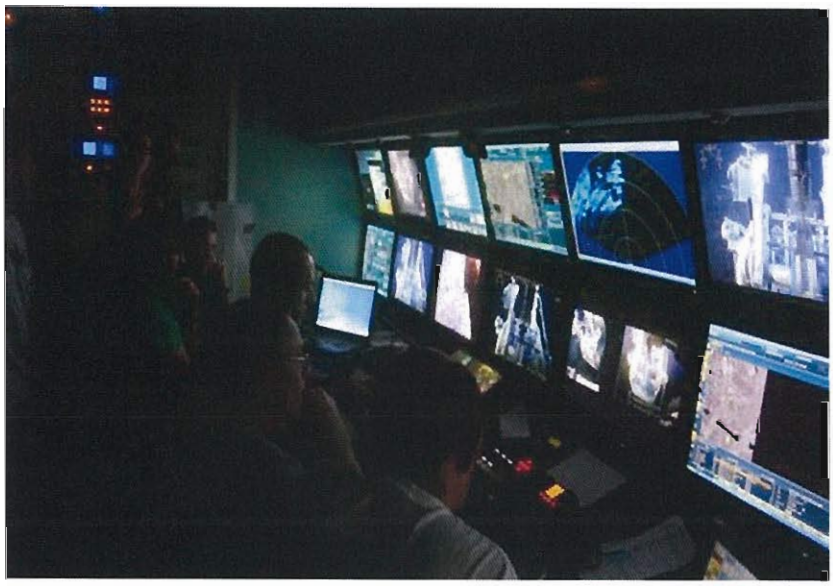
COST ESTIMATE

Section - 250	**$50,000**

Prepared By:	Ed Jambor, P. Eng. Director of Operations
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Control Room New Monitors
Project 12H4

Once the System Operators begin working with the OMS system, more will be known about how to best configure the screens in the Control Room to allow easy visualization and operation of the electrical distribution network. Currently the thought is that a two tiered display similar to the one shown below might provide the best solution.



DETAILED PROJECT DESCRIPTION 2013



2013 Proposed Asset Management Plan

Category Code	Proj Code	Project Description/Scope	CGAAP BUDGET	IFRS BUDGET	Cash Flow (based on IFRS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Cash Flow Total
A Substation Rebuilds																	
A	13A1	Relay Replacements	25,000	25,000								5,000	5,000	15,000			25,000
A	13A2	Battery Bank Replacements	30,000	30,000	2,000	5,000	10,000	13,000									30,000
A	13A3	SF6 Switchgear Modifications	120,000	119,000					9,000	10,000	10,000	30,000	30,000	30,000			119,000
A	13A4	Vault Ladder Replacement	30,000	30,000					10,000	10,000	10,000						30,000
A	13A5	Sub 54 Riser Fusing	15,000	15,000			2,000	13,000									15,000
A Substation Rebuilds Total			**220,000**	**219,000**	**2,000**	**5,000**	**12,000**	**26,000**	**19,000**	**20,000**	**20,000**	**35,000**	**35,000**	**45,000**	**-**	**-**	**219,000**
B Subdivision Rebuilds																	
B	13B1	Silicone Injection of Underground Cable	1,165,000	1,149,000	110,000	100,000	90,000	90,000	90,000	110,000	110,000	110,000	110,000	104,000	75,000	50,000	1,149,000
B	13B2	Subdivision Conversions / Rebuilds with Silicone Injection	2,245,000	2,206,000	25,000	100,000	200,000	200,000	230,000	250,000	250,000	250,000	250,000	231,000	150,000	70,000	2,206,000
B	13B3	Replacement of Air Insulated Sectionalizing Enclosures	480,000	462,000	1,000	1,000	115,000		115,000		115,000		115,000				462,000
B	13B4	Fully Depreciated and Leaking Transformer Replacements	1,080,000	1,040,000	81,000	86,000	85,000	86,000	85,000	91,000	90,000	91,000	90,000	91,000	88,000	76,000	1,040,000
B	13B5	Residential Secondary Pedestal Replacements	25,000	25,000					5,000	5,000	5,000	5,000	5,000				25,000
B	13B6	Vault Transformer Replacements	385,000	374,000	5,000	5,000		95,000	100,000	95,000	74,000						374,000
B	13B7	Installation of Underground Backup Supply	25,000	25,000		1,000		8,000		8,000		8,000					25,000
B	13B8	Installation of Fault Indication on Padmounted Transformers	15,000	15,000	1,000	14,000											15,000
B	13B9	Sub 1, 2 & 28 Underground Conversion	468,000	459,000	10,000	10,000	10,000			100,000	100,000	100,000	129,000				459,000
B Subdivision Rebuilds Total			**5,888,000**	**5,755,000**	**233,000**	**317,000**	**500,000**	**479,000**	**625,000**	**659,000**	**744,000**	**564,000**	**699,000**	**426,000**	**313,000**	**196,000**	**5,755,000**
C Main Feeder																	
C	13C1	Main Feeder Reinforcements	989,000	973,000	10,000	10,000	10,000	110,000	120,000	120,000	120,000	120,000	110,000	100,000	100,000	43,000	973,000
C Main Feeder Total			**989,000**	**973,000**	**10,000**	**10,000**	**10,000**	**110,000**	**120,000**	**120,000**	**120,000**	**120,000**	**110,000**	**100,000**	**100,000**	**43,000**	**973,000**
D City Works																	
D	13D1	City of London (Road Authority) Relocations	1,250,000	1,228,000	140,000	140,000	140,000	150,000	150,000	150,000	88,000		100,000	100,000	70,000		1,228,000
D City Works Total			**1,250,000**	**1,228,000**	**140,000**	**140,000**	**140,000**	**150,000**	**150,000**	**150,000**	**88,000**	**-**	**100,000**	**100,000**	**70,000**	**-**	**1,228,000**
E Developer Projects																	
E	13E1	Developer Driven Distribution Circuits Expansions and Relocations	630,000	614,000	82,000	82,000	75,000	75,000	50,000	50,000	50,000	75,000	75,000				614,000
E	13E2	Residential Secondary Service Upgrades	325,000	321,000	20,000	20,000	20,000	24,000	33,000	33,000	30,000	30,000	30,000	30,000	30,000	21,000	321,000
E	13E3	New Single Family Residential Underground Distribution	1,550,000	1,496,000	65,000	65,000	80,000	101,000	155,000	155,000	155,000	155,000	155,000	155,000	155,000	100,000	1,496,000
E	13E4	New Multi-Housing Underground Distribution	650,000	630,000	30,000	30,000	30,000	60,000	60,000	60,000	70,000	70,000	70,000	70,000	80,000		630,000
E	13E5	New Commercial Distribution Services	2,100,000	2,025,000	100,000	125,000	125,000	190,000	190,000	190,000	235,000	190,000	190,000	190,000	150,000	150,000	2,025,000
E Developer Projects Total			**5,255,000**	**5,086,000**	**297,000**	**322,000**	**330,000**	**450,000**	**488,000**	**488,000**	**540,000**	**520,000**	**520,000**	**445,000**	**415,000**	**271,000**	**5,086,000**
F Network																	
F	13F1	Replacement of Network Vaults / Manholes / Transformers	550,000	536,000	10,000	10,000		100,000	123,000	123,000	120,000	50,000					536,000
F	13F2	Replacement of Primary & Secondary Cables	350,000	341,000	30,000	30,000	30,000	30,000	21,000	30,000	30,000	30,000	30,000	30,000	30,000	20,000	341,000
F	13F3	Eliminate East End Network - Phase 4	120,000	118,000	5,000	5,000		39,000	39,000	30,000							118,000
F	13F4	Manhole Cable Rebuilds	150,000	147,000	2,000	2,000			46,000			47,000		50,000			147,000
F Network Total			**1,170,000**	**1,142,000**	**47,000**	**47,000**	**30,000**	**169,000**	**229,000**	**183,000**	**150,000**	**127,000**	**30,000**	**80,000**	**30,000**	**20,000**	**1,142,000**
G Overhead Line																	
G	13G1	Replacement of Fully Depreciated Poles	300,000	292,000		3,000	3,000	3,000		50,000	50,000	50,000	50,000	42,000		41,000	292,000
G	13G2	Replacement of Poles Susceptible to Pole Fires	300,000	292,000	3,000	3,000	3,000	91,000	92,000	100,000	-						292,000
G	13G3	Rebuild of Fully Depreciated Overhead Areas	170,000	166,000	70,000	50,000	46,000	-	-								166,000
G	13G4	Momentary Mitigation	250,000	245,000	2,500	2,500	2,000	94,000	94,000	50,000							245,000
G	13G5	Sub 1, 2 & 28 Overhead Conversion	4,242,000	4,151,000	150,000	170,000	170,000	420,000	420,000	420,000	450,000	451,000	450,000	450,000	300,000	300,000	4,151,000
G	13G6	Porcelain Arresters Replacement Program	100,000	98,000	50,000	48,000											98,000
G	13G7	Removals & Restoration of Overhead Plant	30,000	30,000						5,000	5,000	5,000	5,000	5,000	5,000		30,000
G Overhead Line Total			**5,392,000**	**5,274,000**	**275,500**	**276,500**	**224,000**	**608,000**	**606,000**	**625,000**	**505,000**	**506,000**	**505,000**	**497,000**	**305,000**	**341,000**	**5,274,000**
H Automation																	
H	13H1	Recloser Installations	195,000	187,000									92,000	95,000			187,000
H	13H2	RTU Replacement Program	50,000	49,000									25,000	24,000			49,000
H	13H3	Control Room Communications Voice System	30,000	30,000								10,000	10,000	10,000			30,000
H	13H4	Control Room Display Wall Servers and Software	60,000	60,000								20,000	20,000	20,000			60,000
H Automation Total			**335,000**	**326,000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**30,000**	**147,000**	**149,000**	**-**	**-**	**326,000**
MM Wholesale Meter																	
MM	13MM1	Wholesale Metering Upgrades	-	-													-
MM Wholesale Meter Total			**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Total E&O Capital Budget			**20,499,000**	**20,003,000**	**1,004,500**	**1,117,500**	**1,246,000**	**1,992,000**	**2,237,000**	**2,245,000**	**2,167,000**	**1,902,000**	**2,146,000**	**1,842,000**	**1,233,000**	**871,000**	**20,003,000**

2013 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	13A1
Project Name:	Relays
Project Driver:	REL

Project Title:	Relay Replacement Program		
Project Manager:	Cole Tavener	**Project Tech.:**	Rolf Reiners
Supporting Reference Material	2008 Substation Deficiency Report		

Description/Justification

Relays are used to monitor system conditions and trip circuit breakers during a fault. London Hydro has a population of 60 electromechanical relays, devices that are nearing end-of-life due to technical obsolescence. In co-ordination with the 4kV plan, a program will be executed to replace electromechanical relays with digital relays. In 2013, the electromechanical relays at Substation 38 will be replaced.

COST ESTIMATE

Section - 110	**$25,000**

Prepared By:	Cole Tavener, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Relay Replacement Program
Project 13A1

The protection relays at many of London Hydro's substations are nearing end-of-life due to technical obsolescence. To address this situation a program for relay replacements has been developed in co-ordination with the 4kV System Plan. Aged electromechanical relay will be replaced with modern digital relays. The digital relays will enhance protection reliability and provide additional information to the control room during faults.



Figure 1: Substation 38 Electromechanical Relays



Figure 2: Substation 96 Digital Relays

2013 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	13A2
Project Name:	Battery Banks
Project Driver:	REL

Project Title:	Battery Bank Replacement Program
Project Manager:	Cole Tavener
Project Tech.:	Rolf Reiners
Supporting Reference Material	2008 Substation Deficiency Report

Description/Justification

Battery Banks supply the DC power required to operate circuit breakers and relays during power failures.

The 48V SAFT-NITE battery bank at Substation 93, installed in 1997, will be replaced in 2013.

COST ESTIMATE

Section - 110	**$30,000**

Prepared By:	Cole Tavener, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Battery Bank Replacement Program
Project 13A2

Battery banks installed in substations provide DC power to enable the operation of circuit breakers and relays during a power failure. The batteries are inspected annually and tested once every four years. Battery banks are replaced based on age and condition.



Figure 1: Battery Charger

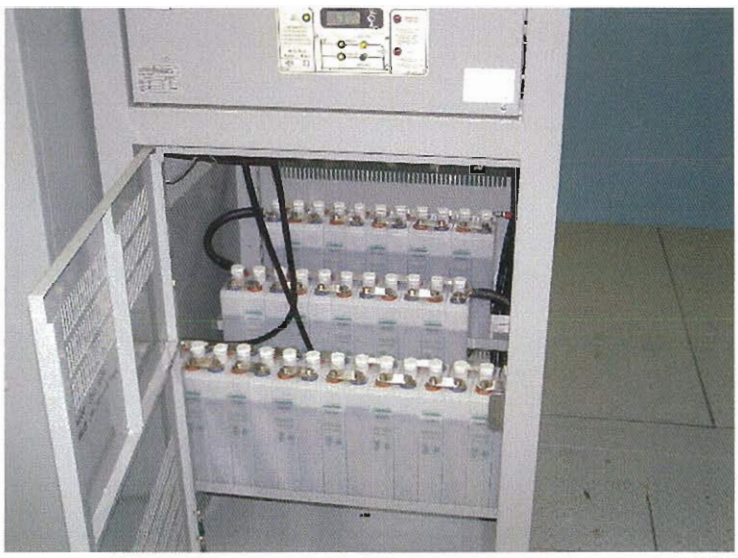


Figure 2: Batteries

2013 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	13A3
Project Name:	SF6 Switchgear
Project Driver:	REL

Project Title:	SF6 Switchgear Modifications
Project Manager:	Cole Tavener
Project Tech.:	Rolf Reiners
Supporting Reference Material	Downtown SF6 Switchgear Failure Investigation

Description/Justification

This project will address the **installation** of four new control systems for the four SF6 switches installed on the 27.6kV downtown loop.

1) Decade Developments
2) Old Oak Properties
3) Galleria
4) One London Place

COST ESTIMATE

Section - 110	**$119,000**

Prepared By:	Cole Tavener, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

SF6 Switchgear Modifications

Project 13A3

The original 27.6kV supply to downtown London was provided using a ringed underground cable. To allow the ring to be sectionalized four SF6 insulated switches were installed. The switches are remotely operable to enable expedient restoration of the downtown load in the event of a fault. In 2011, the switch controllers used to enable remote operation experienced multiple failures. Subsequent investigation by the manufacturer revealed that the controllers, now over 15 years old, are no longer supported. This project will address the **installation** of four new controllers required to maintain the current level of reliability for the 27.6kV downtown load.

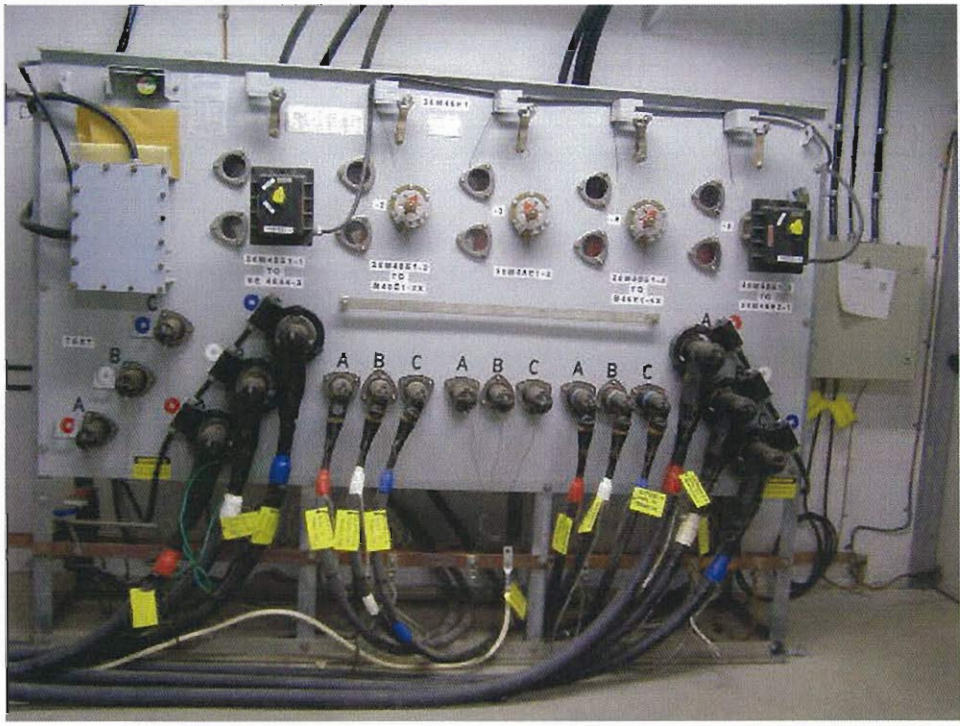


Figure 1: Old Oak SF6 Switch



Figure 2: SF6 Switch Controller

2013 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	13A4
Project Name:	Vault Ladder Replacement
Project Driver:	REL

Project Title:	Vault Ladder Replacement
Project Manager:	Cole Tavener
Project Tech.:	Rolf Reiners
Supporting Reference Material	OEB Audit Inspections

Description/Justification

Vault ladders at NT 7, 8, 27, 39, 40, 47, 48, 52, 55, 58, 59, 65, 68, 80, 94, 96 and 100 will be replaced due to corrosion.

COST ESTIMATE

Section - 110	**$30,000**

Prepared By:	Cole Tavener, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Vault Ladder Replacement
Project 13A4

Due to space restrictions in the downtown core, the majority of the network equipment is installed in vaults. Ladders are installed in the vaults to provide access. As a result of corrosion, a number of the vault ladders have been identified as requiring replacement. This project will address the replacement of vault ladders for NT 7, 8, 27, 39, 40, 47, 48, 52, 55, 58, 59, 65, 68, 80, 94, 96 and 100.



Figure 1 – NT 100 Ladder

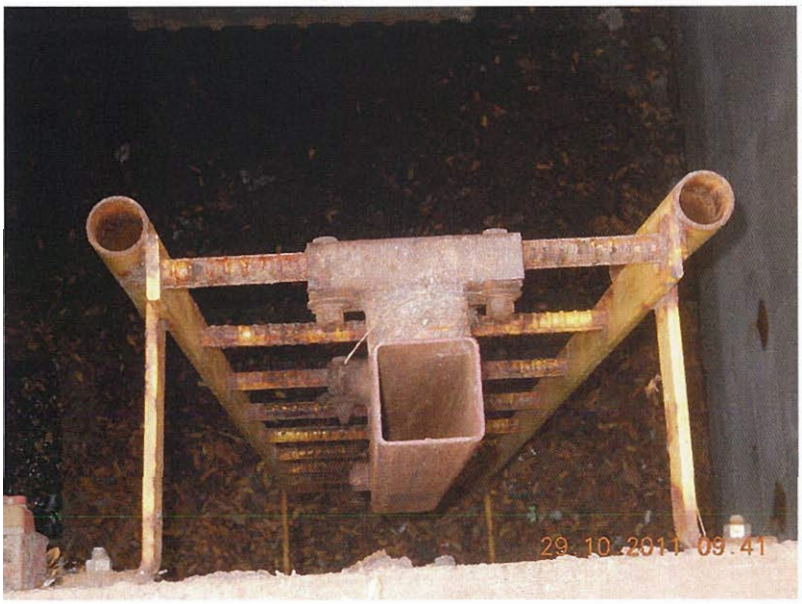


Figure 2 – NT 52 Vault Ladder

2013 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	13A5
Project Name:	Substation 54 Riser
Project Driver:	REL

Project Title:	Substation 54 Riser Fusing
Project Manager:	Cole Tavener
Project Tech.:	Rolf Reiners
Supporting Reference Material	Substation 15 T1 Failure Investigation

Description/Justification

The riser at Substation 54 will be fused to provide a back-up transformer protection and limit interruptions to other customers served by the 27.6kV feeder. This precautionary measure is a result of knowledge gained from the failure of Substation 15 T1.

COST ESTIMATE

Section - 110	**$15,000**

Prepared By:	Cole Tavener, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Substation 54 Riser Fusing
Project 13A5

During the Substation 15 T1 failure, the high-voltage interrupter failed to trip. The interrupter was returned to the manufacturer for testing, but no equipment defects were discovered. Substation 54 employs the same interrupter. As a precautionary measure, the station's 27.6kV riser will be fused to provide a back-up protection for the transformer and to limit interruptions to other customers served by the 27.6kV feeder.

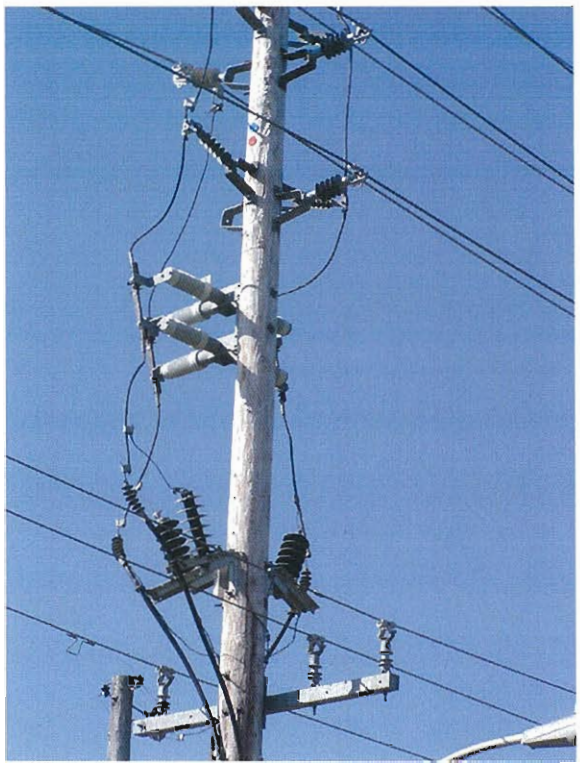


Figure 1: Substation 54 Riser



Figure 2: Substation 83 Fused 27.6kV Riser

2013 ASSET MANAGEMENT PLAN
Project Sheet

Project Number:	13B1
Project Name:	Cable Silicone Injection
Project Driver:	REL

Project Title: Silicone Injection of Underground Cable

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Scott Lasseter/Dane Kirilovic

Supporting Reference Material

Engineering Report Update 2010, **Rehabilitation of Aging Underground Residential Distribution Systems** (2012 addendum)
Asset Sustainment Plan, 2012-2026 Report

Description

This item covers the rehabilitation of underground cable by means of silicone injection in four aged subdivisions. The total length to be injected is estimated at 25.6 km of polymeric cable (25+ years old). These areas were selected using the SPOORE analysis (modeled in the GIS based software Geo Media), which ranks the subdivisions' performance using a five-year history of failures on cables and transformers, as well as a visual representation of leaking transformers from the annual OEB inspections.

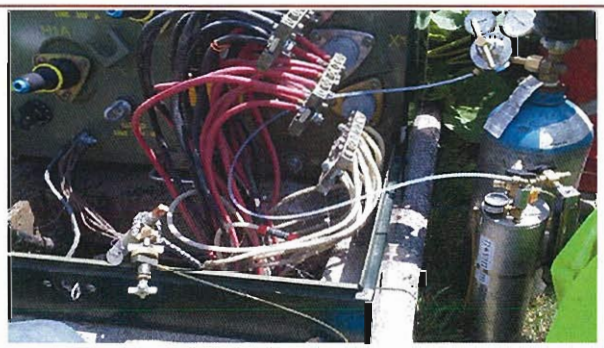
Silicone injection technology increases the lifespan of polymeric cable, adding up to another 40 years of service. In 2011, London Hydro addressed approximately 50 km of aged cable. The rehabilitation will include the replacement of transformers that are deteriorated or leaking, which also improves the customers' downtime by more effective switching. The new transformers are equipped with dual load break switches that allow flexible open points.

It is estimated that at this rate of cable rehabilitation work, the existing population of cable that has passed its lifetime could be addressed over six years. Eventually, a consistent multi-year plan of rehabilitation could bring London Hydro to a complete renewal of all the underground plant that should be retired. In accordance with the 15 year Asset Sustainment Plan, 50 km of cable rehabilitation work per year will be sufficient.

Subdivisions: Northridge, Trafalgar Park, Trillium Woods, and Westwood Village.

COST ESTIMATE

Section - 145	**$1,149,000**



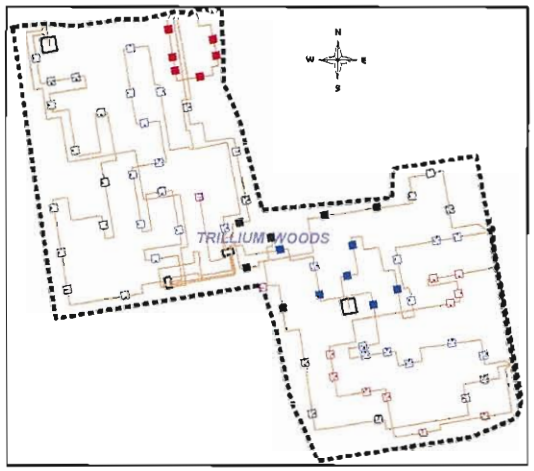
Prepared By: Hassan El Madhoun, E.I.T.
Assistant Distribution Engineer

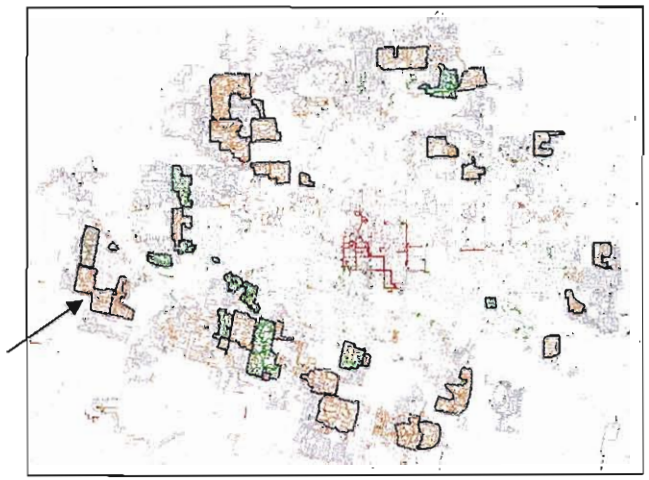
Approved By: Ken Walsh, P.Eng.
Chief Engineer &
V.P. of Operations

1. *Trillium Woods Subdivision (27.6 kV Supply)*

Trillium Woods located southwest of the Boler Road and Baseline Road intersection, occupies an area smaller than 1sq km. Close to 95% of the cable in this subdivision has been in service for over 30 years. This subdivision experienced one large cable fault, multiple transformer failures and ranked the most unreliable subdivision in the 2011 SPOORE analysis.

A total of 14.5 km of cable will be treated with silicon injection. This work will also include changing out as many as one third of the transformers in this subdivision, the majority of which are depreciated live front style transformers. New dead front transformers will be installed at risers for improved operations flexibility. A total of 24 transformers are to be replaced in total as part of this project scope. A single phase switching enclosure unit will also be replaced under this budget item.

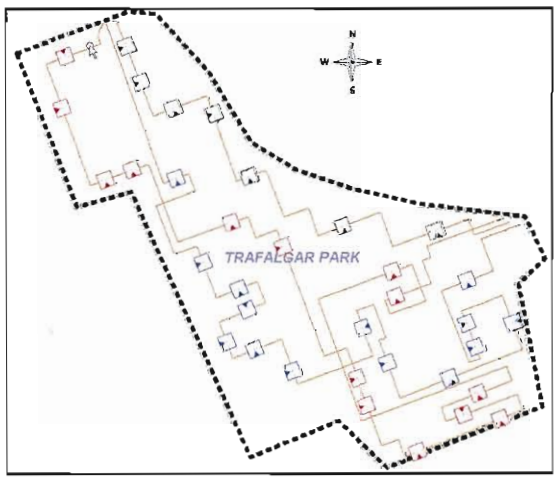


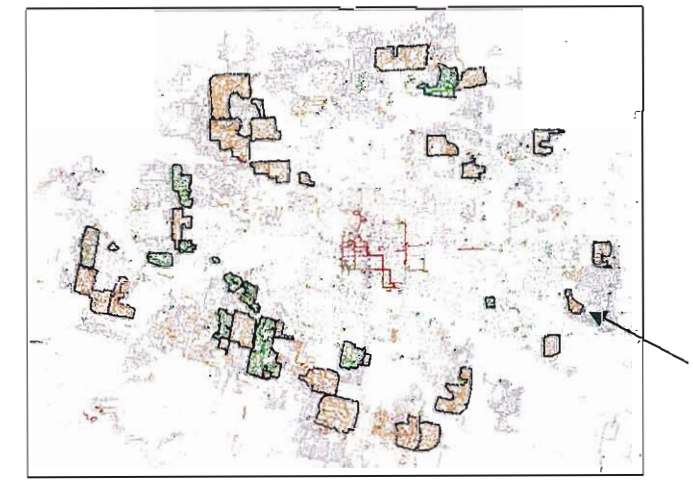


2. *Trafalgar Park (27.6 kV Supply)*

Prior to 2004, Trafalgar Park subdivision was supplied partly at 4.16 kV and partly at 27.6 kV. At that time, the subdivision had poor reliability due to multiple cable faults and radial supply configuration. For that reason it was converted to 27.6 kV which permitted the circuitry to be loop configured. The intention was to provide greater switching flexibility for maintenance and restoration during outages. With the conversions, all padmounted transformers were replaced.

Today, majority of the cable has aged and is now reaching 30 years in service. Another recent cable fault reversed the reliability previously regained in this subdivision. The scope of work in this area is to simply rehabilitate 4.5 km of cable by means of silicon injection.



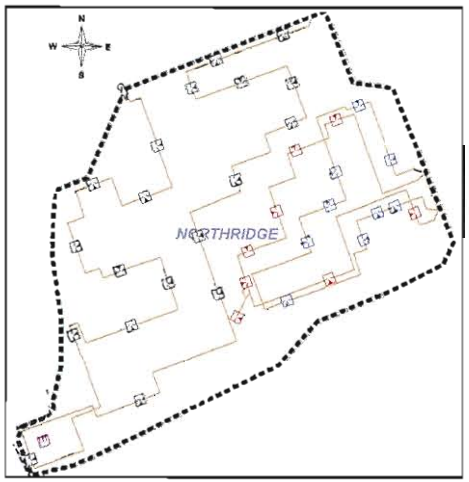


3. ***Northridge (27.6 kV Supply)***

Northridge is located southwest of Fanshawe Park Rd and Highbury St. and supplies approximately 438 customers via 6 km of primary underground cable. The average of cable in this subdivision is approximately 26 years old-- the majority of this cable will reach 30+ years in 2013.

In the early 2000, all transformers in Northridge subdivision were replaced as part of a multi-year plan to convert the area to 27.6 kV supply. The 28 kV over-rated cable was generally less than 20 years old so it was not replaced at the time of the conversion. Today, the cable has reached 30 years of age and has experienced its first cable failure.

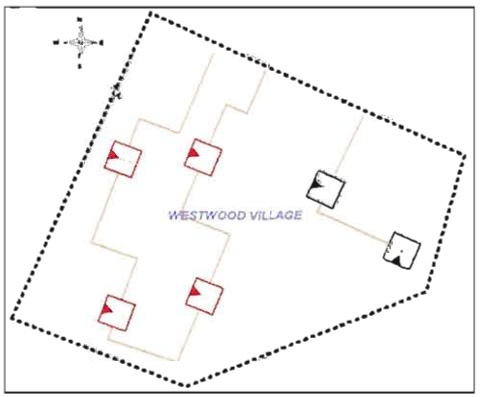
The scope of this project is to silicon inject approximately 6 km of primary cable. The average age of transformers are less than 9 years old and will not be replaced.

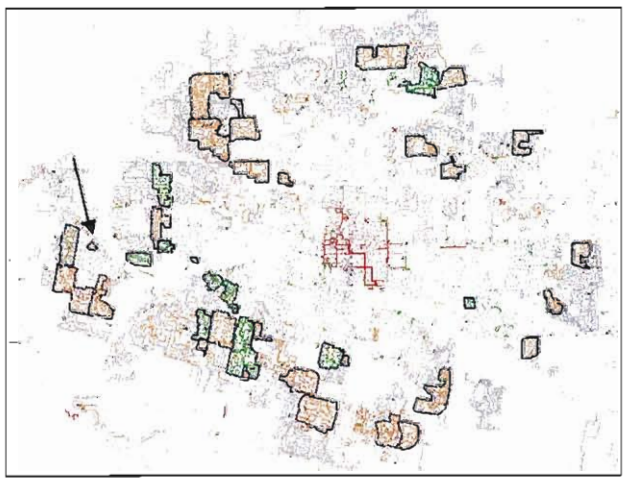




4. ***Westwood Village (27.6 kV Supply)***

This is the smallest subdivision proposed for silicon injection in 2013. It has less than 1 km of cable and is located in the west part of the city at Boler Rd and Commissioners Rd. This subdivision experienced outages due to a cable failure and a transformer failure. The scope of this work is to inject the 35+ years old cable and replace two depreciated padmounted transformers.





2013 ASSET MANAGEMENT PLAN
Project Sheet

London Hydro

Project Number:	13B2
Project Name:	Subdivision Rehabilitation
Project Driver:	REL

Project Title: Subdivisions Conversions / Rebuilds / Silicone Injection

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Jamie Macpherson

Supporting Reference Material

Engineering Report Update 2010, **Rehabilitation of Aging Underground Residential Distribution Systems** (2012 addendum)
Asset Sustainment Plan, 2012-2026 Report

Description

This budget item covers a complete rehabilitation and voltage conversion of three underground residential subdivisions currently supplied at 4.16 kV. The two subdivisions proposed for voltage conversion in 2013 experienced at least one cable failure and several transformer failures. The subdivision rehabilitation work is prioritized based on the results of the SPOORE analysis using a 5-year performance window.

Prior to conversion all depreciated cable will be refurbished by means of cable silicone injection except when the aged cable is not rated for 27.6 kV systems.

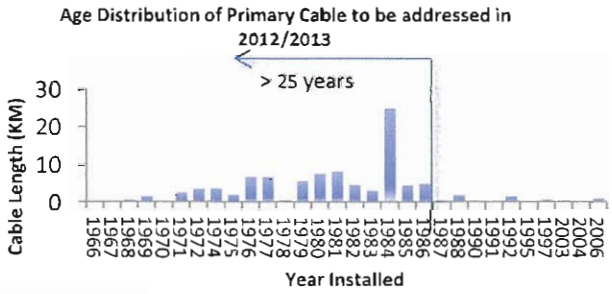
Approximately 14.7 km of cable is planned for injection. Three kilometres of new cable will be installed to close some loops to meet current subdivision design standards. Cable will also be replaced when it is under-rated and cannot be energized at 27.6 kV.

All transformers will be replaced to accommodate for the 27.6 kV conversion; many depreciated live front and pozitek type transformers will be addressed in this project scope. Furthermore, five switching enclosures will be addressed as part of this underground residential subdivision conversion.

Subdivisions: Berkshire Village (4kv), Hickory Hills (4kV), and Oakridge North (4kV)

COST ESTIMATE

Section - 145	**$2,206,000**

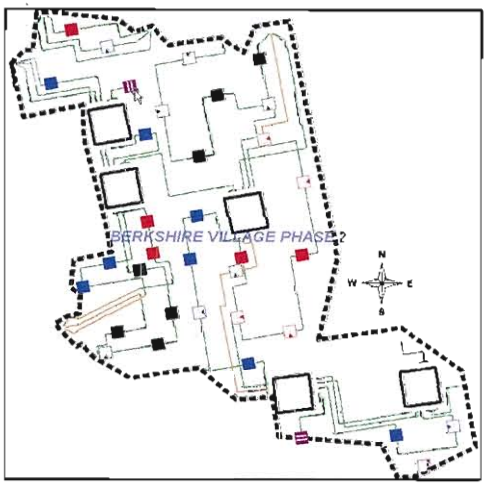


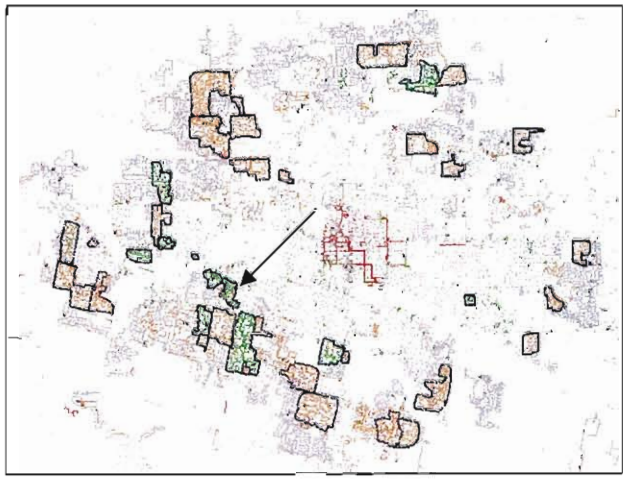
Prepared By:	Hassan El Madhoun, E.I.T. Assistant Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

1. ***Berkshire Village- Phase 2 (4.16 kV Supply)***

The larger Berkshire Village is located at Commissioners Rd east of Wonderland Rd and was built in the late 1960's. This section of the subdivision has 8 km of primary underground cable which supplies about 380 customers via 37 padmounted transformers. Much of the cable in this subdivision was replaced in the late 1980's; almost 90% of cable is now over 25 years of age. Berkshire subdivision experienced 2 primary cable faults and several transformer failures within the last 5 years.

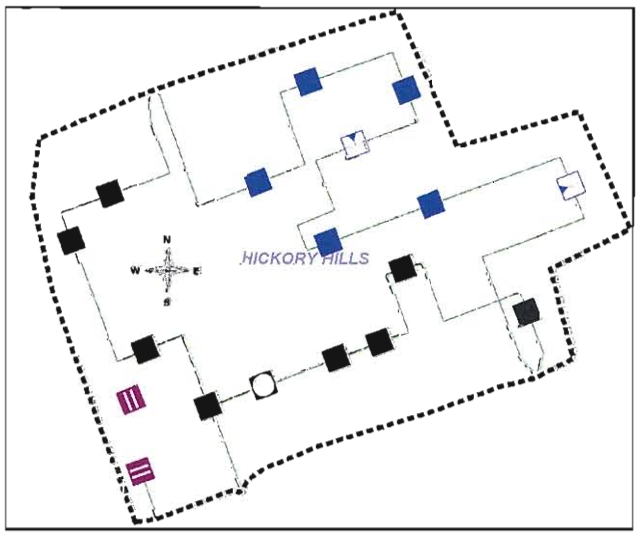
The scope of this project will include silicone injection of 5.7 km of cable and installing approximately 2.3 km of new XLPE cable for necessary system reconfigurations or when cable is not 28 kV rated. Part of this system reconfiguration will facilitate the removal of 5 underutilized air insulated switching enclosure. Two thirds of the in-service transformers were installed in the late 1960's and are live front transformers that reached their economic useful life. All transformers, including several three phase units, will be replaced to accommodate the 4.16 kV to 27.6 kV conversion.

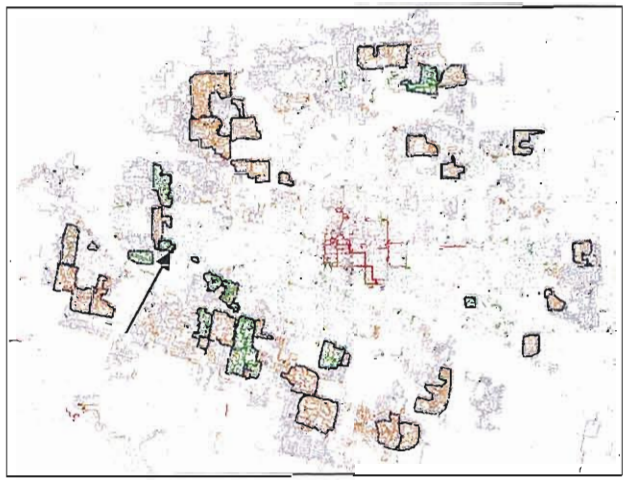




2. ***Hickory Hills (4.16 kV Supply)***

Hickory Hills is a small subdivision in the west part of the city that has 2 km of primary cable and sixteen transformers that are primarily live front. This subdivision has experienced one cable fault on a 32-year old cable. All the cable in this subdivision is now 35+ years old. The scope of this project will include the injection of 2 km of cable, replacing all transformers, and installing 200 m of cable for system re-configuration.

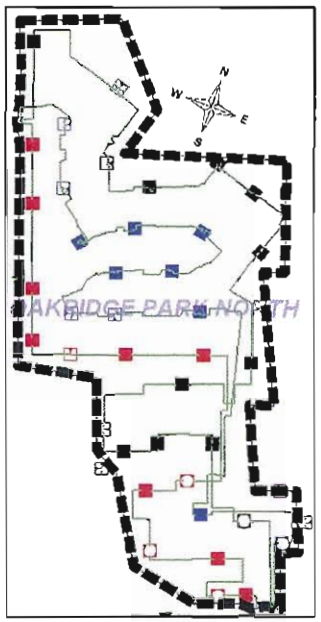




3. ***Oakridge North Subdivision (4.16 kV Supply)***

Oakridge North subdivision, located in the Hyde Park area north of Oxford Rd, has approximately 8 km of primary underground cable that has been in service for 30+ years. Oakridge subdivision has experienced one cable fault in 2008 and another fault in previous years. Live front and positek transformers represent 80% of all transformers in this subdivision.

Approximately 7 km of cable will be silicon injected and an additional 0.5 km of new cable will be installed to complete the 4 kV conversion. The scope of this work will also include the replacement of 40 transformers.





2013 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	13B3
Project Name:	Replacement of SE's
Project Driver:	REL

Project Title: Replacement of Air Insulated Sectionalizing Enclosures

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Jamie Macpherson

Supporting Reference Material

Asset Sustainment Plan-2012-2026 Report,
Distribution Reliability Report: ***Performance Review and a New Perspective for In-service 27.6 kV Three-Phase Air Insulated Sectionalizing Enclosures,*** May 2006

Description/Justification

Year 2013 will be the eighth year into this long-term project intended to eliminate air-insulated switchgear from the 27.6 kV distribution system.

By the end of 2012, 79 units would have been addressed from the time this program was launched back in 2006. It is anticipated that 8 more units (such as the one below) will be addressed this year. Less than half of the original count will remain on the system by at the end of 2013.

COST ESTIMATE

Section - 145	**$462,000**

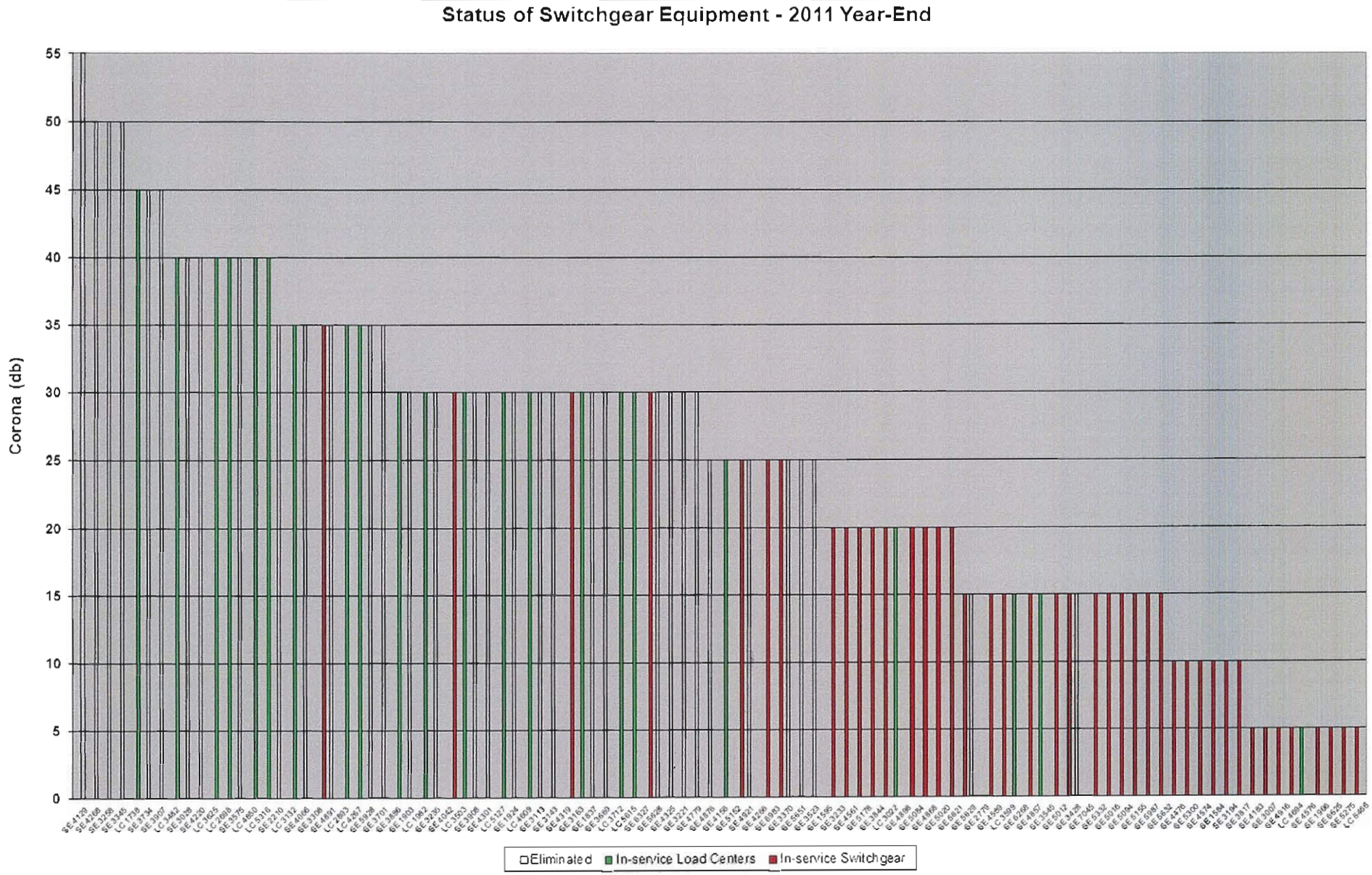


Prepared By: Hassan El Madhoun, E.I.T.
Assistant Distribution Engineer

Approved By: Ken Walsh, P.Eng.
Chief Engineer &
V.P. of Operations

Replacement of Air-Insulated Sectionalizing Enclosures Project 13B3

Earlier research and analysis into the failures of air-insulated switching enclosures on the 27.6 kV system led to the internal publication of an in-depth report at London Hydro in 2006. The findings and recommendations have helped with targeting the most prone-to-failure units which were eliminated without delay. The work conducted over the past six years shows a remarkable, positive impact in performance. From the time the higher-risk units started to be changed out (2006), half of the total number of units have now been addressed. The chart further illustrates that of the equipment that was found at some risk, the majority have been dealt with either by replacement (green bars), or by system reconfiguration (transparent bars). The existing units (red bars) that remain in service will be addressed in the following years as part of this multi-year program.



2013 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	13B4
Project Name:	Leaking Transformers
Project Driver:	SAF

Project Title:	Fully Depreciated and Leaking Transformer Replacement

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Steve Lavell

Supporting Reference Material

OEB Audits conducted by field staff

Description/Justification

London Hydro field staff conduct annual audits of padmounted transformers in accordance with the requirements of the Ontario Energy Board. These audits are meant to identify defective/end of life transformers and transformers which may be weeping oil around the primary and secondary bushings. These matters are usually caused by transformer aging and the degradation of the sealing gaskets.

This project covers the cost to identify and replace the fully depreciated and leaking transformers. This budget item also includes funding for the replacement of transformers that have failed in the field and require replacement.

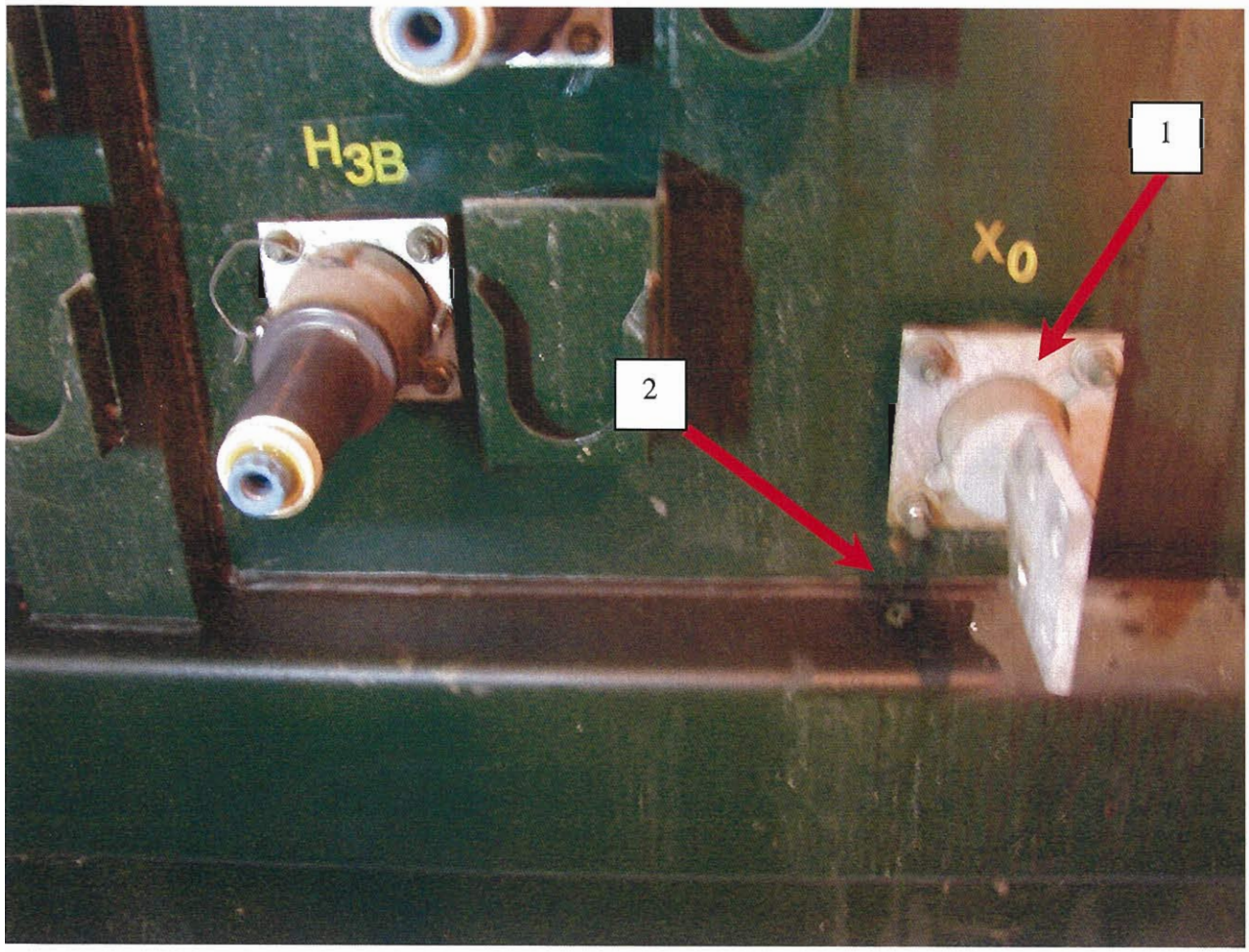
COST ESTIMATE

Section - 145	**$1,040,000**

Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Fully Depreciated and Leaking Transformer Replacement
Project 13B4

London Hydro performs OEB audits on the condition of the padmounted transformers in our system. These audits help us identify potentially defective/end of life transformers for replacement. London Hydro takes its environmental responsibilities seriously and as such continues to invest capital dollars into the identification and removal of these suspect transformers. This budget item also includes funding for the replacement of transformers that have failed in the field and require replacement. The cost to replace a typical suspect transformer ranges between $7,500 - $15,000 depending on transformer type. The allocated amount for this project is $1,040,000.



1) Neutral Bushing
2) Oil Leak

2013 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	13B5
Project Name:	Secondary Pedestal Replacement
Project Driver:	REL

Project Title:	Residential Secondary Pedestal Replacement

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Scott Lasseter

Supporting Reference Material

Asset Sustainment Plan, 2012-2026 Report
OEB Audits conducted by field staff

Description/Justification

London Hydro has a large number of single phase low voltage junction pedestals active in our system. These units are typically used in residential areas. They allow one common bus cable to be divided into several service cables to feed multiple meters. As per the Asset Sustainment Plan report some of these units are at the end of life; they are in excess of 30 years old and the enclosures are starting to corrode. It has also been found that the connections and barriers within the existing units are beginning to fail.

This budget targets the replacement of these existing units with our new non-metalic units shown below. The replacements will be prioritized based on the findings from our OEB audits conducted by field staff and address areas where problems have been experienced in the past in compliance with the Asset Sustainment Plan report.

COST ESTIMATE

Section - 145	**$25,000**

New replacement unit shown to right



Prepared By:	Jagoda Borovickic Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

2013 ASSET MANAGEMENT PLAN
Project Sheet

London Hydro

Project Number:	13B6
Project Name:	Vault Rebuilds
Project Driver:	SAF

Project Title: Vault Transformer Replacements

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Jamie Macpherson

Supporting Reference Material

4 kV Aging Infrastructure System Planning Report - 2011
Asset Sustainment Plan, 2016-2026 Report
OEB Audits conducted by field staff

Description

The Asset Sustainment report identified various indoor transformer vaults as being in poor condition. These vaults were also inspected by London Hydro staff. The following vaults have been identified to be replaced in 2013.

Ridout Street (TV 623 & TV 891)
Grand Avenue Phase 3 (TV 616 & TV 773)
The Asset Sustainment report identified various parts of the system fed out of SUB 1 as being in poor condition. The area will be converted from the 4.16kV distribution system to the 27.6kV distribution system. The underground systems and dry-type transformer vaults in these areas are approximately 50 years old and in poor condition This budget item will allow for the replacement of these dry-type transformers with padmount or pole mount transformers located outside the vaults. It will also allow for the installation and termination of secondary cables from the new transformation to the new disconnects inside the vaults.

All transformer vaults proposed for replacement in 2013 meet the replacement criteria identified in the Asset Sustainment Plan.

COST ESTIMATE

Section - 145	**$374,000**

Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Apartment Vault Replacements
Project 13B6

95 Ridout Street.



1) Dry Type transformer
2) Water Stain on the Floor

2013 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	13B7
Project Name:	Backup Supply Installation
Project Driver:	REL

Project Title: Installation of Underground Backup Supply

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Dane Kirilovic

Supporting Reference Material

Description/Justification

London Hydro has started to experience outages in the residential underground subdivisions that were serviced approximately 30 years ago with a radial underground system. This configuration leaves London Hydro's control room operators with no options to restore power quickly during outages resulting from equipment failure.

This budget item provides for an additional radial supply in one of those subdividsions to be "looped" thereby providing our operators with an alternate source from which they can restore power. This work will greatly improve the speed that power can be restored to these areas and enhance the reliability of supply.

COST ESTIMATE

Section - 145	**$25,000**

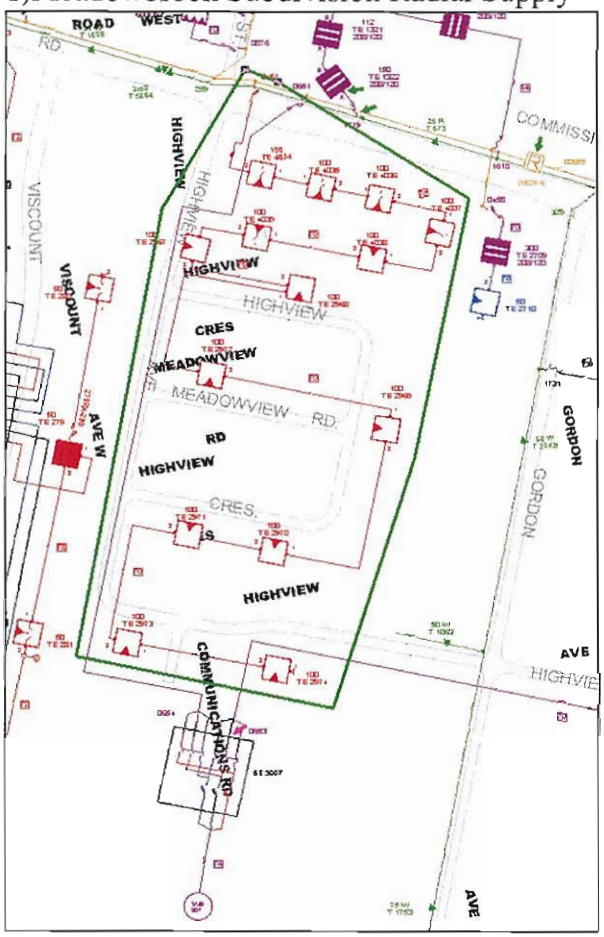
Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Installation of Underground Backup Supply
Project 13B7

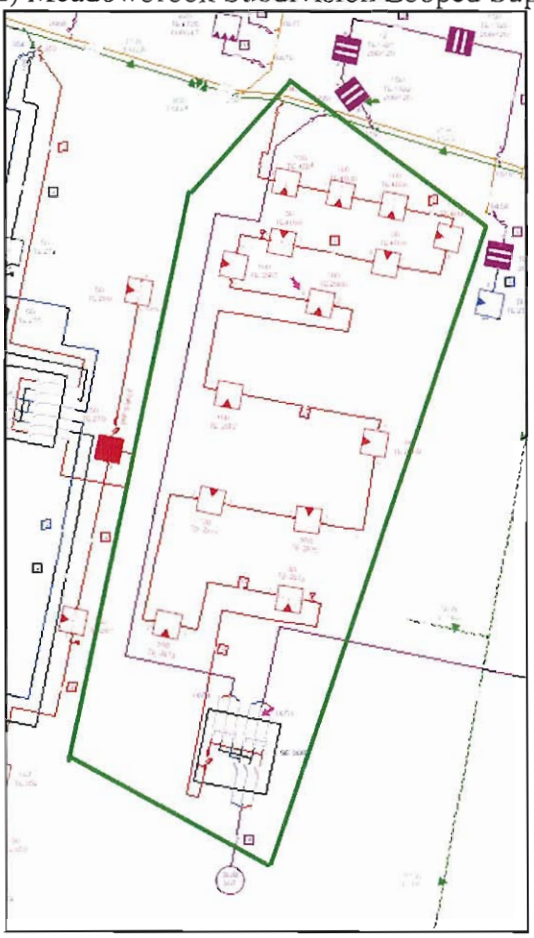
London Hydro has started to experience outages in the underground areas that were installed approximately 30 years ago without a looped supply arrangement. As a result, cable faults within these radially supplied systems lead to prolonged outages due to the absence of switching or reconfiguration options. This budget item will correct the situation by completing the loop and providing an alternate source of supply. One of the remaining radials will be selected on a prioritized basis. For illustration purpose attached are two pictures of the same subdivision where the radial supply has been upgraded to looped supply:

1) distribution system in radial configuration
2) distribution system in looped configuration

1)Meadowbrook Subdivision Radial Supply



2) Meadowbrook Subdivision Looped Supply



2013 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	13B8
Project Name:	Fault Indicator Installations
Project Driver:	REL

Project Title: Installation of Fault Indication on Padmounted Transformers

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Steve Lavell

Supporting Reference Material

Description/Justification

Fault locating of long underground systems can lead to extended outages in the absence of strategically placed fault indicators. In areas without fault indicators, our crews must open each transformer and test the cable in order to determine the location of the fault. Fault indication technology allows for fault assessment from outside of the transformer allowing our crews to quickly locate the fault, isolate the faulted cable and return power to the affected customers quickly.

This item includes the installation of fault indicators in areas with complex or lengthy underground distribution systems.

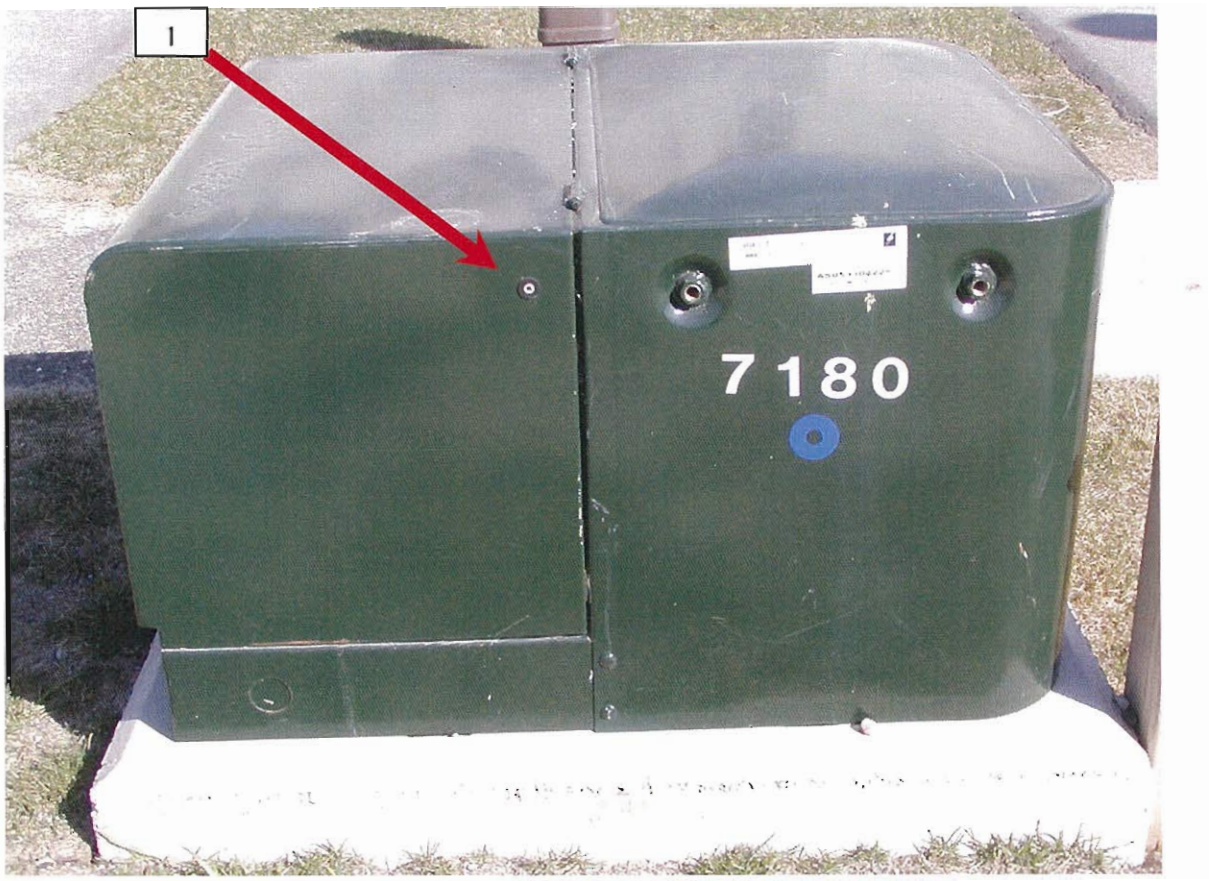
COST ESTIMATE

Section - 145	**$15,000**

Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Installation of Fault Indication on Padmounted Transformers
Project 13B8

As was mentioned prior, the installation of fault indication in areas with lengthy and complex circuit arrangements has the ability to decrease both outage duration and cost of repair. The average underground subdivision contains 16 transformers on a feeder loop. These loops are segmented into two radial sections of 8 transformers to minimize the effects of an outage. Through the installation of fault indication it was found that the average time required to locate a faulted section of cable could be reduced by 1.25 hours. This translates into a savings of roughly 9600 customer minutes per outage.



1) Fault Indicator – Led lights red when transformer has witnessed fault current.

2013 ASSET MANAGEMENT PLAN
Project Sheet

London Hydro

Project Number:	13B9
Project Name:	Zone 'A' Underground Conversion
Project Driver:	SAF, REL

Project Title: Rebuild and Conversion of Sub 1, 2 & 28 Vault Areas (Zone 'A')

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Jamie Macpherson

Supporting Reference Material

4kV Aging Infrastructure System Planning Report - 2011
Asset Sustainment Plan, 2012 - 2026 Report

Description

The *Asset Sustainment Plan Report* identified various parts of the system in this area as being in poor condition. The deficiencies related to the age of the equipment may adversely impact the reliability of supply as well as public and employee safety. The poles and associated hardware are approximately 50 years old. As well, the underground systems and dry-type transformer vaults in these areas are in poor condition. The area will be converted from the 4.16kV distribution system to the 27.6kV distribution system as per the directive outlined in the *4kV Aging Infrastructure System Planning Report*. This budget item will allow for the replacement of these dry-type transformers with padmount or pole mount transformers located outside the vaults. It will also allow for the installation and termination of secondary cables from the new transformation to the new disconnects inside the vaults.

The following vaults have been identified to be replaced in 2013:

- 100 Ridout Street – TV 622
- 64 & 71 Grand Avenue – TV 618 & TV 619
- 102 Grand Avenue – TV 772
- 120 Grand Avenue – TV 2266
- 364 & 390 Grey Street – TV 611 & TV 610
- 435 Grey Street – TV 771
- 374 Simcoe Street – TV 774

COST ESTIMATE

Section - 145	**$459,000**

Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Zone 'A' Underground Vault Conversion
Project 13B9

The initiatives outlined in the *4kV Aging Infrastructure System Planning Report* require converting all 4.16kV within Zone 'A', with Zone 'A' being the service territories for Substations 1, 2 and 28. In addition, the proposed voltage conversion area requires rebuilding and converting depreciated transformer vaults; thus, meeting the criteria outlined in the *Asset Sustainment Plan, 2012 - 2026 Report*. The deficiencies related to the age of the equipment may adversely impact the reliability of supply as well as public and employee safety since these vaults are located in confined spaces within the customer's building.

The following vaults have been identified to be replaced in 2013:

- 100 Ridout St. – TV 622
- 64 & 71 Grand Ave. – TV 618 & TV 619
- 102 Grand Ave. – TV 772
- 120 Grand Ave. – TV 2266
- 364 & 390 Grey St. – TV 611 & TV 610
- 435 Grey St – TV 771
- 374 Simcoe St – TV 774



Dry Type transformer

2013 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	13C1
Project Name:	Main Feeder Reinforcements
Project Driver:	RNF

Project Title:	Main Feeder Reinforcements
Project Manager:	Rod Doyle
Project Tech.:	Hank Bonnar, Jim Soetemans
Supporting Reference Material	4kV Aging Infrastructure System Planning Report - 2011 Asset Sustainment Plan, 2012 - 2026 Report (System Planning Department initiative)

Description/Justification

This budget section is to reinforce main feeders throughout the city by a number of means such as increasing the amount of circuit ties to improve system operability and reliability, increase conductor size to improve load transfer capability, rebuild existing main feeders due to depreciation to maintain existing levels of service or to build new feeders to meet new load growth. London Hydro may undertake these initiatives in conjunction with road authority relocations.

Feeder One (continuation of 2012's construction):
Rebuild and convert 4.16kV west along Nelson Street from Sub 28 to Colborne Street, north on Maitland Street to King Street and west on King Street to Waterloo Street. Horton Street from Wellington Road to Maitland Street and the radial supplies along Burwell Street projected to be completed in 2012. This feeder build positions London Hydro for a future feeder tie between central and southwest London.

Feeder Two (continuation of 2012's construction):
Rebuild and convert 4.16kV along Maitland Street from Nelson Street to Hill Street, west on Hill Street to Wellington Road, south on Waterloo Street to South Street, west on South Street to Wellington Road, underground across bridge to High Street, convert SE's along Wellington Road. Portions of Hill Street and underground work projected to be completed in 2012. This feeder build will improve operability and reinforce ties between central and southwest London.

Feeder Three:
Rebuild and convert the 4.16kV radial feeds along this feeder build. These areas are Horton Street between Hamilton Road and Adelaide Street, William Street between Bathurst Street and Horton Street, and on Bathurst Street east of Adelaide Street. This feeder build will improve operability and reinforce ties between central and northeast London.

These feeder reinforcement builds also assist with the Zone 'A' voltage conversions under Project Numbers 13B9 and 13G5 as per the directives outlined in the *4kV Aging Infrastructure System Planning Report*.

COST ESTIMATE

Section - 140	**$973,000**

Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Main Feeder Reinforcements
Project 13C1

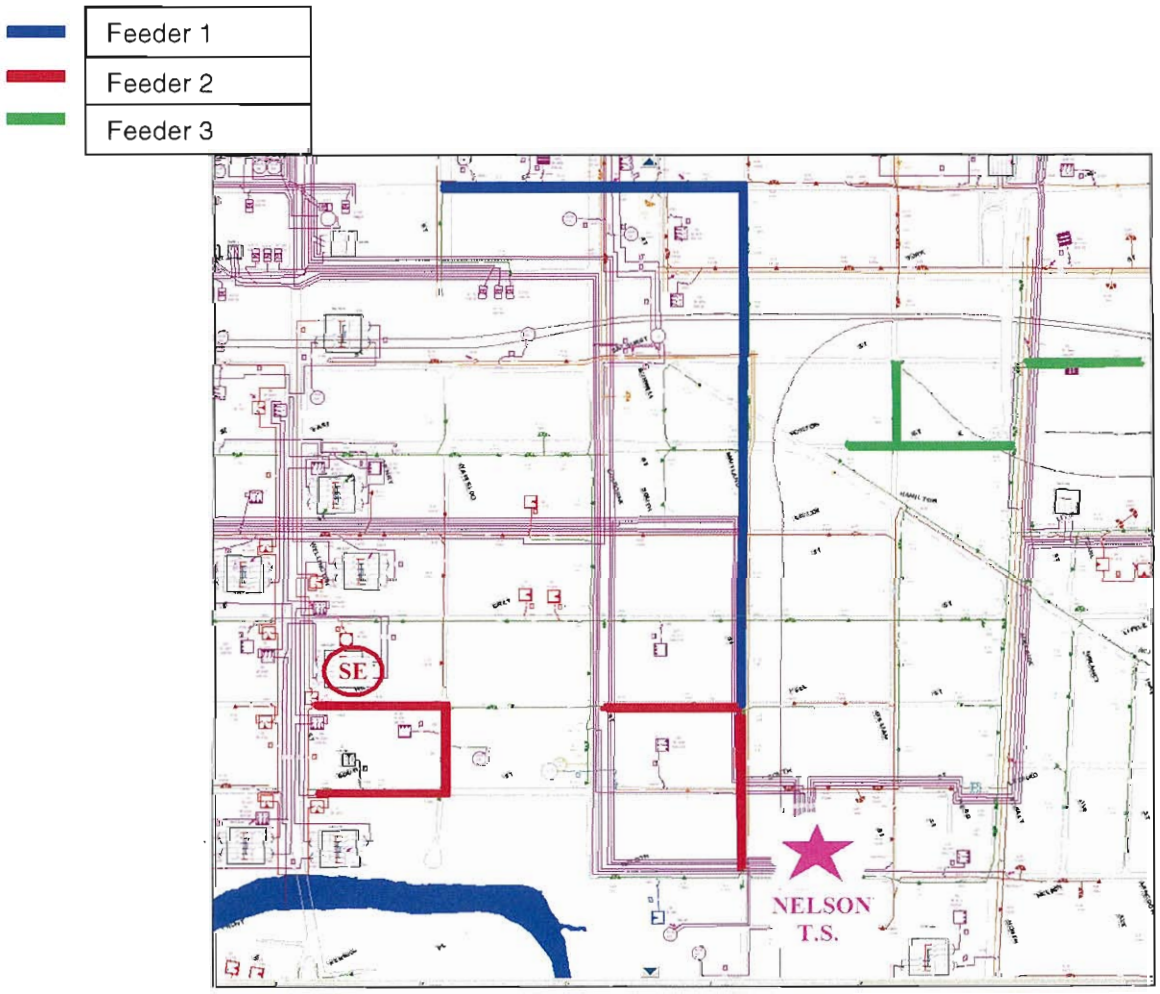
This budget section is to reinforce main feeders throughout the city by a number of means such as increasing the amount of circuit ties to improve system operability and reliability, increase conductor size to improve load transfer capability, rebuild existing main feeders due to depreciation to maintain existing levels of service or to build new feeders to meet new load growth. London Hydro may undertake these initiatives in conjunction with road authority relocations along main feeder routes and/or position London Hydro for future feeder re-configurations in anticipation of a new transformer station.

The initiatives outlined in the *4kV Aging Infrastructure System Planning Report* require converting all 4.16kV within Zone 'A', with Zone 'A' being the service territories for Substations 1, 2 and 28. Also, System Planning Department identified the need for more 27.6kV feeder ties across central London Hydro in anticipation of a future transformer station. Due to the overlapping areas of these projects warrants London Hydro to build these main feeder reinforcements. In addition, the proposed works under this Project Number replaces depreciated infrastructure meeting the criteria outlined in the *Asset Sustainment Plan, 2012 - 2026 Report*.

Feeder One:
This feeder's goal is to head north on Maitland Street to King Street and west on King Street to Waterloo Street to penetrate the downtown area for future 13.8kV non-network conversions. This feeder will make ties with the 4M13 & 26M53 feeders. This feeder will aid with the conversion of the 4.16kV system in the SoHo (South of Horton) district (Substation 28 service territory). This feeder build is a continuation of 2012's construction.

Feeder Two:
This feeder's goal is to head south across the river and connect to the 26M41 on Ridout St. This feeder will aid with conversion of the 4.16kV system in Old South (Substation 1 service territory). This feeder build is a continuation of 2012's construction.

Feeder Three:
This feeder will be constructed in the following years but the radial supplies from its future route along Adelaide Street will be converted to coordinate with the directives under the *4kV Aging Infrastructure System Planning Report*. These areas include Horton Street between Hamilton Road and Adelaide Street, William Street between Horton Street and Bathurst Street and Bathurst Street east of Adelaide Street. Feeder Three build will position London Hydro for a future feeder tie between central and northeast London. Feeder Three construction will continue in 2014.



Main Feeder Reinforcements

2013 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	13D1
Project Name:	City Requested Relocations
Project Driver:	COL

Project Title: City of London (Road Authority) Relocations

Project Manager:	Rod Doyle	**Project Tech.:**	Hank Bonnar & Jim Soetemans

Supporting Reference Material

Description/Justification

This project comprises of the relocation of London Hydro Infrastructure located on the road allowance. These relocations are initiated by the Road Authority (City of London) and are necessary in order to accommodate planned modifications to the roadway.

The terms and conditions under which these relocations occur are specified in the Public Service Works on Highways Act enacted by the Provincial Government. The Act gives a Road Authority the power to ensure that all operating corporations entitled to the use of the road allowance cooperate with the Road Authority to execute any required modifications to the profile of the road allowance in a timely manner. The Act states that an Operating Corporation (London Hydro Inc) must modify or relocate their plant on the road allowance to accommodate the Road Authority's improvements or alterations within a specified time period. The Act also outlines the mechanism for the apportionment of costs for these required works. Typically the Operating Corporation is permitted to recover 50% of the labour and vehicle costs from the Road Authority.

Some of the known relocation projects for 2013 include:
- Hyde Park Road between Oxford Street West and Sarnia Road
- various manhole chimneys, rings and covers adjustments due to repaving
- various other locations
- carryover work from 2012 include the following:
  - Southdale Road West between Wharncliffe Road South and Singleton Avenue
  - Oxford Street West from Hyde Park Road and Sanatorium Road
  - Hamilton Road, Commissioners Road East & Old Victoria Road intersection round about

COST ESTIMATE

Section - 133	**$1,228,000**

Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

City of London (Road Authority) Relocations

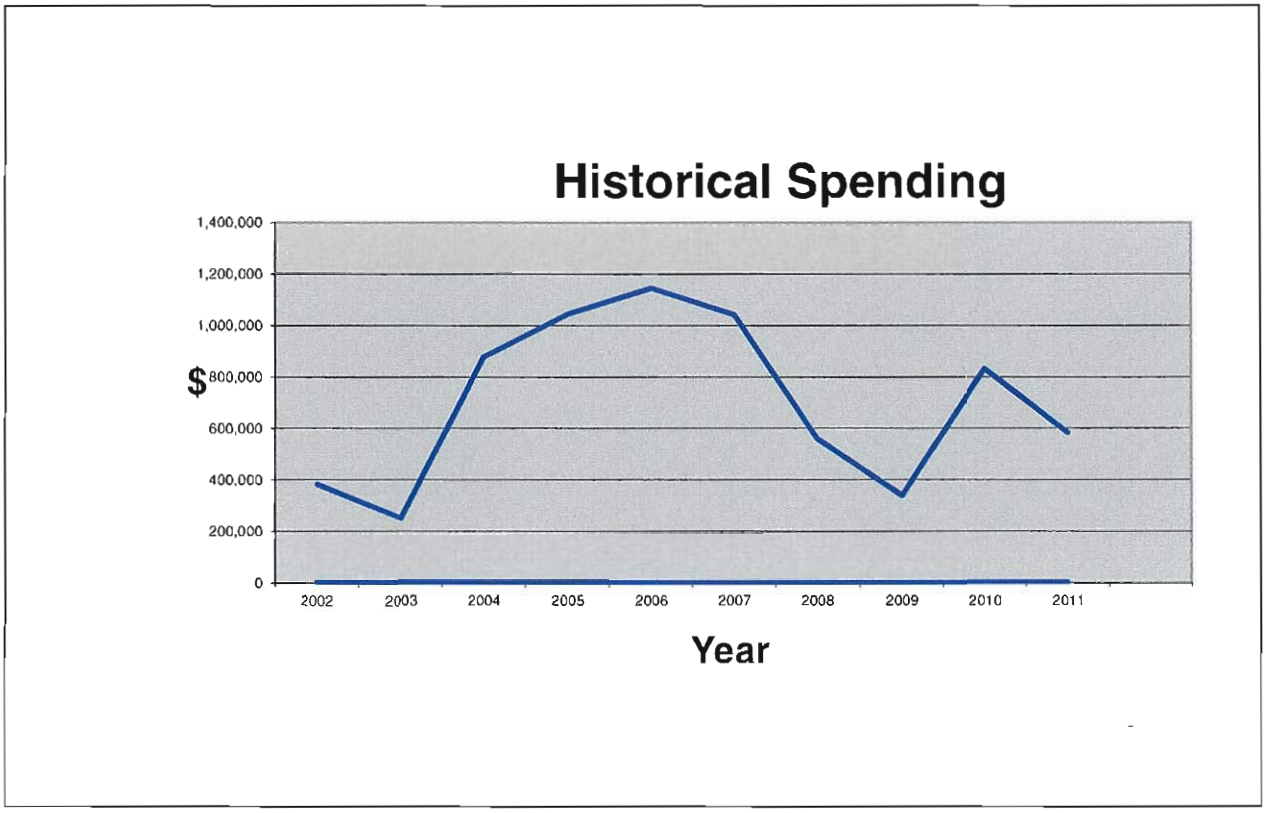
Project 13D1

London Hydro works closely with the City of London to try to determine which of their projects will affect London Hydro's infrastructure. Unfortunately, the City has not defined all their projects for 2013; therefore, the annual expenditures are estimated based on a combination of known projects and base historical spending. Spending in this area has ranged from $249,000 to $1,765,000 in the last several years depending on the projects that were identified by the City of London as being required.

The City of London has identified the following projects of significance for London Hydro to relocate its plant in 2013:

- Hyde Park Road between Oxford Street West and Sarnia Road
- Carryover work from 2012 includes the following:
    - Southdale Road West between Wharncliffe Road South and Singleton Avenue
    - Oxford Street West from Hyde Park Road and Sanatorium Road
    - Hamilton Road, Commissioners Road East & Old Victoria Road intersection reconstruction to a round-about

This budget section also covers various manhole chimney rings and covers adjustments due to repaving and other various locations.



2013 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	13E1
Project Name:	Expansions and Relocations
Project Driver:	DEV

Project Title:	Developer Driven Distribution Circuit Expansions and Relocations

Project Manager:	Jagoda Borovickic/Rod Doyle	**Project Tech.:**	Hank Bonnar

Supporting Reference Material

Description/Justification

This budget item includes extension of the existing high voltage overhead or underground distribution system in order to accommodate new customer developments as they are added to London's service area. This budget item includes all costs associated with the construction of these extensions.

This item also includes the relocation of existing London Hydro plant for accommodating new developments within the city limits. These relocations are required when items such as new proposed driveways and turn lanes for new developments are in conflict with the existing hydro plant. This budget item includes all costs associated with the relocation.

COST ESTIMATE

Section - 131	**$614,000**

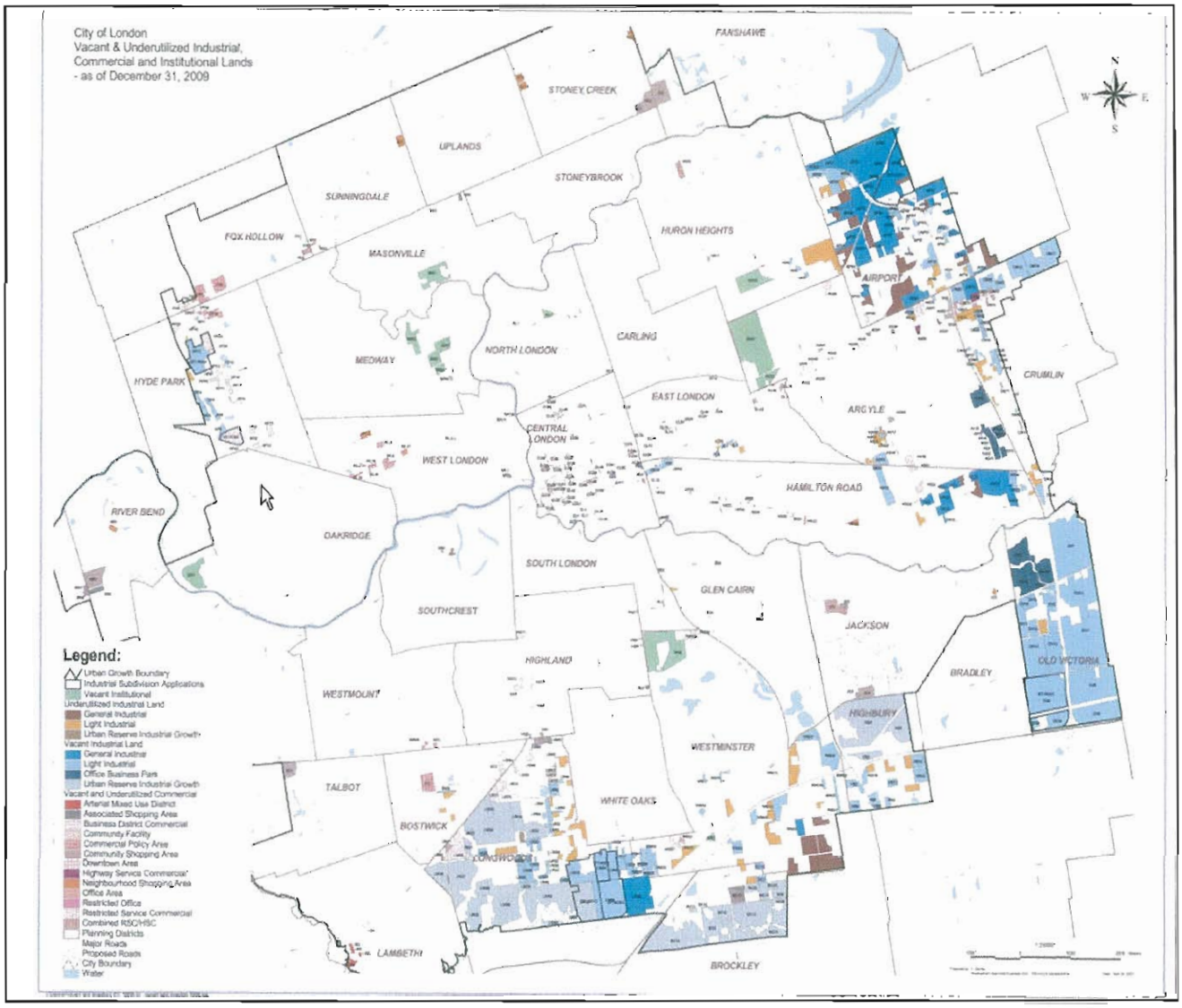
Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Developer Driven Distribution Circuit Expansions and Relocations
Project 13E1

This project comprises the installation and/or modification of electrical equipment that is used in supplying customers' installations. It also includes the work associated with upgrading existing installations.

The London Hydro Conditions of Service Document details how capital contributions are assessed for these installations.

The expansions and relocations that will be required in 2013 are not identified yet. From a budgeting perspective, the annual expenditures are estimated based on a number of factors including: past history, City of London development forecasts and customer inquiries. Based on these factors $614,000 is allocated for expansions and relocations yet to be determined by various developers.



2013 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	13E2
Project Name:	Secondary Service Upgrades
Project Driver:	DEV

Project Title: Residential Secondary Service Upgrades

Project Manager:	Rod Doyle	**Project Tech.:**	Jim Soetemans

Supporting Reference Material

Description/Justification

This budget item includes replacement of the existing low voltage conductors with conductors of increased size from the overhead transformer to the customers' electrical service stacks. These upgrades are often required when customers increase their electrical demands. This item involves all costs associated with these upgrades.

COST ESTIMATE

Section - 131	**$321,000**

Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

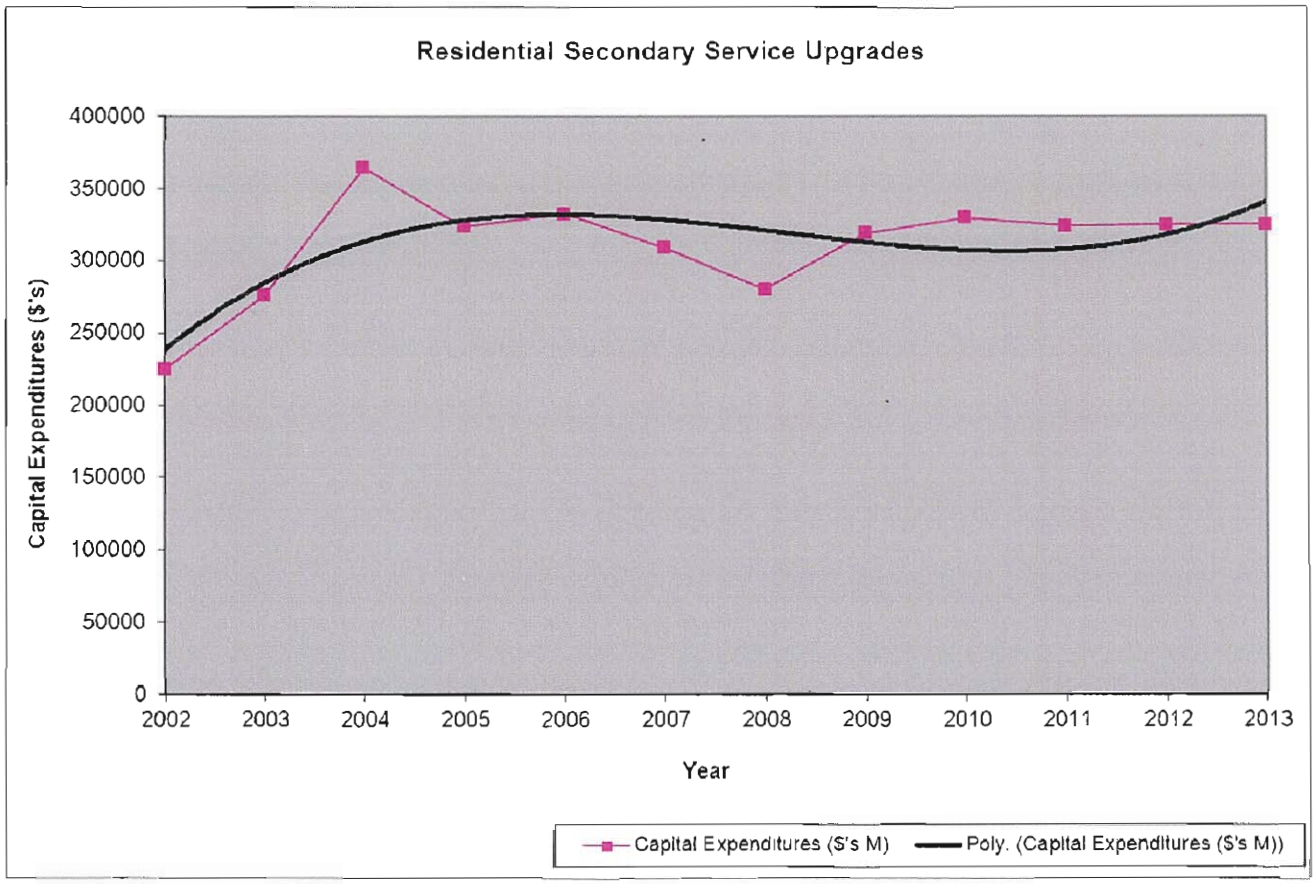
Residential Secondary Service Upgrades

Project 13E2

This project comprises the replacement of overhead low voltage electrical services to residential dwellings. There is no charge to customers for these upgrades as they are part of London Hydro's basic connection for overhead residential customers as defined in the Distribution System Code.

These upgrades are initiated by customers that require an increase to their electrical service size. These requests may be due to issues such as the addition of new load in their home or due to requirements of an insurance company that requires the service to be upgraded to a minimal size and configuration.

From a budgeting perspective, the annual expenditures are estimated based on past history. A graph has been provided below and illustrates the level of required expenditures within London Hydro's service territory.



2013 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	13E3
Project Name:	Residential Underground
Project Driver:	DEV

Project Title: New Single Family Residential Underground Distribution

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Jamie Macpherson

Supporting Reference Material

Description/Justification

This item involves the installation of single family residential underground distribution systems to provide service as needed to developers. We are budgeting $1,496,000 for 2013 based on a number of factors including the past history spending and the forecast by the Canada Mortgage and Housing Corporation.

It is noted that market conditions can create large fluctuations in expenditures from year to year. This item is solely dependant on market conditions. This section will contain several different projects of varying magnitude depending on customer requirements.

COST ESTIMATE

Section - 142	**$1,496,000**

Prepared By:	Jagoda Borovickic, P.Eng Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

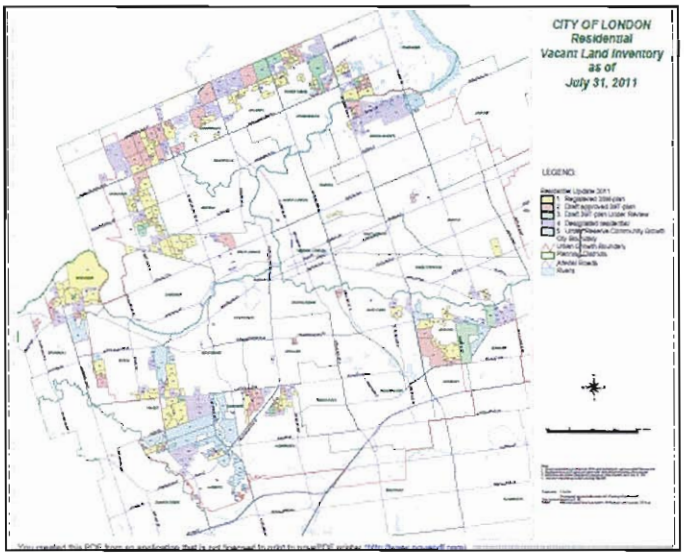
Residential Underground
Project 13E3

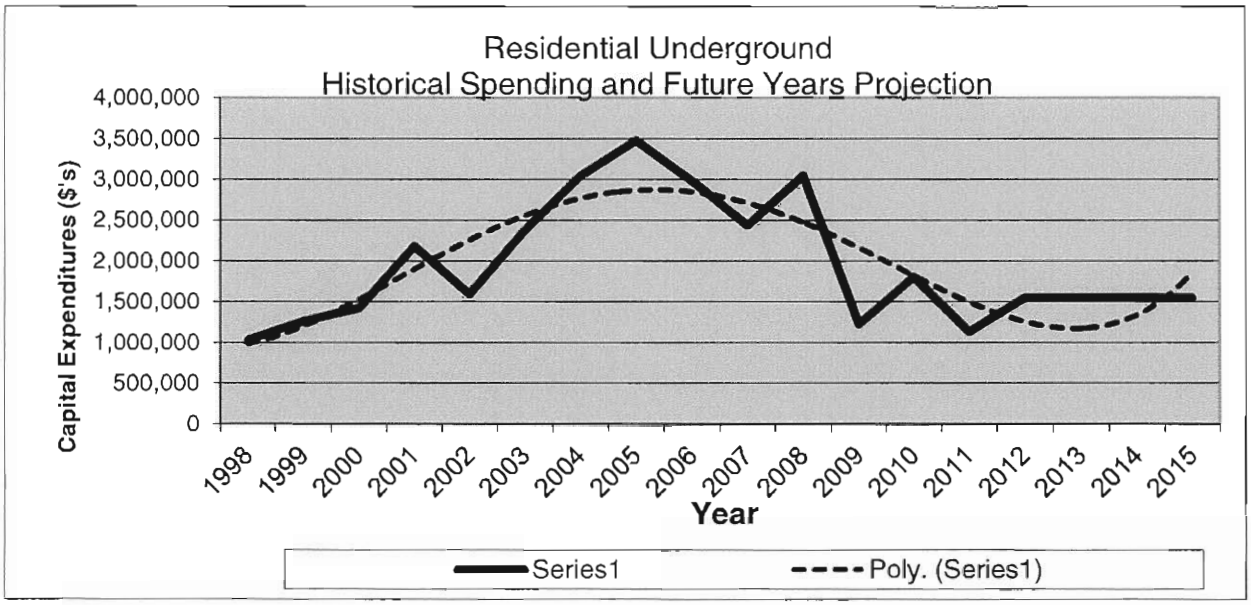
This project involves the installation of single family residential underground distribution systems to provide service as needed to developers.

The London Hydro Conditions of Service Document details how capital contributions are assessed for these installations.

From a budgeting perspective, the annual expenditures are estimated based on a number of factors including: past history, City of London development forecasts, market reviews including Canada Mortgage and Housing Corporation, and customer inquiries. Examples of the various documents created and reviewed are shown. This information is updated each year and the forecasts and budgets are adjusted accordingly.

This collection of information is part of a larger library that is used in the preparation of the 25 year load forecast.





Housing Market Outlook - Ontario Region Highlights - Date Released: Third Quarter 2011

Ontario Region Housing Forecast - New Construction

	Housing Starts	2010	2011(F)*	% chg (2010/2011)	2012(F)*	% chg (2011/2012)	YTD 2011*	YTD 2010*	% chg (2010/2011)
London	Single-Detached	1,461	1,100	-24.7	1,200	9.1	563	802	-29.8
	Multiple	618	520	-15.9	620	19.2	266	490	-45.7
	Total	2,079	1,620	-22.1	1,820	12.3	829	1,292	-35.8

Canada Mortgage and Housing Corporation 6

Housing Starts in London

Apartment development is included in Multihousing at CMHC, however is included in 13E5 Commercial at London Hydro.

2013 ASSET MANAGEMENT PLAN

London Hydro

E&O Department

Project Number:	13E4
Project Name:	Multi-Housing Servicing
Project Driver:	DEV

Project Title: New Multi-Housing Underground Distribution

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Jamie Macpherson

Supporting Reference Material

Description/Justification

This item is for the installation of multi-housing (primarily townhouses and condominiums) underground distribution systems to provide service as needed to developers. We have budgeted $630,000 for 2013 based on a number of factors including the past history spending and the forecast by the Canada Mortgage and Housing Corporation.

This item is solely dependent on market conditions. This section will contain several different projects of varying magnitude depending on customer requirements.

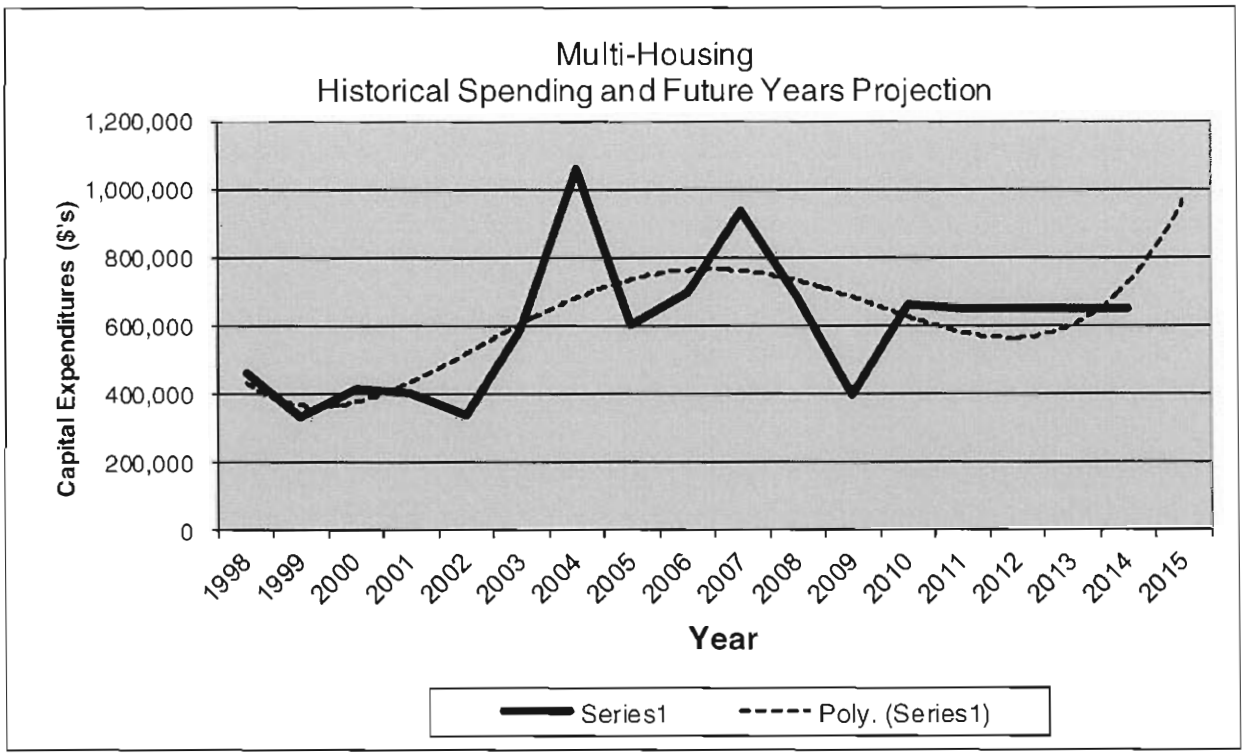
COST ESTIMATE

Section - 143	**$630,000**

Prepared By:	Jagoda Borovickic, P.Eng Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Multi-Housing
Project 13E4

This project involves the installation of multi-housing underground distribution systems to provide service as needed to developers.



The London Hydro Conditions of Service Document details how capital contributions are assessed for these installations.

From a budgeting perspective, the annual expenditures are estimated based on a number of factors including: past history, City of London development forecasts, market reviews including Canada Mortgage and Housing Corporation, and customer inquiries. Examples of the various documents created and reviewed are shown. This information is updated each year and the forecasts and budgets are adjusted accordingly.

This collection of information is part of a larger library that is used in the preparation of the 25 year load forecast.

Housing Market Outlook - Ontario Region Highlights - Date Released: Third Quarter 2011

Ontario Region Housing Forecast - New Construction

	Housing Starts	2010	2011(F)*	% chg (2010/2011)	2012(F)*	% chg (2011/2012)	YTD 2011*	YTD 2010*	% chg (2010/2011)
London	Single-Detached	1,461	1,100	-24.7	1,200	9.1	563	802	-29.8
	Multiple	618	520	-15.9	620	19.2	266	490	-45.7
	Total	2,079	1,620	-22.1	1,820	12.3	829	1,292	-35.8

Canada Mortgage and Housing Corporation 6

Housing Starts in London

Apartment development is included in Multi-housing at CMHC, however is included in 13E5 Commercial at London Hydro.

2013 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	13E5
Project Name:	Commercial Distribution
Project Criver:	DEV

Project Title: New Commercial Distribution Services

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Albert Kanters/Scott Lasseter

Supporting Reference Material

Description/Justification

This item is for the installation of commercial overhead and underground distribution systems to provide service as needed to customers. We have budgeted $2,025,000 for 2013. This item is solely based on market conditions.

This budget is based on past historical expenditure patterns and past history, City of London development forecasts, market reviews, and customer inquiries.

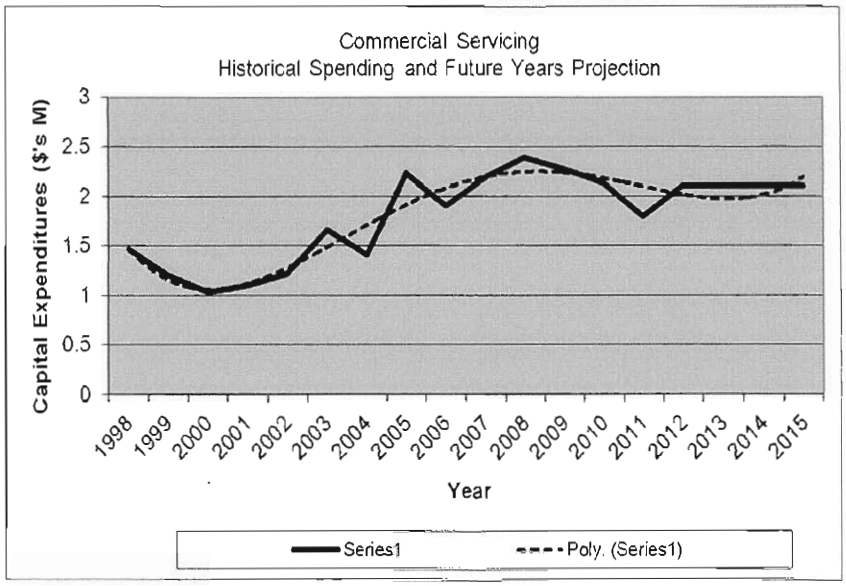
COST ESTIMATE

Section - 144	**$2,025,000**

Prepared By:	Jagoda Borovickic, P.Eng Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Commercial Distribution
Project 13E5

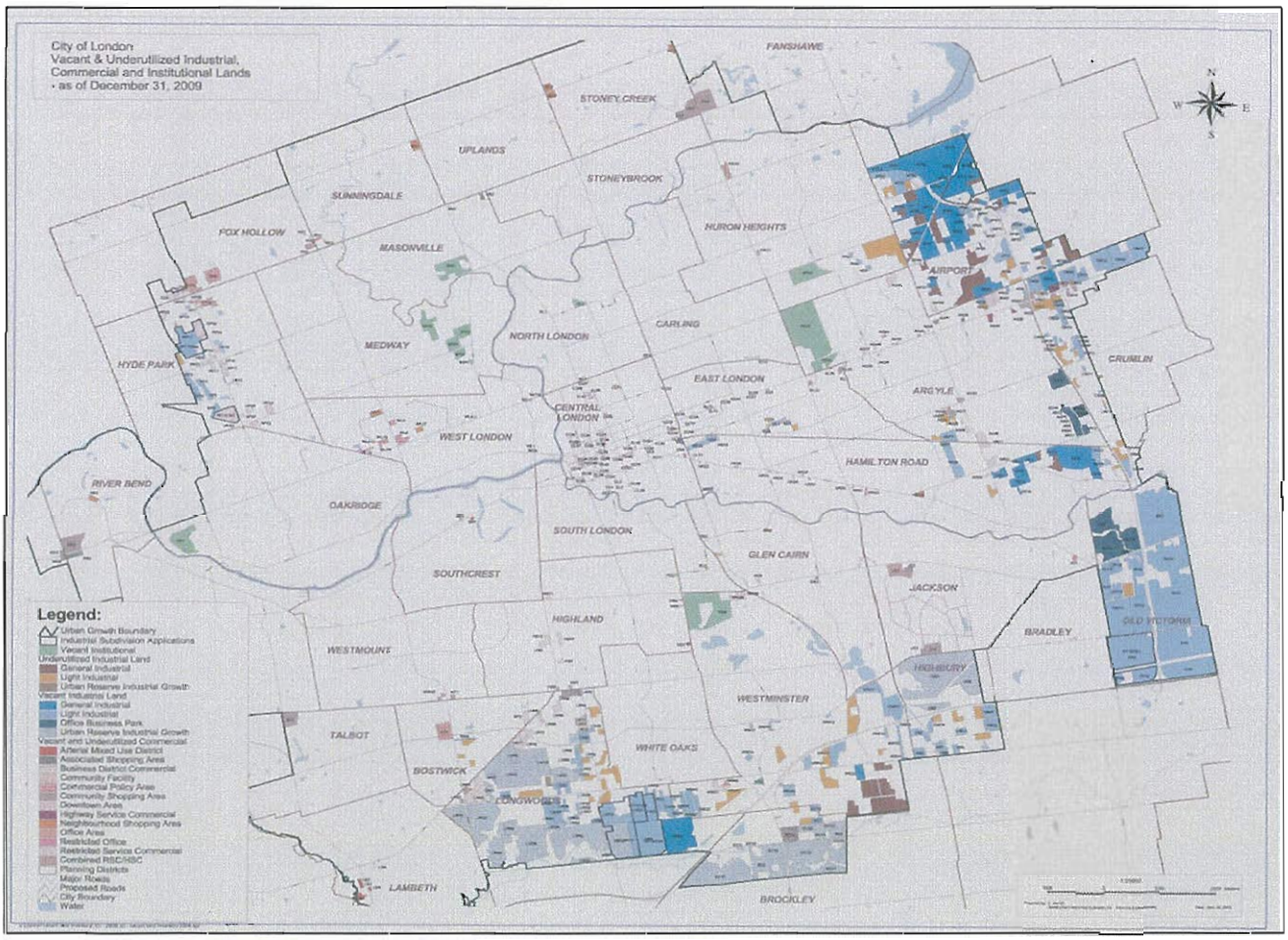
This project comprises the installation and/or modification of electrical equipment that is used in supplying commercial (including apartments) and industrial customers' installations. It also includes the work associated with upgrading existing installations.



The London Hydro Conditions of Service Document details how capital contributions are assessed for these installations.

From a budgeting perspective, the annual expenditures are estimated based on a number of factors including: past history, City of London development forecasts, market reviews, and customer inquiries. Examples of the various documents created and reviewed are shown. This information is updated each year and the forecasts and budgets are adjusted accordingly.

This collection of information is part of a larger library that is used in the preparation of the 25 year load forecast.



2013 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	13F1
Project Name:	Network Vault/Manhole/Tx Replacements
Project Driver:	SAF

Project Title:	Replacement of Network Vaults/Manholes/Transformers		
Project Manager:	Jagoda Borovickic	**Project Tech.:**	Dane Kirilovic
Supporting Reference Material	Asset Sustainment Plan, 2012 - 2026 Report Structural Inspection Reports		

Description/Justification

This item involves the design and installation of structural entities such as concrete manholes, vaults, roof slabs and steel vault grating as well as replacement of network transformers and protectors at various locations.

The condition of the above items is monitored through inspections by a structural engineer based on the Asset Sustainment Plan and observations by our operations staff. This item is used to resolve all safety and reliability issues resulting from these inspections and in compliance with the Asset Sustainment Plan.

COST and TIMING ESTIMATES

Section - 141	**$536,000**

Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operation

Replacement of Network Vault/Manhole/Transformers
Project 13F1

Each year, London Hydro's operations staff conduct inspections of the London Hydro subsurface chambers on a scheduled basis. These inspections are carried out in compliance with the requirements of the Distribution System Code. During the course of these inspections, notes are made to identify the structures that require additional assessment by a Professional Structural Engineer. Additional structures for assessment are identified by the Asset Sustainment Plan report. The structural engineer then provides direction on the appropriate course of action that is required (if any) to maintain the structural integrity and safety of the installation.

The structural engineer's findings are documented and then implemented within the timelines that are specified. Typical findings involve delamination of concrete roof slabs and walls. This can be due to numerous factors including aggregate composition, salt contamination, age and method of construction used at the time. The picture below illustrates a deteriorated roof slab of a manhole.



Sample of a Manhole Roof slab in need of Replacement

2013 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	13F2
Project Name:	Primary/Secondary Cable Replacements
Project Driver:	REL

Project Title: Replacement of Primary and Secondary Cables

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Scott Lasseter

Supporting Reference Material

Description/Justification

Over the years some of the cables in our distribution system have deteriorated and their dielectric strength has been compromised. This is partially due to age, the environment in which they are installed and loading conditions. These sections are often hard to detect until the quality of power is compromised. The degree of the problems can range from low voltage problems to power outages.

When these cables are identified, they are replaced with cables that meets our present day specifications and standards.

This budget item will include the replacement of primary and secondary cables which have reached failure or are approaching the end of their useful service life.

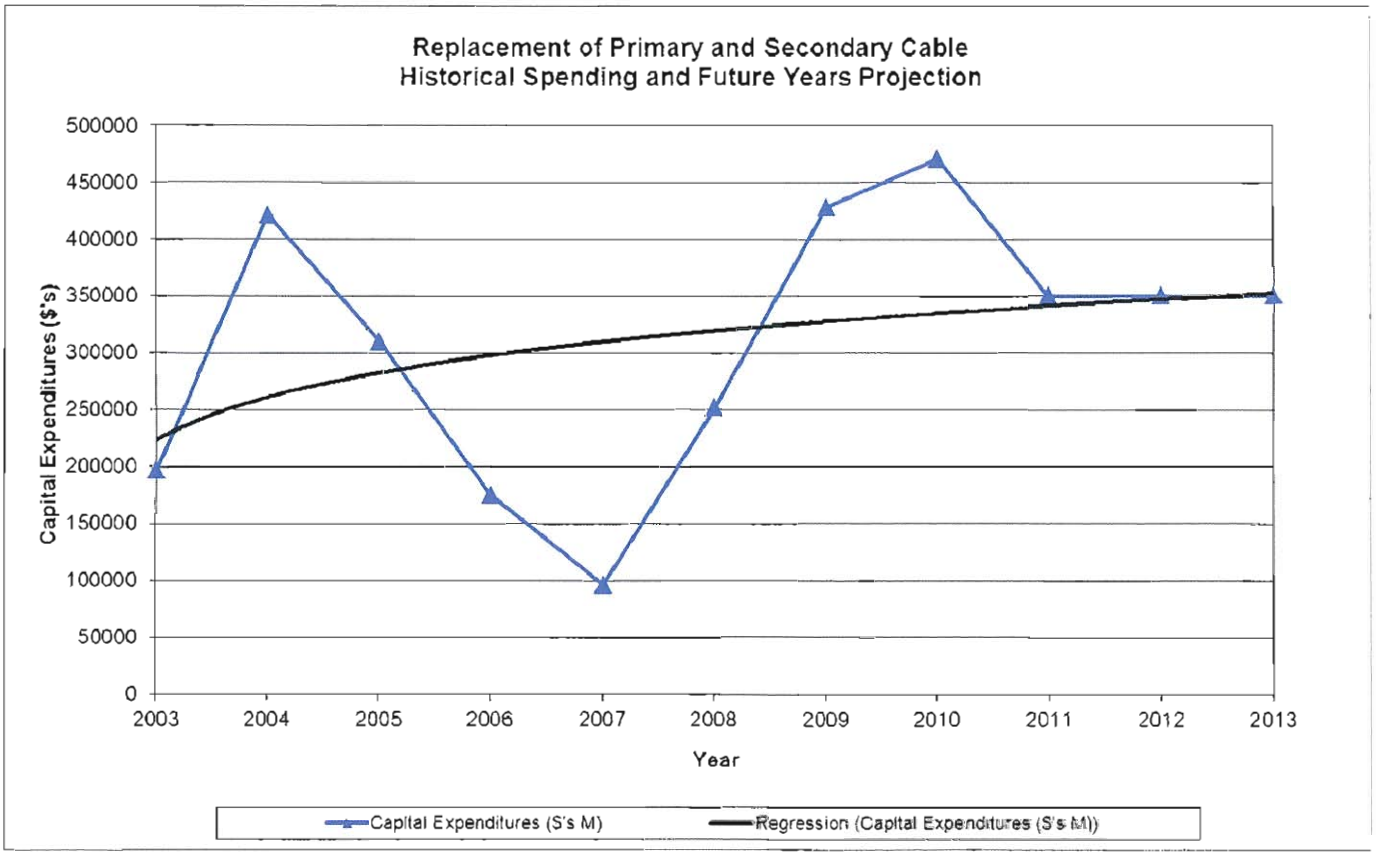
COST ESTIMATE

Section - 150	**$341,000**

Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Replacement of Primary and Secondary Cables
Project 13F2

London Hydro has approximately 1700 km of primary cable in our distribution system and 25 km of low voltage main secondary cable in our downtown core. Although London Hydro is continuously assessing and replacing these cables through identified capital projects, some cables fail unexpectedly and require replacement. This budget item provides for replacement of these cables. Due to the fact that these failures are unplanned, a historical trend is used to estimate the required level funding for the replacements. The graph below illustrates that expenditures have been as high as $470,000 and as low as $100,000.



2013 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	13F3
Project Name:	Eliminate East Network Ph 4
Project Driver:	REL

Project Title:	Eliminate East End Network Phase 4 - Dundas & Rectory Street Area
Project Manager:	Jagoda Borovickic
Project Tech.:	Jamie Macpherson

Supporting Reference Material

Description/Justification

This last phase of the East End Network Elimination project will be completed in conjunction with servicing new developments along Dundas Street easterly of the boundary of Phase 2 project to Rectory Street. Our plan is to provide these services from the 27.6 kV system by installing padmount transformers on the developer's properties. In conjunction with these projects we are planning on installing a padmount transformer on an easement that would be provided by a developer, or an overhead transformer bank along one of the side streets. The transformer will provide supply to the low voltage network grid easterly of the boundary of Phase 2 project to Rectory street. This is consistent with our plan of eliminating the east end network.

COST ESTIMATE

Section - 150	**$118,000**

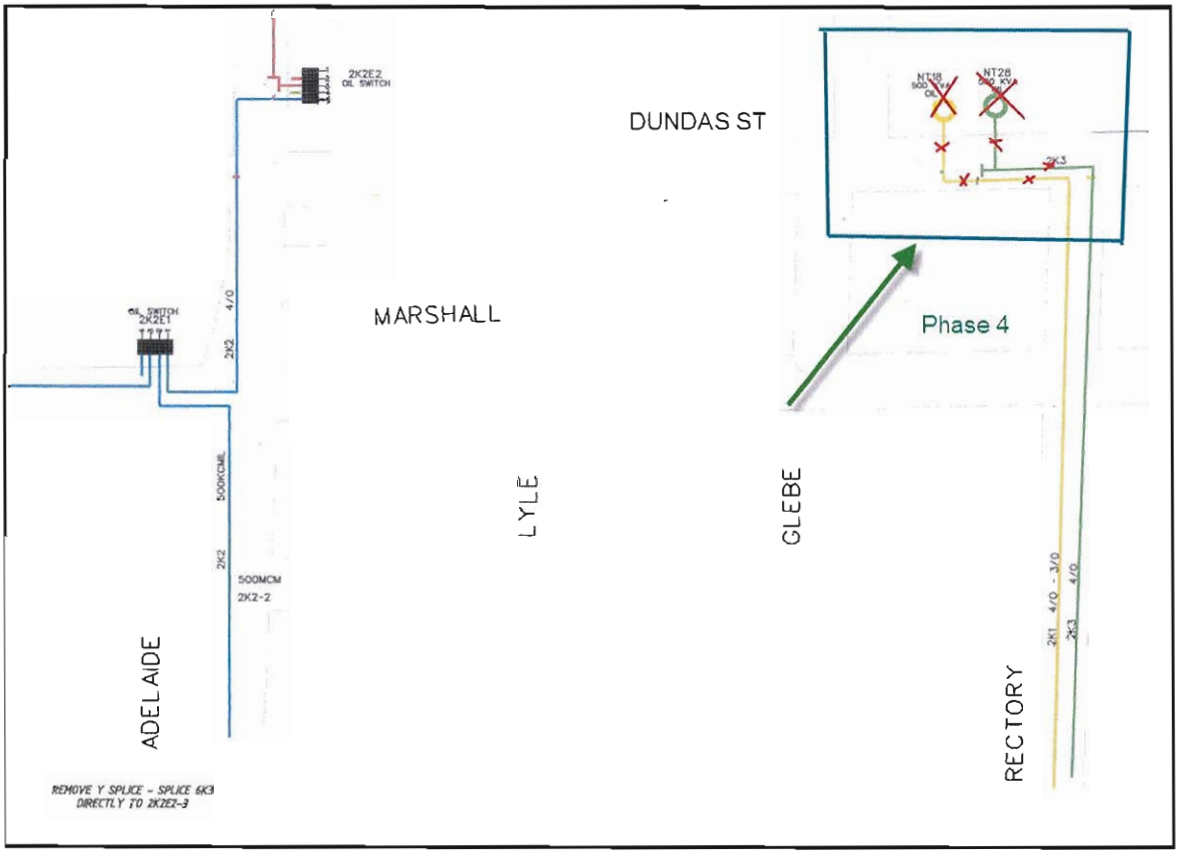
Prepared By:	Allan Van Damme, P.Eng. Director of Engineering
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Eliminate East End Network Phase 4

Project 13F3

This is the last phase of a multi-phase program to eliminate the east end network. The elimination of this network will provide a simpler and safer distribution system. The existing plant is approaching the end of its useful life. The plan will integrate with the redevelopments that are occurring in the area bordered by Adelaide and Rectory Streets along Dundas Street. All load will be converted from the 13.8 kV distribution system to the 27.6 kV distribution system in line with our long term plans for Nelson TS. This phase will address the area of Dundas Street and Rectory Street as shown below.

Area Affected by Phase 4 of the East End Network Elimination



2013 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	13F4
Project Name:	Manhole Cable Rebuilds
Project Driver:	SAF

Project Title:	Manhole Cable Rebuilds
Project Manager:	Jagoda Borovickic
Project Tech.:	Dane Kirilovic

Supporting Reference Material

Description/Justification

The city of London's downtown core is largely supplied from the network system by an extensive low voltage network grid. The network is supplied by 13.8 kV PILC (paper insulated lead cable). The primary cables and the low voltage network grid cables are installed in the common duct and manhole system that has become very crowded over the past fifty years. This item includes replacement of lead primary cables with new EPR flat strap cables, replacement of secondary cables, and reconfiguration of cables within crowded manholes that are difficult to work in.

In addition, this budget will cover installation of cable protecting fuses in the mains of the low voltage grid. High fault energies, that can lead to detrimental failures, are predominant characteristic of the low voltage network grid. These fuse elements limit the fault energy during the failure of the downstream device and decrease probability of the detrimental failures.

COST ESTIMATE

Section - 150	**$147,000**

Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

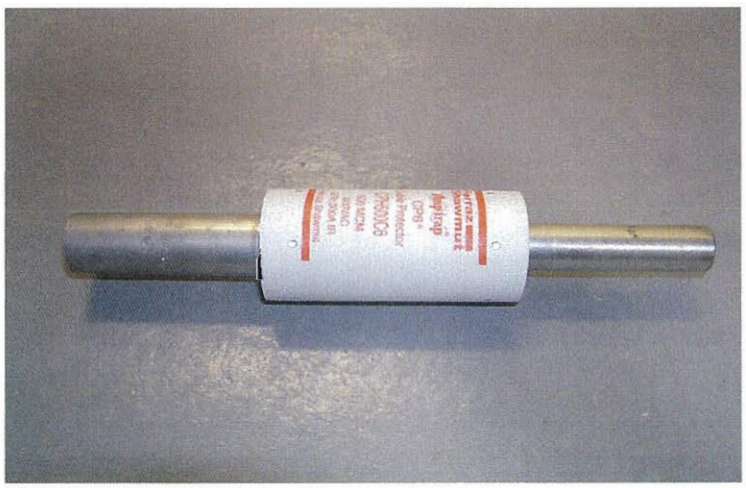
Manhole Cable Rebuilds
Project 13F4

The City of London's downtown core is largely supplied from the network system. The network is supplied by 13.8 kV PILC (paper insulated lead cable). Some of these cables are very old cables installed more than fifty years ago. The primary cables and the low voltage network grid cables are installed in the common duct and manhole system that has become very crowded over the past fifty years. This item includes replacement of lead primary and secondary cables, and removal and reconfiguration of cables within crowded manholes that are difficult to work in. Where possible, the existing lead primary cables are being replaced with a lead free alternative cable. By doing this work we will eliminate unused cables, clear up hazards and make space available for future cable installations. The picture below is a good illustration of a crowded manhole in London's downtown core.



Manhole 678 - Intersection of Dundas St. & Clarence St.

The City of London's downtown low voltage network grid consists of approximately 22 km of copper secondary mains that are routed through the downtown duct and manhole system. London Hydro has installed approximately 3000 cable protecting fuses on this system over the last five years to address the safety issues that are inherent for a system of this design.



Low Voltage Cable Protecting Fuse used on Secondary Network

2013 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	13G1
Project Name:	Replacement of Rotten Poles
Project Driver:	SAF

Project Title: Replacement of Fully Depreciated Poles

Project Manager:	Rod Doyle	**Project Tech.:**	Jim Soetemans

Supporting Reference Material

Pole Test Records
Asset Sustainment Plan, 2012 - 2026 Report

Description/Justification

In the last several years, London Hydro tested over 16,000 wood poles as part of our proactive maintenance approach. We have completed testing of all poles identified as being in poor and fair condition and poles identified in service for over 20 years. Also, approximately half of these poles are retested within the last 5 years as recommended in the previous year's test results. The testing involves performing a visual check of the pole and its equipment, sounding the pole, obtaining a core sample from the base of the pole when required and recording all relevant information.

This budget item will replace the approximately 30 to 40 poles that are anticipated as being fully depreciated and requiring immediate replacement based upon the 2011 pole testing program findings.

COST ESTIMATE

Section - 132	**$292,000**



Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

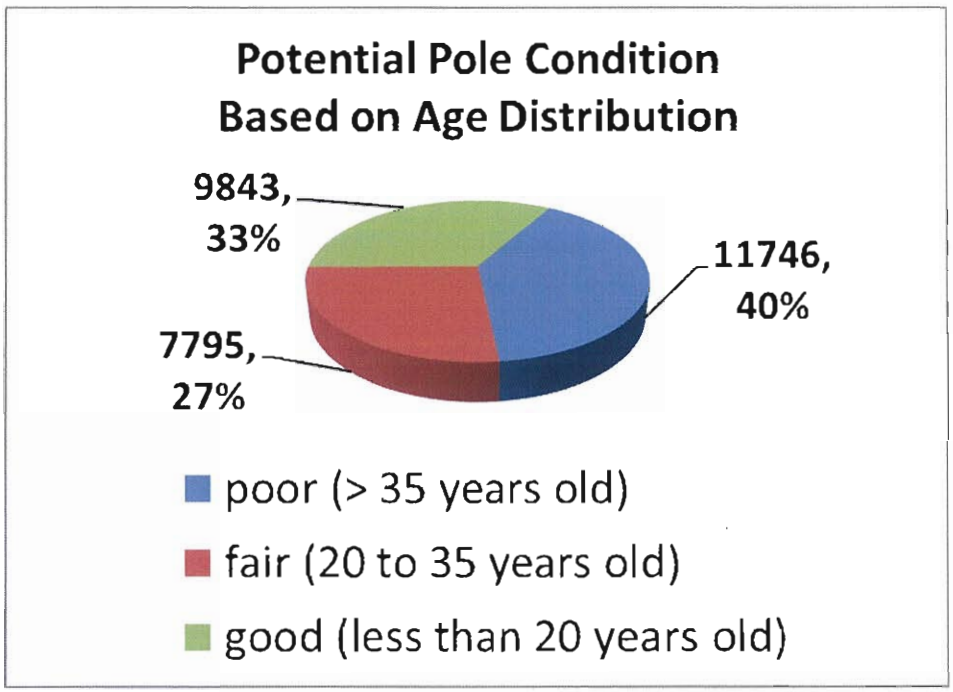
Replacement of Fully Depreciated Poles

Project 13G1

This project involves replacement of the fully depreciated wooden poles that were tested and recommended for replacement.

London Hydro's system contains over 29,000 poles. Approximately 98% of the poles on London Hydro's system are made of wood. In 1998 London Hydro introduced the pole testing program as part of our condition based assessment. The testing was based on the results of the infrastructure audit conducted on London Hydro's overhead system in the same year. Since then, London Hydro tested all poles identified as being in poor or fair condition during the infrastructure audit, poles that supposedly migrated from good to fair condition since the audit, and all poles that were recommended to be revisited in the previous testings. Also, poles that are older than 20 years are tested every 5 years. Pole testing is done on annually basis and capital expenditures are based on the results of the inspections.

A graph showing the overall pole age on London Hydro's system is shown below. Poles greater than 35 years in service have the potential to be in poor condition. It's estimated that 5,390 poles (18%) in our system are over 50 years of age.



Potential Condition of Poles (29,384 Poles in Total) based on age.
The pole age is based on the current GIS data. Some pole ages have been estimated.

The table below summarized the condition of 8,500 poles inspected between the years 2007-2010. Based on past testing results, it's estimated that about 13% of the poles tested are due for replacement within 5 years.

Scale	Condition	% of total pole test population
Replace in 0-2 years	Major Wear	5 %
Re-inspect in 2-4 years	Moderate Wear	5 %
Re-Inspect in 4-5 years	Minor Wear	3 %
Re-Inspect in 10 years	Good Condition	87 %

2013 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	13G2
Project Name:	Replacement of Pole Fire Poles
Project Driver:	REL

Project Title: Replacement of Poles Susceptible to Pole Fires

Project Manager:	Rod Doyle	**Project Tech.:**	Jim Soetemans

Supporting Reference Material

Mitigating Pole Fires on London Hydro's Distribution System Report
Asset Sustainment Plan, 2012 - 2026 Report

Description/Justification

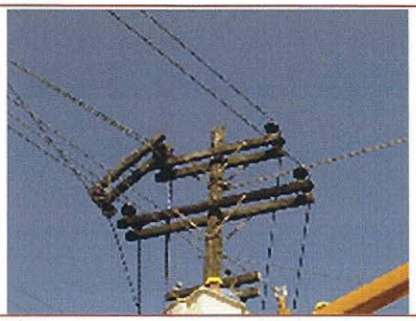
The areas designated for replacement consists of the plant built more that 40 years ago and is identified in the above reports as requiring replacement. This plant consists of outdated and aged materials and construction techniques that are more prone to failure than those used today.

This budget item will replace the pole line along Baseline Road West between Ridout Street and Wellington Road South.

This work will coordinate closely with depreciated overhead rebuilds under Project Number 13G3.

COST ESTIMATE

Section - 132	**$292,000**



Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Replacement of Poles Susceptible to Pole Fires
Project 13G2

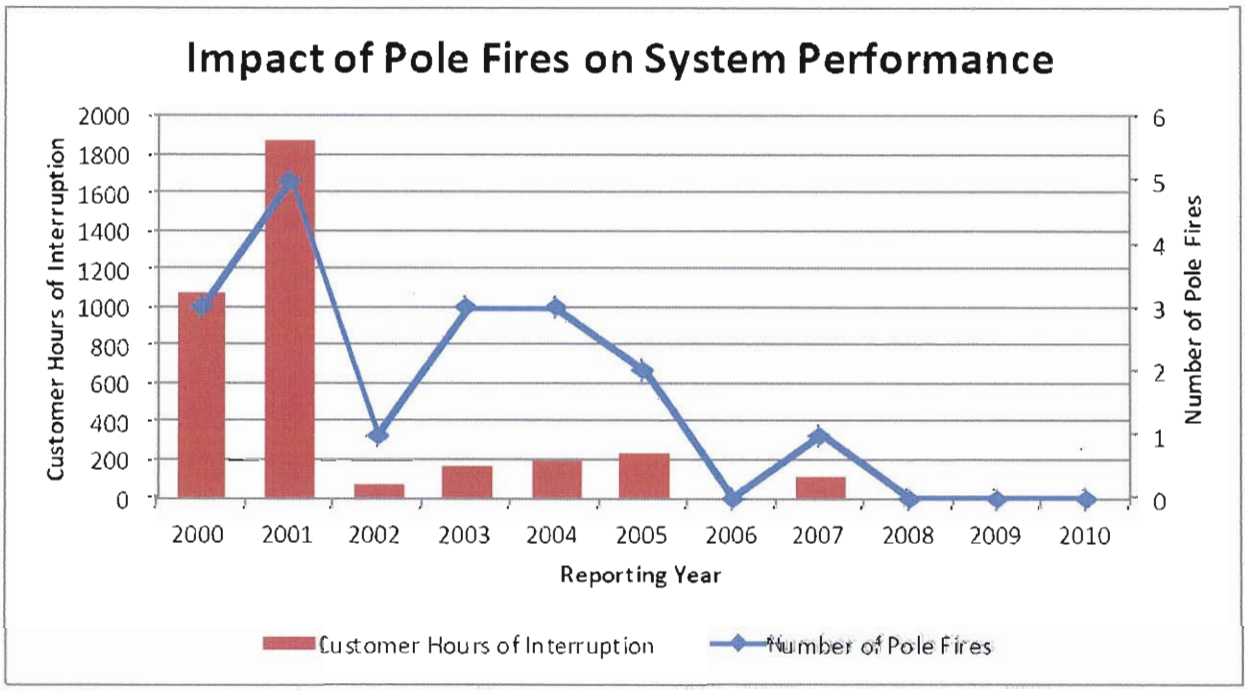
The only project scheduled for 2013 involves replacement of 25 poles susceptible to pole fires and reframing a few adjacent poles along Baseline Road West between Ridout Street and Wellington Road South.

Due to the pole line rebuilds and voltage conversions under Project Number 13G5 in the Sub 1 area, the need for the 4.16kV circuit tie along this section of Baseline Road West is no longer required. Therefore, the 4.16kV load along this section of Baseline Road West will be converted to 27.6kV. Converting the loads along this section are consistent with the requirements under the *Asset Sustainment Plan* and *4kV Aging Infrastructure System Planning Report*. This project will coordinate with the rebuild of depreciated pole lines under Project Number 13G3.

Pole fires occur in specific older types of overhead construction with wood crossarms and pin type insulators. In these types of construction, leakage current tracks over deteriorated insulators and becomes concentrated in places where bolts and steel brackets interface with the wood resulting in fires.

Several years ago London Hydro instituted the pole fire replacement program and to-date has completed 80% of the projects. This resulted in the significant improvement in the system performance as illustrated on the graph below. The replacement program will continue on an annual basis until the time that all pole fire prone poles are replaced.

After completing this pole-fire project scheduled for 2013, 82% of the pole-fire projects will be completed.



Impact of Pole Fires on System Reliability

2013 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	13G3
Project Name:	Rebuild Depreciated Areas
Project Driver:	REL

Project Title: Rebuild of Fully Depreciated Overhead Areas

Project Manager:	Rod Doyle	**Project Tech.:**	Hank Bonnar & Jim Soetemans

Supporting Reference Material

Replacement of Fully Depreciated Overhead Distribution Areas Report, 2010
Asset Sustainment Plan, 2012 - 2026 Report

Description/Justification

The above reports have identified various parts of the system in this area as being in poor condition. The deficiencies related to the age of the equipment may adversely impact the reliability of supply as well as public and employee safety. The poles and associated hardware are approximately 50 years old. Many of the transformers in the area are operating in excess of their capacity due to load which has been added by customers over the years (i.e. air-conditioning and other appliances). These reports confirm we must continue to replace aging plant.

A majority of depreciated plant will be addressed through Project Number 13G5, Zone 'A' Overhead Conversion. This budget section will address a small area outside of Zone 'A' Overhead Conversion: High Street and Chester Street. These streets are radially supplied off Baseline Road West and coordinates with the Baseline Road West pole fire rebuild under Project Number 13G2.

COST ESTIMATE

Section - 132	**$166,000**

Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

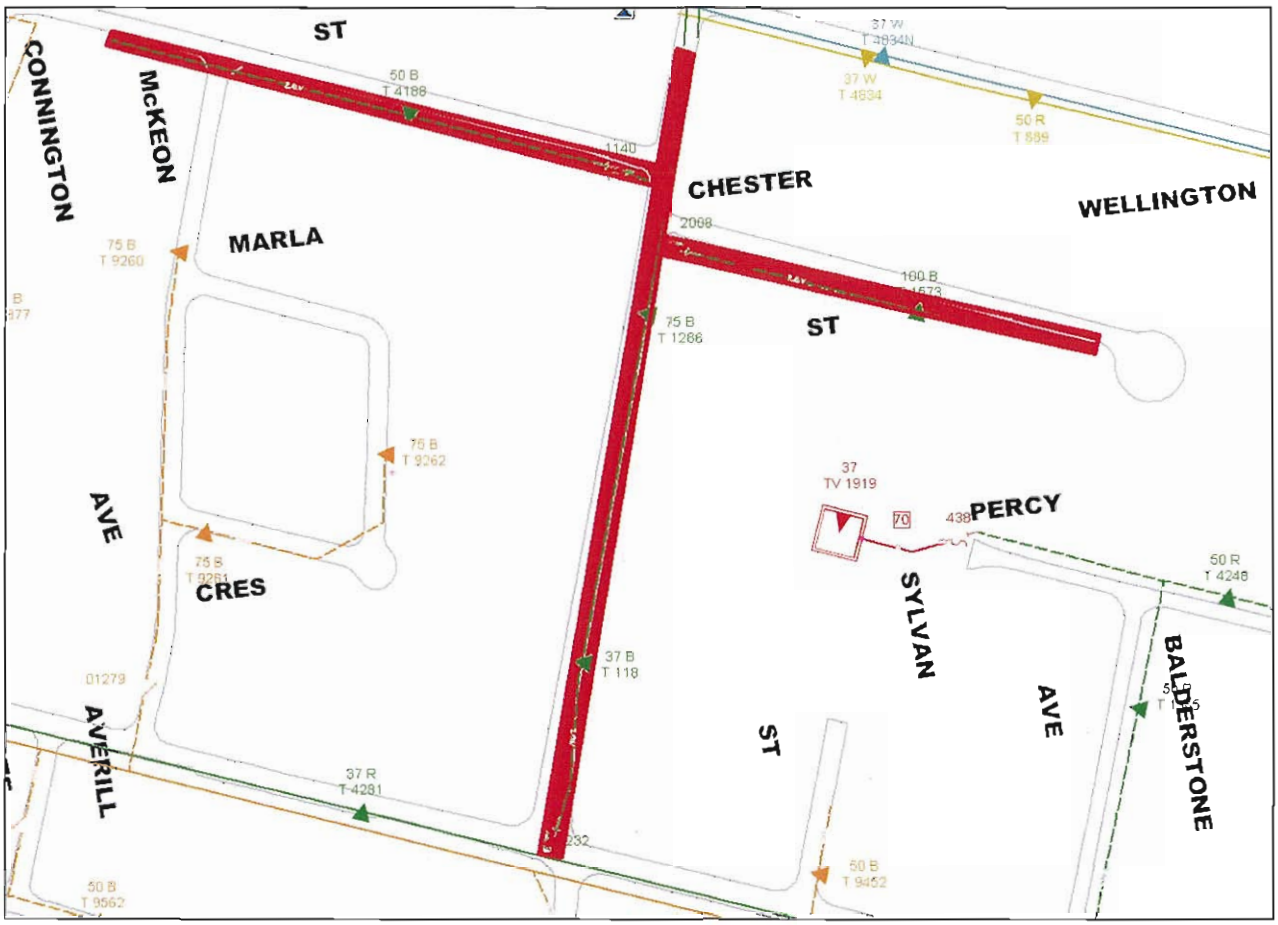
Replacement of Fully Depreciated Areas
Project 13G3

London Hydro has established a set of criteria to be used when prioritizing which fully depreciated overhead areas are to be rebuilt. These include: results from the visual audit conducted on the overhead system in 1998, OEB infrastructure audit results, pole testing results, safety issues, system performance, accessibility and reliability.

London Hydro completed an audit of its most depreciated overhead areas. Twenty-seven areas were evaluated based on a number of factors, such as:

- overall condition, which included pole, wood crossarms, transformers and conductors
- safety conditions, which included adequate anchoring, #6 Copper, grounds, non-standard framing, encroachments
- environment, which included leaking transformers
- accessibility and operability

Some areas are in extremely poor condition and require complete rebuilds. Most of the poorest conditioned areas are at the vintage 4.16kV distribution system. Conversion of this voltage system will be implemented to benefit other system requirements such as offloading substations and improve system efficiency (reduce system losses). Conversion of these depreciated 4.16kV areas are supported in the *4kV Aging Infrastructure System Planning Report – 2011* and must be completed prior to undertaking the rebuilding and converting Zone 'A' in the report.



Sections of Chester St. and High St. Requiring Rebuild

The overhead plant in the above area is fully depreciated and qualifies for replacement under the *Asset Sustainment Plan, 2012 - 2026 Report*.

A majority of depreciated plant will be addressed through Project Number 13G5, Zone 'A' Overhead Conversion. This budget section will address a small area outside of Zone 'A' Overhead Conversion: High Street and Chester Street. These streets are radially supplied off Baseline Road West and coordinates with the Baseline Road West pole fire rebuild under Project Number 13G2.

2013 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	13G4
Project Name:	Momentary Mitigation
Project Driver:	REL

Project Title: Momentary Outage Mitigation for Main Feeders

Project Manager:	Rod Doyle	**Project Tech.:**	Hank Bonnar

Supporting Reference Material

Kinectrics Report No. K-014857-001-RA-0001-R00
Lightning Protection Study for London Hydro - October 2009
Quality of Supply Reports, 2009 & 2010

Description/Justification

This budget section will implement various methods to mitigate the momentary outages experiencing on main feeders.

The two feeders experiencing the most auto-reclose (AR) operations were:
- 32M5, with 7.3 AR's / year for the last 5 years.
- 32M1, with 6.8 AR's / year for the last 5 years.

Mitigation methods recommended may include:
- new recloser
- suspension arresters at various locations
- additional insulated guy rods
- animal protection such as insulated switch/cutout brackets and transformer coverup
- change porcelain insulators

COST ESTIMATE

Section - 132	**$245,000**

Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Momentary Outage Mitigation for Main Feeders
Project 13G4

Outage records indicated that the 32M5 and 32M1 main feeders experience the highest average momentary outages (MAIFI performance category) per year over the last 5 years. The 32M5 feeder experienced 7.3 auto reclose (AR) operations per year on average while the 32M1 was close behind, averaging 6.8 AR's per year.

This budget section will allow various methods to aid in mitigating momentary outages experienced on these two feeders. Implementation to improve reliability include some of the following methods:

- Installation of a recloser in an optimized location upstream of highest momentary outage risk
- Installation of suspension lightning arresters at strategic locations*
- Installation of animal guards on the transformers, undertaken only in locations prone to animal contact
- Replace un-insulated transformer and riser brackets with insulated brackets, undertaken in locations prone to animal contact.
- Installation of additional insulated guying rods on guying near primary circuits.

* Note - The majority of these momentary outages are attributed to lightning and animal contacts. In 2010, London Hydro undertook to implement the lightning mitigation techniques, involving arresters on every pole's top phase as recommended by Kinectrics' *Lightning Protection Study for London Hydro - October 2009* report. A large scale lightning mitigation involving arresters on every pole for this project will not be implemented at this time until London Hydro can properly evaluate the effectiveness of a similar project on the 26M53 feeder. Instead, only a few strategic locations will be chosen for arrester installation.

2013 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	13G5
Project Name:	Zone 'A' Overhead Conversion
Project Driver:	REL

Project Title: Rebuild and Conversion of Subs 1, 2 & 28 Overhead Areas (Zone 'A')

Project Manager:	Rod Doyle	**Project Tech.:**	Hank Bonnar & Jim Soetemans

Supporting Reference Material

4kV Aging Infrastructure System Planning Report - 2011
Asset Sustainment Plan, 2012 - 2026 Report

Description/Justification

The initiatives outlined in the *4kV Aging Infrastructure System Planning Report* require converting all 4.16kV within Zone 'A', with Zone 'A' being the service territories for Substations 1, 2 and 28. In addition, the proposed rebuilds replace depreciated infrastructure meeting the criteria outlined in the Asset Sustainment Plan, 2012 - 2026 Report.

This is the second year of a three year program to rebuild and convert Zone 'A' area. This year will complete the area to permit the decommissioning of Substation 1. The 13.8kV gear will remain at Sub 1. Other highlights for this year's scope include:

- Convert half of Old South Area, consisting of feeders 1F1, 1F4, 21F3, and half of 16F2 and 52F1 feeders.
- Convert most of South of Horton (aka "SOHO") District, consisting of feeders 28F1, 28F2 and 2F1 feeders.

The above work must coordinate closely with the Zone 'A' vault conversions under Project Numbers 13B6 and 13B9 and must coordinate closely with the Main Feeder Reinforcements under Project Number 13C1.

COST ESTIMATE

Section - 132	**$4,151,000**

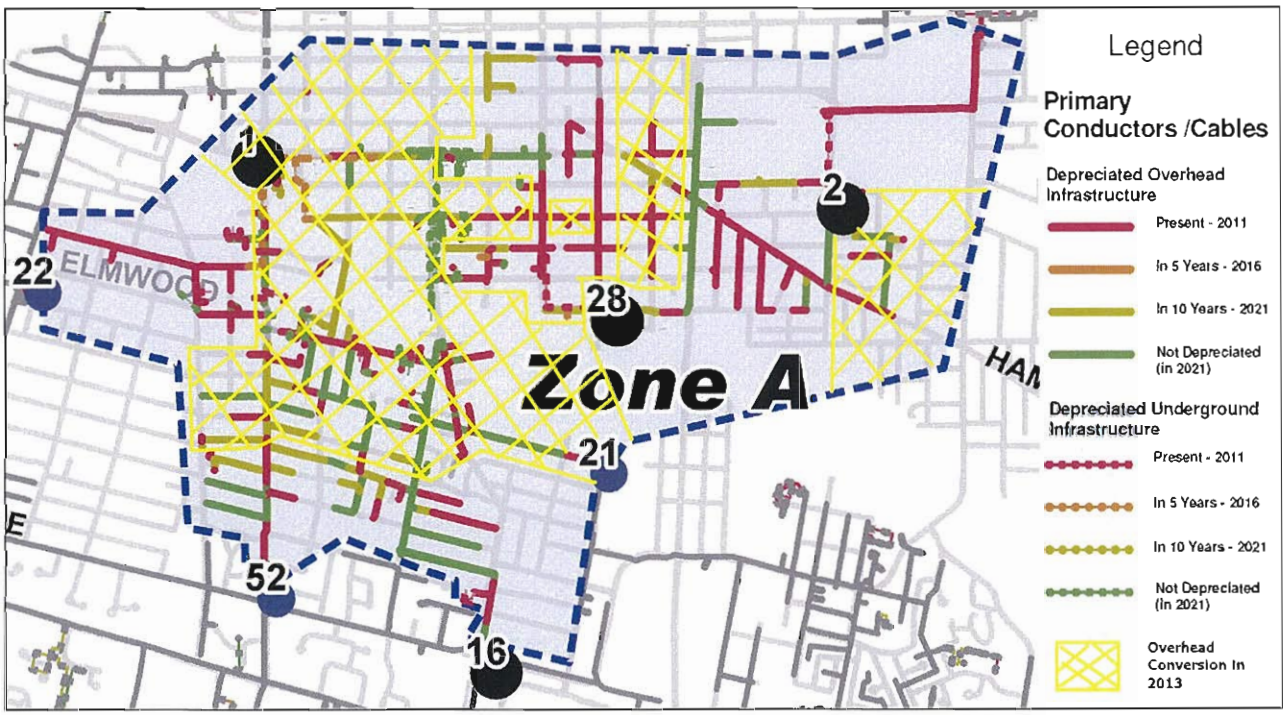
Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Zone 'A' Overhead Conversions
Project 13G5

The initiatives outlined in the *4kV Aging Infrastructure System Planning Report* require converting all 4.16kV within Zone 'A', with Zone 'A' being the service territories for Substations 1, 2 and 28. In addition, the proposed rebuilds replace depreciated infrastructure meeting the criteria outlined in the *Asset Sustainment Plan, 2012 - 2026 Report*.

This budget section is the second phase over the next few years to convert Zone 'A'. Highlights of completing this scope of work includes:

- All Substation 1 load is converted.
- All of 28F1 and 28F2 4.16kV feeders are converted.
- 28F3 4.16kV feeder north of Little Simcoe Street is converted.
- All of 2F1 4.16kV feeder is converted.
- All of 21F3 4.16kV feeder is converted.
- Half of 52F1 and 16F2 4.16kV feeders are converted. The tie between these two feeders along Windsor Avenue will remain.



Zone 'A' Area

The above work must coordinate closely with the Zone 'A' vault conversions under Project Numbers 13B6 and 13B9 and must coordinate closely with the Main Feeder Reinforcements under Project Number 13C1.

After this scope, most of Zone 'A' will be converted except for the following:

- 4.16kV feeders 28F3, 2F3 and 2F4 remain. These feeders back each other up. These feeders are confined to a small area bounded between Adelaide Street, Rectory Street, Little Simcoe Street and Nelson Street.
- 4.16kV feeder tie between 2F2 and 9F3. These feeders back each other up.

These remaining 4.16kV areas will be converted in 2014 to complete the Zone 'A' scope.

2013 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	13G6
Project Name:	Porcelain Arrester Replacement
Project Driver:	SAF

Project Title:	Porcelain Arrester Replacement

Project Manager:	Hassan El-Madhoun	**Project Tech.:**	Sherri Bechtel

Supporting Reference Material

March 2011 Reliability Incident Summary Report

Description/Justification

This budget item is for the replacement of Porcelain Distribution Class Arresters. This is the second year of a multi-year program intended to target and eliminate all known locations of porcelain arresters and replace them with polymer style arrester.

COST ESTIMATE

Section - 132	**$98,000**



Prepared By:	Hassan El Madhoun, E.I.T. Assisstant Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Porcelain Arrester Replacement
Project 13G6

Porcelain arresters are known to have a poor seal, thereby letting in moisture. Moisture ingress can reduce the Maximum Continuous Operating Voltage (MCOV) and the porcelain arrester can overheat and fail, sometimes violently, causing a safety concern.

Based on the best known date of when London Hydro stopped purchasing Porcelain Arresters, the initial estimate of number of porcelain arresters locations was identified: 275 risers equipped with porcelain arrestors and approximately 1400 transformers. A full audit of our system will be conducted over 2011-2013. After an annual spending of $98 K in 2012 and 2013 to start the program, the full scope of the project may be determined after the audit is completed.



Fig 1. Arresters at risers

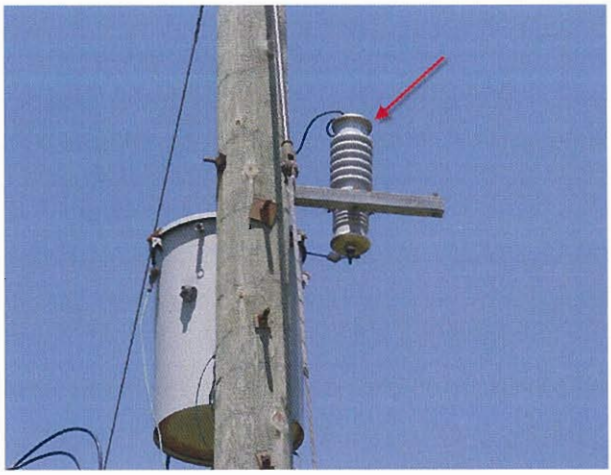


Fig 2. Transformer arrester

2013 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	13G7
Project Name:	Removal and Restoration
Project Driver:	REL

Project Title: Removal and Restoration of Overhead Plant

Project Manager:	Rod Doyle	**Project Tech.:**	Hank Bonnar & Jim Soetemans

Supporting Reference Material

Description/Justification

In 2013, London Hydro will be completing overhead pole line rebuilds in various areas within the city. These rebuilds involve many pole hole excavations and pole removals. This budget will be used to complete restoration in these areas. It is noted that these removals must be coordinated with our joint use partners such as Bell & Rogers and thus timing is dependent on external parties.

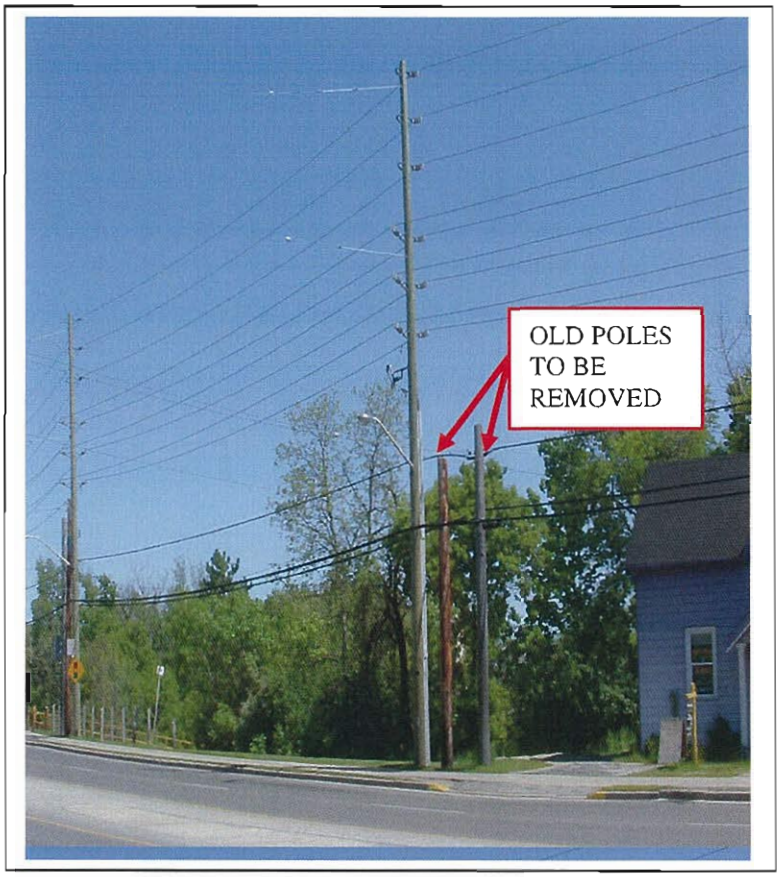
COST ESTIMATE

Section - 132	**$30,000**

Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Removal and Restoration
Project 13G7

The picture below is an example of new hydro pole construction, where the old structure is still supporting 3rd party attachments. The final phase of construction involves the removal of this structure, but must be co-ordinated with the 3rd party utilities (i.e. Rogers Cable, Bell) still attached to our poles.



2013 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	13H1
Project Name:	Recloser Installations
Project Driver:	REL

Project Title: Automation on Feeders - Recloser Installations

Project Manager:	Rod Doyle	**Project Tech.:**	Jim Soetemans

Supporting Reference Material

Quality of Supply Report 2010
Use of Reclosers on London Hydro's Electrical System, Sept. 2003

Description/Justification

This project has been budgeted to install 3 reclosers to facilitate SCADA switching, fault isolation and restoration. Installation of these devices has resulted in significant improvements in reliability. The reclosers will be installed at the following locations:

1) In place of loadbreak switch P51-2 on Wharncliffe Road South north of Elmwood Avenue. This will aid in sectionalizing the 26M41 feeder.

2) In place of switch SW 0369 on Exeter Road at Meg Drive. This will be an open point between the 19M22 and 19M37 feeders.

3) In place of loadbreak switch O56-1 on Southdale Road West east of Boler Road. This will aid in sectionalizing the 32M8 feeder.

COST ESTIMATE

Section - 250	**$187,000**

Prepared By:	Rod Doyle Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Recloser Installations
Project 13H1

The installation of automated switches or reclosers on major feeders has a positive impact on the duration and frequency of outages. London Hydro now has over 100 automated devices in the field and plans to continue installing reclosers until there is an average of 2.5 reclosers per 27.6 kV feeder; thus, sectionalizing each feeder to approximately 1000 customers between reclosers.

The installation of reclosers is a very cost effective way of improving SAIFI reliability (System Average Interruption Frequency Index). A report was developed into an industry paper entitled "Use of Reclosers on London Hydro's Electrical System" (included in abstract) that examined various methods for evaluating the cost effectiveness of reliability improvement programs.

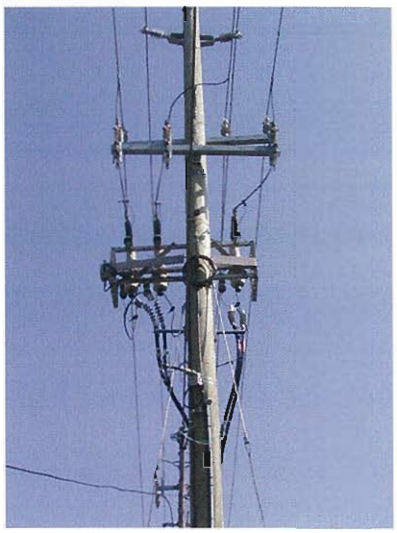


Figure 1 – Horizontal Recloser Installation

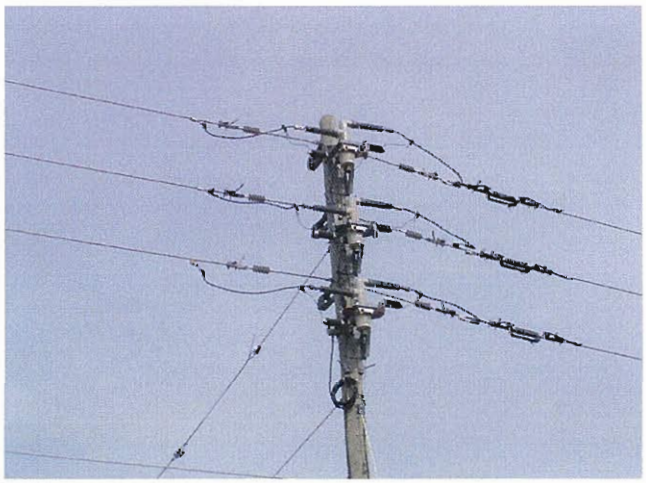


Figure 2 – Vertical Recloser Installation

2013 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	13H2
Project Name:	RTU Replacement Program
Project Driver:	REL

Project Title:	Remote Terminal Unit (RTU) Replacement Program

Project Manager:	Cole Tavener	**Project Tech.:**	Rolf Reiners

Supporting Reference Material	Asset Sustainment Plan - Electrical Distribution System: 2012 - 2026

Description/Justification

The purpose of this project is to implement the standard remote terminal unit (RTU) design developed in 2011. It is part of a program to address the replacement of up to 20 RTUs between 2012 and 2017.

COST ESTIMATE

Section - 250	**$49,000**

Prepared By:	Cole Tavener, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Remote Terminal Unit (RTU) Replacement Program
Project 13H2

RTUs provide the interface between substation devices and the SCADA master computer. In addition to remote control, these devices enable remote observation of the system's configuration and load flows. The ability to observe the system remotely is critical to system reliability, specifically System Average Interruption Duration Index (SAIDI).

London Hydro currently utilizes 45 RTUs to monitor its substations. Over half the asset population is no longer supported by the manufacturer and the oldest units have exceeded their expected useful life by nearly a decade. One third of the asset population consists of piloted equipment that was found to be inadequate. To maintain system observation and control capabilities, a RTU replacement program is required.

Manufacturer	Type	Quantity	Earliest Installation
Cat Com Systems	Rantech	22	1983
GE Multilin	DART	5	1995
SEL	2032	4	2007
SEL	RTAC	5	2011
Natis Communications	RTU3200	3	2008
G&W	ATC	3	2000
GE Multilin	Ibox	2	2003
GE Multilin	D20	2	2002

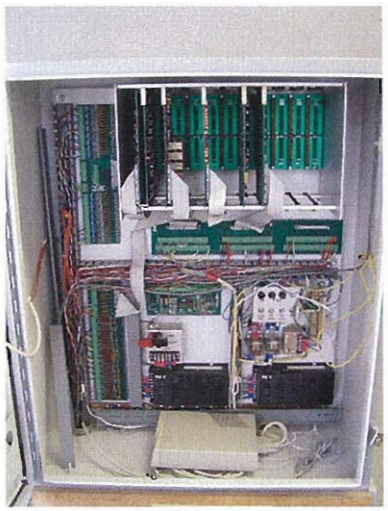


Figure 1 – Rantech RTU



Figure 2 – SEL 2032 RTU

2013 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	13H3
Project Name:	Voice System
Project Driver:	REL

Project Title: Control Room Communications, Voice System

Project Manager:	Cole Tavener	**Project Tech.:**	Rolf Reiners

Supporting Reference Material

Description/Justification

The operations voice system currently employed in the control room, and throughout the building, will be replaced with a modern system that is better suited to operate in conjunction with the digital voice radio system installed in 2011.

COST ESTIMATE

Section - 250	**$30,000**

Prepared By: Cole Tavener
Distribution Engineer, P.Eng.

Approved By: Ken Walsh, P.Eng.
Chief Engineer &
V.P. of Operations

Control Room Communications, Voice System
Project 13H3

The operations voice system utilized in the control room, and throughout the office, is an analogue system that is no longer supported by the manufacturer. In 2011 the operations mobile radios were migrated from analogue signaling to digital signaling, resulting in reduced voice clarity on the operations voice system. To improve voice clarity and eliminate an unsupported system, the voice system will be replaced with a modern system.

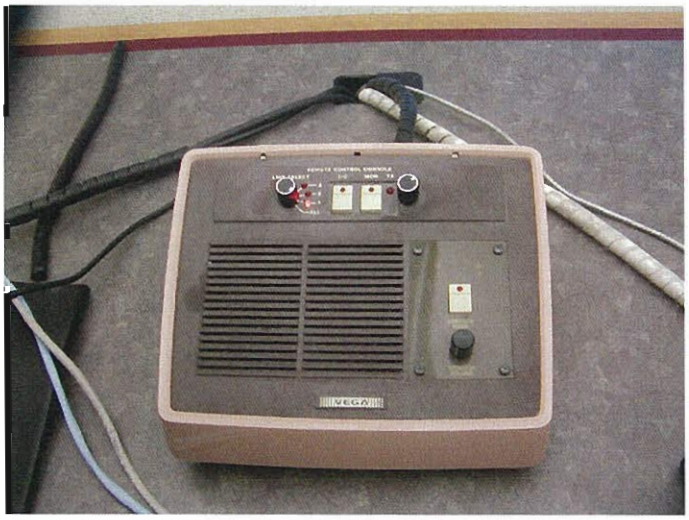


Figure 1 – Control Room Voice Radio Console



Figure 2 – Office Voice Radio Handset

2013 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	13H4
Project Name:	Display Wall Servers
Project Driver:	REL

Project Title: Control Room Display Wall Servers & Software

Project Manager:	Cole Tavener	**Project Tech.:**	Rolf Reiners

Supporting Reference Material

Description/Justification

This project will address the replacement of end-of-life servers and software required to enable the control room display wall to be operated in split-screen mode.

COST ESTIMATE

Section - 140	**$60,000**

Prepared By:	Cole Tavener, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Control Room Display Wall Servers and Software
Project 13H4

The video display wall in the control room has the capacity to split into multiple screens, enabling the operators to use the display wall independently. This functionality is controlled by two servers running Activu software. The servers and software were purchased in 2004. This equipment has reached end-of-life and must be replaced. This project will address the purchase of new servers and implementation of new software in order to maintain the split screen capability of the video display wall.



Figure 1 – Control Room Display Wall



Figure 2 – Display Wall Servers

Engineering Abstracts

Throughout this document reference has been made to various internal reports and other relevant sources of information. These reports have been used to develop the Engineering & Operations Asset Management Plan for 2012 & 2013. It is recognized that these reports are highly technical in nature and may contain proprietary information and therefore, are not included in the Asset Management Plan for general distribution. For information the following abstracts have been prepared.

- **Engineering Instruction EI-31, Asset Management Policy & Procedures – Electric Distribution System, November 2011**

  This Engineering Instruction describes the policies and procedures used by London Hydro to manage its electrical distribution system assets. It also defines the decision making roles and responsibilities that lead to the preparation and review of the Asset Sustainment Plan and the yearly Capital Budget.

- **Asset Sustainment Plan – Electrical Distribution System: 2012 – 2026, November 2011**

  This report provides a comprehensive assessment of all of London Hydro's major electrical distribution assets. It documents the age and condition of major assets so we can anticipate potential performance problems and plan strategies and spending programs to manage our safety, environmental and service reliability risks at the lowest life cycle cost. With a well-managed plan we are able to make informed decisions about assets as they age, specifically, whether and when to maintain, refurbish or replace them.

- **2011 Housing Market Outlook Reports –** This a collection of reports produced by the Canada Mortgage and Housing Corporation which are available on the internet. These reports speak to the housing starts for single family residences and multi-unit housing in Canada, Ontario and the London area. London Hydro uses these reports, as one resource, in the development of their capital projects.

- **4kV Aging Infrastructure System Planning Report - 2011 –** The planning report on the aging 4.16 kV infrastructure studies London Hydro's 4kV distribution system and applies reliability centered assessment to identify the highest priority areas requiring permanent solutions. The goal is to address existing and potential system deficiencies over the course of the next dozen years - in terms of priority zones instead of individual substations.

- **EDRO An Innovative Approach in Performance Benchmarking for Better Asset Management –** London Hydro has completed substantial work in the area of reliability. This paper is a furtherance of that effort. The work focuses on ascertaining which reliability metrics are affected by engineering design and good maintenance practices. In this context, capital replacements are treated as end stage maintenance. The paper identifies the metrics which contribute to the statistics and provides projections and recommendations for improvements.

- **Mitigating Pole Fires on London Hydro's Distribution System –** This report addresses issues associated with the number of increased wooden pole fires caused by the flow of uncontrolled electrical current through the pole. A background of the contributing factors relating to the modes of failure and their impact on reliability of supply are provided. The extent and impact of the failures are quantified and solutions involving available technology and practices are provided for the purpose of identifying capital expenditures.

- **Multi-year Rehabilitation Plan For Aging Underground Residential Distribution Systems –** The addendum to this report discusses London Hydro's continued use of its proprietary methodology (SPOORE) to prioritize those subdivisions with cables that are at risk of failure due to their age and past performance. The continually updated addendum records the previous rebuild initiatives and lists subdivisions based on the SPOORE analysis for the following year. The paper also stresses the need to replace aging cable at the rate it was put into the ground in the 1970's and 1980's.

- **New Supply Capacity for London Hydro (2006 – 2010) Addendum –** The new Supply Capacity 2008 Addendum reviews the London Hydro load forecast and the five year feeder build plan that was initiated in 2006. City of London forecasted growth and land use projections are used to develop a detailed forecast on a feeder basis that is compared to the long term growth trend using linear regression. The forecast model is updated and validated with actual peak load data from the past three years. The feeder capital build plan is reviewed and priorities are reaffirmed. The need and timing for a new transformer station to supply the City of London is established.

- **Refurbishment of the Electric Supply to London's Core Network System –** This report was produced by London Hydro Network Planning Department and outlines an integrated plan to refurbish the supply to the downtown core in conjunction with the addition of 27.6kV supply capacity at Nelson T.S. These interdependent projects occurring over the next four years will result in the replacement of a significant amount of sixty-year-old end of life infrastructure. The existing single source 13.8kV supply to the downtown core network will be replaced with an interconnected 27.6kV system that will allow London Hydro to meet the future needs of downtown London.

- **Use of Reclosers on London Hydro's Electrical System** - Up until recently reclosers were not available in a phase over phase arrangement. As a result they were not suitable for most urban environments. With the advent of vertically arranged reclosers, we can now prevent upstream customers from seeing some downstream faults altogether by opening and isolating the downstream problem area before the main feeder breaker locks out. This not only reduces the length of the outage but also the number of customers affected. Reclosers can therefore improve both SAIDI and SAIFI reliability indices. This paper calculates how effective reclosers can be in improving reliability, how many are required in a feeder segment and at what cost

APPENDIX 2C – ASSET SUSTAINMENT PLAN

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Electric Distribution System

Asset Sustainment Plan: 2012 to 2026

(Nov 2011)

Confidential and Privileged

Pre-Amble

KINECTRICS

I have thoroughly reviewed London Hydro's "Electric Distribution System Asset Plan: 2012 to 2026".

This document provides background information that forms the basis for a long term sustainment strategy. This strategy addresses both capital and maintenance needs of existing distribution assets and is aimed at meeting corporate objectives in the most cost-effective manner possible by utilizing "total life cycle cost" Asset Management approach.

The plan includes high level description of the life cycle process form London Hydro's perspective, challenges facing this Local Distribution Company, and, for each asset category:

1. Age and Life Expectancy
2. Condition
3. Inspection Plan
4. Risk Assessment
5. Asset Sustainment Plan

Capital projections for 2012-2026 as well as Operating and Maintenance expenditures for 2012 and 2013 are also included in the plan and are based on specific asset information contained in the plan as well as professional expert opinion of London Hydro's staff.

This plan is expected to become a major component of the Asset Management Plan and, as such should be updated on an annual basis.

Yury Tsimberg, P. Eng.
Director – Asset Management
Kinectrics Inc.

Executive Summary

The purpose of London Hydro's Electric Distribution System Asset Sustainment Plan (ASP) is to develop a complete understanding of the major distribution assets owned by London Hydro, so the objectives stated in London Hydro's overall asset management policies and procedures are met. The ASP plan documents the age and condition of London Hydro's major distribution assets so potential performance problems can be anticipated and long term spending patterns can be predicted as necessary to manage risks within acceptable levels and optimize service reliability at the lowest life cycle cost. With a well-managed plan London Hydro can make informed decisions about assets as they age, specifically, whether and when to maintain, refurbish or replace them.

London Hydro's Engineering & Operations Asset Management Plan for 2012 and 2013 has two components:

- Infrastructure related projects that result from engineering and planning studies and also operational issues;
- City Developer works which are externally driven and are, for the most, part growth related.

The ASP focuses on the 'natural' life cycles of assets and does not anticipate for their advanced retirement due to external drivers such as City Developer related projects. Hence, discussions related to the 15 year replacement and refurbishment plan assume that assets will reach their average life expectancy without external intervention.

Based on the life expectancy, condition, risk and potential performance problems that may be associated with each asset, this ASP proposes an average yearly replacement/refurbishment plan for the next 15 years.

London Hydro's inspection and maintenance activities for each of its major distribution assets are also discussed in the report.

Background and Discussion

Purpose:

London Hydro's Electric Distribution System Asset Sustainment Plan (ASP) provides an overview of the major electric distribution assets owned by London Hydro and describes how London Hydro optimizes the life-cycle value of physical assets to provide safe and reliable service in an efficient and effective manner. This plan documents the age and condition of the distribution assets and enables London Hydro to anticipate potential performance problems and to plan strategies and spending programs to manage risks and service reliability.

London Hydro's Asset Sustainment Plan:

London Hydro has developed a comprehensive ASP which outlines the operating and capital activities that are necessary to ensure that London Hydro continues to provide safe, reliable, and efficient distribution of electricity to its customers.

There are a number key drivers for the ASP:

- Acts, regulations, codes and guidelines;
- Safety considerations;
- Environmental considerations;
- Financial Prudence;
- Good utility practice; and
- Customer expectations.

The key drivers are reviewed annually and adjustments to the plan are made based on changes in legislation, system performance reviews, safety assessments, infrastructure studies, and results of customer satisfaction surveys.

There are also three key elements used to develop the ASP for each major group of assets:

1. Asset Demographics and Condition Based Assessments;
2. Reliability Analysis and Risk Assessment; and
3. Obsolescence.

Annual Operating and Capital Program:

The annual operating and capital program is prepared by staff and is reviewed by the Audit Committee prior to being approved by the Board of Directors. The ASP predicts average required future activities for fully depreciated or obsolete assets and is just one of the inputs used when budgets are developed and presented for approval. Since the ASP considers long term trends and averages, a one-to-one relationship cannot be drawn between the average replacement levels recommended in the ASP and the capital or operating budget in any given year. The ASP is very useful, however, for forecasting the general levels of future replacements that will be required. The level of asset replacement currently proposed in the 2012 and 2013 capital budget is consistent with the average levels described in this report. The section on page 17 entitled "Applying the ASP in Practice" further describes how the information provided in this report relates to capital budget plans and average life spans for accounting purposes.

Approaches to Asset Sustainment:

The failure rate of most major assets can be shown using a bathtub curve (Figure 1), which illustrates three potential stages of asset failure:

The first stage represents a decreasing failure rate, often described as infant mortality. This failure rate is initially high but quickly decreases within hours or days of installation and can be accounted for by defects in the equipment itself or errors in handling or installation.

The second stage represents a relatively constant failure rate. At this stage, after the equipment is installed properly and well before its End of Life (EOL), the failure rate is low and constant. When failures do occur, they are generally of a random, unpredictable nature.

The third stage sees an increasing failure rate. In the late life of the asset, the failure rate increases, as age and wear or original design defects take their toll on the product.

An asset sustainment plan must anticipate the third stage of escalating failure rates to determine when refurbishment and/or replacement is necessary. Some assets can be run to failure with minimal safety and reliability risks whereas others need to be replaced before failures start to escalate.

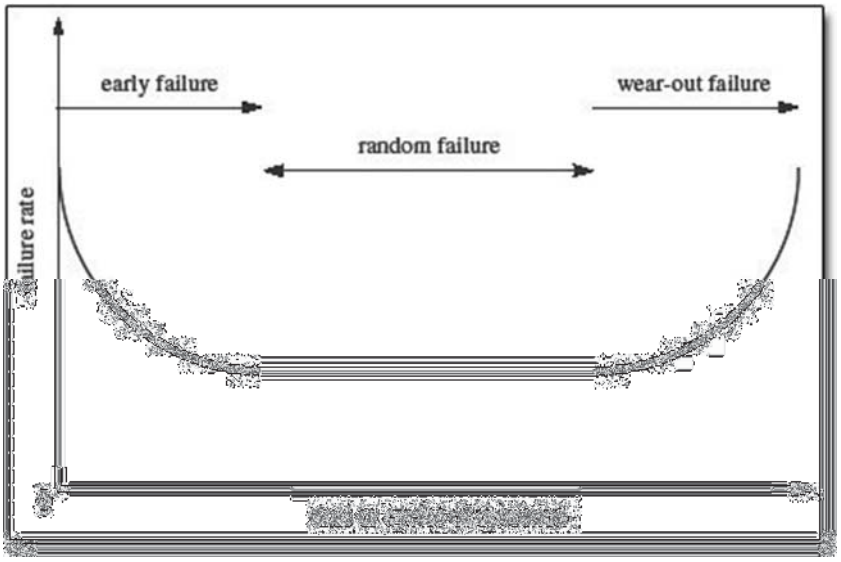


Figure 1 – The Bathtub Curve

Besides determining when each asset should be refurbished and/or replaced, the ASP needs to determine and record which assets require scheduled testing and/or inspections.

There are two main aspects of assets maintenance: **Corrective Maintenance (CM)** and **Preventative Maintenance (PM).**

The **Corrective Maintenance** aspect focuses on reacting to problems when they occur.. In some cases, this approach may result in reliability issues as well as higher costs because by the time the problem is found, refurbishment or replacement may be the only options left. This approach is only suitable if the equipment is non-critical and if the consequences of failure are not serious. In distribution networks this method is widely used for low voltage secondary cables, for example, where no cost effective preventative maintenance measures are available.

Preventative Maintenance takes a proactive approach to maintaining equipment before it breaks down and causes problems with safety or system reliability. PM can be further divided into **Time-Based Maintenance (TBM)** and **Condition-Based Maintenance (CBM)**. TBM, which is the more traditional approach, follows a set maintenance schedule at fixed time intervals. CBM involves continuous monitoring and inspection or testing to determine when maintenance is required based on the condition of the equipment. Three types of maintenance approaches are discussed next.

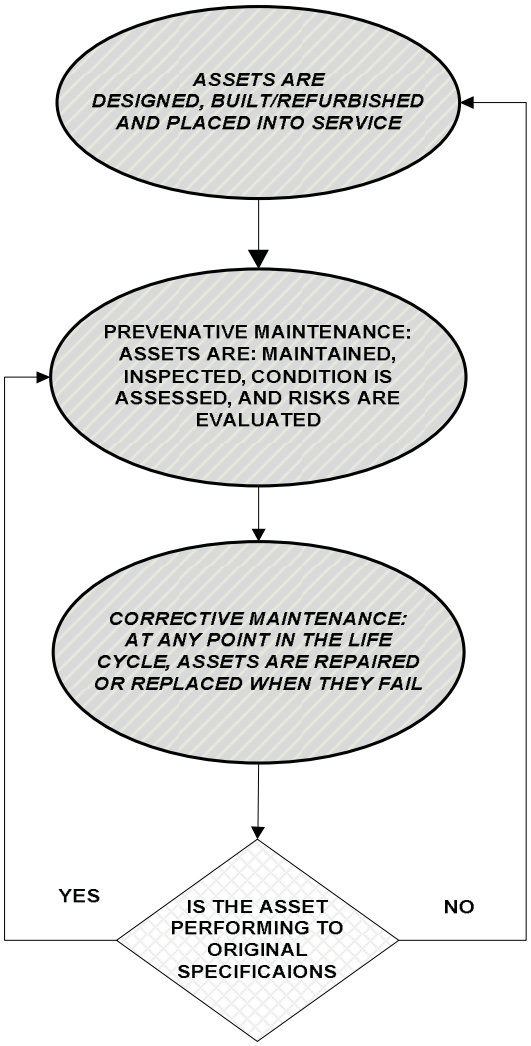
Timed-Based Maintenance (TBM), with its fixed time intervals for inspection and maintenance, is the easiest and most widely used PM method. Time intervals are either given by the manufacturers or are based on the judgement and experience of those who work with the asset, and the intervals may be shortened or lengthened depending on the history of problems with that asset. London Hydro uses this method, for example, to perform regular maintenance on breakers, protectors, relays and batteries.

In **Condition-Based Maintenance (CBM)**, maintenance activities are triggered by the estimated or measured condition of certain properties that reach a predetermined threshold. When the condition of an asset can be estimated or measured directly, CBM can lead to more effective decisions that can improve reliability and/or lower costs compared to TBM. London Hydro uses this method for managing its poles. London Hydro uses various testing methods to determine whether a pole has started to deteriorate and the results are used to determine when poles should be retested or replaced. This practice increases reliability by ensuring that poles are replaced on a planned schedule before they fail, and it lowers costs by ensuring that poles that are in good condition are not replaced prematurely simply based on their age.

Reliability-Centered Maintenance (RCM) is an approach focused on identifying and establishing the operational, maintenance, and capital improvement policies that will manage the risks of equipment failure most effectively. RCM involves both Corrective Maintenance and Preventative Maintenance approaches, but evaluates the priorities for maintenance and ranks replacement and refurbishment activities based on the impact of failure. The result is a program that focuses scarce economic resources on those items that would cause the most disruption if they were to fail. For many of London Hydro's assets, (for example, underground cables and small distribution transformers), no cost effective maintenance activities can be performed, so London Hydro uses a RCM approach to develop refurbishment and replacement schedules. London Hydro is moving towards adopting some form of RCM for each asset, and where it does not, the Asset Sustainment Plan will identify this gap.

The Asset Lifecycle:

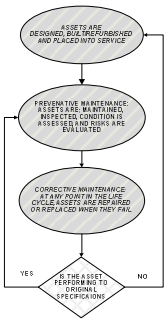
The following flowchart describes the lifecycle of an asset from design/installation to replacement. Each element of the cycle is presented in the following section.



Procedures:

The following section describes the procedures that are followed for each step of the asset sustainment process.

Step 1



Assets are designed, built and placed into service.

Engineering Design

London Hydro has a comprehensive set of Engineering Design Standards certified by professional engineers that form the basis of the design of the distribution system. These standards are maintained in an up-to-date status and procedures are in place to ensure that all users have current document sets. In order to ensure a consistent methodology is used for the introduction or revision of standards at London Hydro, there is a formal procedure for introducing new standards. All staff follow this procedure to ensure that important changes are vetted by, and communicated to, all stakeholders.

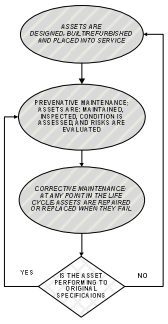
Procedures have been set in place to ensure that staff receives ongoing training and periodically attends industry conferences and seminars to keep up-to-date with best practices. When new assets are designed, various design options are considered and factors that affect reliability (increased automation for example) and operational flexibility (such as redundancy and alternate feeds) are balanced with cost to provide an optimal solution.

London Hydro keeps up-to-date with new products to ensure that the designs that are developed use equipment that is safe and effective for the job. The Standards Engineer works

closely with the Reliability Engineer to identify equipment problems as early as possible and to implement mitigation measures that may be required.

London Hydro has developed a formal equipment approval process to comply with the Electric Safety Authority's requirement to use only approved equipment in electric distribution systems. The Approval Process defines how London Hydro uses certified tests, approvals by professional engineers, trial periods and good utility practices to ensure that equipment does not pose a safety hazard to the public or employees. The Standards Engineer ensures that the equipment approval process is followed whenever new equipment is introduced to London Hydro.

Step 2



Preventative Maintenance: Assets are: Maintained, Condition is Assessed and Risks are Evaluated

Preventative Maintenance of Assets

The ASP describes the current maintenance and testing activities performed on all of London Hydro's major assets and also describes how the work is recorded and how decisions are made regarding when assets need to be refurbished or replaced. Engineers develop preventative maintenance plans and ensure that staff receive training and participate in industry committees, equipment shows, conferences and seminars as required to keep up-to-date with leading maintenance practices and technologies.

Inspection and testing

Engineers ensure that London Hydro's assets are inspected in accordance with equipment specifications, good utility practice and as required by the OEB Distribution Code or more frequently as described herein.

The Supervisors responsible for each area, use the information from the inspection audits to determine what work needs to be completed immediately, what work can be scheduled in a timely manner, what work can be deferred until the next inspection or is not required at all, and when the scope of work required needs further Engineering study.

In addition to the infrastructure audit requirements of the OEB, London Hydro undertakes numerous other condition assessments including infrared analysis, corona testing, pole testing, transformer oil sampling, etc. Any resulting deficiencies are reported, assessed and either maintained or replaced through a capital program.

Specific to the OEB inspection program, the following is a description of the audit and maintenance for each department:

Overhead Lines:

- Overhead distribution systems are inspected on a three year cycle.
- London Hydro has developed an inspection checklist for various overhead components including switching devices, regulators, conductors and cables, poles, hardware and attachments. Approximately 10% of poles are also tested each year for structural integrity.
- All trees growing around or near high voltage overhead lines are trimmed on a five year cycle. All trimming is performed in accordance with ANSI standards to preserve the health and appearance of trees as best as possible.

Underground Residential & Commercial Distribution:

- Underground distribution systems are inspected on a three year cycle.
- Recognizing that much of the underground system is inaccessible, the OEB requires that the inspection only include padmount transformers, switching enclosures, and visible cable risers.
- Padmount transformer checklists consist of checking the transformer for oil leaks, and examining insulators, barriers, paint and metal for deterioration or corrosion. All cable accessories that are visible are also checked for integrity and to ensure that no tracking is visible.
- Switching enclosures, with a history of failures, have been put on a yearly inspection cycle. Inspections include insulators, barriers, corrosion, and corona testing.

Municipal Substations

- Substations are inspected on a monthly cycle. Inspections include checking for leaking transformers, oil levels, all gauges, cut grounds and making sure fences have not been tampered with.
- In addition to the general substation inspection program described by the OEB, London Hydro also carries out an extensive maintenance program on all substations, circuit breakers and switchgear.
- Circuit breakers and switchgear are thoroughly inspected on a three year cycle. Relays also have maintenance performed on them at the same time.

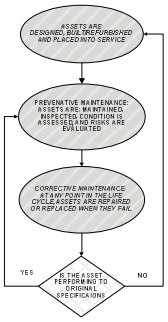
Network System

- The network transformers are inspected on bi-monthly cycle. Inspections include checking the transformer for oil leaks, oil levels and rust.
- Network protectors are fully tested on a three year cycle.
- As well as the transformer inspection, the vault is checked for any structural defects which include the walls, floor, roof as well as the grates.

Maintenance Holes

- Maintenance holes are inspected on a five year cycle.
- While not an OEB requirement, maintenance holes are inspected for structural integrity. Electric components are included in this inspection. Of interest, London Hydro takes pictures inside the maintenance holes which it converts to 360 degree views. These views are used for following and planning feeder routes and give an indication of the conditions inside each chamber.

Step 3



Corrective Maintenance: At any point in the process, assets are repaired or replaced when they fail.

Corrective Maintenance: Asset Failure

When assets fail, Supervisors determine the cause of the failure and make judgments about whether the failure is routine or requires further investigation. If, during the repair, serious deficiencies or emergent issues are discovered that could affect other similar assets, Supervisors will bring this information to the attention of the Director of Operations, who will involve the Engineering Department and other resources, as required, to develop an action plan.

Managing System Reliability

London Hydro takes operational performance very seriously. It does not rely on regulation as the impetus to maintain performance levels. London Hydro subscribes to the philosophy that meeting customer expectation for excellent system performance is part of its mission as a corporation.

London Hydro has engineers who are dedicated to analyzing and reporting on London Hydro's reliability performance. They analyzes all of London Hydro's outages and creates a monthly report to describe the root cause and recommended action plans for all outages that caused 50,000 or more customer outage minutes that month. Failure trends are also analyzed and reported on and this information forms one of the inputs for this ASP.

In terms of performance, London Hydro constantly monitors the metrics to determine what trends, if any, are developing. The reliability indicators assist in developing the programs within the ASP.

Capital investments made over the past few years appear to be yielding positive results – reliability has improved. Significant work has taken place in specific areas where the infrastructure was visibly aging, or where trend analysis indicated deficiencies. The graphs below show the reliability performance over a period of time dating back to 1994. Notwithstanding that there are yearly fluctuations; the overall trend is positive in that the frequency (SAIFI), duration (SAIDI) indicators are trending lower as shown in Charts 1 and 2 below. Yearly fluctuations result from variations in weather such as extreme lightning, excessive snowfalls, and ice storms.

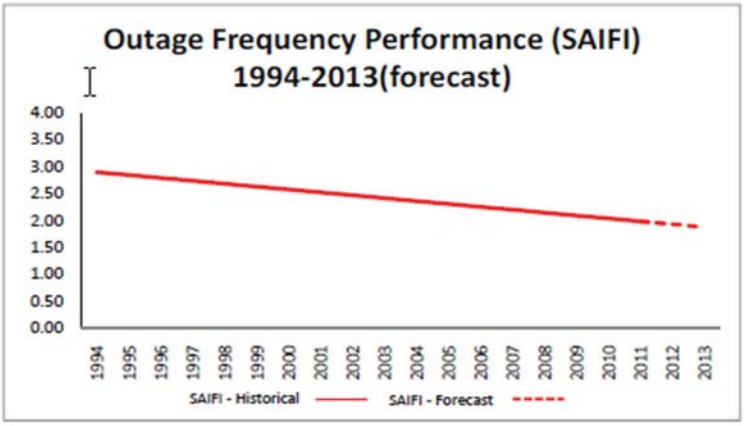


Chart 1 - Historical SAIFI

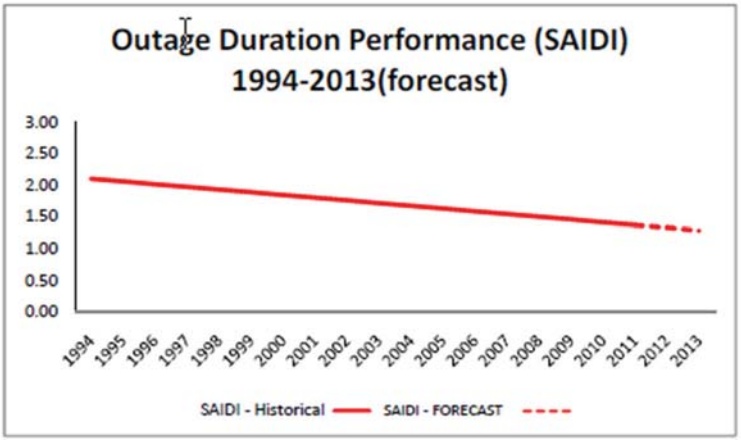


Chart 2 - Historical SAIDI

Opportunities to improve reliability also include optimizing the inventory supply chain. There are several elements of material management that can be configured to improve response and resulting restoration times. One these involves managing emergency inventory. It is critical that an appropriate amount of inventory be available for making repairs in the event of emergency situations such as storms and equipment failures.

The amount of spare material held in inventory depends on the type of equipment, the amount in service and the resupply options. Optimizing the inventory in terms of these variables involves identifying opportunities for using substitutes, adherence to standard materials and developing supplier alliances that will enhance resupply options.

London Hydro undertakes regular reviews of its emergency inventory levels and has established supplier alliances for most of the inventory items.

Assessing Risks to Safety and the Environment

The ASP describes how risks to safety and the environment are assessed for each major asset and how this information is used to develop maintenance, refurbishment and replacement plans.

Throughout the year, as field staff routinely identifies equipment problems that could pose risks to safety or the environment, Supervisors ensure immediate issues get resolved and non-urgent issues get tabled for budget consideration.

Applying the ASP in Practice

When preparing maintenance, capital and financial plans it's necessary to recognize the difference between the average life expectancies discussed in this plan and the average age of assets that are removed from service. The life expectancies developed in this plan are used to prepare programs to maintain the reliability and safety of the electric system; this is not the same as the average age of assets that are removed from service. A number of external factors that are outside the scope of the ASP will often require assets to be removed from service before their predicted end of natural life. Some of these factors are described below.

- Regulatory (Public Service Works on Highways Act)
- Technical Obsolescence
- Energy Efficiency Advantages
- Environmental Issues (designated substances such as lead, for example)
- Severe Weather
- Design flaws resulting in premature failure of entire group of assets (porcelain insulators, painted Grey Munsell poles)
- Damage to Assets by third parties (vehicle accidents)
- Assets stranded when customers cease operations

In addition, there are internally driven factors that can also require assets to be removed from service before their natural end of life such as:

- System Capacity Upgrades

- System Voltage Conversions
- Area rebuilds that affect both old and new assets

Consider for example, wooden poles. In section 1.1.1, the ASP has determined that the average wood pole has a life expectancy of 50 years. This is the lifespan used in the ASP to predict how many poles will need to be replaced over the next 15 years because they have reached their end of useful life.

In practice, however, many poles need to be replaced before they have reached their end of life. Some poles are broken every year due to vehicle accidents and others are prematurely damaged by trees and large limbs during storms. When an entire street or line is rebuilt and upgraded to new standards or to a higher voltage, not every pole in the run will be at end of life, but they all still need to be replaced. Road widenings that are mandated by the municipality can also result in poles being removed from service early. When so much of the cost of line relocations and rebuilds is attributable to labour and equipment, it's not economical to reuse a 30 year old pole that only has a portion of its remaining life left.

In all these examples, the average age of poles removed from service is lower than the average life expectancy used for reliability and safety planning. Confirming this, an analysis of the capital projects involving pole replacements budgeted for 2012 and 2013 shows that only 80% of the poles we plan to replace in 2012 and 78% of the poles in 2013 will be 50 years of age or older. This same principle applies to other assets where additional factors such as technical obsolescence, energy losses and environmental/health issues can also apply resulting in a practical life that can be considerably less than the theoretical life.

The reliability and safety driven recommendations in the ASP therefore represent only one of the many external and internal factors that need to be considered when capital budgets are prepared.

ASP Review

The Chief Engineer and Vice President of Operations reviews the ASP on an annual basis to ensure that it continues to meet London Hydro's strategic objectives and to confirm that all of the processes and procedures described in it are being followed.

The Director of Operations reviews the ASP annually to update the details regarding the life expectancy and condition of existing assets as well as any additional risks identified in the past year.

Every year the Director of Engineering revises the short and long-term capital activity described in the ASP.

Summary:

The purpose of this ASP is to optimize the life cycle value of the physical assets in order to ensure safe and reliable service to London Hydro's customers.

The main undertaking in this ASP is to determine which assets have the greatest impact on safety, reliability and cost in the event of failure and to focus efforts on those assets. Once those assets are identified, key decisions need to be made using RCM techniques on how often to maintain them, and whether to refurbish or replace them and when.

London Hydro recognizes the importance of using some form of RCM for each asset. An asset without a management plan will eventually fail and this could cause reliability problems. Asset failure has cost implications since repairing a failed asset in an emergency is usually more costly than maintaining the asset or replacing it as part of a scheduled replacement plan. Unplanned failures can also pose a safety hazard for the public and London Hydro's employees. In addition, when planning and budgeting for the sustainment of the assets, it is essential to ensure that there are sufficient capitals funds are set aside. It is also recognized that over-maintaining or replacing assets too early can be costly. London Hydro's ASP aims to identify future asset replacement patterns to help balance year-to-year capital spendings.

Finally, by defining the overall responsibilities and procedures for the ASP and by documenting the current condition and asset sustainment strategy for each asset, London Hydro can determine where it needs improvement.

Asset Sustainment Plan 2012 to 2026

The Asset Sustainment Plan (ASP) is developed to optimize the life-cycle value of physical assets. As a subset of a more comprehensive Asset Management Plan, the ASP provides valuable insight and direction for maintaining safe and reliable service using the equipment, or assets, on hand at the lowest long-term cost.

Discussions in this report, regarding proposed replacement and refurbishment plans of assets are dependent on information that is dynamic in nature. For this reason, the ASP is considered a living document, and will be updated on a regular basis as new asset condition and age data becomes available, and as average asset replacement costs change.

This Asset Sustainment Plan covers only the Electric Distribution System; other major assets, such as London Hydro's vehicles and power operated major equipment, buildings and office equipment, including furniture and computer hardware and software, are covered in separate management plans.

London Hydro's Distribution System:

London Hydro services all customers within the City of London's boundary. It also services the City's water pumping plant located immediately north of the municipal boundary. Electricity is supplied by six high voltage transformer stations located throughout the City. These stations are owned and operated by Hydro One. The distribution circuits emanating from these stations operate at a variety of voltages, the most predominant being 27.6kV and 13.8kV. The system also has 39 substations which step down voltage from 27,600 or 13,800 to 8,320 or 4,160 volts. In addition, the system has 3 substations with 27.6kV to 13.8kV transformation, and three switching stations that consist of only 13.8kV switch gear.

The distribution network includes 52 Feeders at 27.6kVs, plus additional feeders at 13.8kV, 8.32kV, and 4.16kV. There are approximately 15,000 pole and padmounted step-down transformers. London Hydro owns approximately 29,000 poles and shares space on another 3000 poles owned by Bell Canada and Hydro One Networks. In total, London Hydro has approximately 2,600 km of primary conductor.

Most of the core area of the city is fed by an extensive underground system consisting of approximately 300 maintenance holes (of a total of 1,099 maintenance holes in London Hydro's service territory), concrete encased duct structure and, for the most part, 15kV paper insulated lead covered power cable. Within the core area, there is also a separate low voltage network grid distribution system consisting of 78 transformers housed in 59 vaults under the sidewalks of city streets. The high voltage sides of the transformers are fed at 13.8kV and the low voltage sides are interconnected through more than twenty kilometres of 120/208 volt cables in a grid pattern providing a reliable network supply to core area residential and commercial customers. Recently, London Hydro has completed a multi-year project to provide an alternative supply option to the core though the construction of a 27.6 kV ring bus system. This state of the art system provides enhanced operating flexibility and ensures continuity of supply to the businesses and residents in the city's core in the event of a failure of Hydro One's Nelson transformer station - this 115 kV station was constructed in 1949 and is the only source of 13.8 kV in the city.

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1 - Overhead

Introduction

At the end of 2010, London Hydro had approximately 1,330 km of primary overhead circuits. For the purpose of this ASP, discussion on overhead circuits includes poles, crossarms, insulators, transformers, overhead switches, conductors, wooden pins and hardware, which are all covered separately in the following discussion.

Both London Hydro and Bell Canada own poles throughout the city and share the use of these poles for their equipment. London Hydro inspects Bell poles during regular pole inspections and notifies Bell of any Bell poles that need immediate replacement. Bell then supplies or reimburses London Hydro for the cost of the pole and London Hydro performs the pole replacement. Most Bell owned poles are used in rear yard construction. Bell and London Hydro use each other's poles as a matter of course and pay each other a joint use fee for doing so. Throughout this report, any discussion about the number of poles, age of poles or pole testing results refers only to poles owned by London Hydro. References to overhead circuits include all circuits whether they are on London Hydro or Bell owned poles.

1.1 Poles

1.1.1 Age and Life Expectancy

London Hydro has 29,384 poles, approximately 98% of which are made of wood. London Hydro presently purchases fully treated, chromated copper arsenate cedar poles that are commonly used in Ontario due to their natural resistance to decay.

Typically, poles can last from 40 – 60 years. More precisely, historical recommendations from pole testing results indicate that poles on London Hydro's system have an average useful life of 50 years. There are several factors that affect the structural integrity and hence the average life of wooden poles;

dynamics such as the species of wood, the type of wood preservative used, the surrounding environment (ground moisture, insects etc.) and external mechanical damage can all affect the life span of a pole. Although London Hydro uses an average of 50 years as a basis for asset sustainment and capital planning purposes, the actual life expectancy can vary widely. Some wood poles reach their end of life after only 35 years, whereas others are still structurally sound after 70 years of service. The condition of a pole is more important than its age when evaluating remaining life.

Age data is available on approximately 90% of the poles on the system. The data is of varying quality due to the following factors:

1. When data was first entered into the original CableCad GIS system, it appears that round number dates were entered wherever the age could be estimated. It is not clear what criterion was used, but there are now large groups of poles with installation dates of 1950, 1960, 1970, 1980 and 1990. For the purpose of this ASP, London Hydro took the round number dates of 1950, 1960, 1970, etc., and distributed those poles across their appropriate decade using weighed distribution.
2. There are still some 3,000 poles in the GIS system that do not have a recorded installation date. London Hydro has assumed that these poles are likely older, rather than newer, and so for the purpose of this ASP, London Hydro has distributed them across the years 1940 to 1990 in the same proportion as existing data.

London Hydro has also visited poles to take photographs and to determine pole age data. If the age of the pole could not be captured from pole tags or estimated based on nearby infrastructure of similar physical condition, the age was left unknown.

Furthermore, since 1998 London Hydro has engaged experienced pole testing companies to visit older poles on the system to perform a visual inspection and to test the poles for rot. In most cases, the contractor performing the inspection recorded any information available on a date tag or provided an estimated pole installation date based on the contractor's knowledge and experience. Wherever this information is available, it is used to override the dates described in 1 or 2 above. Approximately 12,500 poles fit into this category.

This exercise was necessary to be able to estimate how many poles will reach their end of life over the course of this plan.

London Hydro is currently working to improve this data by enhancing the tools available in GIS to permit staff in the field to enter data into the GIS system from handheld tablet computers while performing their OEB audits. This enhancement will allow detailed information on condition, date tag or estimated age, type of attachments (crossarms, wood pins, guys, etc.) to be captured on every single pole in the system. Over the next 2 or 3 years it is expected that the data will improve significantly.

London Hydro has started developing and enhancing the existing GIS system for use as the central repository for all data related to assets including detailed make and model information, date of installation, as well as inspection, condition, maintenance, failure and replacement history. Moving forward, these additional attributes will also help keep detailed records of new poles when they are installed on the system.

In the meantime, based on the available data and the estimated distribution of unknown and round number dates described above, Figure 1-1 shows the best installation dates for all the poles on the system. London Hydro does not use age as the only criterion for determining replacement; instead these numbers give us a sense of how many poles will likely need to be replaced in the near future.

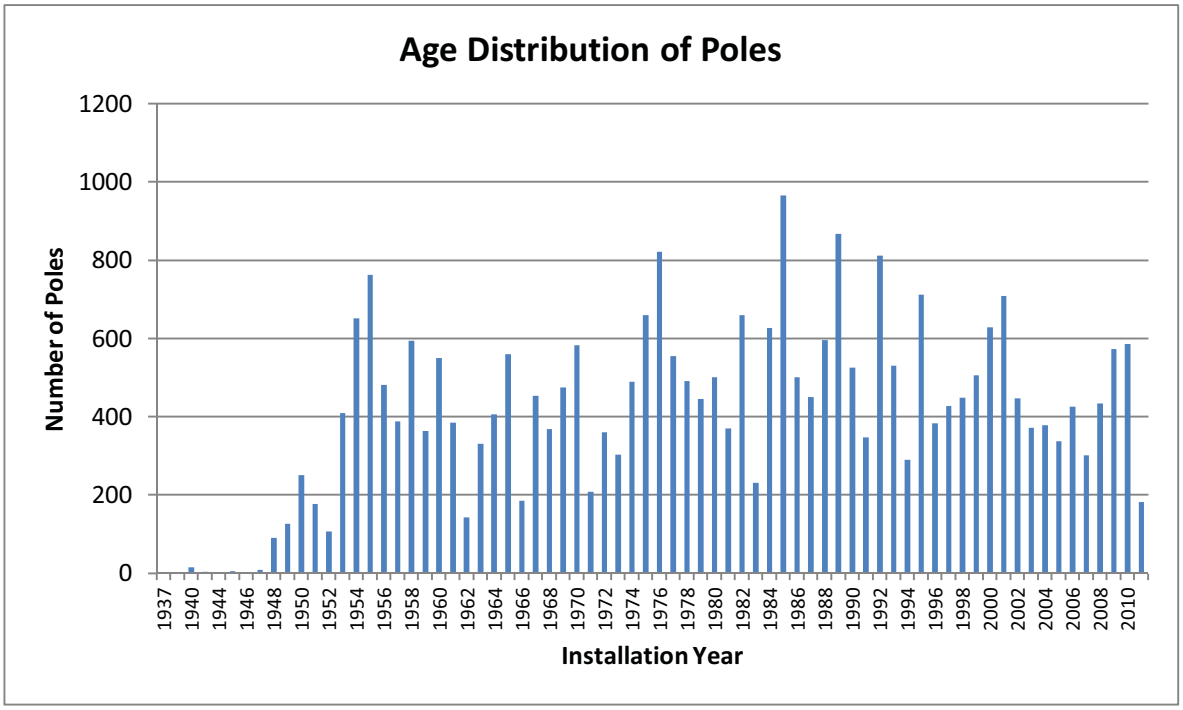


Figure 1-1 - Age Distribution of Poles

Based on the information available, the data suggests that approximately 10,500 poles, or 36% of the total population, will reach 50 years of age over the next 15 years- that is, if no poles are replaced over this planning horizon.

1.1.2 Condition

In 1998 London Hydro engaged Acres International to assist in conducting an extensive infrastructure audit. The audit classified all overhead circuits on London Hydro's system as being in good, fair or poor condition, where good, fair and poor were defined as follows:

Good - The equipment is less than 15 years old, is free from any serious deficiencies and is expected to have a useful remaining life of 25 years or more.

Fair - The equipment is between 15 and 35 years old, has limited deficiencies and is expected to have a remaining life of 10 to 25 years.

Poor - The equipment is over 35 years old, has serious deficiencies that adversely affect safety or reliability and has a useful life of less than 10 years.

London Hydro has continued to assess the condition of poles via pole testing programs since its first engagement with Acres International to assess the condition of poles and overhead plant. Pole testing is only conducted on poles that are classified as being in potentially fair or poor condition. A pole that has been in service for 20 to 35 years is considered in fair condition, until tested to determine otherwise. Likewise, a pole that has been in service for over 35 years is considered to be in poor condition, until tested. Poles that are less than 20 years old are not pole tested; however, these poles are still visited during the OEB overhead audit every three years for possible pre-mature wear.

Given that the pole testing program has now tested all poles that were considered to be in 'Poor' or 'Fair' condition in 1998 (see section 1.1.3), it is unlikely that there is a significant number of dangerously weak poles on the system.

Poles that were in 'Good' condition in 1998 might have migrated to 'Fair' or 'Poor' condition in the intervening years. For this reason, the ongoing testing of poles should continue to ensure that as poles age they do not pose a safety hazard.

Although the above 1998 audit information is useful, it is not as reliable as the actual results of pole testing. Table 1-1 summarizes the condition of the 8,500 poles inspected between the years 2007-2010.

Table 1-1 - Condition Assessment from 2007-2010 Pole testing

Scale	Condition	% of total pole test population
Replace in 0-2 years	Major Deterioration	5 %
Re-inspect in 2-4 years	Moderate Deterioration	5 %
Re-Inspect in 4-5 years	Minor Deterioration	3 %
Re-Inspect in 10 years	Good Condition	87 %

The 1998 audit provided an excellent way to select and rank poles to be tested, but now the actual test results represent much more accurate information on the actual condition of the poles.

Based on pole age data approximately 33% of poles are now likely over 35 years old and 17% of London Hydro's poles are presently over 50 years old. However, the number of poles over 50 years of age will increase by two fold over the 15 year planning horizon of this plan, and the percentage of poles over 50 years of age is estimated to rise to 36% unless replacements keep up with pole demographics.

In addition to continuing with the pole testing program, the plan to give field staff all the existing information on a handheld computer as they perform their audits will allow us to update this information for every pole on the system. Trying to do this with paper records is unmanageable so when audits are currently conducted, the only information that is recorded is when there is a problem that needs repair. Once the field auditing tools are in place, visual inspection once every three years as part of the OEB audit will then complement the pole testing data.

Grey Munsell Poles

In 2003 a number of Grey Munsell poles failed during a windstorm, revealing that most of these poles were rotting prematurely. These poles were purchased with a grey cementitious coating for aesthetic reasons, but the coating inadvertently trapped moisture inside the poles. A proactive program was introduced to replace all the Grey Munsell poles on the system. Of the 182 poles that were found to be in service, all of the poles have now been replaced with the exception of a small number of poles that will be removed as part of a future road widening project. They will remain in service until 2015 but have been guyed to ensure safety.

1.1.3 Inspection Plan

Regular inspection of wood poles can identify rotting poles that require replacement. Although wood pole testing can never be 100% accurate, the physical inspection and testing of poles can help to eliminate weak poles from the system.

Each year London Hydro tests approximately 10% of the poles on the system, and those that are identified as needing immediate replacement are scheduled for replacement within twelve months. Poles that are still safe but show reduced strength are scheduled for retesting within five years. Since the 1998 Audit, all of the poles in the sections of line that were identified as being in either poor or fair condition have been tested. London Hydro's pole testing program tests poles that are at minimum 20 years old. To address all the poles that continue to fall in the 20+ age category, London Hydro will need to continue testing about 3,000 poles a year for approximately 5 years.

It is important for the testing program to continue each year to ensure that all of London Hydro's older poles get tested on a regular basis. The contractors engaged to perform the tests are experienced in estimating pole installation dates, and they provide year of installation estimates and species along with pole test data. They also do a visual inspection of the attached hardware during the inspection and report any issues.

In addition to the testing program, the OEB requires London Hydro to inspect all of its overhead circuits at least once every three years. Any serious deficiencies found are fixed immediately, and the information collected on the general condition of the circuits is used to help develop London Hydro's overhead line replacement program. Below is the Inspection Checklist, which shows the type of data collected during the inspection.

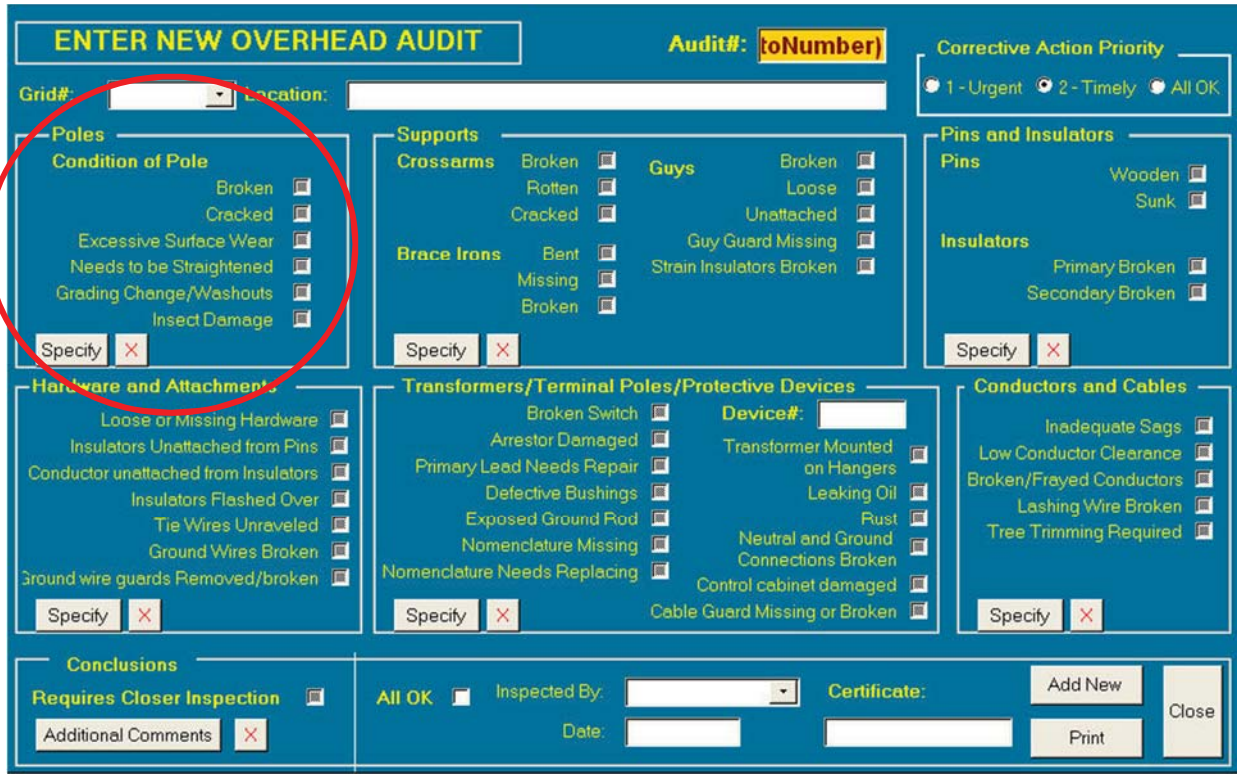


Figure 1-2 - Inspection Checklist – Overhead (Poles)

1.1.4 Risk Assessment

Poles that have begun to rot can pose a safety hazard to employees who are required to climb them. They can also affect system reliability during storms and can pose a hazard to the public if they fail.

Although 17% of London Hydro's overhead circuits are estimated to be over 50 years old, all of the poles in older line sections have been tested and any poles that were found to pose an immediate hazard have been replaced; approximately 2% of the poles tested each year are replaced as a result of the pole testing program and recommendations.

London Hydro may wish to consider applying RCM techniques to identify poles that are critical to system reliability and safety (corner poles with multiple circuits, for example) and perhaps test those poles more frequently. In the next two years London Hydro has dedicated staff to visit each pole on the system to collect the necessary data to be able to conduct RCM to further prioritize pole replacements schedules.

1.1.5 Asset Sustainment Plan

Although there are maintenance techniques available to extend the life of poles (e.g. ground line truss systems and wraps), London Hydro does not currently use these techniques; depreciated poles are simply replaced. London Hydro continuously monitors the marketplace for alternative products and has installed some steel and fibreglass composite poles on a pilot basis.

London Hydro's depreciated poles are replaced on a pole-for-pole basis in which the existing hardware is simply transferred to the new pole or by rebuilding an entire pole line consisting of multiple poles where all hardware, including conductors and transformers, are replaced.

The replacement of poles on a pole-for-pole basis depends on the yearly testing and inspection program results. Historically, London Hydro has replaced anywhere from 30-40 poles per year as part of this replacement program.

The majority of London Hydro's depreciated get be replaced as part of multi pole rebuild capital programs where all overhead attachments and conductors are replaced with the pole structures. The overall plan for replacing depreciated pole lines is covered in section 1.8 (Fully Depreciated Overhead Lines - Sustainment Plan).

1.2 Crossarms

1.2.1 Age and Life Expectancy

For thirty years or more, London Hydro's standard designs have used armless construction; however, a number of older overhead circuits that use wooden crossarms are still in service. Whenever crossarms are needed for new construction for dead-ends, taps, etc., steel crossarms are used; however, London Hydro has experimented with composite crossarms for a few projects. Records are not available that show the number of crossarms in use or their age, but it can be assumed that any wooden crossarms on the system are 35 years old or older.

1.2.2 Condition

London Hydro inspects all of its crossarms once every three years as part of the mandatory OEB audit. Although London Hydro does not know how many crossarms and, in particular, older wooden crossarms are on the system, it is known how many problems have been found over the past three years: 44 crossarms were found to be rotten, one was broken, 20 were cracked, the brace irons were bent on one and were missing on another. From these results it can be concluded that, from a visual standpoint, London Hydro's crossarms are generally not in the best condition, and since all wooden crossarms are over 35 years old, their structural integrity cannot be guaranteed.

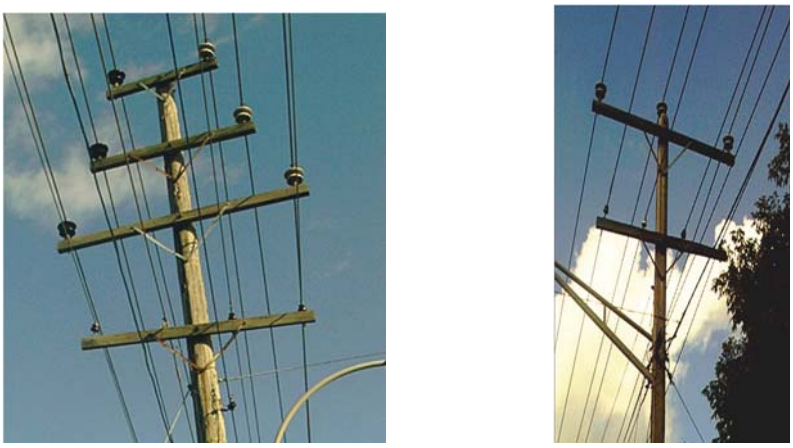


Figure 1-3 - Christmas Tree Framing Construction (Left), and Wood Crossam Construction (Right)

In 2001, London Hydro introduced a pole fire mitigation program to address reliability problems associated with pole fires. The program was a response to the finding that 27.6 kV overhead circuits with wooden crossarms and particularly those with Christmas tree framing construction were susceptible to pole fires.

London Hydro has been aggressively replacing 27.6 kV structures that have wooden crossarms, and all those with Christmas tree framing have now been replaced[1]. Approximately 50 poles have been replaced under the pole fire mitigation program in 2011. As of the end of 2011, 197 poles with wooden crossarms and 27.6 kV circuits remain and still need to be replaced.

All wooden crossarms on the system are over 35 years old and would have been identified as being in poor condition in the 1998 Audit. However, any poles with 27.6 kV circuits on wooden crossarms that have been tested and found to be in poor condition have already been replaced. Therefore, the remaining 197 poles are structurally sound for now but eventually need to be replaced to address the wooden crossarms and aging poles.

1.2.3 Inspection Plan

London Hydro does not perform any formal testing on crossarms but does conduct a thorough visual inspection on all overhead circuits once every three years as part of the OEB mandatory audit. Below is a form showing the type of data collected on this asset during the audit. Any deficiencies found are recorded in an MS Access database. Equipment found to require 'urgent' attention is slated for immediate replacement/repair.

1 "Mitigating Pole Fires on London Hydro's Distribution System" (Updated: Oct. 2009)

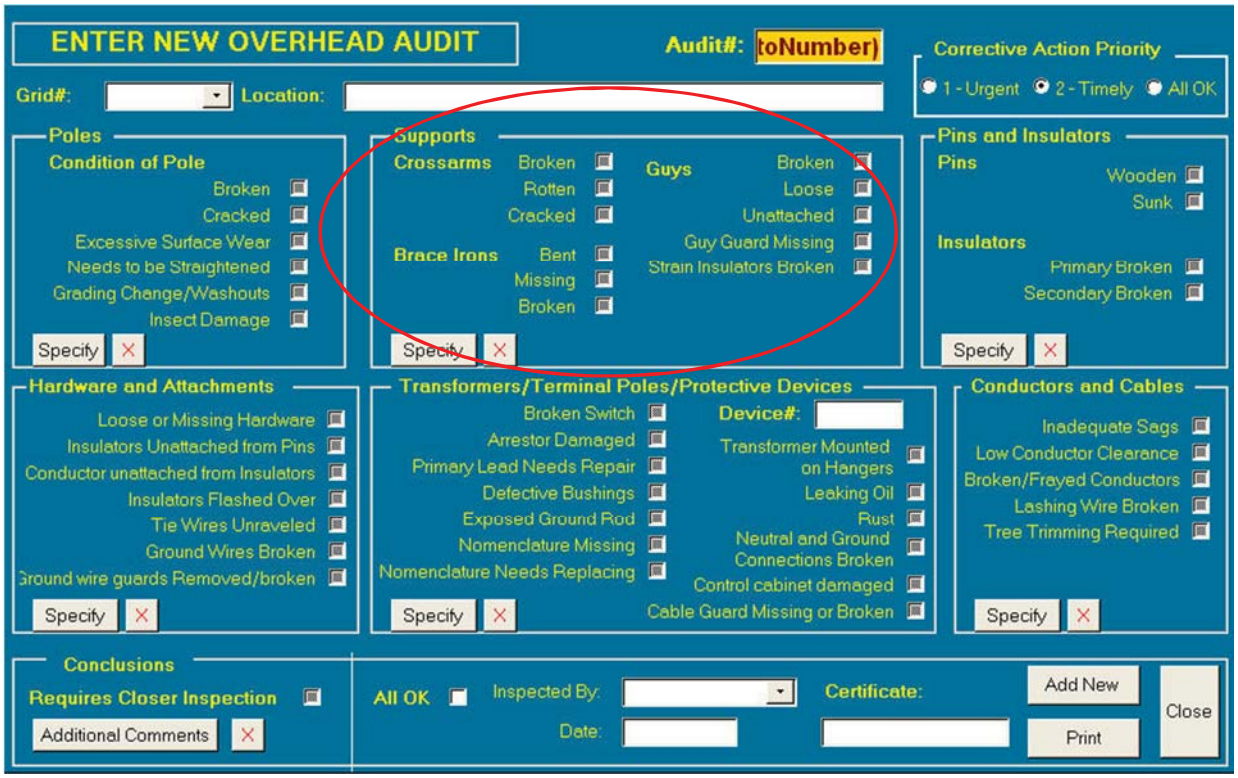


Figure 1-4 - Inspection Checklist – Overhead (Crossarms)

1.2.4 Risk Assessment

From 1999 to 2001 pole fires caused almost 40,000 customer-hours of interruption. The pole fires in 2001 alone accounted for 15% of London Hydro's SAIDI outage statistics. A severe pole fire can also cause the top of a pole or crossarms and their associated conductors to fall, causing a potentially serious safety hazard to employees and the public. As a result of these problems, London Hydro started a replacement program[2] to gradually eliminate all 27.6 kV wooden crossarms on the system. RCM techniques were used to identify which circuits would have the most detrimental effect on reliability if a pole fire occurred, and the circuits were subsequently ranked for replacement. All the structures that had multiple wooden crossarms in a Christmas tree configuration have now been replaced and only 197 poles with simple wooden crossarms and 27.6 kV circuits remain.

2 "Mitigating Pole Fires on London Hydro's Distribution System (Updated: Oct 2009)

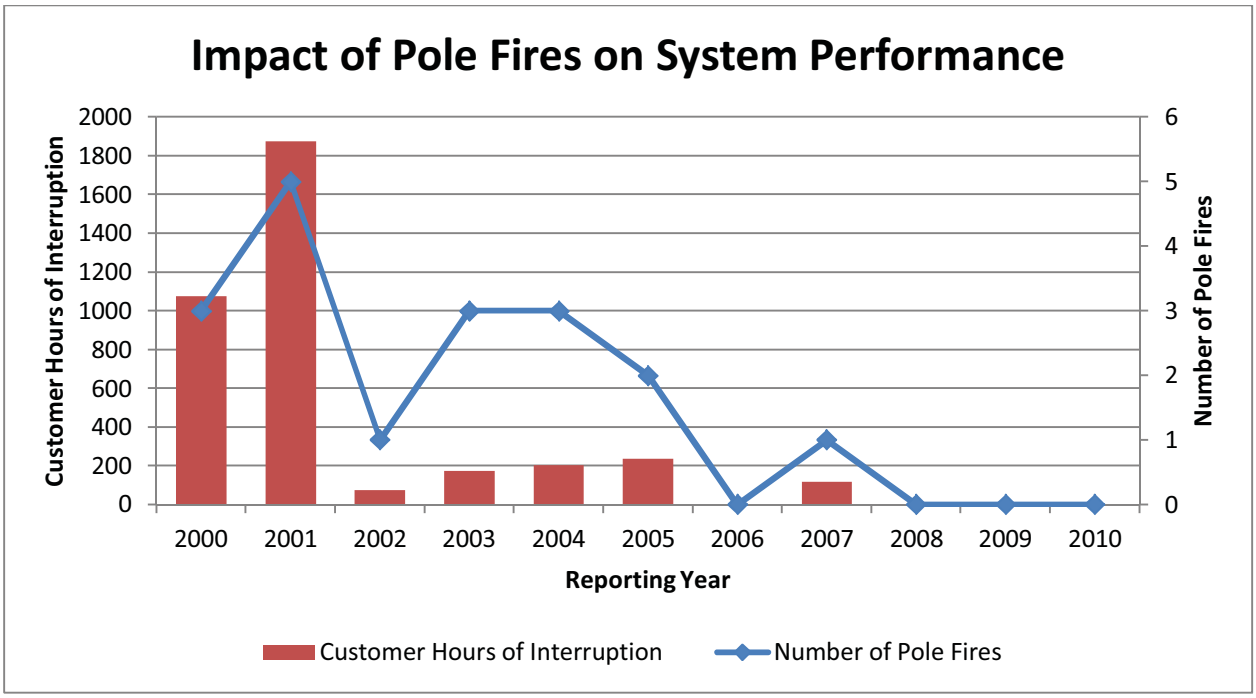


Figure 1-5- Impact of Pole Fires on System Performance

As a result of this program, the impact of pole fires has decreased significantly since 2001. There was only one pole fire in 2007, and to ensure continued good performance, the program needs to continue until all poles with wooden crossarms are eliminated.

1.2.5 Asset Sustainment Plan

A report entitled "Mitigating Pole Fires on London Hydro's Distribution System (Oct 2009)" focuses specifically on structures with wooden crossarms and on plans for their replacement under capital programs. Since 2001 London Hydro has identified the poles with wooden crossarms, and, to date, approximately 66% of those poles have been replaced.

1.3 Insulators

1.3.1 Age and Life Expectancy

Prior to the early 1980's, all of the insulators on the overhead system were made of porcelain or glass. These insulators have served the industry well, and they last virtually indefinitely as long as they are not mechanically damaged. However, they are quite heavy and costly, and since the 1980's they have been replaced with polymer-based materials.

Since they generally do not fail, it is not particularly valuable to know the number and age of porcelain insulators on the system; they are replaced whenever the pole line on which they are used is rebuilt.

While most porcelain insulators last indefinitely, two exceptions have been found with insulators manufactured by Ohio Brass and Lapp. Some of these insulators, purchased between 1976 and 1983, may fail suddenly and prematurely because of a manufacturing defect. See the following section, "1.3.2 Condition" for more details.

London Hydro has been buying much lighter and lower cost polymer insulators for approximately 25 years, and to date they have generally held up well. Polymer insulators are also more hydrophobic than porcelain, which causes water to bead up more readily and results in less electrical tracking and fewer failures. Polymer insulators are now the industry standard across North America. Since these insulators are made of a completely different material, however, it remains to be seen what their estimated life expectancy will be. For the purpose of this report, we will assume that they will last at least as long as the poles on which they are mounted and that no special program will be needed to arrange for their early replacement.

However, certain makes and models of polymer dead-end insulators have also experienced premature failure. Some have proven to be made from substandard materials that disintegrate in ultraviolet light or

were constructed poorly, which resulted in internal tracking and eventual failure. London Hydro does not have accurate records to determine how many polymer based dead-end insulators are on the system, but any that are still in service would have a limited future life span. For more details, see the following Section 1.3.2.

1.3.2 Condition

Although most porcelain and glass insulators are in excellent condition, as described above, a manufacturing defect was discovered in Ohio Brass and Lapp insulators manufactured between 1976 and 1983. Fourty-one in-service mechanical failures have occurred on London Hydro's system with these insulators over the past 10 years[3]. Some of these porcelain line post insulators have been found to contain deficiencies that lead to failure, but it isn't certain that all insulators made by Lapp and Ohio Brass during this period will fail. The quality problems are likely confined to certain batches. Therefore, these insulators have only a slightly higher probability of mechanical failure than the general population.

London Hydro has also experienced premature failure of Permali and EPAC dead-end polymer insulators[4] . It is estimated that approximately 400 Permali insulators were installed between 1975 and 1978. These insulators were constructed with inadequate UV inhibitors and many have disintegrated and failed on London Hydro's system over the years. Once they start to fail, they can also contribute to pole fires. Permali dead-end insulators are automatically replaced whenever they are found where work is taking place. It is not known how many of these are left on the system, but the last failure occurred in October 2007 and prior to that, two failures occurred in 2004. It is not likely that many are left on the system, but any that remain should be considered to be in poor condition. A two year project to audit the entire overhead system will help identify the location and quantity of these insulators.

London Hydro has experienced a different problem with EPAC dead-end insulators relating to the way the polymer skirts were glued to the internal fibreglass rod. In some cases moisture gets in and the

3 "Mitigating In-Service Mechanical Failures of Porcelain Line-Post Insulators on Aerial 16/27.6Y kV Distribution Systems (October 2009)"

4 Monthly Reliability Incident Summary Report, Oct. 2007

insulator starts to track internally. London Hydro experienced a number of failures in 2000 and 2001 and, as a result, suspended purchasing this make of insulator in 2001. It is not known how many of these are left on the system but they are always replaced if they are found in an area where work is taking place. The last failure took place in June 2007, and it is unlikely that many are left on the system; however, any that remain should be considered to be in poor condition.

1.3.3 Inspection Plan

London Hydro does not perform any formal testing on insulators but does conduct a visual inspection on all overhead circuits once every three years as part of the OEB mandatory audit. Below is a form showing the type of data collected on this asset during the audit. Any deficiencies found are recorded in an MS Access database. Equipment found to require 'urgent' attention is slated for immediate replacement/repair.

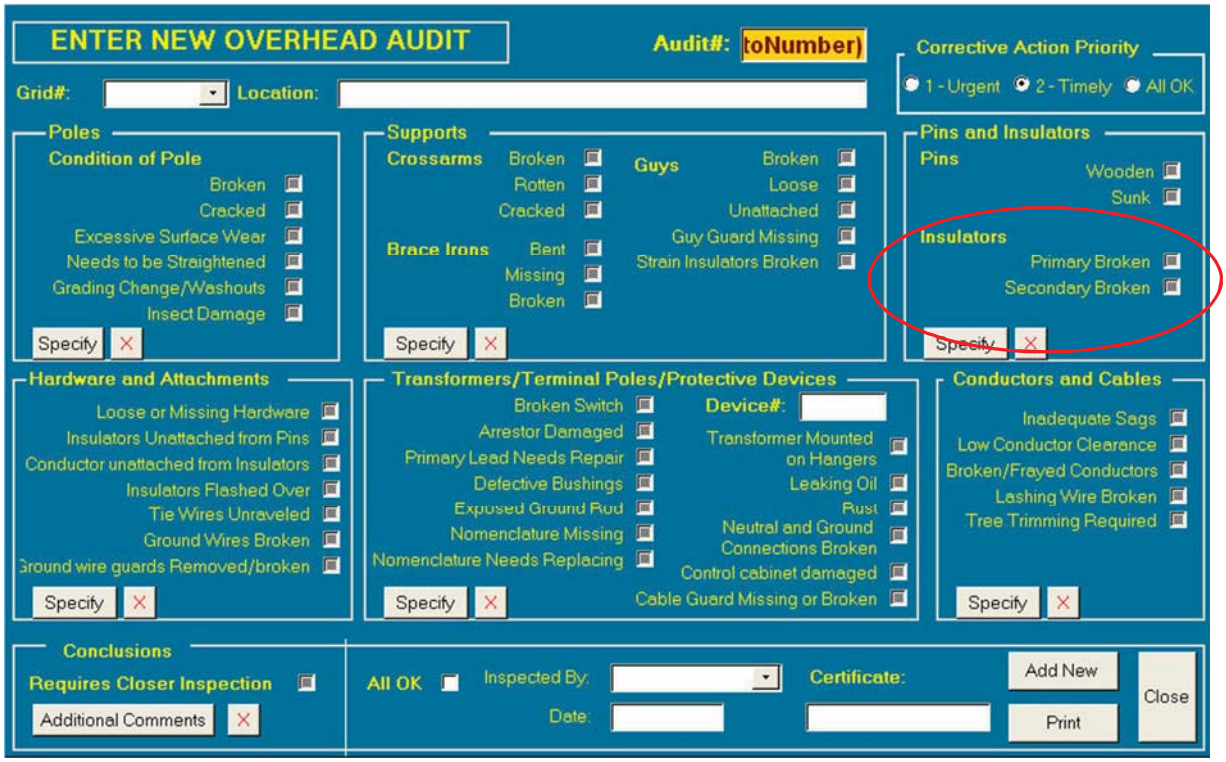


Figure 1-6 - Inspection Checklist – Overhead (Insulators)

Once it became evident that Ohio Brass and Lapp insulators could pose a safety hazard, purchasing records, the GIS system and field inspections were used to determine how many insulators on the system were prone to failure. Detailed information on the type of insulators that were installed are not currently kept in the GIS system, but the dates when certain lots of insulators were purchased were linked to dates when new poles and insulators were installed to try to estimate where the suspect insulators may have been installed. The same effort has not been used to find the Permali and EPAC insulators since it is likely that most of them have now been replaced.

The effort to track individual components and their location is time consuming so London Hydro tracks only major equipment. However, as part of the GIS enhancements project scheduled for 2011-2012, London Hydro plans to link information from individual SKUs (manufacturer, model, date of installation etc.) for all field installations through the use of Compatible Units (CUs) in the Engineering Department. As CUs are selected during the design process, the information associated with all the material within the CU will populate the GIS system automatically with very little manual effort. The ability to link CUs to the GIS system will allow future users to track the location and type of equipment down to a very detailed level.

1.3.4 Risk Assessment

When a porcelain line post insulator fails, the energized conductor it supports usually falls towards the ground. Generally, enough tension is in the line to prevent the conductor from dropping right to the ground, but it can pose a severe safety hazard to any employees who happen to be working below. If an insulator is cracked and ready to fail, the disturbance and movement caused by workers nearby can be all that is necessary to cause it to let go completely. A failed insulator can also cause the affected conductor to fall into other circuits below, resulting in outages that can affect multiple circuits. The following chart illustrates the impact broken insulators have had on London Hydro's reliability in recent years.

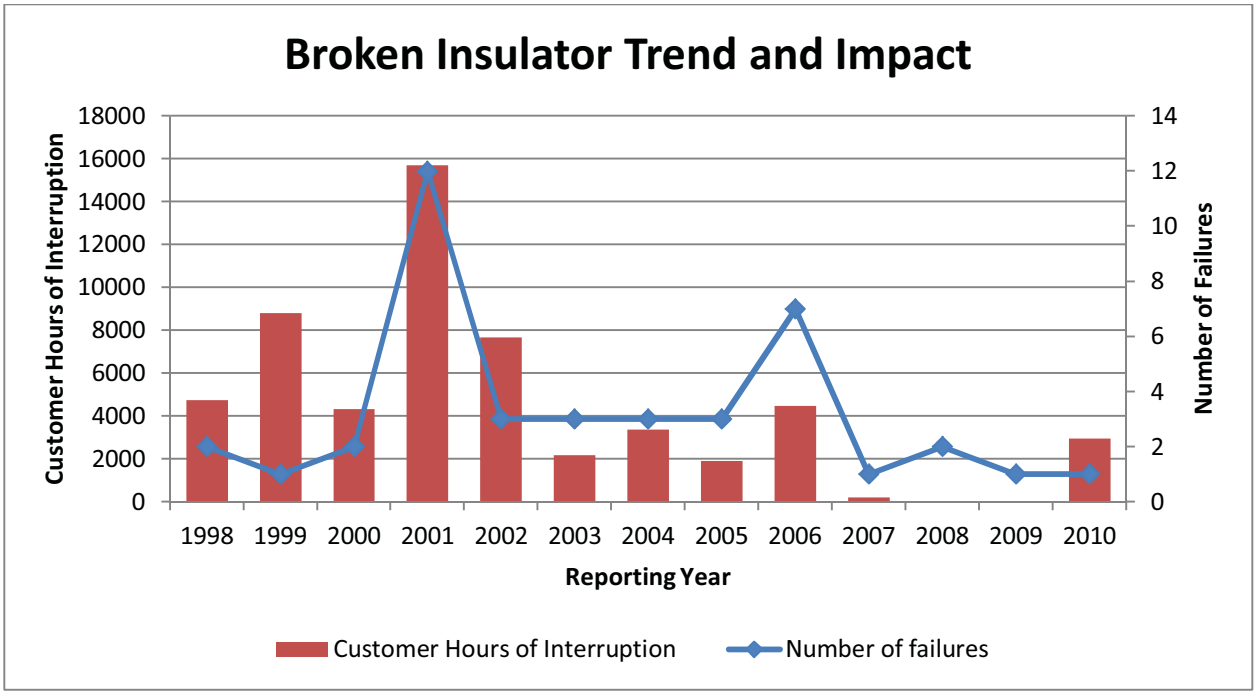


Figure 1-7 - Broken Insulator Trends and Impact on System Performance

Similarly, when a polymer, dead-end insulator disintegrates and fails, it generally causes an outage on that circuit, but since few of these are left on the system, they do not likely pose a high risk to system reliability.

1.3.5 Asset Sustainment Plan

The report entitled "Mitigating In-Service Mechanical Failures of Porcelain Line-Post Insulators on Aerial 16/27.6Y kV Distribution Systems (Oct 2009)" addresses problems that arose with certain porcelain insulators and outlines the progress of their replacement.

In 2001 London Hydro identified the problems with porcelain line-post insulators and established a replacement program. Replacement of grey insulators was given priority due to their higher failure rate.

However, in recent years, the failure of brown insulators has increased and their replacement was given priority in 2007.

London Hydro identified 5,650 Ohio Brass and Lapp porcelain post insulators on its system that were likely manufactured between 1976 and 1983. Of these, 5,600 have been changed out in replacement programs from 2002-2010. The program has been successful as evidenced by the reduction in outages as shown in Figure 1-7, "Broken Insulator Trends and Impact."

Once the location of the insulators was identified, RCM techniques were used to rank the projects for replacement using the following criteria:

- Express feeders without automated switches, ranked according to the number of connected customers.
- Express feeders between a feeder circuit breaker and the first automated switch, ranked according to the number of connected customers.
- Express feeders' sections where insulators have failed.
- Insulators installed on other backbone sections.
- Insulators installed on fused laterals.

Since 2002 London Hydro has spent over $2 million replacing 99% of the areas where these insulators were known to be in use. A recent failure of a LAPP insulator, outside of the known areas where insulators were used, makes it apparent that there may still be some unknown pockets where these insulators are still in service.

London Hydro has not established a proactive program for replacing Permali and EPAC polymer dead-end insulators, but crews have a standing instruction that whenever they perform work on a pole on which these insulators are installed, they are replaced automatically. A program started in mid-2011 to visit all 29,384 poles in the city to conduct a thorough inspection and to document all locations where suspect insulators are present. This will be part of a very comprehensive and lengthy audit, but it will provide valuable and detailed information on London Hydro's overhead system. If more of these insulators are found another program will be developed to replace them.

1.4 Transformers

1.4.1 Age and Life Expectancy

In 2011, London Hydro's overhead distribution system had 8,005 overhead transformers. Although older transformers have been known to last up to 60 years or more, it is expected that distribution transformers built since the 1960s have an average life expectancy of 40 to 50 years. For the purpose of this report, a useful life span of 50 years is used. London Hydro has name-plate data on its transformers, and the following chart shows the age distribution of the overhead pole-mounted transformers on the system.

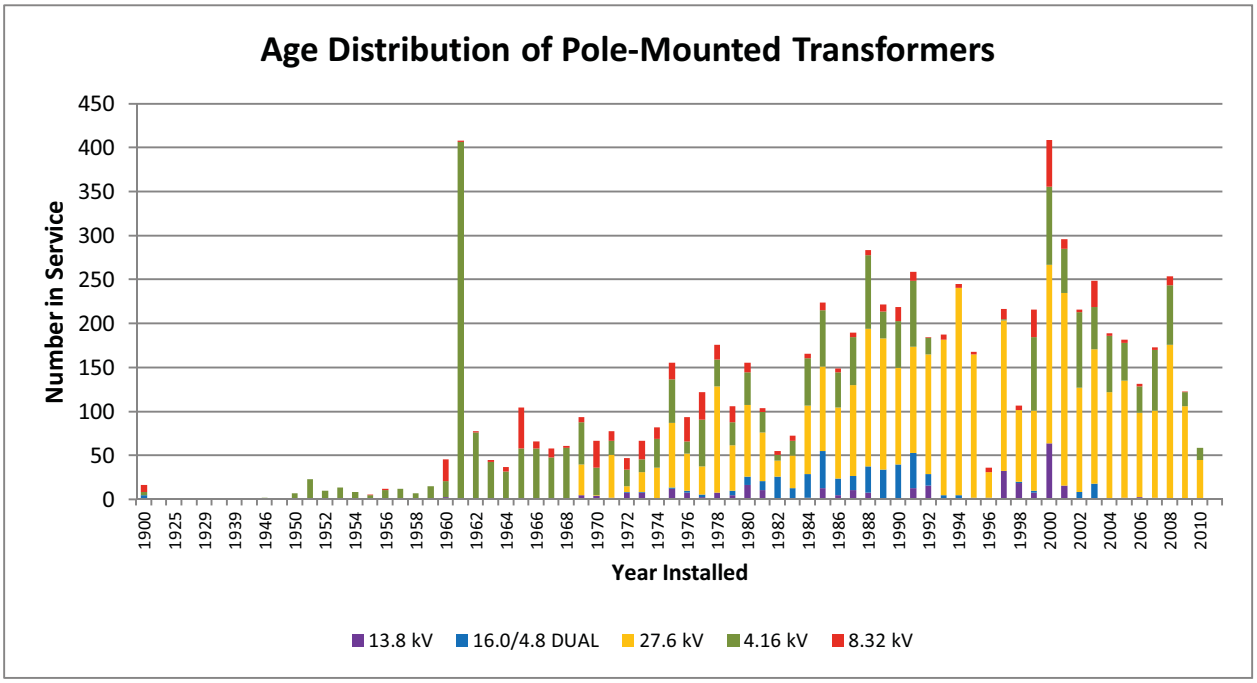


Figure 1-8 - Age Distribution of Pole-Mounted Transformers

Note: The large population of transformers in 1961 represents transformers inherited from Ontario Hydro during the City of London Annexation in 1961. At that time the age of the transformers was unknown and they were all assigned a 1961 installation date. All of these transformers are certainly older than 50 years in age.

1.4.2 Condition

London Hydro inspects all of its pole-mounted transformers once every three years as part of a mandatory OEB audit. Of the 8,005 pole-top transformers on the system, 41 problems have been found over the past three years related mostly to damaged arresters and broken neutral and ground connections. London Hydro also experienced 28 overhead transformer failures in 2010, representing only 3% of the population. Based on these findings, it can be concluded that London Hydro's overhead transformers are generally in good to excellent condition.

1.4.3 Inspection Plan

London Hydro does not perform any formal testing on transformers but does conduct a thorough visual inspection on all overhead circuits once every three years as part of the OEB audit. Below is a form showing the type of data collected on this asset during the audit. Any deficiencies found are recorded in an MS Access database. Equipment found to require 'urgent' attention is slated for immediate replacement/repair.

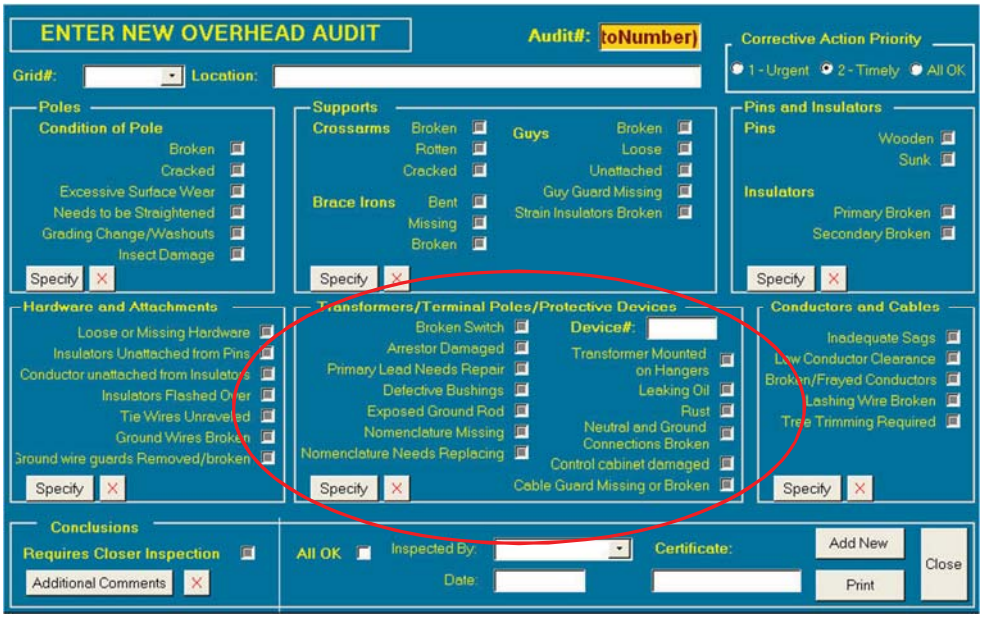


Figure 1-9 - Inspection Checklist – Overhead (Transformers)

1.4.4 Risk Assessment

Transformers can pose a risk to reliability if they fail and if they fail catastrophically, they can pose a safety risk to the public. Transformer fuses are designed to prevent catastrophic failure; however, they cannot always prevent overloaded transformers from boiling over, and spreading hot oil into the environment. Across North America, approximately 10% of all transformers have also been found to be inadvertently contaminated with PCBs above 50 ppm. To reduce the risks associated with PCB fluids, London Hydro has tested all of the transformers on its system and any found to be above 50 ppm have been retrofilled so that no PCB contaminated transformers are left on the system.

In addition, in the late 1990s, London Hydro used its GIS system and customer billing information to estimate the load on all its distribution transformers. Any transformers that were found to be severely overloaded were replaced to reduce the risks associated with overloads. With respect to system reliability, each pole top transformer feeds only a limited number of customers so the risk to system reliability of individual transformer failures is very low.

1.4.5 Asset Sustainment Plan

London Hydro does not proactively replace individual pole-mounted transformers; rather lets them run to failure or replaces them as part of a pole line rebuild. In general, the condition of the poles or the need for new capacity drives the replacement of a pole line, not the condition of the overhead transformers.

Nevertheless, it is useful to see that, based on a life expectancy of 50 years, it can be expected that 1,731 transformers will need to be replaced over the next 15 years. This amount represents 21% of all pole-mounted transformers in service. It has been estimated that the proposed rate of pole replacement plans, discussed Section 1.8, will involve the replacement of a sufficient number of pole mounted transformer to ensure their timely replacement.

1.5 Overhead Switches

1.5.1 Age and Life Expectancy

London Hydro has 240 manually operated 27.6 kV loadbreak switches, 75 automated 27.6 kV switches, 63 automated 27.6 kV reclosers, and six 8 kV reclosers on its overhead system. There are also five gang-operated air break (non-loadbreak) switches left on the 27.6 kV system that are gradually being replaced. The manual loadbreak switches have been in use for decades and are likely 50 years old or older.

The average life expectancy of a manually operated loadbreak or airbreak switch is approximately 50 years. For loadbreak switches, failure of the arc snuffers can lead to flashovers and insulator damage. Age and corrosion can cause deterioration of the linkages and alignment and this too can lead to switch failure during operation.

All of London Hydro's automated switches and reclosers on the 27.6 kV system use vacuum switches for breaking load and are relatively new with the oldest switches being installed in the early 1990s. Although a few have failed in service, there is not enough operating history to be able to predict accurately future failure modes or life expectancy. However, London Hydro is aware that the batteries used with automated switches have a life expectancy of approximately 7 years.

1.5.2 Condition

It is not easy to determine the condition of a loadbreak or automated switch simply by visual inspection. Switches normally fail while they are being operated, and, on average, London Hydro has experienced one to two failures a year over the past few years. Although some loadbreak and airbreak switches are likely over 50 years of age, it is believed that the general condition of this asset class is quite good.

1.5.3 Inspection Plan

Overhead switches are included in the inspection of overhead circuits that occurs once every 3 years as part of the OEB audit, but, as stated above, apart from minor problems such as missing padlocks or ground connections, not much can be determined by visual inspection.

1.5.4 Risk Assessment

Since many of these switches are used on 27.6 kV main feeders, their failure can lead to loss of power to a significant number of customers; however, because there has only been one or two switch failures a year, this group of assets has not had a significant impact on London Hydro's system reliability.

1.5.5 Asset Sustainment Plan

After some loadbreak switches failed in the early 1990s, London Hydro started a maintenance program to operate and clean all manual loadbreak switches on a five-year cycle. This program was discontinued in 2004 because the cost could not be justified based on the low number of failures. If the number of failures increases in the future, London Hydro will resume the maintenance program. The current strategy is to run the switches to failure or replace them as part of a pole line rebuild.

Given the relative newness of London Hydro's automated switches and 27.6 kV overhead reclosers, there is no need to consider their replacement within the planning horizon of this report. Since they are very costly, however, future asset sustainment plans will need to consider refurbishment / replacement strategies as they begin to age. In the meantime, London Hydro does replace batteries on all automated switches at least once every five years.

Although in-line switches are not a significant enough asset to justify a separate ASP, London Hydro had a serious incident involving the failure of a Firon in-line switch in 2007. One of these switches came apart causing one conductor to fall to the ground and a second to wrap around another circuit on the same pole. This posed a significant safety hazard to the public and resulted in the loss of power to three 27.6 kV feeders (two feeders were tied together at the time to accommodate construction). This single incident contributed 7% to London Hydro's SAIDI for the year.

In response to this incident, London Hydro developed an ad hoc plan to manage this asset. London Hydro worked with the manufacturer to identify the failure mechanism and then identified all the Firon switches in the system that could experience the same type of failure. All Firon switches with the same potential problem were replaced as necessary.

1.6 Conductors

1.6.1 Age and Life Expectancy

Although London Hydro has records in its GIS system to determine how many kilometres of different types of overhead conductor it has in its system (556 Al, 1/0 Al, Hendrix, etc.), this information would not add much value for the purpose of this report. Instead, the age, condition and sustainment plans to replace aging conductors are considered together with the general discussion on poles in section 1.1.

The majority of the conductors on the system pose no risks or challenges and are either reused by transferring them from old poles to new poles or are replaced. However, London Hydro has 31 km of 2.4 kV # 6 solid copper conductor circuits on its system[5] and due to problems with this conductor (discussed below in section 1.6.2), all this wire can be considered to be at end of life. London Hydro's system also has some pockets of 4 kV bundled primary conductors that consist of three phases of insulated line wire triplexed together. These bundled primary conductors can be considered to be at the end of their life.

1.6.2 Condition

Most conductors can be considered to be in good condition with the exception of 2.4 kV #6 solid copper conductors. This type of conductor has become brittle with age and is subject to break from fatigue, which can cause the conductor to fall to the ground when contacted by branches or during windstorms. All #6 solid copper conductors can be considered to be in poor condition.

The insulation on bundled primary conductors is prone to failure after being in service over 30 years. Although the records on the location of all the bundled primary conductors are incomplete, they are likely in poor condition and can be considered to be at end of life.

5 From GIS query run June 2011.

1.6.3 Inspection Plan

London Hydro does not perform any formal testing on conductors but does conduct a visual inspection on all overhead circuits once every three years as part of the OEB mandatory audit. Although it is difficult to assess the structural integrity of an overhead conductor from the ground, such inspections have found the occasional damage from arc flashes or fraying. Below is a form showing the type of data collected on this asset during the audit. Any deficiencies found are recorded in an MS Access database. Equipment found to require 'urgent' attention is slated for immediate replacement/repair.

As part of this inspection, London Hydro performs an infrared survey on the overhead system to find "hot spots." Hot spots are associated with overheating that could be the result of component overloading or failure or, more often, electrical resistance due to a poor connection at a contact mating surface. Every year an infrared survey is completed on all overhead lines in the areas scheduled for OEB inspection. Any problems found are fixed immediately.

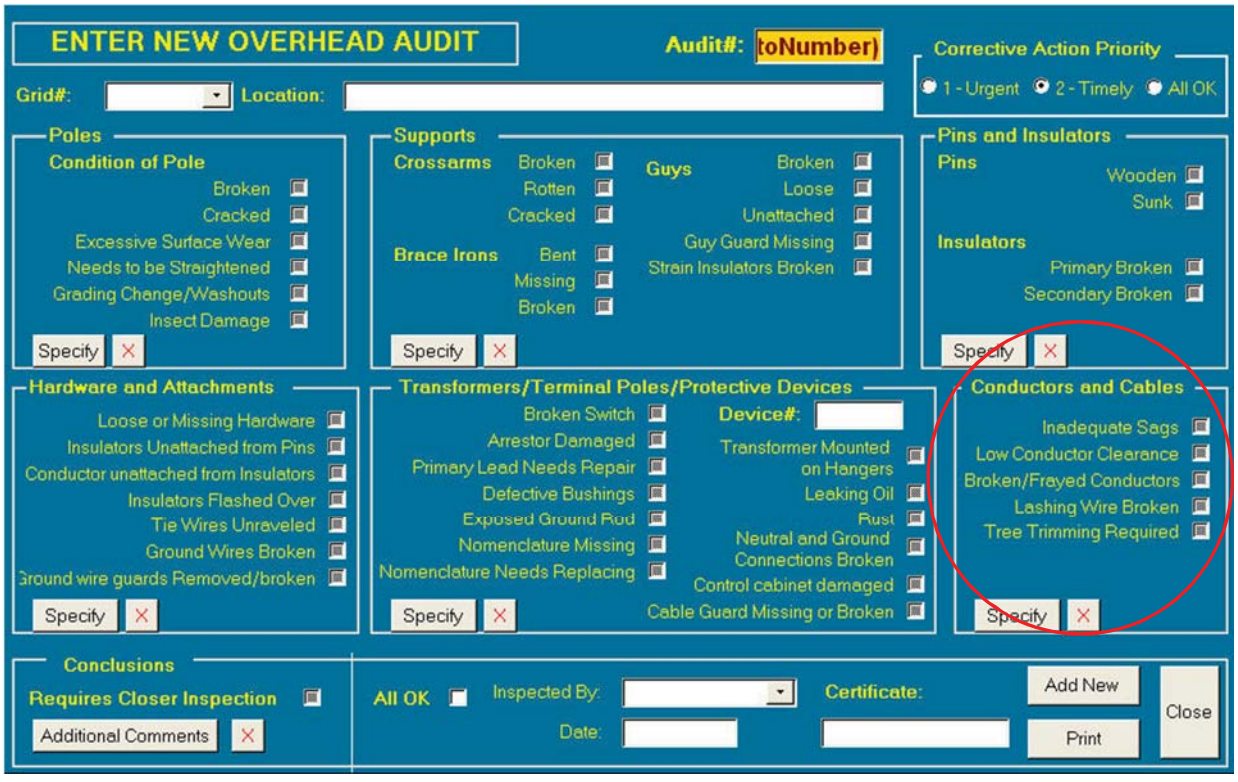


Figure 1-10 - Inspection Checklist – Overhead (Conductors)

1.6.4 Risk Assessment

Conductors generally pose little risk with the exception of the 2.4 kV # 6 solid copper conductors, discussed above. This conductor is used in older areas of the city and has been known to break when stressed by wind or tree branches or when handled. Broken conductors can pose a significant safety risk because they can fall to the ground or fall on top of workers on the pole.

The main risk posed by bundled primary conductor is also the risk that it too may fall to the ground during failure. The close proximity of the triplexed conductors could theoretically cause a phase to phase fault from deteriorated insulation to escalate into a three phase fault resulting in the entire span burning down. This has not yet happened that London Hydro is aware of, but it is an area that should be monitored.

A special category of risk has become prevalent in recent years relating to the theft of copper ground conductors. London Hydro has discovered the loss of down grounds on poles in certain areas of the city. If enough grounds are removed from the system, elevated neutral potentials and unsafe touch and step potentials during system faults can result. Whenever missing grounds are discovered, London Hydro places a priority on replacing them as soon as possible. Once every three years the entire system is inspected as part of the OEB audit and staff are trained to look for missing grounds.

1.6.5 Asset Sustainment Plan

Most conductors are replaced when pole lines are rebuilt, and so conductors do not need a separate replacement plan. However, all of the 2.4 kV #6 solid copper conductors need to be proactively replaced regardless of the condition of the supporting poles. London Hydro has replaced some of the #6 solid copper conductors in Old South in 2009, but it represents less than 10% of this type of conductor on the system. It is estimated that 18 km (60%) of existing # 6 copper will be replaced as part of the 10 year

plan to replace aging 4 kV infrastructure. Further plans need to be developed to address the remaining 40% of existing # 6 copper as soon as possible before an unsafe failure is experienced.

Currently there are no plans in place to identify or replace the 4 kV bundled primary on the system, but as it ages and more failures start to occur, a replacement plan will need to be developed. In many cases bundled primary was used as a way to avoid the difficult framing required to accommodate the space requirements of bare primaries. Replacing the bundled primary could, therefore, require pole replacement and reframing as well as stringing of conductor.

London Hydro still has open wire secondary circuits in a number of areas in the city. This legacy construction cannot easily accommodate increasing loads as customers upgrade their services. In most cases, the weatherproofing that was originally coating the wires has also fallen off and the conductors are bare. These circuits are difficult to work with due to the lack of space between conductors. Short circuits caused by branches, animals and downed energized conductors are also common. Although London Hydro does not have a specific program for replacing open wire secondaries, their presence is factored into the planning when areas are considered for rebuild.

As part of the efforts to manage reliability, London Hydro has a reliability-centred tree trimming program. As trees grow around the lines, they can pose safety issues and reliability problems. During heavy winds and ice storms, tree branches will cause outages as they contact the overhead conductors, and, if the branches are heavy enough, they can completely break poles and conductors. London Hydro uses a combination of its own personnel and contractors to trim trees around primary conductors on a five year cycle. Trees around pole lines that carry only secondary circuits are not trimmed and neither are trees around secondary service drops. The number of outages caused by tree contacts is generally small (except during significant storms) but is monitored each year by the Engineering and Operations Department. When planning its tree trimming program, London Hydro weighs tree trimming frequency and extent with aesthetics and cost while maintaining system reliability.

1.7 Wooden Pins and Hardware

1.7.1 Age and Life Expectancy

In older style construction, wooden pins are set in a hole in wooden crossarms to mount insulators. London Hydro does not have any records to indicate how many wooden pins are still used on the system, but these pins are used only in wooden crossarms, a number of which are still on the system. Any wooden pins still on the system would be over 35 years old. The pins are made of very dense hardwood and are expected to last 60 years or more; however, the area around the holes in which they sit will often rot, causing problems in the condition of the installation.

1.7.2 Condition

All of the wooden pins on London Hydro's system are inspected once every three years as part of the mandatory OEB audit and over the past three years, 18 problems have required attention. All of the wooden pins on the system would be over 35 years in age and should be considered to be in poor condition.

1.7.3 Inspection Plan

London Hydro does not perform any formal testing on wooden pins but does conduct a thorough visual inspection on all overhead circuits once every three years as part of the OEB mandatory audit. Below is a form showing the type of data collected on this asset during the audit. Any deficiencies found are recorded in an MS Access database. Equipment found to require 'urgent' attention is slated for immediate replacement/repair.

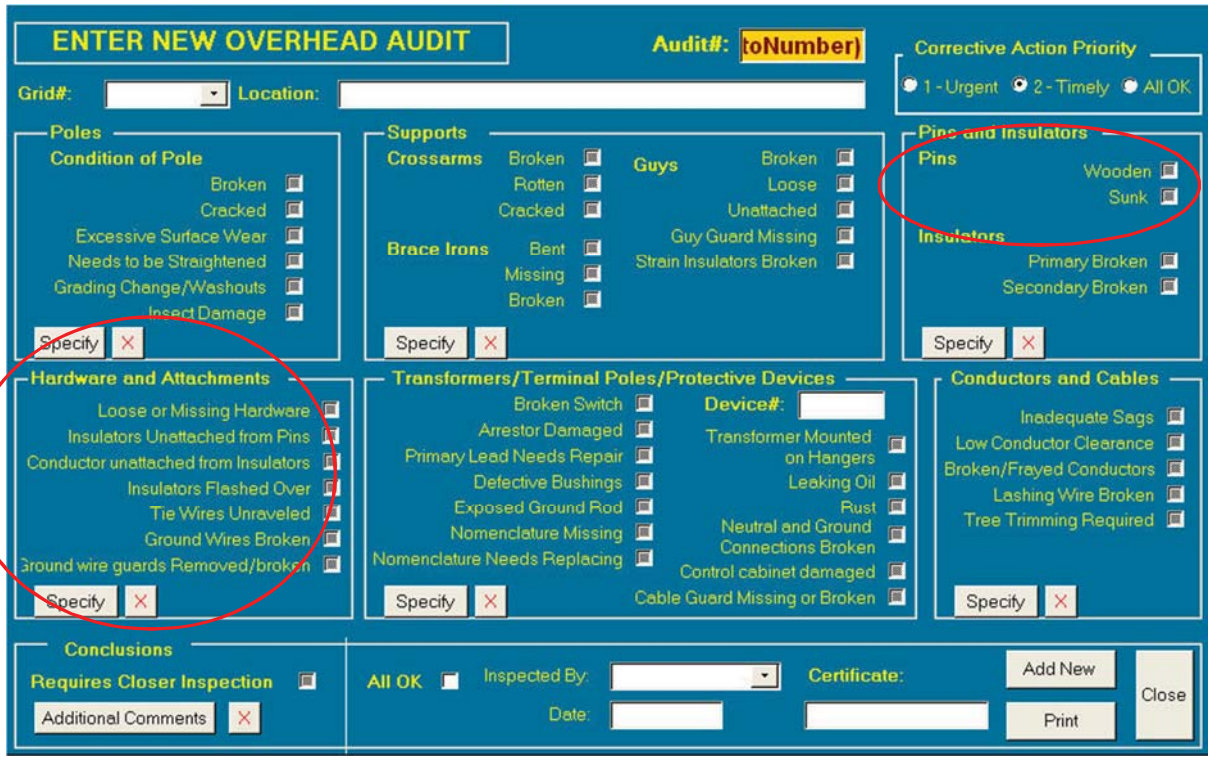


Figure 1-11 - Inspection Checklist – Overhead (Wooden Pins and Hardware)

1.7.4 Risk Assessment

Over time, wooden pins, or, more frequently, the area on the crossarms around the pin, rots and causes the pin and insulator to either sink down onto the crossarm or break away completely. If the wooden pin assembly breaks away, the energized line can come down and create both a safety hazard and an outage.

London Hydro inspects all of its wooden pins and crossarms once every three years and specifically looks for sunken pins indicating that rot has occurred. Outright failures are rare so risks to reliability are low, but the safety concerns rank high.

1.7.5 Asset Sustainment Plan

Areas with many wooden pins would more than likely have been identified as being in poor condition during the 1998 Infrastructure Audit. All the areas that are shown as being in poor condition in the GIS database are considered when overhead rebuild plans are developed.

1.8 Fully Depreciated Overhead Lines - Sustainment Plan

London Hydro's depreciated poles can be replaced on a pole-for-pole basis in which the existing hardware is simply transferred to the new pole or by rebuilding an entire pole line consisting of multiple poles where all hardware, including conductors and transformers, are replaced.

A basic pole-for-pole replacement in which the existing hardware is simply transferred to the new pole can cost on average $2,500. The replacement of poles on a pole-for-pole basis depends on the yearly testing and inspection programs results. Historically, London Hydro has replaced anywhere from 30-40 poles per year as part of this replacement program.

In contrast, the replacement of fully depreciated pole lines which require the replacement of conductors, hardware, and transformers will have varying costs that are much higher than the pole-for-pole replacement cost. Increased costs over and above one pole replacement are attributed to the cost of stringing of new conductors, extra guying costs due to higher poles and conductor tensions, increased engineering cost, and extra removal and restoration costs such as old guying and conductors. The majority of London Hydro's poles are replaced under a capital program with several drivers:

- The replacement of poles on a spot basis that have been found deficient during regular testing and inspection;
- The replacement of poles to rebuild a fully depreciated pole line, which has been confirmed to be necessary through testing and inspection;
- The replacement of poles in depreciated 4 kV areas as part of a multi-year voltage conversion plan;
- The replacement of poles or upgrading of lines to accommodate increased capacity requirements;
- The systematic replacement of poles with wooden crossarms, which have been found to be susceptible to pole fires;
- The replacement of Grey Munsell poles, which have been found to be decaying prematurely;
- The replacement of poles as part of a road widening or developer-requested relocation of poles.

Table 1-2 shows the estimated number of Km's on our system with single, double, triple, or quadruple circuits along with the estimated number of associated poles.

Table 1-2 - Estimated Number of Km of Overhead Circuits on London Hydro's System by Type

No. of Circuits per Pole Line	Total Primary Circuit Length	Estimated No. of Poles[6]
Single – 1 phase	586 km	13,427
Single – 3 phase	248 km	5,670
Double	345 km	3511
Triple	120 km	889
Quadruple	31 km	172
Secondary Only	N/A[7]	5715[8]
Totals	1330 km	29,384 poles

Assuming that depreciated poles are distributed amongst single, double, triple, and quadruple circuits in the same ratios as in Table 1-2, the following table shows the estimated number of poles that may need to be replaced over the next 15 years.

Table 1-3 - Estimated number of depreciated poles to replace over the next 15 year

No. of Circuits per Pole Line		Number of poles over 50 years of age (in 15 years)
Single- 1 phase	45%	4,751
Single- 3 phase	19%	2000
Double	13%	1373
Triple	3%	317
Quadruple	1%	106
Secondary Only	19%	2012
TOTAL		10,599

6 Estimated based on average of 40-45m span per pole

7 Secondary poles do not count for total circuit (HV) length

8 Values for secondary length and no. of poles were derived from Total No. of Poles in GIS minus sum of Estimated No. of Poles for Single, double, Triple, Quadruple primary circuits

London Hydro has approximately 100 km (in circuit length) of overhead circuits installed on 2,600 poles owned by Bell Canada. London Hydro does not keep records of the age nor condition of Bell poles. London Hydro does, however, inspect Bell poles during regular pole inspections and notifies Bell of any Bell poles that need immediate replacement. As the general condition of Bell poles is unknown, London Hydro will assume in this report that 50% of Bell poles will reach end of life over the next 15 years. Consequently, London Hydro will need to consider replacing an addition 1,300 poles over the next 15 years which would also include the replacement of the conductors, transformer, and related hardware on those poles. Combined, it is estimated that London Hydro will need to allocate the appropriate resources to replace, on average, close to 700 London Hydro poles and overhead circuitry on 90 Bell owned poles per year over the next years. The cost to accomplish this will vary year over year depending on how many circuits are involved with each pole.

London Hydro has a "Worst Feeder" program in which the Reliability Engineer examines the performance of all feeders on the system and makes recommendations to improve the performance of the ten worst feeders. If a feeder appears on the list for a second or third year, special efforts are made to identify the maintenance or capital improvements that can be made. RCM techniques are used regularly to ensure that capital dollars are spent where they will have the most impact. The worst feeder program is discussed in the "2010 Quality of Supply Report".

1.9 Summary and Recommendations

London Hydro has a comprehensive ASP for poles and overhead circuits. Poles are tested frequently to ensure public and worker safety, and the test results are the main driver for developing the capital replacement plan. The age of the older poles has been estimated during inspections and testing and based on these estimates, London Hydro has developed a forecast for the number of poles that are likely to require replacement over the next 15 years to keep up with the replacement of fully depreciated poles, overhead circuits and transformers. The levelized asset sustainment rate is approximately 700 poles per year for 15 years. Historically, over the last decade, London Hydro has replaced anywhere from 420-685 poles a year at an average of 500 poles per year.

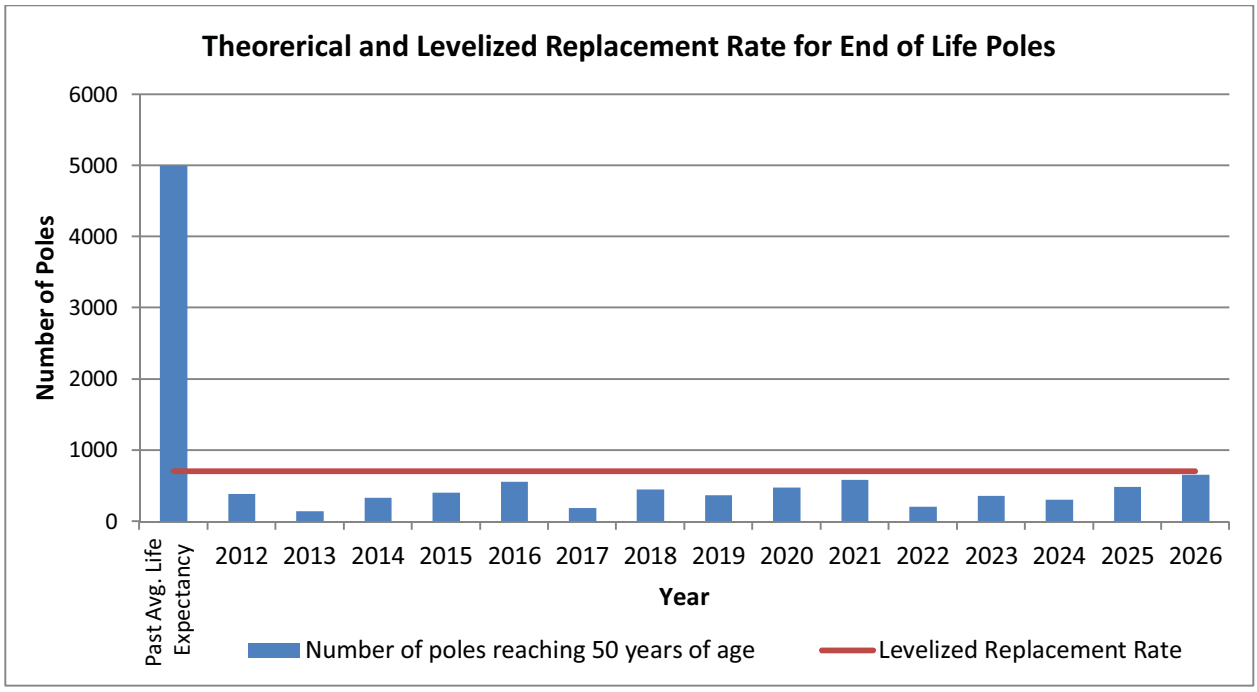


Figure 1-12 - Theoretical and Levelized Replacement Rate for End of Life Poles

London Hydro has a good reliability-centred process for identifying individual assets that need an ad hoc maintenance or replacement program to address safety or reliability issues. For example, in the past five years, ad hoc programs have been developed to address failing insulators, Firon switches, wooden crossarms and Grey Munsell poles.

London Hydro has over 31 km of # 6 solid copper overhead conductors on its system, which poses a potential safety hazard. London Hydro is currently developing a program, starting with the 2012 budget, to proactively replace all of the #6 solid copper conductors on its system. Plans will also be required eventually to identify and replace all the 4 kV bundled primary conductor on the system.

London Hydro has age data on most of its newer poles and estimated age data for poles that have been inspected or tested, but there are a number of poles for which no age data is available. To address this, London Hydro has started a multiyear program to conduct a detailed audit of the entire overhead distribution system to obtain the best age estimate possible.

It is important for the testing program to continue each year to ensure that all of London Hydro's poles get tested on a regular basis.

London Hydro intends on applying RCM techniques to identify poles that are critical to system reliability and safety (corner poles with multiple circuits, for example) and perhaps test these poles more frequently.

Improved data is important to ensure that London Hydro's infrastructure replacement plans can be targeted and on time. Plans to allow field staff to collect asset condition data in the field as part of the GIS enhancements project should result in considerable improvement in the data.

London Hydro should also consider ways to use the GIS system to calculate the length of single phase and three-phase single, double, triple and quadruple circuit lines to more accurately forecast the long-term replacement/refurbishment of fully depreciated lines.

2 - Primary Underground Cable

London Hydro owns the following primary high voltage cable assets[9]:

Table 2-1- Residential / Commercial Cable

Cable Voltage	Cable Type		Cable Size	Circuit Length (m)	Conductor Length (m)
15 kV	Alum	XLPE	#1/0	8,973	16,141
15 kV	Copper	XLPE	#1/0	3,541	3,785
			#2	1,081	1,871
			#3/0	4,401	7,485
15 kV	Copper	EPR	#2/0	149	447
28 kV	Alum	XLPE	#1/0	1,142,723	1,500,137
			#2/0	5,796	15,078
			250 kcmil	212	636
28 kV	Copper	XLPE	#3/0	97,452	108,628
5 kV	Copper	Polyetheylene	#1/0	576	576
			#2	1,306	1,438
			#3/0	3,284	4,280
			#4	217	217
			#6	314	738
		EPR	#1/0	1,011	1,433
			#2	5,038	9,628
			#3/0	170	170
			#6	381	457
		XLPE	#1/0	4,585	5,063
Grand Total				1,281,210	1,678,208

Note: To obtain the actual length of cable installed, 3-phase circuits with triplexed single-phase cables were multiplied by three.

[9] Conductor type and quantity is based on GIS records extracted in 2011

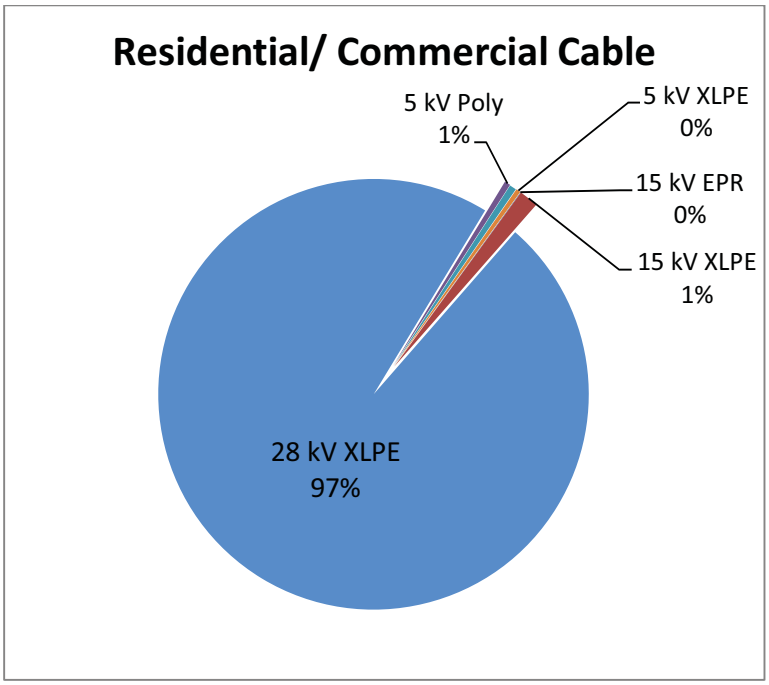


Figure 2-1 - Residential / Commercial Cable, based on conductor length

Table 2-2 - Downtown/Station Egress Cable

Cable Voltage	Cable Type		Cable Size	Sum of Circuit Length (m)	Sum of Conductor Length (m)
15 kV	Copper	PILC	#3/0	24,244	24,244
			#4/0	2,143	2,143
			500 kcmil	4,270	4,270
			600 kcmil	38,188	38,188
28 kV	Alum	C.N.	1000 kcmil	16,550	49,564
			350 kcmil	657	1,971
28 kV	Alum	L.C.	1000 kcmil	24,140	72,358
30 kV	Copper	C.N.	750 kcmil	1,714	5,142
5 kV	Copper	PILC	350 kcmil	513	513
			500 kcmil	6,193	6,193
8 kV	Copper	PILC	750 kcmil	367	1,101
Grand Total				118,979	205,687

Note: To obtain the actual length of cable installed, 3-phase circuits with triplexed single-phase cables were multiplied by 3.

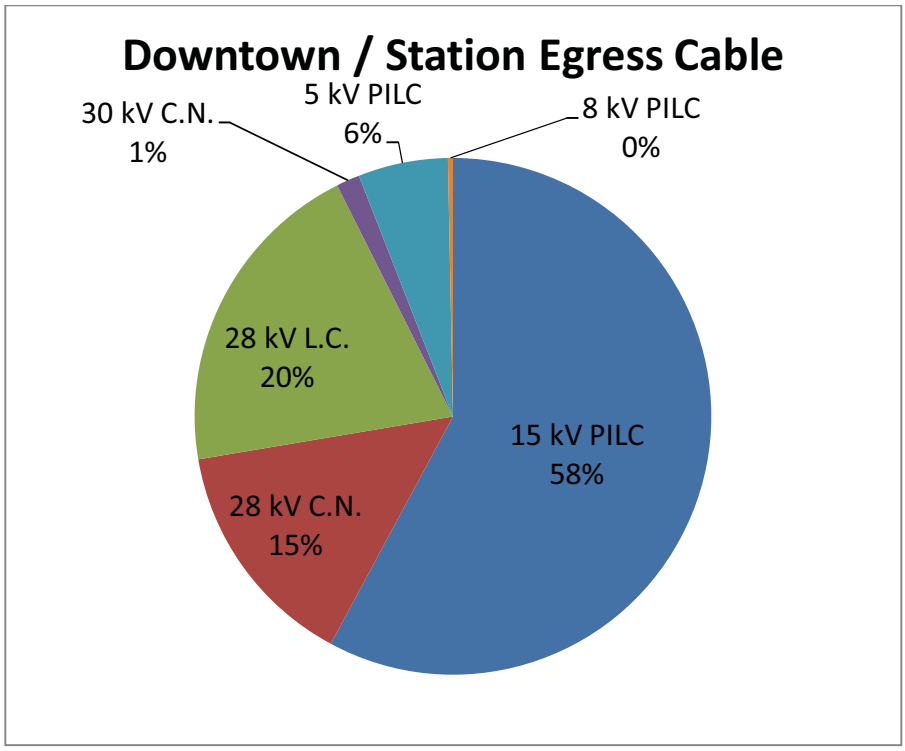


Figure 2-2 - Downtown / Egress cable Circuit Length

The lengths of underground cables in the table above are extracted from London Hydro's GIS database, which shows cable in a semi-geographic manner; that is, cables are not always represented in their exact location and, therefore, the information available does not reflect exact lengths. Currently, the only way to obtain accurate lengths would be to measure the lengths manually from the underground distribution drawings. These drawings are gradually being transferred to the GIS database, and when they have all been completed, a more precise measurement of the installed cable can be obtained.

This ASP covers the following two specific applications of underground cable separately:

- Residential / Commercial Underground Cable and
- Downtown / Station Egress Cable.

2.1 Residential / Commercial Underground Cable

The majority of London Hydro's primary underground cable is found in residential subdivisions. There is a comprehensive ASP for residential underground cable that documents what London Hydro owns and proposes a long-term sustainment plan for addressing the aging assets over time. The Engineering Report "Rehabilitation of Aging Underground Residential Distribution Systems" (April 2010) analyzes the typical life cycle of underground residential cables, discusses the causes and general timeline of cable deterioration and uses that information to give a comprehensive assessment of London Hydro's cable assets in terms of age and reliability. This information forms the basis of a long-term RCM (Reliability-Centred Maintenance) cable replacement/refurbishment plan that ranks subdivisions in need of cable replacement based on a number of factors including impact on reliability.

2.1.1 Age and Life Expectancy

Of the primary high voltage cables listed above, approximately 1,678 km are in residential underground subdivisions or are used for commercial services. As shown in Table 2-1- Residential / Commercial Cable, this table refers to the actual conductor length not the circuit length. At this time there is no simple method for accurately determining how much cable is used exclusively for commercial services, but it is likely to be less than 5% of the total.

Studies have shown that 28 kV XLPE insulated cable manufactured before 1980 can be expected to last 20 to 25 years. Cable manufactured between 1980 and 1990 is expected to last 25 to 30 years, and cable manufactured in 1990 and after has an expected life span of over 30 years. For planning purposes, the optimistic life spans of 25, 30 and 35 years are being used, respectively. London Hydro's observation is that the older style 5kV polyethylene and rubber insulated cable lasts an average of 29 years before failing.

Table 2-3 - Life Expectancy of XLPE 28kV Cable

Cable Vintage and Type	Useful Life of cable
28 kV XLPE (<1980)	20-25 years
28 kV XLPE (1980-1990)	25-30 years
28 kV XLPE (>1990)	30-35 years

Since cables manufactured in 1990 or later are expected to last 35 years (until 2025) and cables manufactured in 1989 or earlier are expected to last 30 years (up to 2019), the 15 year time horizon of this ASP only needs to consider the cables manufactured in 1990 or earlier. In addition, London Hydro has a number of subdivisions in which 28 kV cable is used but only energized at 4.16 kV-almost 7% of 28 kV is energized at 4.16kV and 2% is energized at 8.32kV and 13.8 kV. This cable is expected to last considerably past the useful life suggested for cable energized at 27.6 kV.

The figure below illustrates London Hydro's underground residential and commercial cables in terms of their age distribution.

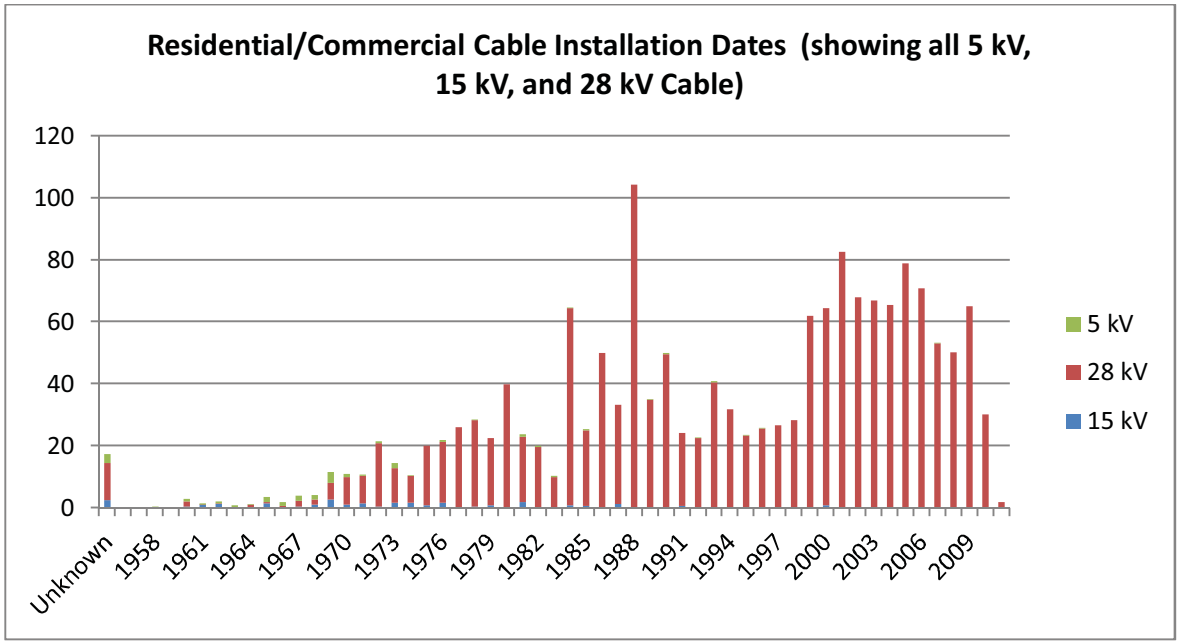


Figure 2-3 - Residential/Commercial Cable Installation Dates

Table 2-4 - Theoretical Km's of cable reaching end of life in the next 15 years

Cable Vintage	km Length of Cable	Useful life	At end of life today	At end of life by 2026 (excluding today's end of life count)	Total km's of cable to address over the next 15 years
<1980	238 km	25 years	238 km	0 km	238 km
1980-1989	406 km	30 years	64 km	343 km	407 km
>1990	1033 km	35 years	0 km	74 km	74 km
		TOTAL	302 km	417 km	719 km

As Table 2-4 shows, a total 719 km of cable will need to be replaced or refurbished over the next 15 years. As mentioned above, 7% of the 28 kV rated cable is energized at 4.16 kV; this represents 16 km of the cable installed before 1980 and 66 km of the cable installed between the years 1980-1989. This implies that out of the 302 km of cable considered at end of life today only 220 are at a higher risk of failure today; however, all of this cable will likely need to be addressed over the next 15 years.

2.1.2 Condition

The SPOORE (Safety, Performance, Operability, Outage, Risk, Environment) analysis is a tool developed by London Hydro for analyzing the performance of older cables in subdivisions. It measures the safety risks posed to employees and to the public, the impact of faults on overall reliability, the complexity of the system's operation and whether the system poses environmental risks due to leaking transformers. These indices are used to rate subdivisions in terms of their need for cable and/or transformer replacement. This analysis addresses system operating conditions and reliability, and, economically, it optimizes the spending to address problems. Since the inception of the SPOORE analysis, London Hydro has effectively reduced the outages due to cable faults and, in so doing, improved it's reliability performance.

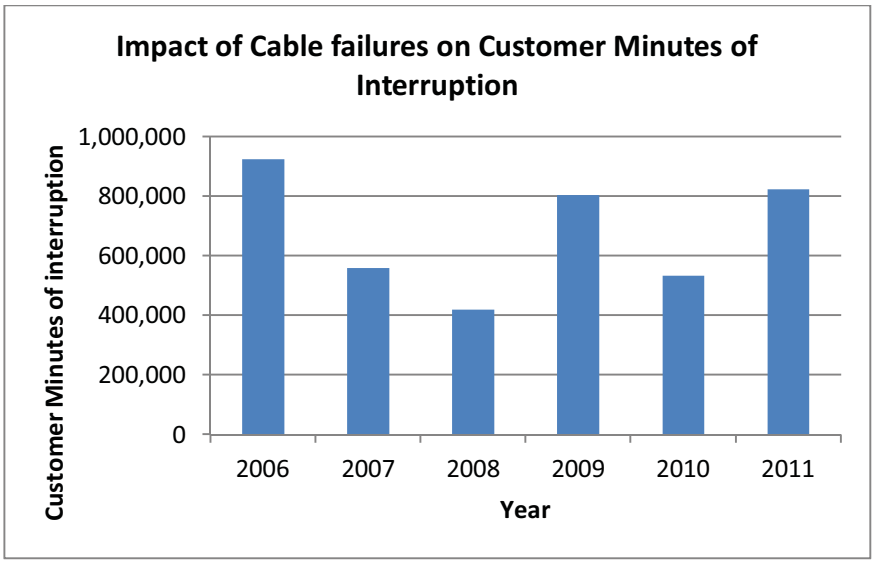


Figure 2-4 - Impact of Cable failures on Customer Minutes of Interruption

In addition to the criteria listed above, the SPOORE analysis also takes cable life spans into account. Since different cable types and different eras of cable have their own failure rates, cable life rating is incorporated into the evaluation to anticipate future replacement needs.

Of the 1,678 km of URD cable London Hydro has in service, 302 km or 18% is currently past its life expectancy. Most of this cable must be considered to be in poor condition and at imminent risk of failure.

2.1.3 Inspection Plan

Transformers in subdivisions need to be inspected every three years in order to meet OEB requirements. As part of this program, the portion of cable visible in the transformers and the cable terminations are inspected for any signs of tracking, discolouration or corrosion. Any obvious problems with cable risers (such as a missing cable guard or damaged terminator) would be noticed during the OEB audits of the overhead system. The majority of the cable, however, is buried and cannot be visually inspected.

In 2004 London Hydro worked with DTE Energy on a pilot program to use partial discharge techniques to try to assess the condition of URD cables in the Westmount subdivision. While a number of techniques can be used to test the dielectric integrity of high voltage cable,[10] DTE's partial discharge techniques were unique because they could be performed on energized cables. The process of taking cables out of service to perform standard dielectric tests is very costly and can only be justified for mission critical cables. It is not cost effective to perform standard dielectric tests for subdivision cables. Unfortunately, the partial discharge pilot program was not successful. Some cables that tested well, failed shortly thereafter and some cables that tested poorly are still in service today. London Hydro will continue to follow any new developments in cable condition assessment techniques, but for now, will rely solely on the SPOORE analysis to make cable replacement decisions.

2.1.4 Risk Assessment

Risk Assessments take into consideration risks to safety of the public and London Hydro employees, risks to the environment, and risks to service reliability. These risk factors are measured using the SPOORE analysis described above allowing for very sound RCM based decisions in this area. The SPOORE analysis is an excellent way to rank cable replacement programs because it takes into consideration that not all cable failures have the same impact on reliability. Cable failures in some subdivisions disrupt service to more customers and last much longer because of the electrical configuration in that subdivision compared to others. Cable failures that pose a greater risk are ranked higher in the decision making process.

Figure 2-5 depicts the number of failures experienced at London Hydro for a given installation year. These numbers were graphed to further illustrate cable failures per cable vintage. As is shown below, the frequency of cable failure is higher for cables installed between the 1970's and late 1980's. These older vintages of cable are addressed in the SPOORE analysis.

10 Some standard dielectric tests include AC, DC or VLF hi-potting of cable to chart gradual deterioration over time, polarization index, power factor, tan delta, etc.

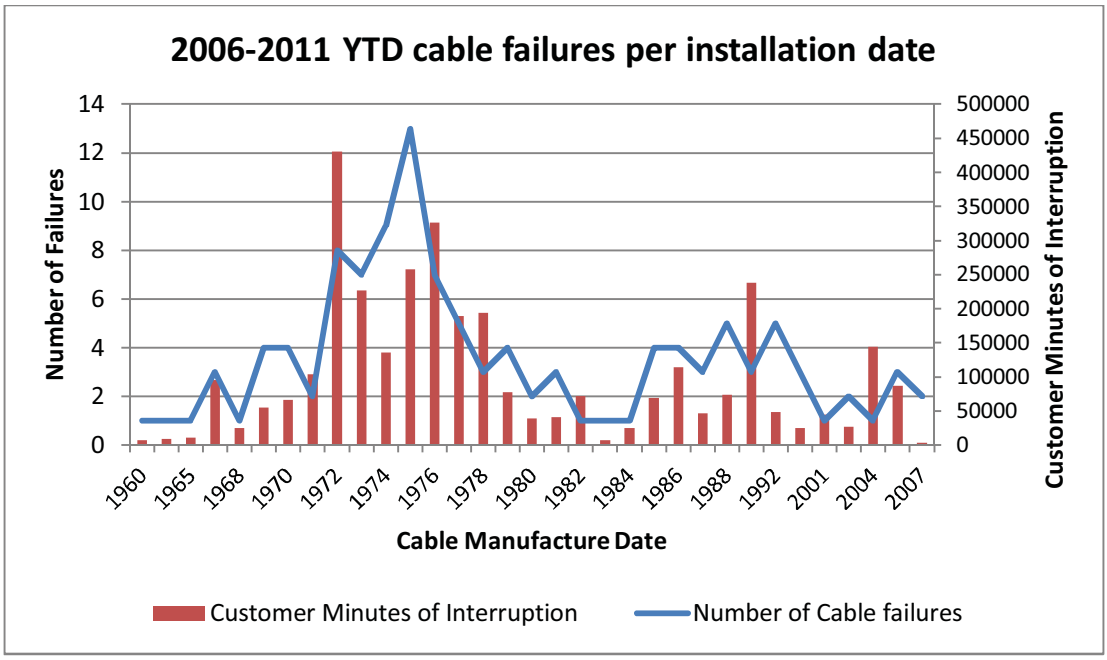


Figure 2-5 - Failures per vintage cable

In general, defective equipment accounts for almost 50% of London Hydro's SAIDI outage statistics, and cable failures represent the largest subcategory, contributing 30% of the defective equipment failures. The figure below illustrates the overall contribution to SAIDI by type of equipment and voltage level.

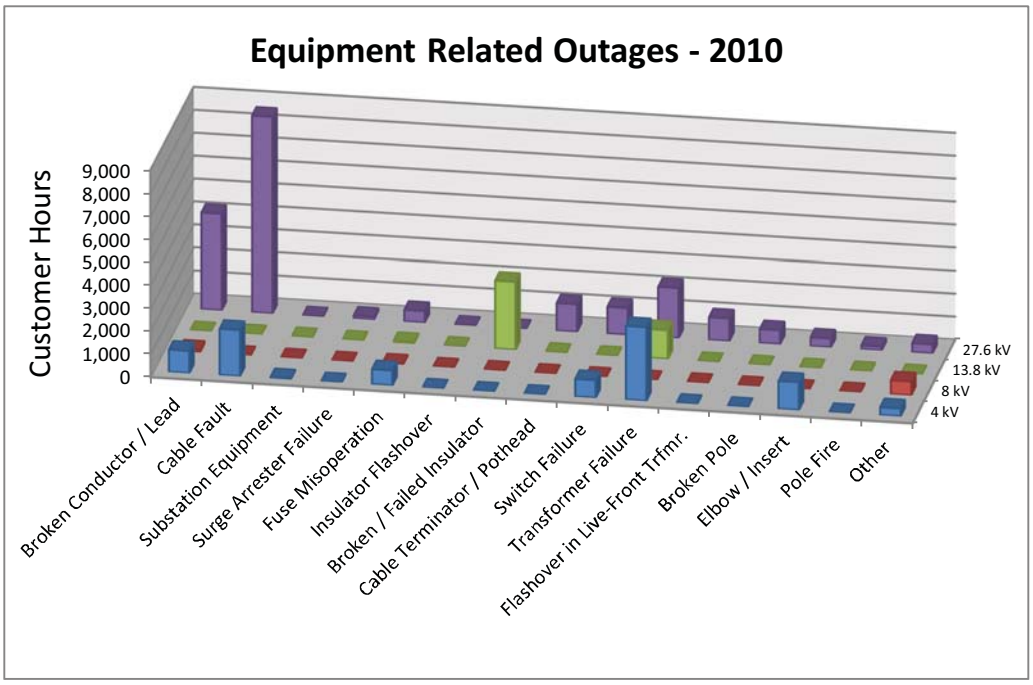


Figure 2-6- Equipment Related Outages - 2010 (SAIDI)

Notwithstanding end of life projections, London Hydro currently does not replace cable in a subdivision until failures actually start to occur. The consequence of this practice is that there is a "pent up demand" of 302 km of cable that is now theoretically overdue for replacement. Technically, there is no need to replace this cable before it starts to fail, but planners need to be aware that as time passes, a sudden increase in the number of failures could put a strain on resources. For example, some years back a number of cables in a single subdivision started failing rapidly in succession causing the residents to experience eight lengthy outages in less than a month. The cables were already very close to their end of life, and it is believed they were subjected to additional stress after a lightning storm, causing a sudden spate of failures. The risk of customer dissatisfaction increases if a large population of cables in the city remain in service past their expected average life span.

2.1.5 Asset Sustainment Plan

London Hydro follows an RCM approach to address aging underground residential cables. The plan is based on benchmarking the asset's end of useful life and using this information to forecast how much cable needs to be replaced in the planning horizon. However, London Hydro currently does not replace cables simply because they are old. The SPOORE analysis is used to determine which cables are actually failing and to help decide when to schedule replacement for each subdivision based on the assessed risks.

In terms of refurbishment, London Hydro piloted a program in 2002 to extend the life of XLPE cable using silicone injection but because the costs for underground boring came down shortly thereafter, it became more cost effective to replace the cables than to use silicone injection (See London Hydro's June 2003 analysis, "Net Present Value – Silicone Injection vs. Directional Boring"). Recent competition, however, has once again made refurbishment by means of silicone injection cost effective. Since there has been no subsequent failures experienced in the cables injected with silicone in the pilot area, the plan to use this method to refurbish cables in the coming years will be used again. In 2010, approximately 30 km of cable have been injected. Another 50 km were injected by the end of 2011.

When determining how much cable can be silicon injected and how much has to be replaced, there are a number of variables to consider. For example, 4 kV energized cable (not rated for 27.6kV supply) will always be replaced and not injected with silicone if it will be converted to 27.6 kV supply. Also, not all cables can be injected cost effectively; if too many splices or sections were repaired with strand block cable through which the silicone cannot flow, the only cost effective remedy is to replace the cable. Balancing the above variables and considering London Hydro's recent experience of rehabilitating cables via silicon injection, it is estimated that 80% of the cable is viable for Silicon Injection and 20% will need to be replaced.

In addition, when cables are being replaced, it is London Hydro's policy to replace all 5kV rated cables with 28kV cable whether or not a subdivision is being converted to a higher voltage. The higher voltage cable should last longer if it remains energized at 4.16kV and if a change in plans requires voltage conversion in the future, the cable will be ready.

London Hydro does not use the SPOORE analysis for high voltage cables that feed commercial customers since, by its design, the SPOORE analysis can only be applied on multiple lengths of cable that feed multiple customers. Most runs of cable for commercial customers feed only one customer and London Hydro's strategy is to let these cables run to failure. The loss of power to a single customer has a negligible effect on London Hydro's overall reliability. When a customer requires a more reliable supply, London Hydro offers a dual feed option with either manual or automatic transfer between two sources of supply.

Figure 2-1 shows that theoretically 302 km of residential/commercial URD cable is overdue for replacement. On top of that, in the next 15 years an additional 417 km of cable will theoretically become due for replacement or refurbishment.

Figure 2-7 shows the number of km's of underground residential cable that theoretically needs to be addressed over the next 15 years to sustain the residential cable asset and theoretically maintain a reliable supply of the underground system.

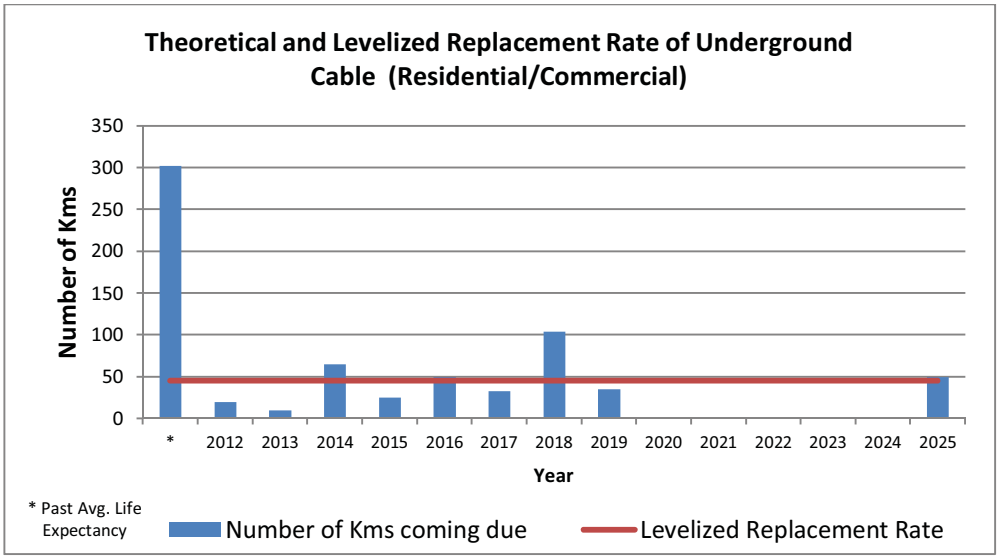


Figure 2-7 - Km's of underground residential/commercial cable expected to reach end of life over the next 15 years

Note: The table above indicates that zero km's of cable will reach end of life years between the years 2020-2024. This is due to the fact that cable installed after 1990 has a longer life expectancy than cable installed before 1990 (see Table 2-3). To elaborate, cable installed in 1989 will start to reach end of life in 2019 and cable installed in 1990 will reach end of life in 2025.

2.2 Downtown / Station Egress Cable

This section of the ASP covers the high voltage paper insulated lead (PILC) and the 750 and 1000 kcmil XLPE cables on the system. PILC cables are used on the downtown 13.8 kV system and at 4 kV substations. The 750 and 1000 kcmil XLPE cables are used on the downtown 27.6 kV system and as Transformer Station feeder egress cables. These cables are of major importance since they feed high profile customers in the downtown area or large numbers of customers on an entire feeder.

2.2.1 Age and Life Expectancy

London Hydro has approximately 205 km of Downtown and Station Egress XLPE cable, including 77 km of PILC cable (see Table 2-2) that is expected to last 60 to 70 years. For planning purposes, the optimistic lifespan of 70 years is being used. From Figure 2-8 it can be concluded that 3 km of PILC cable will reach end of life at the end of the 15 year sustainment plan; an additional 25 km of cable with unknown install date can be assumed at end of life for the purpose of this sustainment plan.

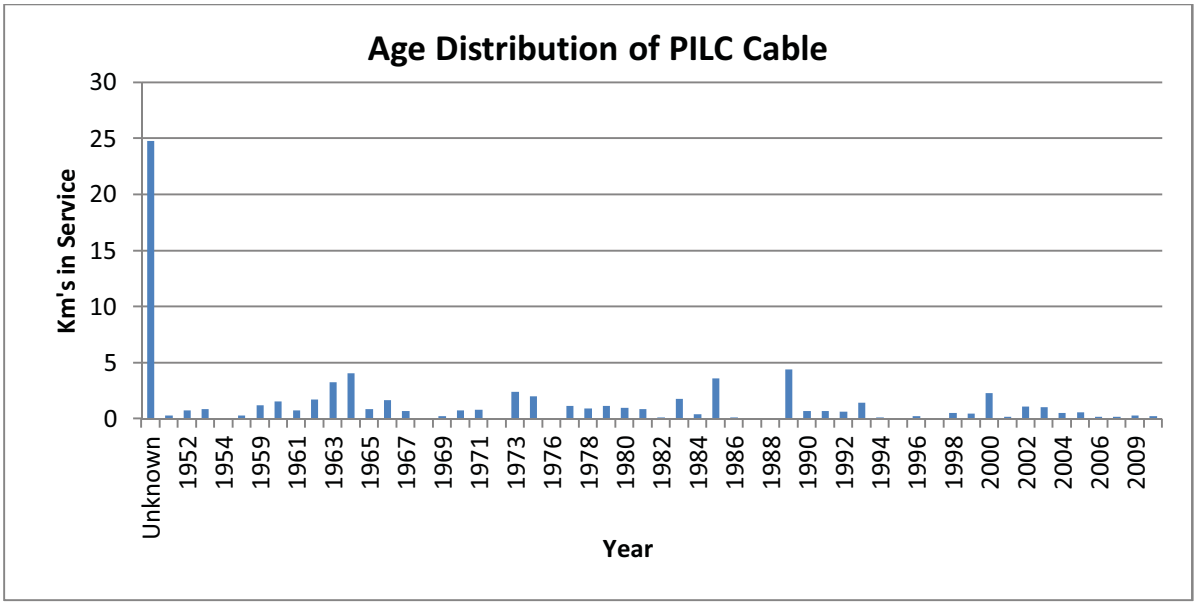


Figure 2-8 - Age Distribution of in service PILC cable

As shown earlier, XLPE cable manufactured between 1980 and 1990 has a life expectancy of 30 years and XLPE cable manufactured after 1990 is expected to last for 35 years.

Table 2-5 - Life Expectancy of XLPE and PILC Cable

Cable Vintage and Type	Useful Life of cable
Large 28 kV XLPE (<1980)	20-25 years
Large 28 kV XLPE (1980-1990)	25-30 years
Large 28 kV XLPE (>1990)	30-35 years
PILC	60-70 years

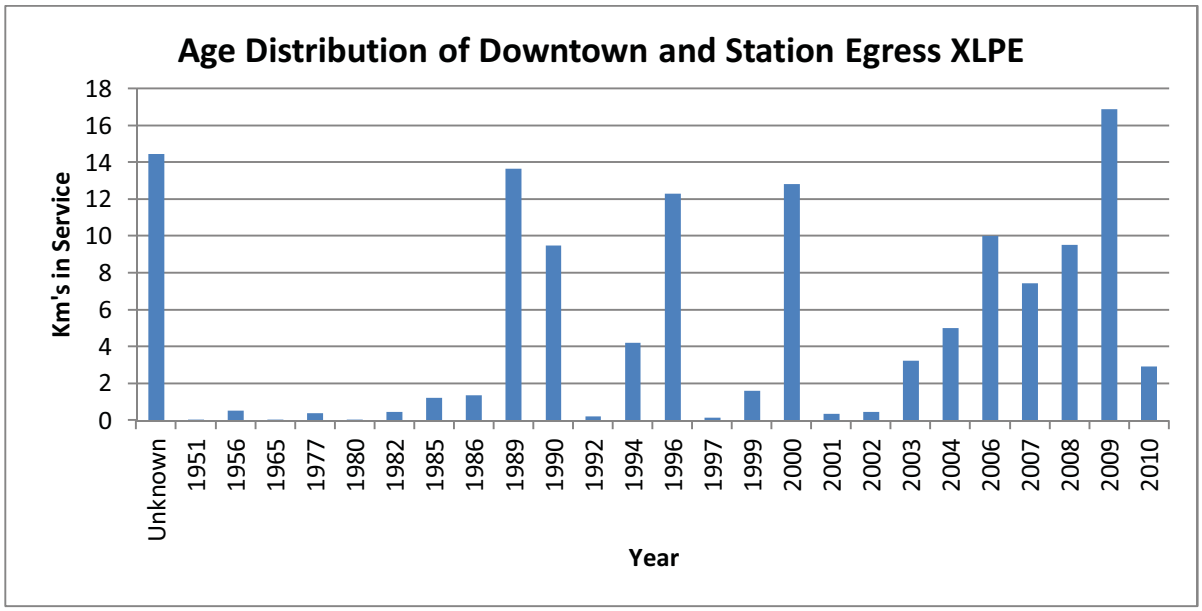


Figure 2-9 - Age Distribution of Downtown and Station Egress XLPE

The above chart illustrates that 42 km of XLPE type of cable will reach its estimated lifespan and will need to be considered for replacement over the next 15 years. Cable installed since 1990 is expected to last for 35 years and only in the year 2025 some of this cable will start to reach its expected end of life.

In summary, the above charts show that, theoretically, 70 km of Downtown and Station Egress cable will reach its expected useful life over the next 15 years.

2.2.2 Condition

The following chart shows the number of cable faults London Hydro has experienced on PILC type cables over the past 10 years:

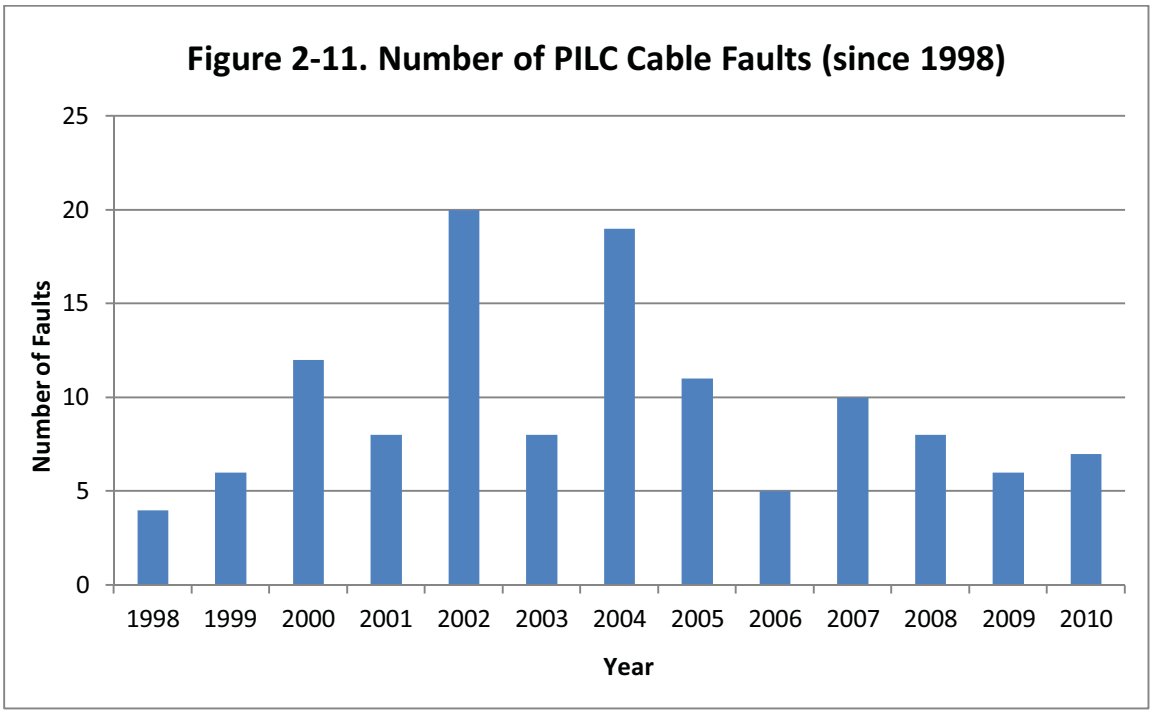


Figure 2-10 – Number of PILC Cable Faults (Since 1998)

No consistent trend emerges from the number of failures over recent years so it can be assumed that the overall condition of London Hydro's PILC cable is currently stable.

The following chart shows the number of cable faults London Hydro has experienced on Downtown and Station Egress XLPE cables over the past 10 years.

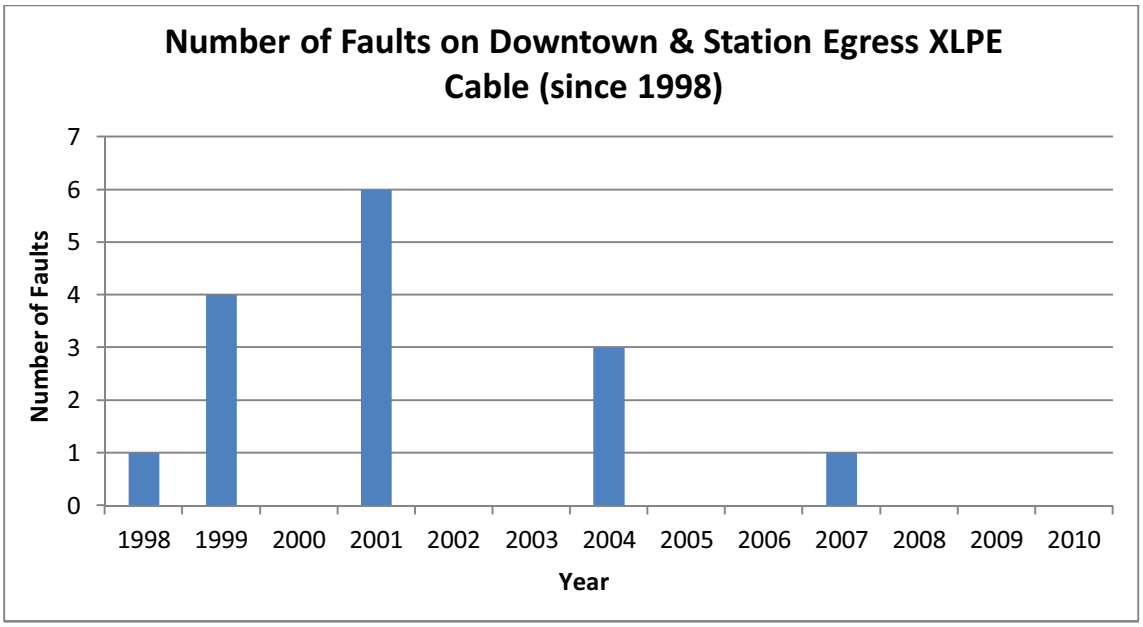


Figure 2-11 -Number of Faults on Downtown & Egress XLPE Cable (Since 1998)

In 2001 four cable faults occurred on the 26M48 feeder, but those were traced to a known cause and, therefore, do not indicate a trend. Currently, London Hydro's downtown and Station Egress XLPE cables are in good condition.

2.2.3 Inspection Plan

Transformers on the network system are inspected once a month; maintenance holes and oil and SF_6 switches on the downtown system are inspected once every three years. As part of this inspection program, the portion of cable visible at the equipment or in the maintenance hole is inspected for any signs of deterioration, but the majority of the cable is located inside ducts and cannot be visually inspected.

Similarly, the overhead distribution system is inspected once every three years to meet OEB requirements. Any problems in the condition of cable risers and terminations would be found during the regular audit, but most of the cable is inaccessible for inspection. Currently London Hydro does not have a formal testing program for evaluating the condition of these cables.

2.2.4 Risk Assessment

As noted in Section 2.1.3, a number of techniques are available for testing the dielectric integrity of high voltage cables. For a number of reasons London Hydro does not currently perform routine tests of its Downtown and Station Egress cable. The design of the downtown network system is such that the cables operate in parallel, so a fault on a PILC network cable does not result in a power outage. Similarly, a number of redundancies have been built into the non-network system; therefore, outages that result from PILC cable failures on this system are typically short in duration because a number of redundant paths are available for switching to a different source of supply. Going forward, London Hydro is contemplating redesigning and simplifying the non-network system and in so doing needs to take care when the redundancies are removed to ensure that routine cable faults do not cause extensive outages. If failures become critical, London Hydro should consider establishing a formal yearly testing program on critical cables to track their condition and to replace cables proactively when they start showing signs of deterioration but before they fail. The cost of such a program compared to the improved reliability would have to be studied.

Similarly, London Hydro has no routine testing program for XLPE station egress cables. As can be seen from Figure 2-9, most of this cable is fairly new and has not experienced many failures, but as these cables age, the risk of failure will increase and the impact on reliability can be significant. It is recommended that London Hydro consider initiating a regular testing program for all critical station egress XLPE cables.

2.2.5 Asset Sustainment Plan

Currently London Hydro follows a ‘run to failure’ approach for all of its Downtown and Station Egress cables. There was a program in the late 1990s to proactively replace 4 kV PILC substation feeder cables but no activity has occurred in this program since 2002. London Hydro is currently at a turning point with the 4 kV system and has developed a 4kV plan which will also addresses aging 4 kV PILC substation cables. Station Egress cables are generally fairly short, so even if future testing showed a cable reaching its end of life, it is unlikely that consideration of silicone injection or any other such refurbishment

technique would be used – the cable would simply be replaced. London Hydro is currently not aware of any refurbishment techniques for extending the life of PILC cable.

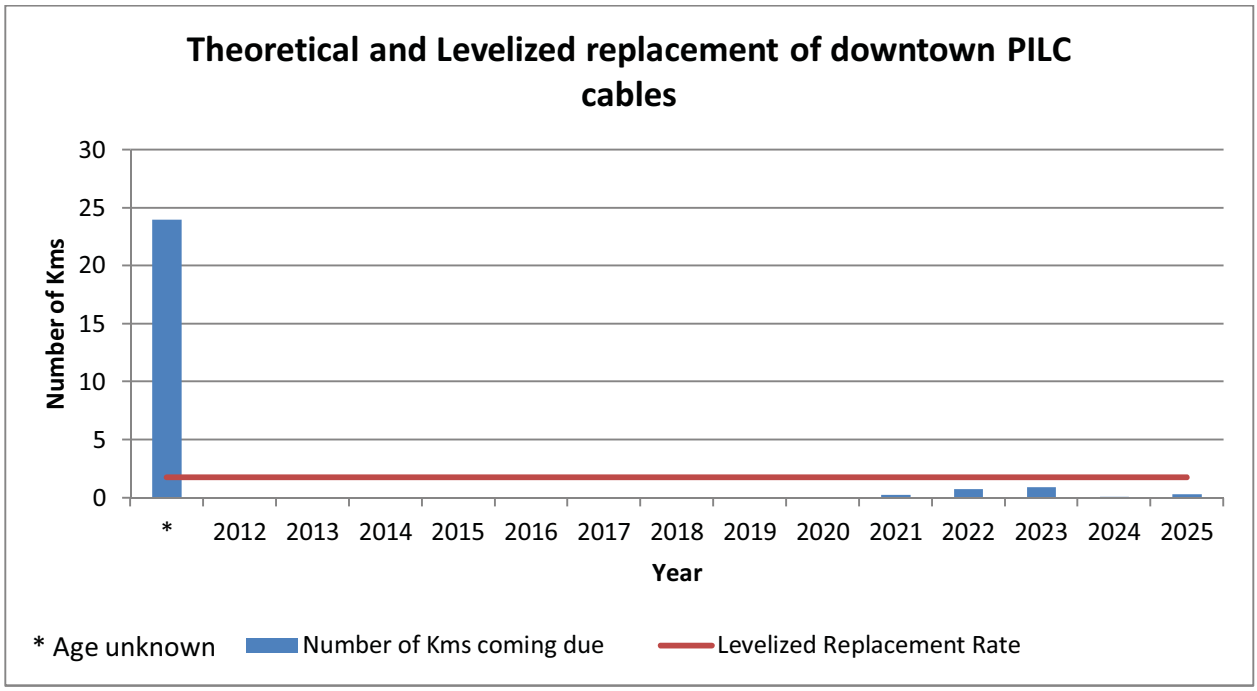


Figure 2-12 - Theoretical and Levelized Replacement of PILC Cable[11]

In 2008 London Hydro experimented with a new flat strap PE insulated cable to use as a substitute for PILC cable. This cable has worked well and there are plans to use it extensively to replace older 600 kcmil PILC cables when it fails. In 2009 and 2010 London Hydro has also installed a new network ring bus that has made approximately 11.5 km of 600 kcmil PILC cable obsolete. The ring bus consists of flat strap PE insulated cable and it feeds new 27.6 to 13.8 kV step down transformers that, in turn, tie into the existing 3/0 network 'children' cable.

London Hydro is also considering an overall plan to replace the 3/0 PILC children cables that are Y-spliced throughout the downtown area to feed all the network transformers. In fact, when network transformers are refurbished or replaced with newer units, the high voltage chambers are retrofitted to

[11] London Hydro does not currently have plans to extensively replace or refurbish PILC or XLPE egress cable, but the 15 year theoretical and levelized replacement schedule gives an indication of the potential resources required to replace this asset if London Hydro chooses to be more aggressive. But at this point, the reliability of the system as discussed earlier does not justify capital expenditure to proactively replace these cables in the near future.

accept EPR flat strap cable. Once enough of these are installed, a method will be considered for replacing entire sections of 3/0 PILC with the alternative flat strap EPR cable. The configuration of the new network ring bus has also allowed us to eliminate an additional 4.2 km of 3/0 PILC children cable.

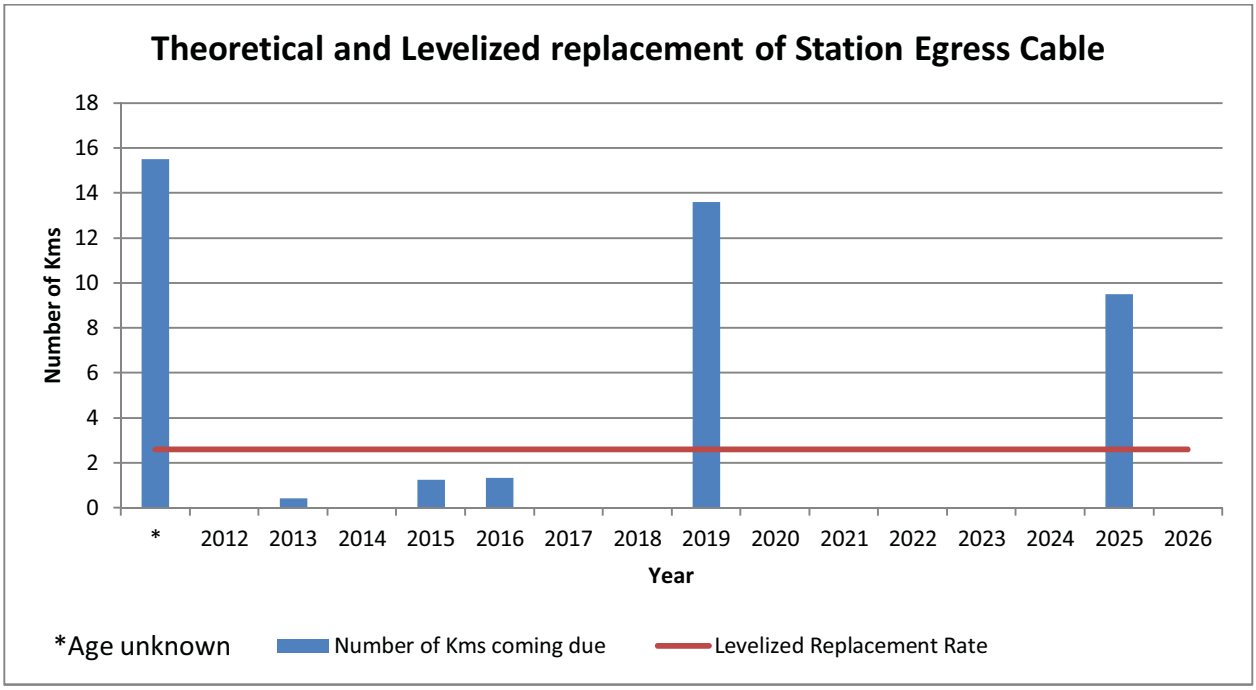


Figure 2-13 - Theoretical and Levelized Replacement of XLPE Station Egress Cable

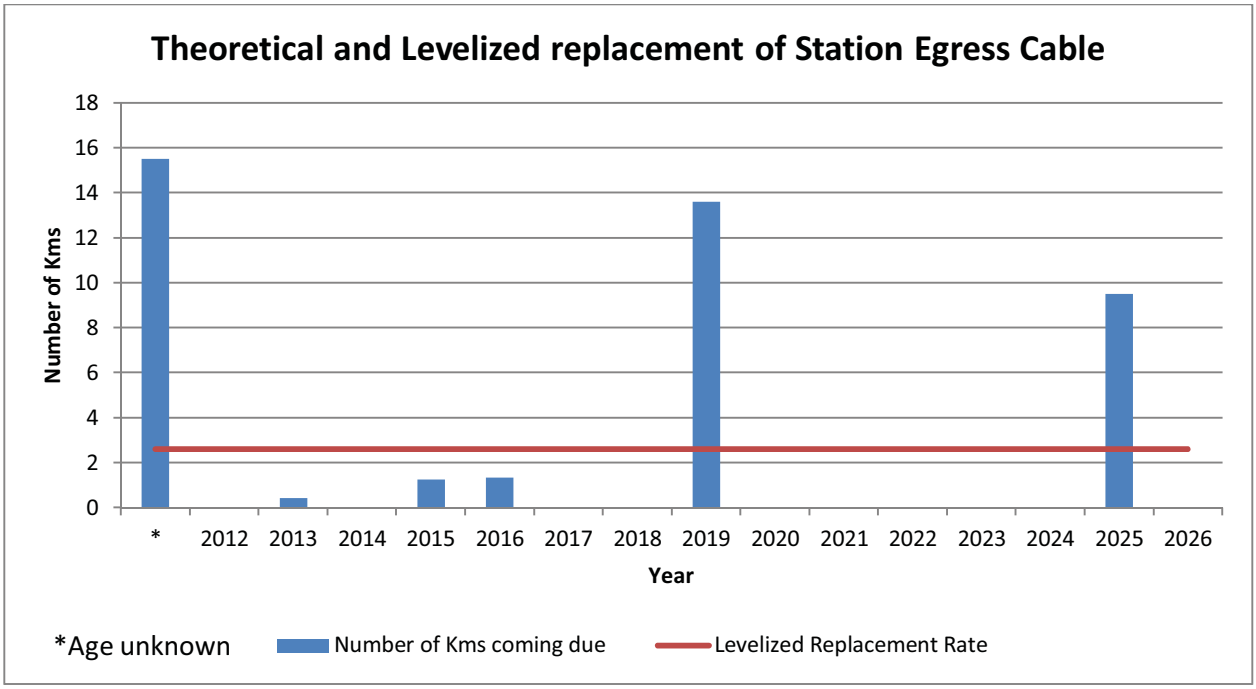


Figure 2-13 above show, approximately 70 km of Egress and PILC cable is at end of life or will reach end of life over the next 15 years. Since the new network ring bus will soon make a total of approximately 16 km of PILC cable obsolete, this number can be revised downwards and only 54 km of cable will need to be addressed.

Replacing PILC cable with EPR requires the use of special transition splices at both ends of the new cable segment. This splice is more costly than the regular PILC-PILC splice. Furthermore, the size of the transition splice can make it difficult to fit in a crowded manhole and in these cases it will be necessary to extend the cable to the next manhole and make the splice there. Scenarios similar to this, lead to variations in the average per meter cost that must be considered when forecasting expenditures for this type of cable.

3 - Substations

Introduction

London Hydro has 38 substations with a 4.16 kV distribution voltage and one substation with an 8.32 kV distribution voltage supplying primarily residential load. London Hydro also has three stations with 27.6 kV to 13.8 kV transformation and three switching stations that consist of only 13.8 kV switchgear. Most of the stations were installed 30 to 40 years ago when the City of London was in a rapid growth stage and when the common distribution voltage was 4.16 kV.

In 2009 London Hydro constructed three new substations – Subs 10, 11 and 12. These 27.6 kV to 13.8 kV step-down stations are available to supply the downtown network. The stations consist of transformers, padmounted solid dielectric switchgear, neutral resistors and digital relays.

3.1 Transformers

3.1.1 Age and Life Expectancy

London Hydro has found that older substation transformers can last up to 60 years but anticipates that transformers installed after 1965 will have a 50 year average lifespan. Of the 58 substation transformers in service, the chart below shows that 30 or 51% will reach their end of life over the next 15 years.

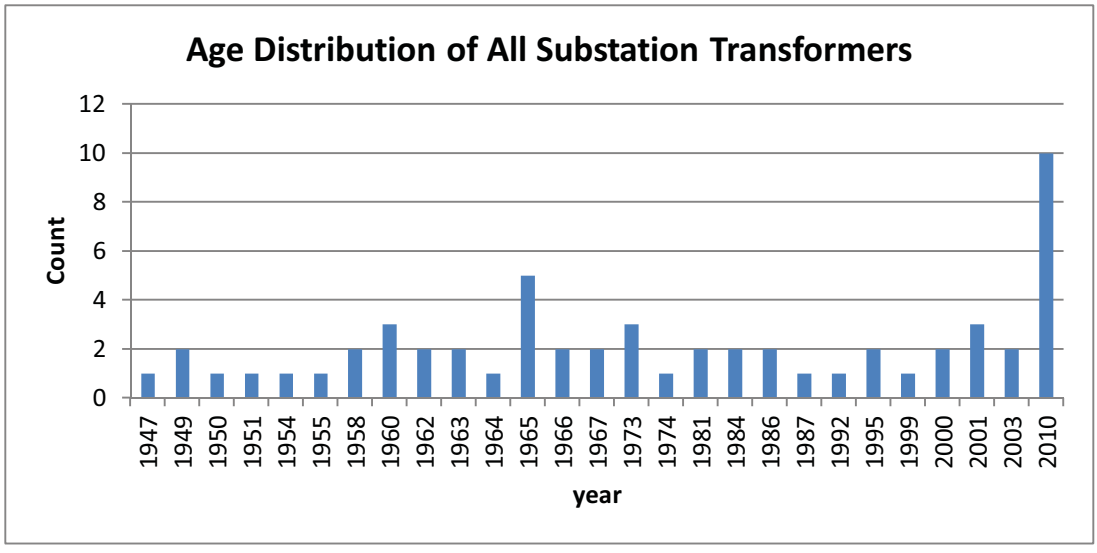


Figure 3-1 - Age Distribution of All Substation Transformers

3.1.2 Condition

Although London Hydro's substation transformers are relatively old, they rarely get overloaded and are generally in fair condition. Regular maintenance is required to repair leaks, and although some transformers leak repeatedly, they are kept under control. In 2011, seven transformers have been identified with persistent leaking problems and they are between 45-64 years old. Most of London Hydro's substation transformers are free breathing, so the oil is exposed to air; as a result, dissolved oxygen levels are relatively high. Nine substation transformers have consistently been shown to have poor oil quality during testing and an additional seven have marginally poor results. Given that 14, or 24%, of London Hydro's substation transformers are over 50 years of age and of those five are over 60 years of age, the assumption can be made that the condition of these older units is suspect.

3.1.3 Inspection Plan

The OEB requires that all open bus outdoor stations be inspected at least once a month and that all other types of stations be inspected at least once a year. London Hydro's inspections are more frequent (typically indoor stations are visited every two months); the inspection checklist used by London Hydro can be found on the following page. The data is entered into an MS Access database so summary reports can be easily generated and progress on repairs can be tracked.

In tandem with the inspection of each substation, oil samples are obtained each year to undergo physical property and dissolved gas analyses and in 2009 London Hydro also started using furan analyses to evaluate the condition of the paper insulation. The results of these tests are used to monitor the health of the oil and to provide an indication of incipient faults that could be developing inside the transformer or tap changer. Records of the results of the gas in-oil analysis are kept and compared to previous readings. Any anomalies are reviewed to determine if a shutdown inspection or additional maintenance activity on the substation transformer is required.

London Hydro also performs an annual infrared survey of all its substations to look for overheated connections and components.

Although a number of other inspection methods are available, such as doble testing, dielectric loss and spectroscopy, polarization index, etc., London Hydro does not use them routinely to monitor the condition of its substation transformers. They rarely get overloaded and the cost to perform sophisticated analyses cannot be justified.

London Hydro relies on the results of the annual oil analysis and the detailed inspections to develop its maintenance and replacement plans.

SUBSTATION EQUIPMENT INSPECTION CHECKLIST

Substation#: 01 **Year: 2009** **Month: 06**

Location: Ridout - SWC of Ridout and Horton streets - 4Kv building

Locks/Gates/Doors						
Fence						
Trees/Shrubs						
Warning Signs						
T1-L Structure	**Urgent**	**Timely**	**Ok**	**Comments**	**Repaired**	**Date**
Locks/Handles/Doors						
Paint/Corrosion						
Insulators						
Arrestors						
Bird/Animal/Nests						
Swgr/Cubicles/Fuses	**Urgent**	**Timely**	**Ok**	**Comments**	**Repaired**	**Date**
Locks/Handles/Doors						
Paint/Corrosion						
Oil Leaks						
Lights/Heat/Vents						
Cables/Connections						
Indicator/Relay Light						
Building/Vault	**Urgent**	**Timely**	**Ok**	**Comments**	**Repaired**	**Date**
Condition of Yard						
Exterior Brick/Siding						
Cleanliness						
Fire Ext.						
Canopy/Yard Lighting						
Inside Lighting						
Batteries	**Check Result**			**Comments**	**Repaired**	**Date**
Bank Voltage						
Cell #1/F1						
Cell #2/F2						
Cell #3/F3						
Charge Rate						
Water Level						
SF6 Switches	**Check Result**			**Comments**	**Repaired**	**Date**
Gas Pressure						
Temperature						
Rotate Light						
Transformer(s)	**Urgent**	**Timely**	**Ok**	**Comments**	**Repaired**	**Date**
Locks/Doors						
Oil Leaks						
Oil Level						
Paint/Corrosion						
Insulators						
Bus/Elbow Connections						
Temperature Gauge						
	T1	**T2**	**T3**	**Comments**	**Repaired**	**Date**
Temperature						

Tuesday, June 09, 2009 1:39:59 PM **Inspected by:** _____ **Date:** _____

3.1.4 Risk Assessment

The main risk posed by aging substation transformers is the risk to reliability if they fail. However, the majority of London Hydro's substations were built to allow for backup in the case of a transformer failure. The 4 kV Aging Infrastructure System Planning Report (2011) analyzes how much backup is available from adjacent substations and ranks those transformers and stations with limited backup as having a higher priority for maintenance and/or replacement. London Hydro has some stations that have a limited backup from adjacent stations during peak times; these stations, therefore, warrant increased scrutiny.

London Hydro's only 8 kV station feeds the rural annexed area south of London and this station will remain in service at 8 kV until it can be efficiently converted to 27.6kV. Since this station has no backup, an outage would last for the duration of the repair, but this would be a low probability event. This station is fed by two 2,000 kVA transformers that are 60 and 62 years old. If one transformer fails, the other one can pick up the load. London Hydro further improved the situation by installing step-down transformers in 2010 to supply some of the 8 kV load. London Hydro also stocks a spare 8 kV transformer so the replacement could typically be made within a day.

Older transformers also pose a potential risk to the environment due to oil leaks. Even if oil does not leave the substation site, persistent oil leaks can migrate through the gravel and soil and eventually make their way into the groundwater.

Since substation transformers were routinely topped up with oil, most of these transformers became cross-contaminated with PCB fluids since the same drums and equipment were used to maintain Askarel transformers on the network system. When it became known that PCBs were an environmental contaminant, London Hydro arranged to have all of its substation transformers tested and decontaminated. Samples were also taken from the surrounding concrete foundation, soil and gravel, and appropriate measures were taken to ensure that all of London Hydro's substation sites and transformers are PCB-free.

3.1.5 Asset Sustainment Plan

In 2011, London Hydro's System Planning Department has developed a 4 kV Aging Infrastructure System Planning Report that addresses the aging 4 kV assets which includes Substations, underground and overhead plant. The goal of this report is to identify and mitigate existing and potential risks related to the aging 4 kV infrastructure by strategically planning capital work for areas of concern.

The recommended 8-10 year plan in the 4 kV Aging Infrastructure Report will eliminate 11 of the older substation transformers; a total of 15 transformers will be decommissioned as the 4.16 kV to 27.6 kV conversion work is completed.

London Hydro can also explore the option of re-deploying relatively new transformers, as they are removed from service, in order to extend the overall life of other stations if the intention is to keep them in service for several more years until plans are made to convert them.

London Hydro will perform preventative maintenance on substation transformers whenever oil tests indicate that the oil has degraded to an unacceptable level or when the gas analysis shows that arcing by-products are present. The preventative maintenance can involve drying and filtering oil that has absorbed excessive moisture or cleaning and repairing tap changers that are arcing. Historical oil testing records are kept and compared to determine when maintenance activities need to be performed.

Corrective maintenance can also be required on older transformers, in particular, to repair oil leaks. If leaking persists and is difficult to manage, the transformer will rank higher in priority for capital improvements.

3.2 Switchgear

3.2.1 Age and Life Expectancy

London Hydro has 30 switchgear line-ups at its substations. Five of these assemblies contain breakers or switches for the protection and switching of London Hydro's non-network 13.8 kV system and the remaining 25 house breakers for the 4 kV system. Since air magnetic breakers are highly maintainable, the switchgear assembly can last almost indefinitely as long as spare parts are available and housings are maintained to prevent rust. London Hydro has a plentiful supply of spare parts for most of the switchgear currently in service. Therefore, age is not an important factor when considering replacement and refurbishment of London Hydro's station switchgear with the exception of one remaining line-up of 4 kV under-oil circuit-breaker switchgear that was built in 1959 and is nearing end of life. This 4 kV under-oil switchgear is planned for replacement in 3-5 years as part of the long term 4 kV conversion plans. London Hydro also has 13.8 kV oil-filled switchgear at Subs 2 and 6, but plans are being made to redesign the non-network 13.8 kV system to eliminate the need for this switchgear.

The chart below (Figure 3-2) shows the age of each of the switchgear line-ups and indicates by year the voltage of each assembly. A second chart (Figure 3-3) shows the number of units of station switchgear by manufacturer. As indicated above, plans will be made to redesign the non-network 13.8 kV system and this will likely eliminate the need for 13.8 kV station switchgear altogether.

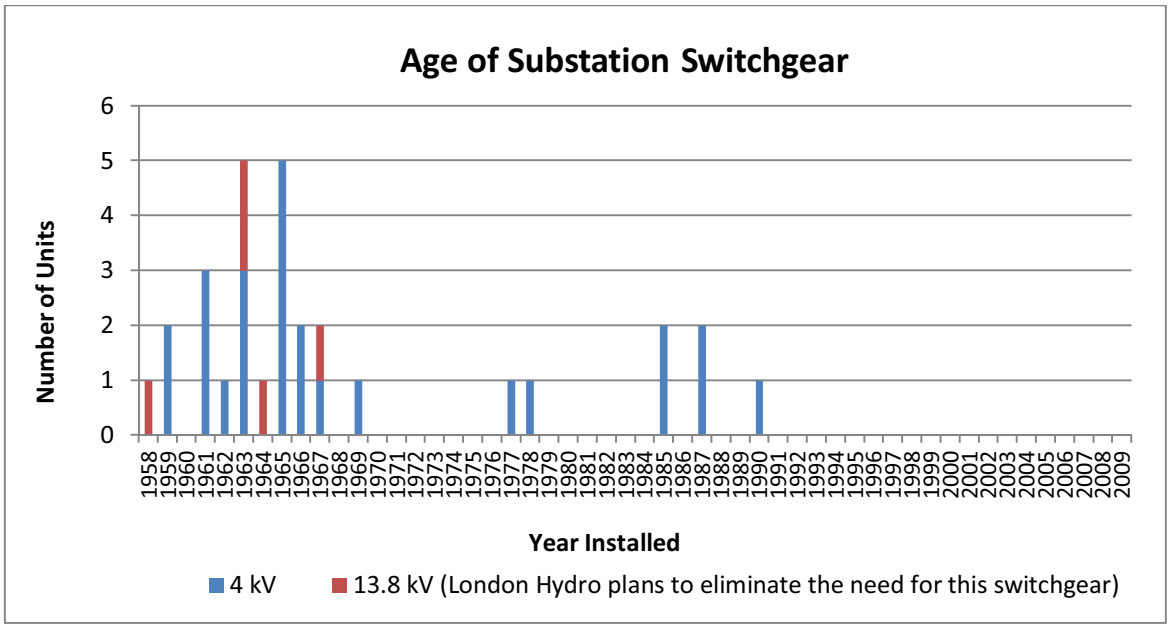


Figure 3-2 - Age of Substation Switchgear

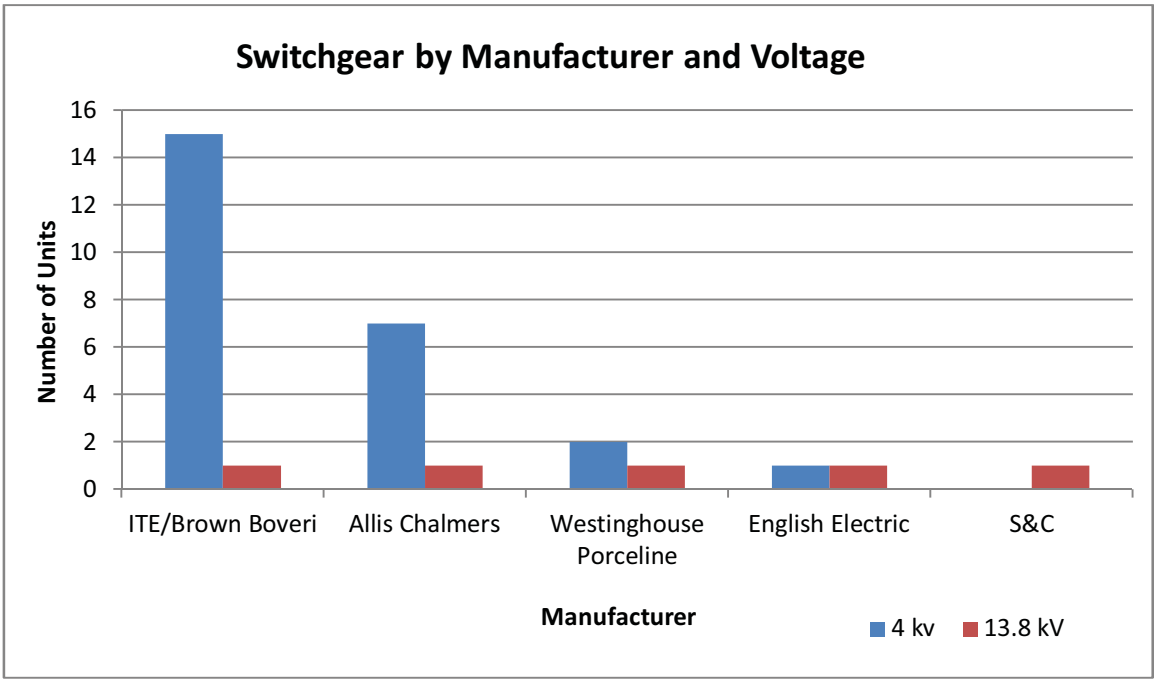


Figure 3-3 - Switchgear by Manufacturer and Voltage

In addition to traditional switchgear assemblies, London Hydro also owns 11 padmounted electronic reclosers and ten oil-filled pole-mounted reclosers that substitute for breakers at some of the distribution substations. The oil-filled reclosers are standard pole-top units that have an average life expectancy of 50 years, and they are now reaching their end of life. The padmounted reclosers are all less than 20 years old and have an average life expectancy of 40 years.

In addition, six new LC's and 10 new interrupters act as circuit breakers at Subs 10, 11, and 12.

3.2.2 Condition

London Hydro keeps detailed records of the condition found and the maintenance performed on its substation switchgear. Circuit breakers have many moving parts that are subject to wear, and they undergo some contact damage every time they open to interrupt an arc. However, London Hydro regularly maintains and repairs all of its breakers, so the switchgear can be considered to be in good condition. An exception to this would be the switchgear at Subs 2, 6 and 92, which contain oil filled breakers. There are plans to eliminate Sub 92 and plans are being developed to address Sub's 2 and 6 switch gear assemblies. The most serious problems found over the years relate to moisture ingress due to corrosion of the metalclad housings of outdoor gear, but timely repairs have kept London Hydro's outdoor switchgear in fair to good condition.

The oil-filled overhead reclosers that remain in service are older units that are reaching their end of life. They can be considered to be in poor to fair condition. The electronic padmounted reclosers are all relatively new and are in excellent condition.

3.2.3 Inspection Plan

The OEB requires that all open bus outdoor stations be inspected at least once a month and that all other types of stations be inspected once a year (The inspection checklist used by London Hydro staff

can be found immediately following Section 3.1.3). The data is entered in an MS Access database so summary reports can be generated and progress on repairs can be tracked.

London Hydro inspects indoor stations more frequently than required: usually once every two months. The main purpose of these inspections is to perform battery checks, to confirm that the station is secure and to check that in the winter all heaters are working. A more thorough inspection is conducted whenever the breakers are overhauled as part of the maintenance program (See Section 3.2.5 for more details). London Hydro also performs an annual infrared survey of its switchgear to look for hot spots.

3.2.4 Risk Assessment

The main risk posed by poorly maintained switchgear is the risk to reliability if the internal bus fails. Since each line-up of switchgear serves multiple feeders, such a failure can result in a loss of power to a large area. London Hydro uses RCM techniques to analyze how much backup is available from adjacent substations, and switchgear with limited back up is assigned a higher priority for maintenance. It is recommended that this process be formally documented and communicated to staff so the relative importance and frequency of station maintenance at critical stations is well understood.

All of the reclosers are stand-alone units that protect only single feeders. Most feeders are relatively easy to backfeed so the failure of an individual recloser does not pose an undue risk to reliability. London Hydro has, however, experienced the catastrophic failure of an oil-filled recloser on the 27.6 kV overhead system that resulted in an explosive fire and a worker being sprayed with hot oil. The failure of any oil-filled piece of electrical equipment can always pose a potential risk to safety. All 27.6 kV oil-filled reclosers have now been removed from London Hydro's system but a number of 4 kV and 8 kV units remain in service.

Switchgear that is poorly maintained can also fail during operation and can pose an arc flash hazard to employees.

3.2.5 Asset Sustainment Plan

Circuit breakers are thoroughly maintained on a regular cycle and maintenance activities include lubrication, testing, cleaning, replacement of arc chutes, etc. At the stations that still use oil-filled breakers or pole-mounted reclosers, the oil is replaced when appropriate.

Details on the maintenance performed and the conditions found at each station are kept on the Intranet for access by all London Hydro staff.

If a station is eliminated through 4 kV conversion or reduced in size to a mini-sub (2500 kVA padmounted transformer with padmounted reclosers), London Hydro keeps the legacy switchgear for spare parts or refurbishes it for reuse at another station when appropriate. London Hydro has not purchased new station switchgear for approximately 20 years, but has reconditioned switchgear that is in good condition and moved it to older stations as part of a refurbishment plan.

London Hydro does not have a specific capital plan for replacing substation switch gear on its own; however, plans such as the existing 4 kV Aging Infrastructure plan and the upcoming non-network 13.8 kV plan will help facilitate the removal of substation switch gear. The 8-10 year plan proposed by the 4 kV Aging Infrastructure System Planning report will result in the removal of seven air magnetic and one 4 kV oil filled switchgear lineup.

3.3 4 kV and 8 kV Substation T1-L Switches

3.3.1 Age and Life Expectancy

The figure below shows the number of T1-L switches used at London Hydro's 4 kV substations by type. These switches are on the primary side of the transformer and are used to isolate the 27.6 kV or 13.8 kV feed to the entire substation. Unless a switch has been replaced, it will be the same age as the 4 kV switchgear assembly. London Hydro expects these switches to last approximately 50 years.

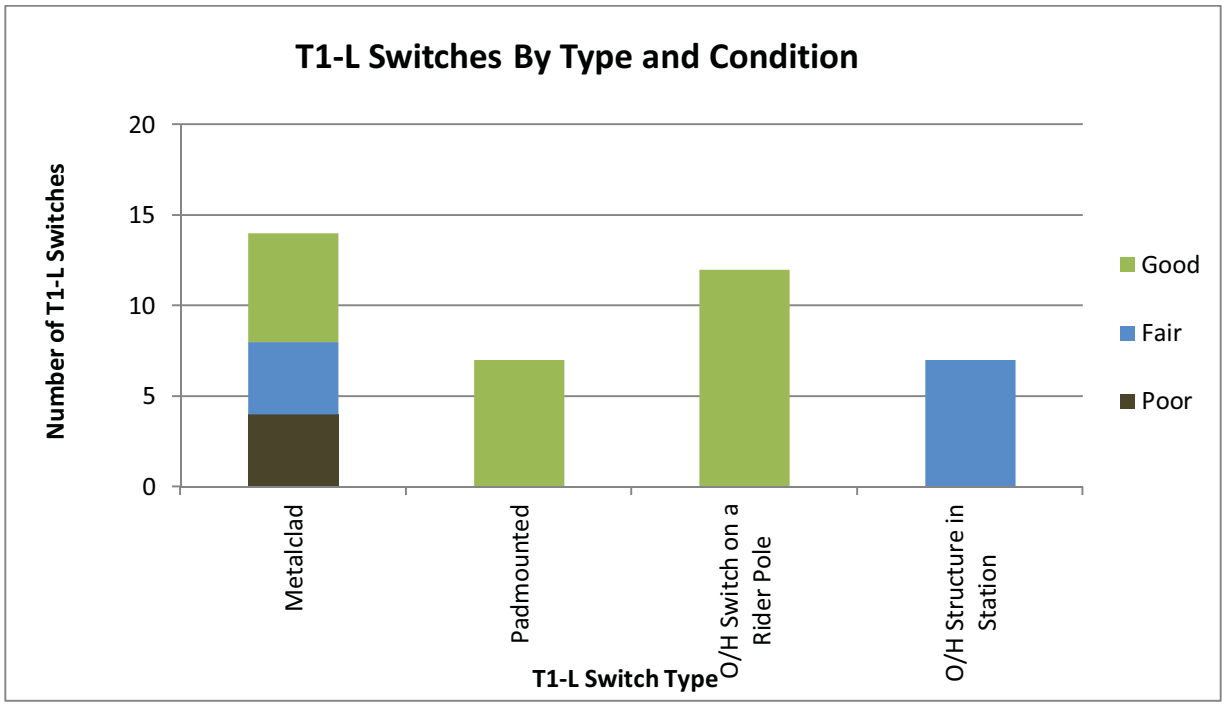


Figure 3-4 - T1-L Switches by Type and Condition

3.3.2 Condition

As illustrated above, London Hydro's T1-L switches are generally in good to fair condition, with the exception of the metalclad switches of which 29% are in poor condition. These switches are prone to rusting at the metalclad seams and despite efforts to repaint and caulk, four of London Hydro's T1-L switches can be considered to be at end of life.

3.3.3 Inspection Plan

T1-L switches are inspected on a yearly basis as required by the OEB, and the inspection checklist used by London Hydro staff can be found immediately following Section 3.1.3. The data is entered into an MS Access database so progress on problems found and repairs made can be tracked.

3.3.4 Risk Assessment

The main risk posed by the failure of a T1-L switch is the risk to reliability. Failure would result in the loss of power to an entire substation. London Hydro uses RCM techniques to analyze how much backup is available from adjacent substations to prioritize the maintenance on switches. If a substation's service territory can be supplied from adjacent 4 kV feeders, the outage would be relatively short and would pose a minimal risk to reliability. If a substation has no backup at all, the outage would last for the duration of the T1-L switch replacement or repair; such substations are given higher priority for maintenance.

3.3.5 Asset Sustainment Plan

In addition to general substation inspection programs, London Hydro also performs periodic maintenance on the T1-L switches housed in Metalclad structures or on overhead lattice structures inside substations. Maintenance activities include lubrication, testing of contact resistance, cleaning, painting, caulking, replacement of arc chutes, etc.

London Hydro has plans to replace four T1-L switches in 2012 at substations that will likely remain in service during the planning horizon. Furthermore, four Metalclad T1-L switches, two padmounted, and

two overhead switches will likely be eliminated in the next 8-10 years as part of the 4 kV conversion plans.

Fifteen of the substation T1-L switches are considered to be in poor to fair condition. In addition to the T1-L switches that will be eliminated as per the 4 kV conversion plans, London Hydro anticipates that it will need to replace one T1-L switch a year in order to sustain the substation switchgear assets.

3.4 Relays

3.4.1 Age and Life Expectancy

London Hydro has a mix of electro-mechanical and electronic relays at its substations. Any electro-mechanical relays still in service would be the same age as the associated switchgear. As Figure 3-5 below illustrates, London Hydro has now replaced the electro-mechanical relays at eight substations with electronic SEL relays, which have all been installed in the last five years. In addition, over the last ten years, London Hydro has converted eight substations to mini-subs and replaced the switchgear with reclosers or solid dielectric switches, which are also outfitted with electronic relays. London Hydro expects the electro-mechanical relays to have an average life expectancy of 50 years. There is not enough experience with electronic relays to estimate their average life expectancy; however, they will likely not need to be replaced over the next 15 years. Older substations that use pole mounted reclosers to protect the 4 kV and 8 kV feeders instead of breakers do not have relays.

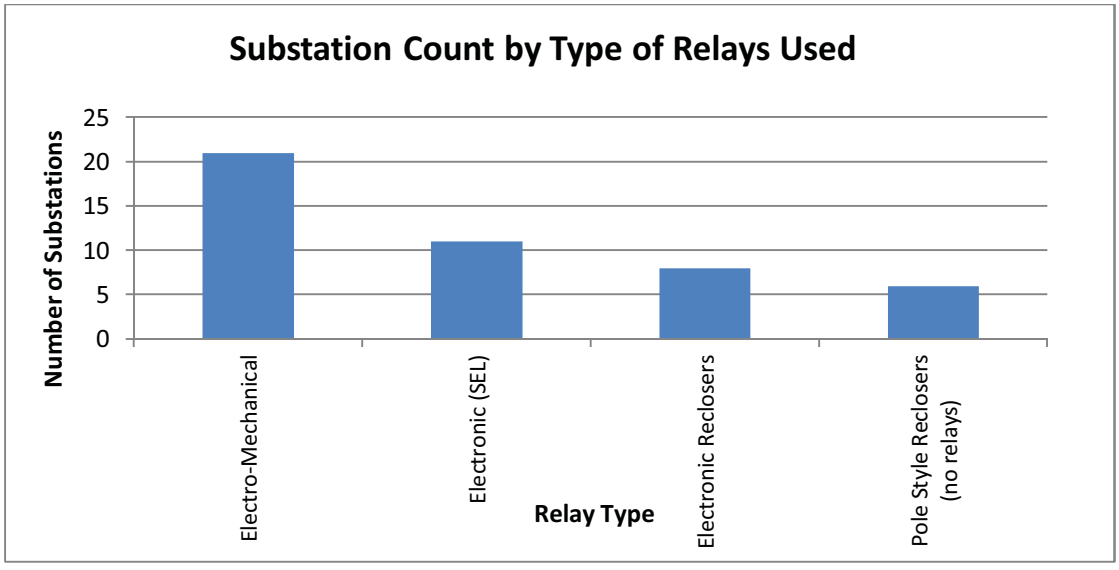


Figure 3-5 - Substation count by Type of Relays Used

3.4.2 Condition

Almost half (21) of London Hydro's substations still use electro-mechanical relays. As these relays age, they need to be calibrated more frequently. Many of London Hydro's electro-mechanical relays are old enough to be considered in poor to fair condition. Since all of London Hydro's electronic relays and electronic reclosers are new (less than ten years old), they can be considered to be in excellent condition.

3.4.3 Inspection Plan

London Hydro does not have a specific inspection plan for relays, but will attend to relays whenever mis-coordination occurs. During the maintenance cycle (see below) all relays are thoroughly inspected.

3.4.4 Risk Assessment

The failure of a relay can result in the loss of power to an entire 4kV feeder; however, all of London Hydro's 4 kV feeders have back-up feeds available (the 8kV rural feeders fed from Sub 97 do not have back-up, but they are protected by pole mounted overhead reclosers – no relays are involved). The consequence of relay failure, therefore, poses a minimal risk to reliability. However, relays are relied upon to interrupt faults on the main portion of a feeder to ensure public safety and limit equipment damage. Therefore, good calibration and maintenance are important.

3.4.5 Asset Sustainment Plan

Whenever the breakers and switchgear at distribution substations are scheduled for major maintenance, maintenance is also performed on all the relays at the substation. Relays are tested for operation, calibrated and cleaned or overhauled when necessary.

Over the past five years London Hydro has selectively replaced electro-mechanical relays with electronic relays at stations that are likely to stay in service for the foreseeable future. Relays that are in fair condition were recovered from these stations together with relays from stations that have been converted to mini-subs or eliminated altogether. This practice has provided a modest stock of usable spares.

Long term plans to address the aging 4 kV infrastructure over the next 8-10 years, will result in the removal of 6 stations equipped with electro-mechanical relays.

Seven substations have been outfitted with simple electronic relays that still need an RTU at the substation to communicate with the Control Room while one substation (93) has intelligent electronic relays that can communicate directly. London Hydro does not anticipate the need for capital expenditure to individually replace aging relays as a modest stock of usable spares will be obtained through the process of decommissioning stations as voltage conversion work takes place.

3.5 Buildings

3.5.1 Age and Life Expectancy

Seventeen of London Hydro's Substations are housed in buildings and one building (Sub 2) no longer houses any switchgear, but is still included as a substation asset that London Hydro needs to maintain. These buildings range in age from 97 years of age (Sub 4) to 27 years of age (Sub 48). London Hydro's buildings are all built on solid foundations with block or brick construction and can last indefinitely with proper maintenance. The following table shows the year in which each substation building was built.

Table 3-1- Substation Building Ages

Substation	Age
2	1921
4	1913
6	1929
15	1960
16	1961
17	1965
18	1961
23	1964
25	1961
27	1963
29	1965
36	1965
37	1968
38	1966
48	1983
52	1966
54	1969
92	1959

3.5.2 Condition

In general, the buildings are in good to excellent condition and will require no replacement or major refurbishment over the next 15 years.

3.5.3 Inspection Plan

During routine substation inspections the buildings are checked to ensure that they are secure and the public cannot gain access to the electrical equipment housed within. The OEB requires indoor stations to be checked at least once a year, but will often inspect them every couple of months while doing battery checks.

3.5.4 Risk Assessment

As buildings age they can pose a risk to workers or the public if structural components fail. There is also a risk to reliability from leaking roofs and vandalism. A major leak or flooding may result in damage to other assets in the building and may affect power supply and reliability.

3.5.5 Asset Sustainment Plan

London Hydro has a Facilities Manager who looks after the maintenance of all of London Hydro's real estate assets. It is anticipated that London Hydro will continue to fund modest repair activities, such as new roofs, window replacements, landscaping etc. No major structural repairs are expected over the next 15 years. Furthermore, five of the eleven stations planned for conversion are currently housed in brick buildings. London Hydro does not currently have plans for removing the substations buildings but will maintain them until plans are made to eliminate them.

3.6 Batteries

3.6.1 Age and Life Expectancy

London Hydro maintains 31 banks of substation batteries with the oldest dating from 1997. Batteries are required at substations with circuit breakers to allow the breakers to be opened and closed during power outages. Stations with electronic reclosers on the 4 kV feeders rely on power from the 27.6 kV system to operate the recloser and only small batteries are required for the electronic relays. If properly maintained, batteries are expected to last 10 to 15 years.

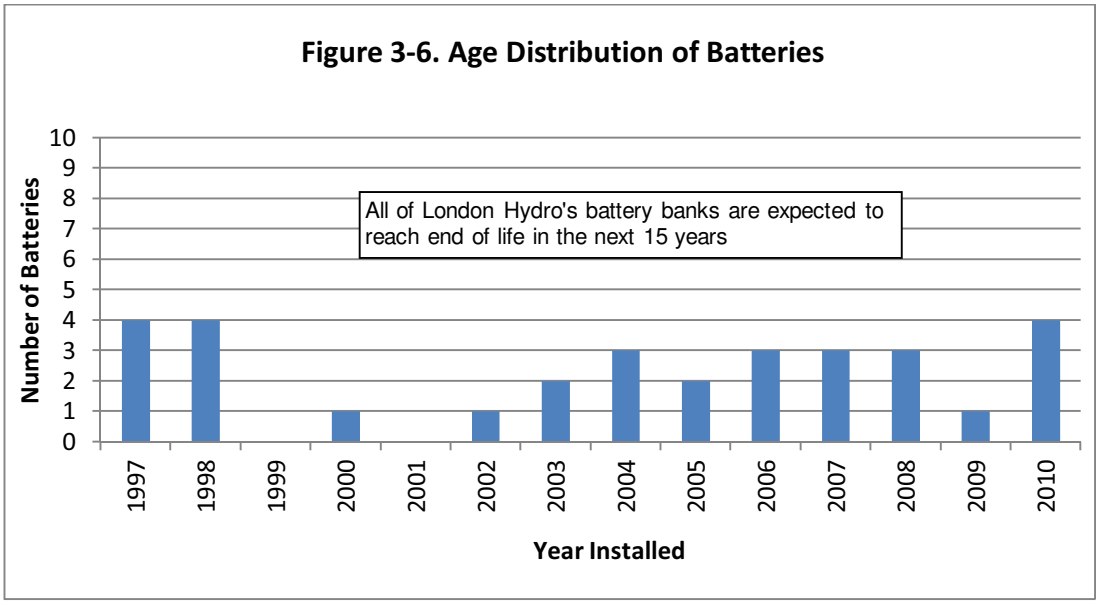


Figure 3-6 - Age Distribution of Batteries

3.6.2 Condition

London Hydro's battery banks are replaced as part of an ongoing program, and they are well-maintained and in good condition.

3.6.3 Inspection Plan

London Hydro inspects its batteries at least once every two months to check voltages and electrolyte levels. Battery voltage is also measured and communicated to the Control Room via London Hydro's SCADA system.

3.6.4 Risk Assessment

Batteries are a critical component of distribution substations since they need to be in good working order to allow the resetting and operation of circuit breakers during power outages. The failure of batteries can result in power outages lasting longer than necessary.

3.6.5 Asset Sustainment Plan

Two schedules for battery maintenance have been developed. The first is an inspection program to ensure that all batteries are inspected, tested and cleaned at least once every two months and the second is a more rigorous program to perform battery draw-down testing at each substation at least once every three years.

London Hydro has a budget for the replacement of batteries at substations as they age. Over the time horizon of this ASP, all 31 battery banks will reach their end of life. However, several substations are planned to be converted/eliminated within the next 8-10 years as per the 4 kV Aging Infrastructure report. For this reason, 9 battery banks will be eliminated and hence no capital expenditure for these stations is required. The remaining 22 batteries will need to be replaced over the next 15 years. Six battery banks will be 15 years old in 2013; those are planned for replacement in 2012 and 2013. The remaining 16 units will need to be addressed over the years 2014-2026.

3.7 Summary and Recommendations

London Hydro is at a turning point with its 4 kV substations. Although the substation assets are in relatively good condition and pose minimal risks to reliability, many of the 4 kV assets have reached their end of life; including 4 kV overhead and underground circuits. The 4 kV Aging Infrastructure System Planning report has identified, assessed, prioritized, and recommended an 8-10 year plan to address the depreciated 4 kV plant. Drivers such as Asset Condition, Station Contingency, Reliability, Station Loading, and Future Developments & plans have been an integral part of the planning process to efficiently manage the end of life transitions.

London Hydro plans on keeping the spending on substations at a minimum knowing that the current long term plan is to convert to 27.6 kV. London Hydro's existing plan of addressing the aging 4kV substation asset will include the removal of the following assets over the course of the next 8-10 years:

Substation Asset	2-4 year plan	5-7 year plan	8-10 year plan
Substation Transformers	Facilitate the removal of 5 station transformers	Facilitate the removal of 5 station transformers	Facilitate the removal of 5 station transformers
Switchgear Lineup	Eliminate 3 air insulated switchgear lineups, and one oil filled switchgear lineup	Eliminate 2 air insulated switchgear lineups, and one padmounted style of switch gear lineup	Eliminate 2 air insulated switchgear lineups, and 2 padmounted style of switches
T1-L Switches	Replace 4 T1-L switches in substaions	Eliminate 1 SF6, 2 polemounted, and 1 padmounted T1-L switches	Eliminate 1 SF6, 1 polemounted, and 2 padmounted T1-L switches

4 - Padmounted Transformers

London Hydro has 6,764 padmounted transformers on its distribution system. 1,107 transformers are three-phase units and are primarily used for commercial services. The majority of these transformers are supplied at 27.6kV primary voltage. A mix of 4.16kV and 13.8kV transformers makes up the remaining 136 three phase padmounted transformers.

5,657 single phase padmounted transformers are installed on the system and are mainly used in residential subdivisions and can be located in the front yard or backyard of homes. A total of - 5,088 transformers are installed on the 27.6kV system. Similar to the three phase transformers, units that are fed by 4.16kV or 13.8kV primary voltage are a small percentage of the total count. Both three phase and single phase transformers are discussed in this section.

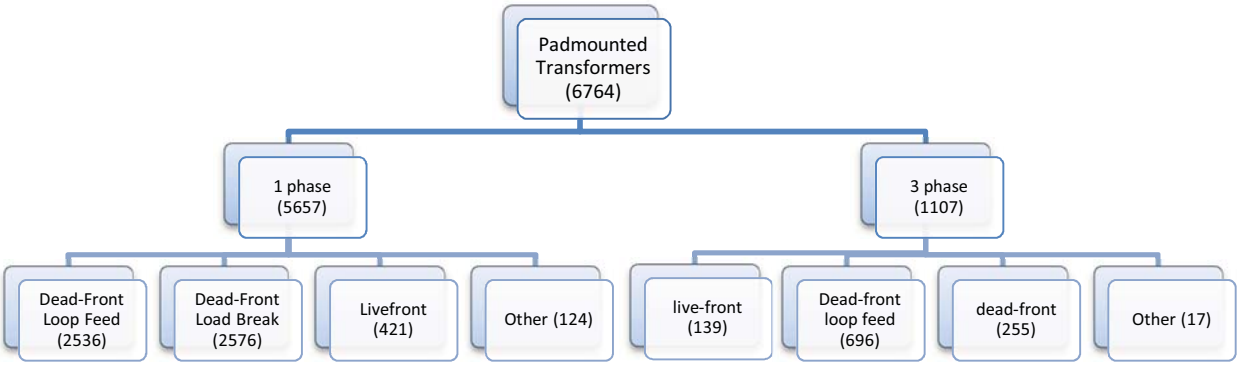


Figure 4-1 - Breakdown of Padmounted Transformers

4.1 Age and Life Expectancy

Padmounted transformers have a useful life range of 30-40 year and are expected to operate without major refurbishment or maintenance during their life cycle. For the purpose of this ASP, a typical life of

40 years is used for the average life expectancy to estimate their 15 year replacement rate. Figure 4-2 and Figure 4-3 show the age distribution of transformers per voltage class.

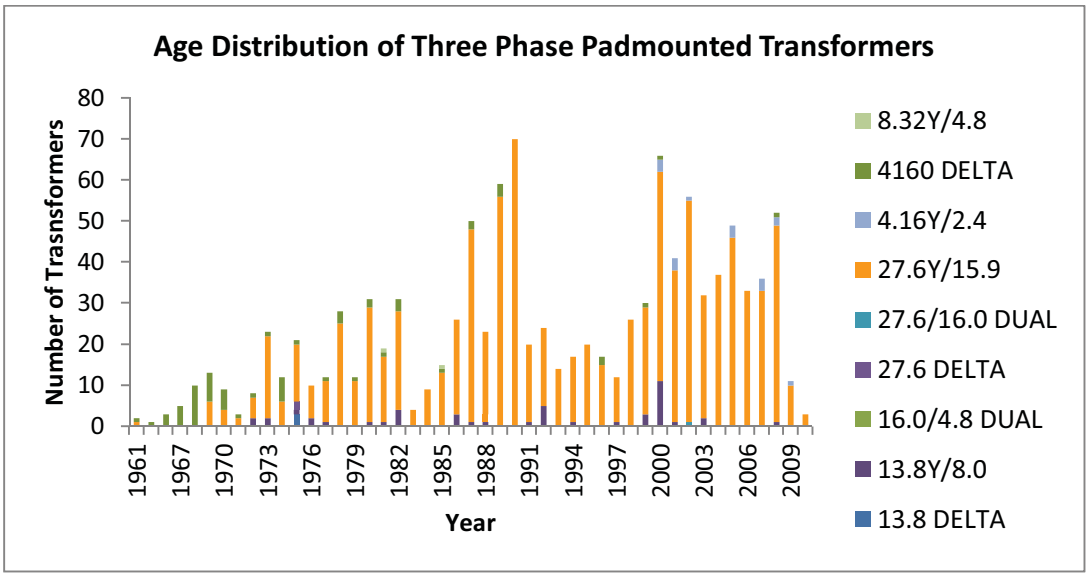


Figure 4-2 - Age Distribution of Three Phase Padmounted Transformers

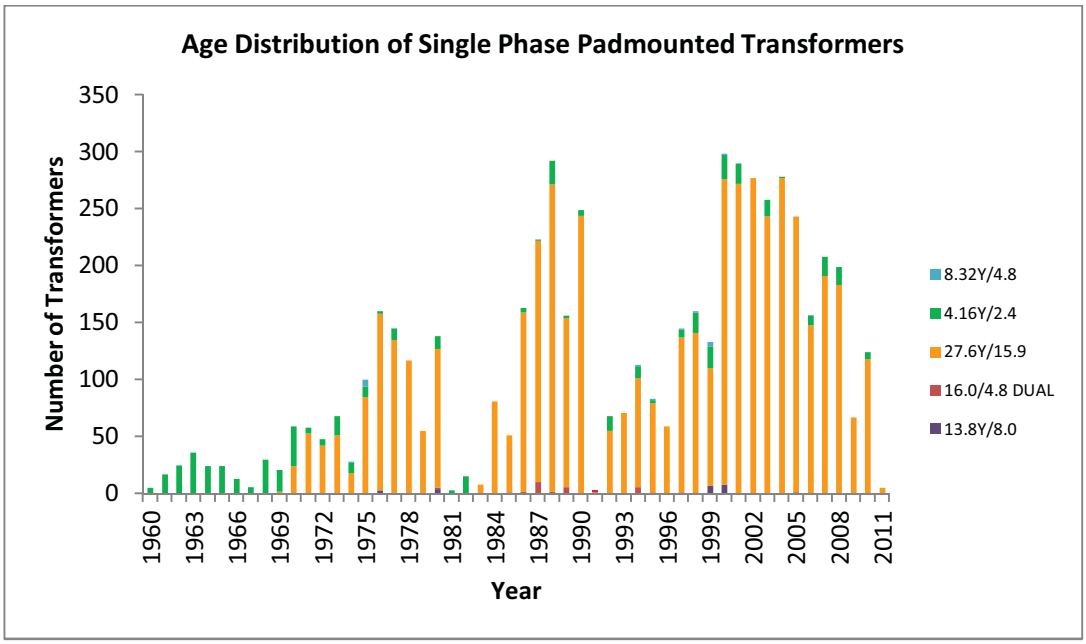


Figure 4-3 - Age Distribution of Single Phase Padmounted Transformers

4.2 Condition

London Hydro inspects all of its three phase padmounted transformers once every three years as part of the mandated OEB audit. Table 4-1 - Inspection Results from 2009-2011 Audits illustrates the general condition of the 5,200 transformers inspected during the 2009-2011 inspection cycle.

Table 4-1 - Inspection Results from 2009-2011 Audits

	Corrosion/Paint	Placement	Lock	Grade Change	Access	Oil Leaking (Y/N?)	Barriers	Insulators
Good	74%	99%	98%	98%	89%	97% (No)	91%	91%
Fair	22%	1%	2%	2%	6%		3%	3%
Poor	4%				5%	3% (Yes)	6%	6%

As a result of this inspection, 185 transformers, considered in poor condition, have already been replaced and/or refurbished.

Paint peeling and corrosion account for most of the problems reported. Transformers that exhibit corrosion are more likely to leak oil in the near future. London Hydro uses a 5-point ranking system to grade the severity of a leak. Transformers that receive a ranking of 5 are replaced immediately; those that receive a 4 are scheduled to be replaced within a month; those receiving a 3 are monitored and replaced within an annual budget cycle. Scores of 1 or 2 indicate minor problems due to seepage that do not pose an immediate concern, and these results are noted and the transformers scheduled for re-inspection in a time frame shorter than the three year period.

Figure 4-4 and Figure 4-5 present the age distribution of single phase and three phase transformers respectively based on whether they are live-front or dead-front type.

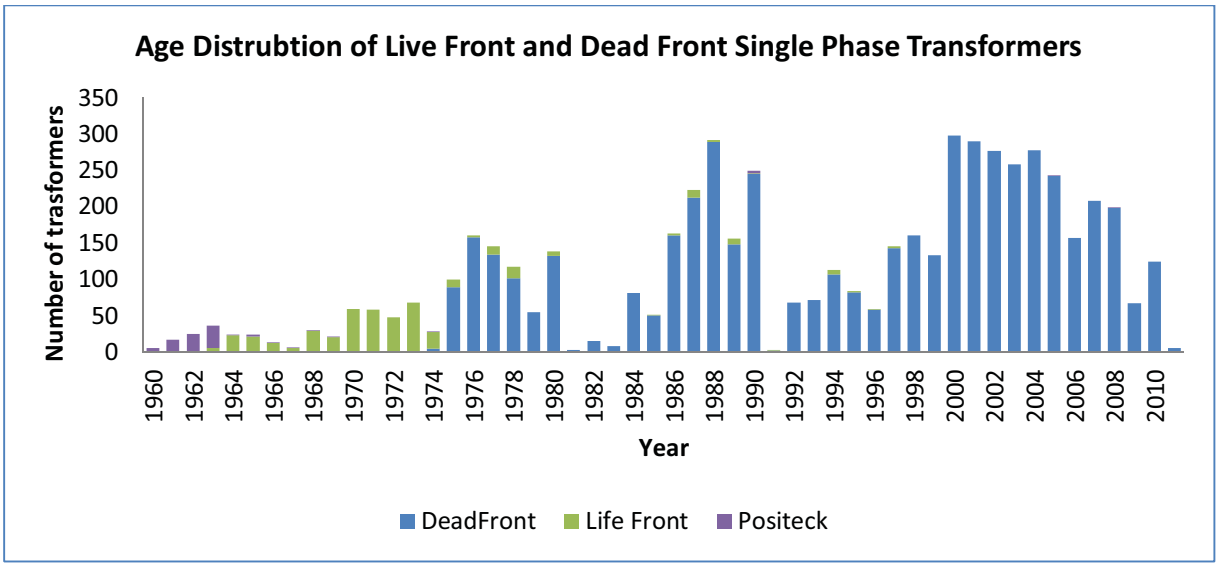


Figure 4-4 - Age Distribution of Single Phase Transformers by type

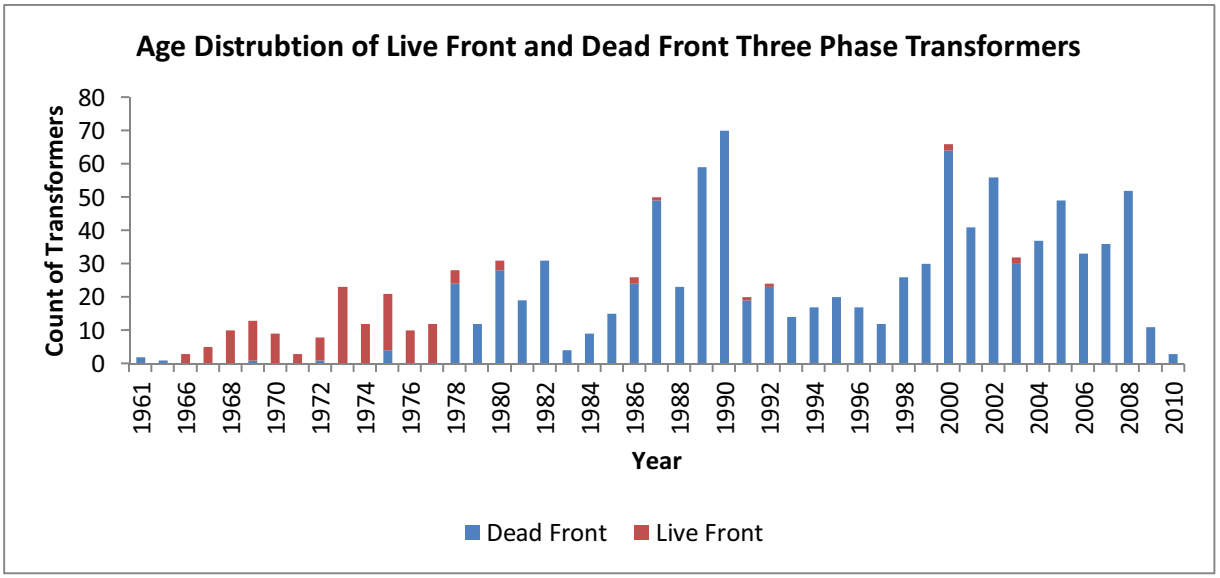


Figure 4-5 - Age Distribution of Three Phase Transformers by type

The charts show that:

- 70% of single-phase **live-front** transformers will reach their useful life by the end of 2011 and this will rise to 100% by the year 2026. These transformers will continue to score poorly on corrosion levels, barrier and insulation failures, as well as oil leaking assessments during the OEB audits.

- 100% of the single-phase transformers that are over 40 years of age are live-front style.
- 0% of the single-phase dead-front transformers have reached the threshold of 40 years. This will change to 40% in 15 years.
- 90% (42 units) of the live-front three-phase transformers have reached the theoretical end of their useful life as of 2011.

4.3 Inspection Plan

London Hydro conducts a thorough visual inspection on all padmounted transformers once every three years as part of the OEB mandatory audit. Below is the form showing the type of data collected on this asset during the audit. During the inspection, London Hydro also uses an infrared camera to look for overheated connections or components. Any deficiencies found are recorded and equipment found to require 'urgent' attention is slated for immediate replacement/repair.

In addition, London Hydro is investigating the merits of performing oil samples on three phase transformers rated 250kVA and above.

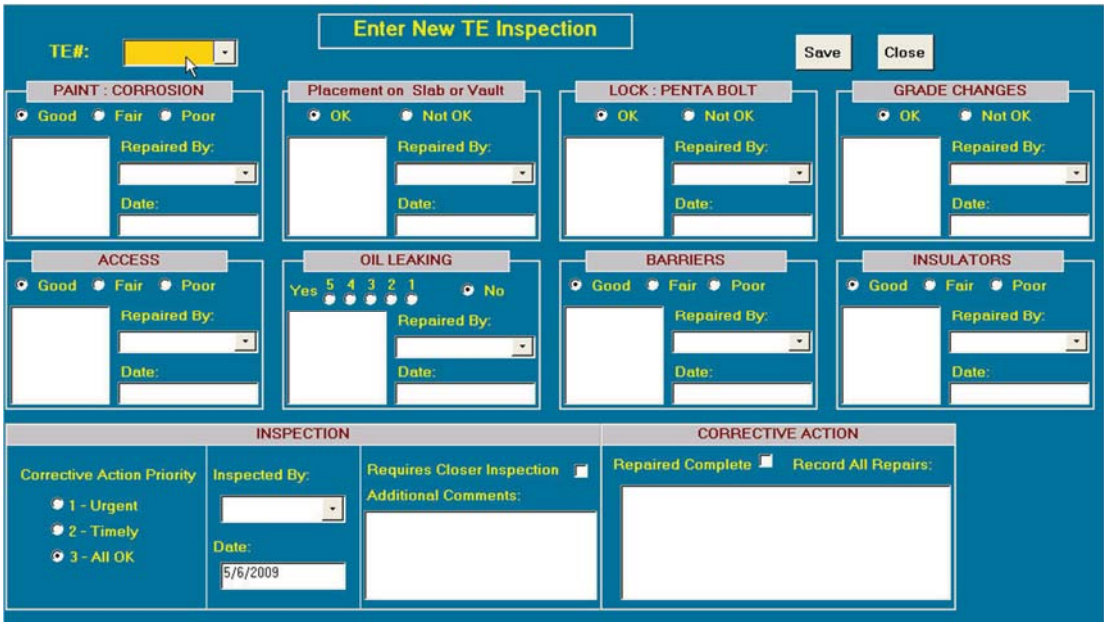


Figure 4-6 - Inspection Checklist –Padmounted Transformers

4.4 Risk Assessment

Transformer failures pose a risk to reliability if they fail, but since each transformer feeds only a limited number of customers, the impact of an individual transformer failure is very low. As live-front transformers age, they become a safety risk to employees. Switches can fall apart while they are being operated and there is an ever-present risk of flashover.

Across North America, approximately 10% of all transformers have been found to be inadvertently contaminated with PCBs above 50 ppm. To eliminate the risks associated with PCB fluids, London Hydro has tested all of the transformers on its system and have retro filled any found to be above 50 ppm so that no PCB contaminated transformers are left on the system.

In the 1990s London Hydro along with other utilities, experienced a handful of canister fuse failures on three-phase padmounted transformers. Certain combinations of gassing fuses and weak spring mounts resulted in the explosive ejection of the canister fuse – in some cases blowing the door off the transformer. Work is ongoing to trace the history of this problem and to define the current situation.

As mentioned above, padmounted transformer failures have a minor impact on the overall system reliability. On average, London Hydro experiences about 30 failures annually related to padmounted transformers. The statistics below include failures of components attached to the transformers' housing, such as loadbreak elbows, inserts, live front transformer barriers, and failure of mechanical switches.

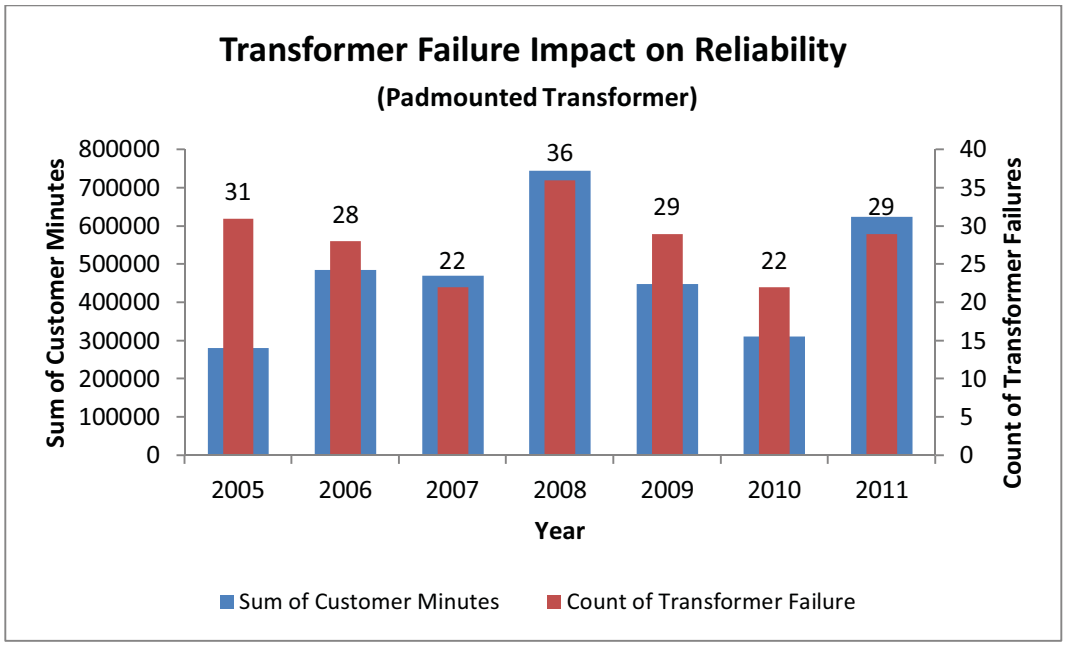


Figure 4-7 - Transformer Failure Impact on Reliability

4.5 Asset Sustainment Plan

4.5.1 Single Phase Transformers

This plan has identified that 1498 single-phase transformers will reach their theoretical end of useful life by 2026; 434 of these will reach end-of-life by 2013. That is not to say that all of these units will be replaced in that time horizon. There are a number of elements that are considered in determining which transformers will be replaced in a given budget cycle and of these age is only one consideration.

In order to sustain the single phase padmounted transformer assets, London Hydro should continue to monitor the reliability performance of its transformer populations and plan to target the replacement of approximately 100 transformers per year. Considering that London Hydro is implementing a multi-year cable rehabilitation work in its residential underground system (see Section 2.1.5), the replacement of these single phase transformers will be naturally aligned and scheduled for refurbishment at the same time. This will also facilitate the silicon injection of cable by providing switchable transformers in these subdivisions.

Figure 4-8 shows the theoretical replacement schedule for single phase padmounted transformers; when levelized over the horizon of 15 years, it's equivalent to 94 transformers per year.

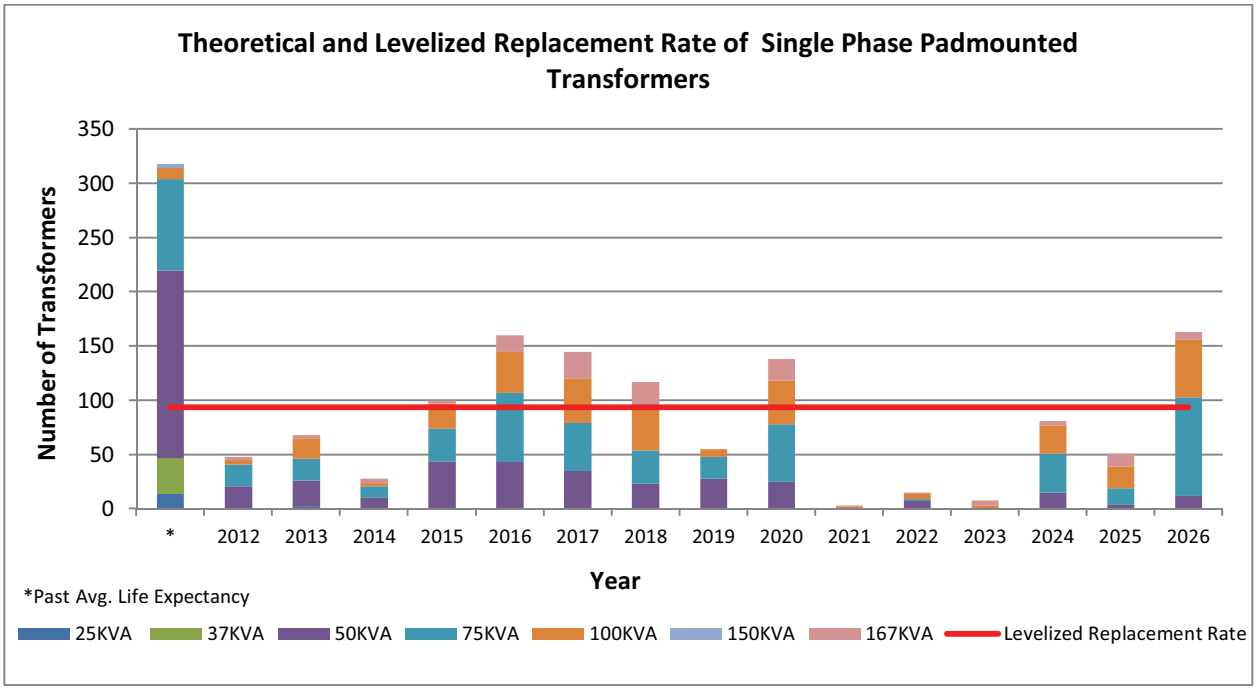


Figure 4-8 - Single phase transformers reaching end of life over the next 15 years

4.5.2 Three Phase Transformers

This plan has identified that 331 three-phase transformers will reach their end-of-life by 2026 and also that 77 of these will reach end-of-life by 2013. As indicated above, not all of these units will be replaced in that time horizon. There are a number of elements that are considered in determining which transformers will be replaced in a given budget cycle ad of these age is only one consideration.

The theoretical replacement rate of three phase padmounted transformers is shown in Figure 4-9; the yearly levelized replacement rate is approximately 21 transformers.

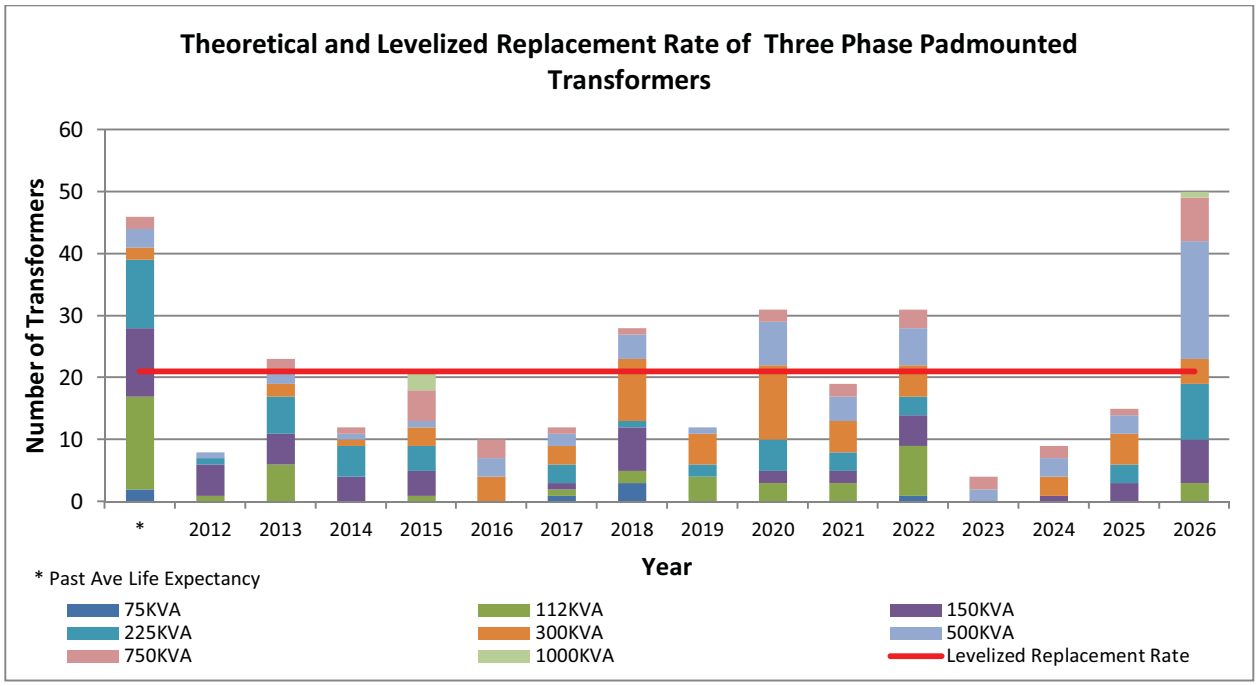


Figure 4-9- Three phase transformers reaching end of life over the next 15 years

5 - Padmounted Switchgear

London Hydro has 186 padmounted style switchgear units on its distribution system. The oldest of these were introduced in the early 60's and are live front air insulated switching enclosures. Over the years, London Hydro has used the nomenclature "SE" to refer to Padmounted Air Insulated Switchgear Enclosure.

Typically, Switching Enclosures (SEs) consist of a three-phase enclosed busbar and four bays, each connecting to the bus via a manual switch providing a means of redistributing power via a maximum of three bays. In total, there can be up to twelve cables terminated inside one unit. SEs serve two purposes: one is switching and/or isolating functionality and the second one is a protective function. The fuses accomplish the protective function, by operating when a fault current is sensed downstream, while maintaining the power to the customers on adjacent phases (if the loads are single phase).

Generally, SEs are positioned at the entrance to a residential subdivision, fed by a riser or by another SE. Very often, if the subdivision is large enough, two or three SEs could be connected in series, typically fed from more than one direction and looping through the subdivision with established normally open points. This arrangement is most common in order to provide backup supply in case of a faulted section of the system.

In 2006, London Hydro introduced a new type of switchgear which has solid dielectric insulation and was given the nomenclature "LC" for Load Center.

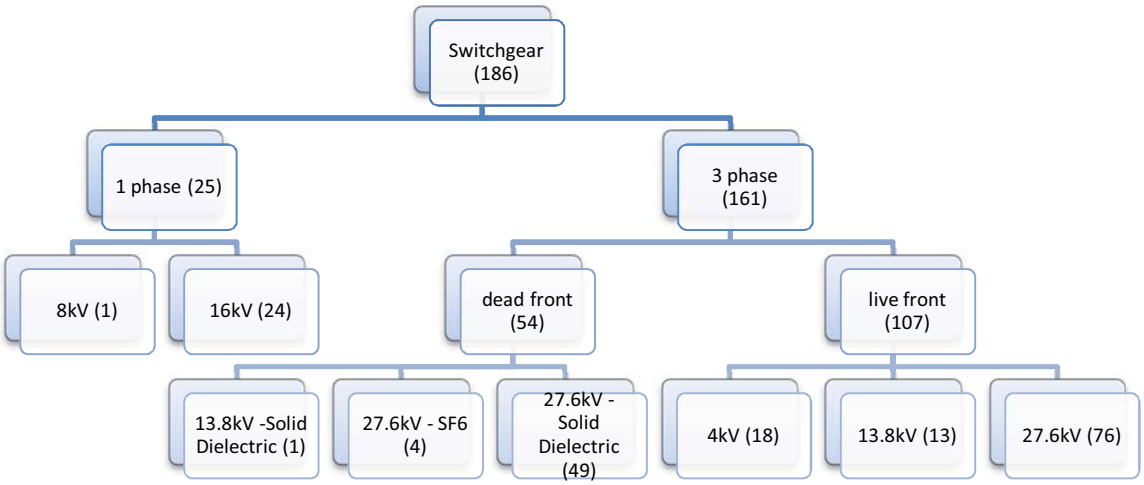


Figure 5-1 - Breakdown of Switchgear by type and voltage class

5.1 Age and Life Expectancy

London Hydro has three types of switchgear that utilize different insulation mediums: Air-insulation (SE), Gas Insulation (SF6) and Solid-Dielectric insulation (LC). The average useful life of the switchgear is dependent on its vintage and insulation class. The useful life of London Hydro's Switching Enclosures is 40 years for Air Insulated switchgear and it is expected to be 50 years for Solid Dielectric switch gear. London Hydro inspects and maintains all of its major assets and expects the vast majority to reach the maximum useful life.

Table 5-1-Useful life of Padmounted Switchgear

Insulation Type	MIN	TYP	Max
Air Insulated	20	20	40
Gas Insulated	30	30	50
Solid Dielectric	30	30	50

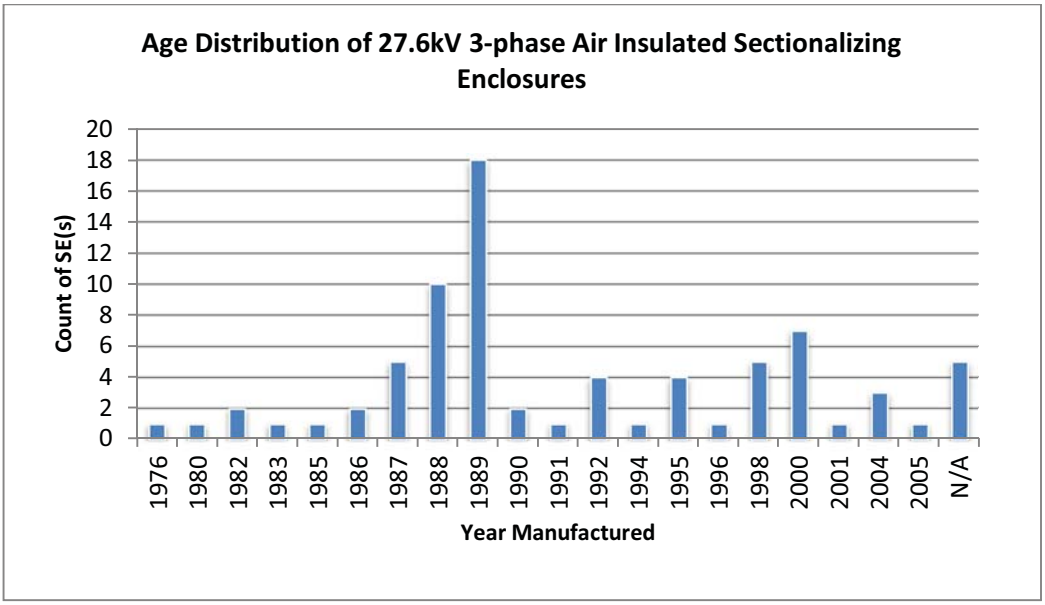


Figure 5-2 - Age Distribution of Sectionalizing Enclosures - Air Insulated 27.6kV

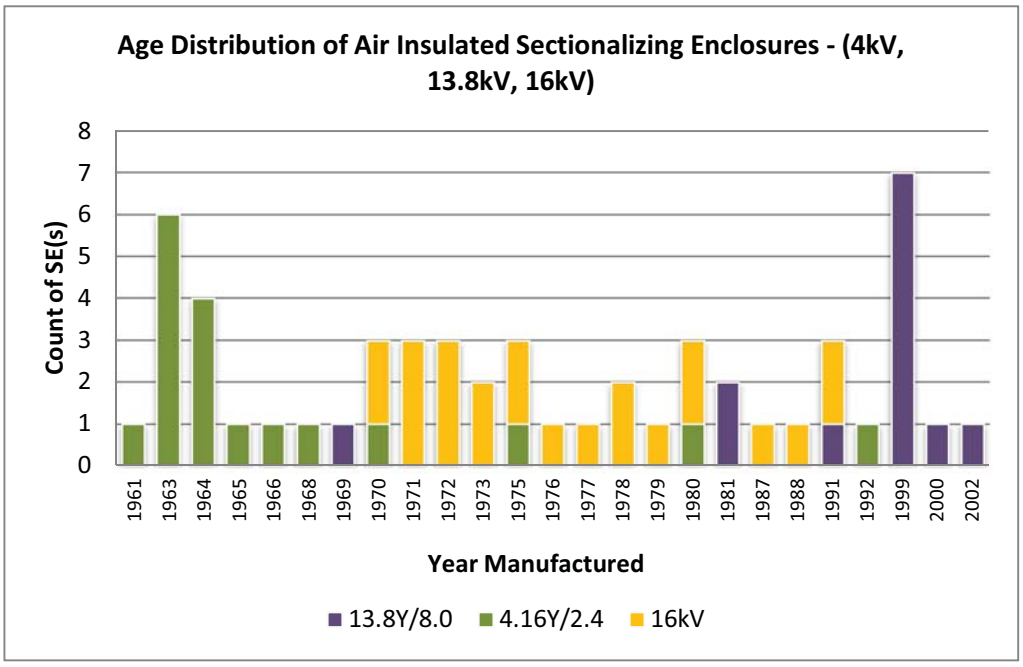


Figure 5-3 - Age Distribution of Sectionalizing Enclosures - Air Insulated (4kV, 13.8kV, 16kV)

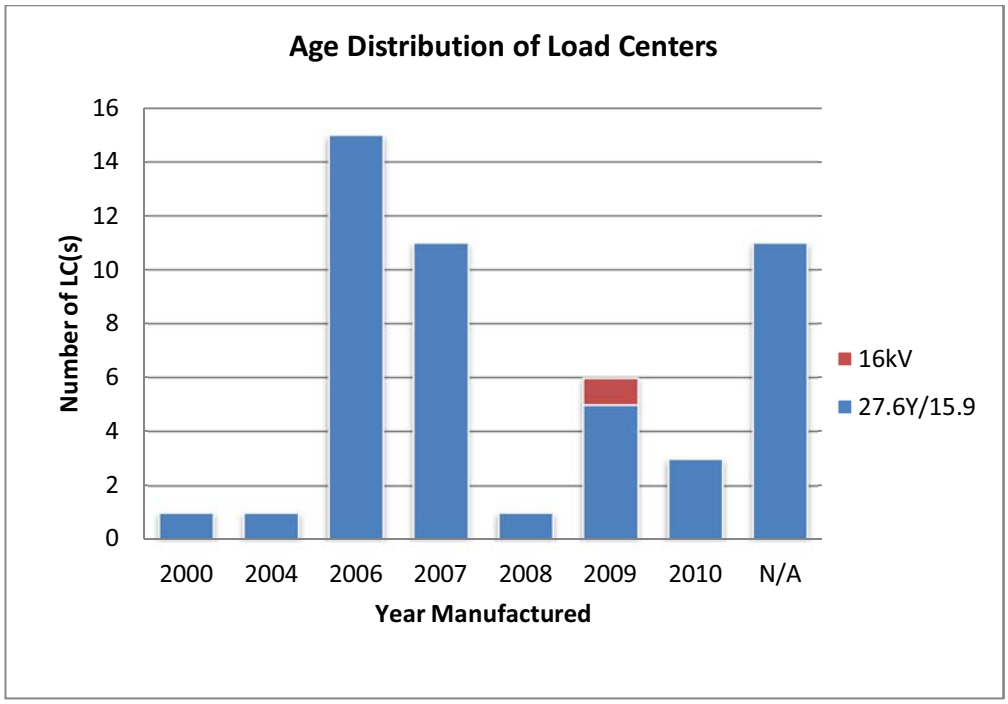


Figure 5-4 - Age Distribution of Load Centers

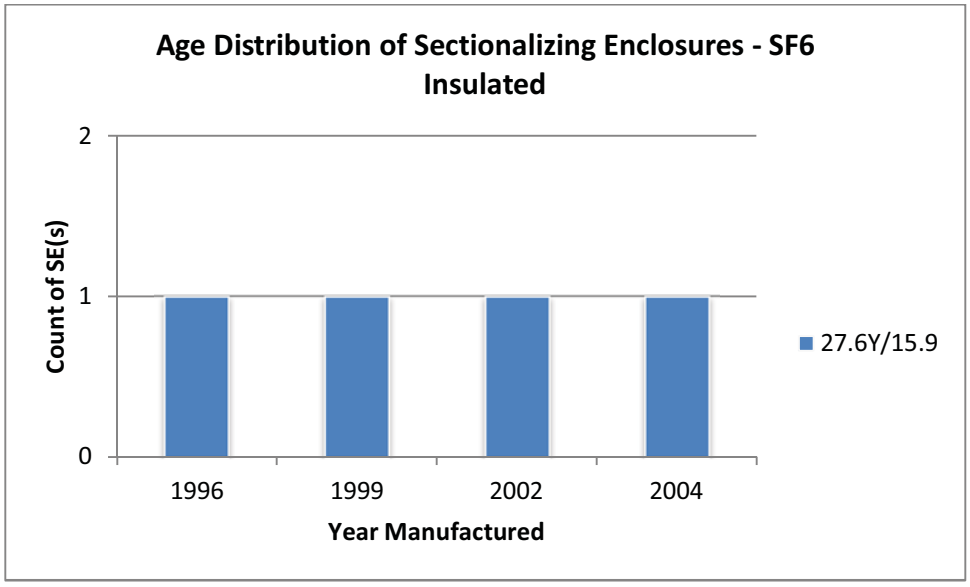


Figure 5-5 - Age Distribution of Sectionalizing Enclosures - SF6

5.2 Condition

London Hydro has experienced many deficiencies and failures with the 27.6kV live front (air-insulated) pad-mounted switching enclosures. A number of failures in the late 1990's led to the adoption of a dry ice cleaning program with the assumption that in-service flashovers and failures in this type switchgears are due to contamination and damp conditions. The dry ice cleaning program did not, however, mitigate the flashover failures of air insulated 27.6kV switchgear at London Hydro. In 2006, an extensive review of the SE performance and failure modes concluded that the flashovers leading to failure in 27.6kV SE's stem from corona activity (trapped ionized gases) in the SE's.

Following the 2006 review, an aggressive replacement program has been implemented and it has significantly reduced the total count of SE's identified with high corona levels. In the last 5 years a significant improvement has been shown in reducing customer outages related to SE failures. Since 2006, approximately 68 live front padmounted switching enclosures units, operating on the 27.6 kV have been either removed or replaced with deadfront (solid-dielectric) switchgear.

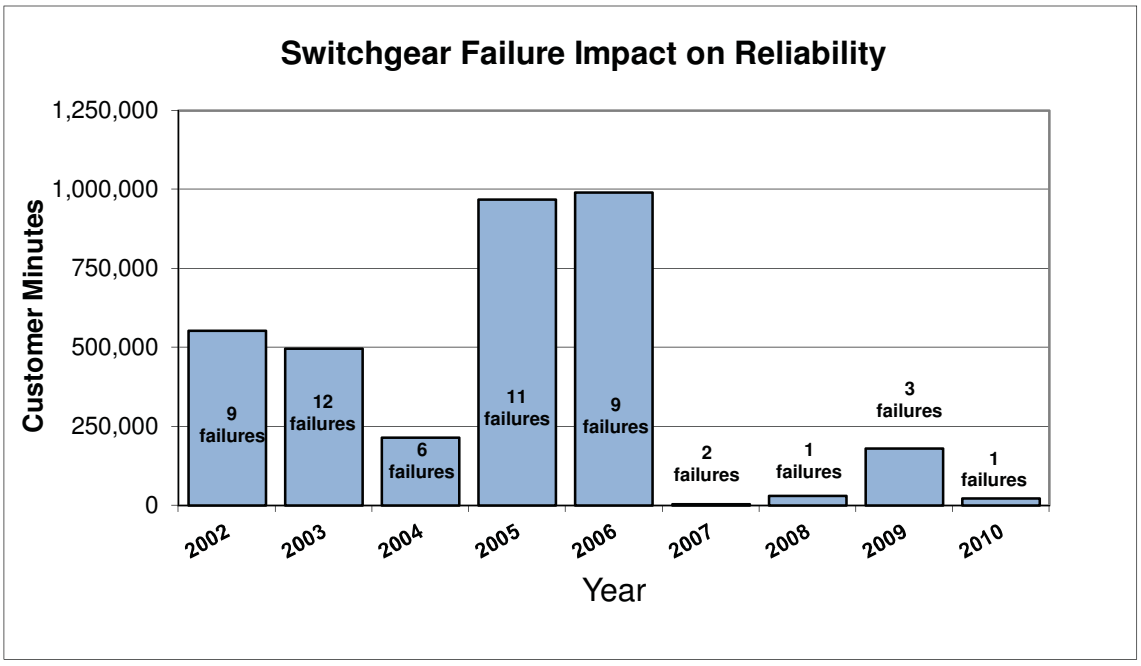


Figure 5-6 - Switchgear Failure Impact on Reliability

Both the 13.8kV SE's and solid dielectric LC's are relatively new and can be considered in good condition. The yearly inspection and maintenance plans will maintain these units in operable and satisfactory condition over this planning horizon.

5.3 Risk Assessment

Switching Enclosures are an essential part of the underground distribution system. However, they are infrequently used for switching operations and they typically interrupt load well below their ratings. Therefore, switchgear aging and eventual end of life is often established by mechanical failure, e.g. rusting of the enclosures or ingress of moisture and dirt into the switchgear causing corrosion of the operating mechanism and degradation of insulated barriers.

In Addition, in-service 27.6kV three-phase air insulated SE's installed on London Hydro's system have experienced frequent internal flashover failures. It has been determined through research and field measurements, that high levels of "corona" are the root cause of the flashover failure in the 27.6kV air insulated SE's. [12]

Switching Enclosures are mainly installed in an open environment and are therefore exposed to adverse environments where rusting of the enclosure or ingress of impurities such as moisture and dirt act as a catalyst in shortening useful life. Again, the useful life of a Switching Enclosures is not solely related to the age of the equipment but also its environmental setting.

London Hydro has experienced 74 failures inside air-insulated gear since 1995. This is a significant rate of failure considering the investment in replacing the failed units. It is recognized that the design rating of the units is 25 kV and this explains partly why failures on the 4 kV system are rare (the same units are being used on both systems).

Year 2000 was the time when London Hydro initiated a maintenance program for the SEs using the "dry-ice cleaning" process. This method cleans the unit using carbon dioxide dry ice blast sprayed over the interior parts of switchgear units (insulators, barriers, fuses, blades, etc). At the time, many utilities were

12 Performance Review and a New Perspective of In-Service 27.6kV Three-Phase Air Insulated Sectionalizing Enclosures" report, 2006

implementing this program in an attempt to maintain the insulating components clean of dust and contamination that could become conductive. The results were not as good as expected and failures continued to occur.

For 27.6kV rated equipment operating at 13.8kV and 4kV, the risk of failure primarily results from aging. In these instances replacement timelines are age dependant and this is reflected in the schedule in section 5.5. However, for air insulated units operating at 27.6kV, there are other problems in addition to age that need to be considered. Hence, the replacement rate of air insulated switch gear operating at 27.6kV has been addressed appropriately in section 5.5.1.

5.4 Inspection and Maintenance Plan

In 2000, an extensive inspection was performed on all of London Hydro's SE's to determine the causes of failure and to recommend solutions. After attempts at re-insulating, refurbishing and dry-ice cleaning, it was determined that corona generation was the root cause of the problems. A complete corona survey was conducted in 2006 and has been repeated as required to rank units for replacement.

Annual inspection audits are done on all SE's and LC's; the OEB audit requirement is once every three years. London Hydro also takes the opportunity to use an infrared detector to look for hot spots during the annual inspection. Furthermore, these field inspections are a crucial part in ranking critical SE's (deteriorated with higher risk of failure).

5.5 Asset Sustainment Plan

A replacement schedule of the major types of depreciated Switching Enclosures is included at the end of this section.

5.5.1 Air-insulated 27.6kV switchgear

Despite efforts to mitigate the high rate of failure, the SE's continued to fail and London Hydro experienced 11 failures in 2005 as well as 9 failures in 2006. Air insulated SE's continue to experience flashover failure, but the rate and impact on reliability has decreased significantly.

After establishing that intense corona activity in medium voltage SE's was the root cause of the problem (these air insulated SE's are under-rated for operating at 27.6 kV), London Hydro began a program to replace SE's with non air-insulated enclosures and to continue eliminating non-essential units.

There are 67 27.6kV units remaining on the system. The current plan is to replace/eliminate all high voltage 27.6kV air insulated switchgear expriencing high corona levels with solid dielectic load centers over the next 8 years as illustrated in the 15 year replacement schedule (Figure **5**-**7**). Critical units, with high corona levels, are given priority for replacement/elimination on a yearly basis. The ranking is driven from the annual inspection audits.

5.5.2 Air-insulated 16kV, 4.16kV

Today, there are a total of 24 single-phase 16kV and 18 three-phase 4kV switching enclosures in service. Virtually, all of the 4kV and 80% of the 16kV switching enclosures will need to be dealt with over the next 15 years. See Figure 5-2 for the proposed 15 year replacement schedule.

5.5.3 Air-insulated 13.8kV

The useful life of a 13.8kV air insulated switching enclosure is at least 20 years. Today, four of these SE's have been in service for over 20 years, but, yearly maintenance and inspection plans have allowed for the 13.8kV units to remain in operable conditions— extending their useful life to their maximum range of 40 years.

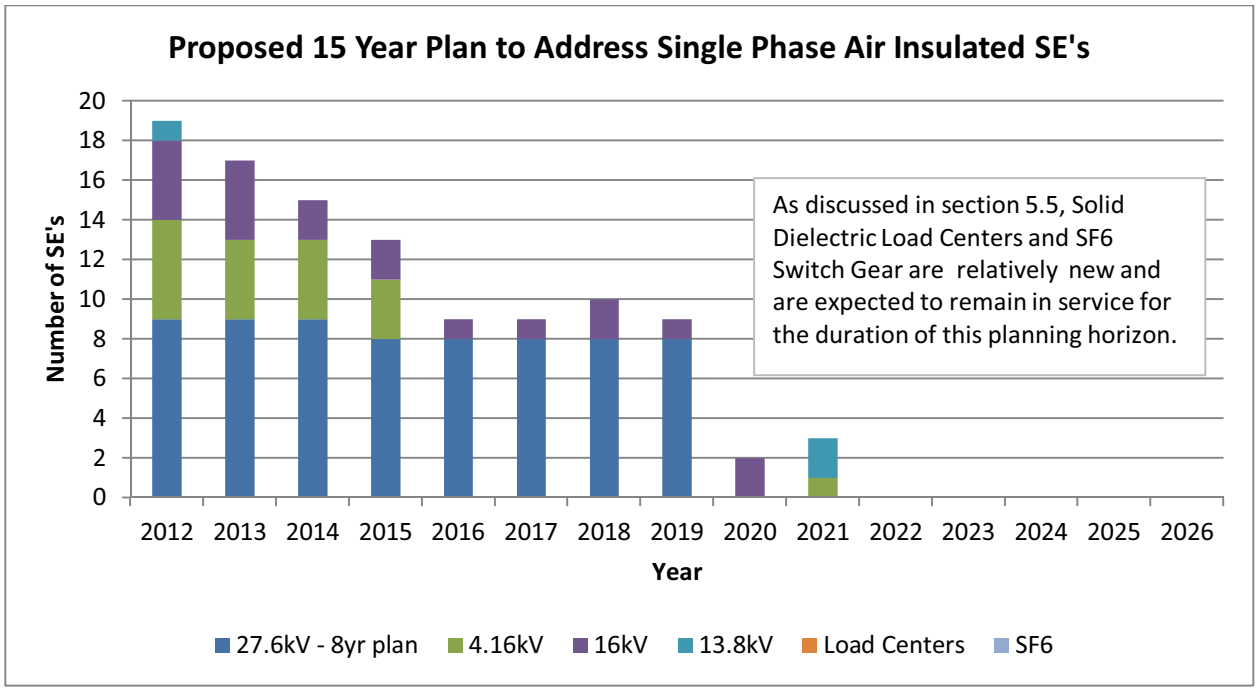
13.8kV SE's installed after 1990 will be nearing 40 years of service at the end of the planning horizon and will need to be considered in a future 15 year plan. However, two older 13.8kV units may need to be replaced as they have reached their theoretical useful life. With appropriate inspection and maintenance, the replacement date of these units can be extended.

5.5.4 LC's (Dielectric Insulation)

Load Centers have been recently introduced to the London Hydro system and are expected to last 40 years. The 49 solid dielectric LC's that were installed to replace the air-insulated units are very new and will likely remain in excellent condition over the next 15 years.

Summary:

The Figure 5-7 below shows the proposed 15 year replacement rate for switchgear at or reaching end of life over the course of this planning horizon.



5-7 - **Count of Switching Enclosures reaching their life expectancy over the next 15 years**

6 - Network Transformers & Protectors

London Hydro's network system is divided into two areas – the main downtown core and the east end network at Adelaide and Dundas Street. The network in the downtown core consists of five primary 13.8 kV feeders, five oil switches that divide the feeders into ten children, 76 transformers and an interconnected 208 volt secondary system. The east end network, similarly, has a 208 volt secondary and consists of 2 transformers and three primary 13.8 kV feeders. There are also a number of spot networks that feed customers at 600 volts.

The high voltage cables that are associated with the network system are covered in Section 2, "Primary Underground Cable," and the secondary system associated with the network is covered in Section 10.2, "Network Secondary Cables and Accessories." The replacement of an old network transformer with a newer one will require a PILC-EPR transition splice of the primary cables in the manhole to allow for an EPR style termination of the cables at the transformer chamber. The additional cable and transition splices are not a subset of this asset group, but are discussed here for completeness.

In 2009 London Hydro constructed a new ring bus feed for the network system to permit the network to be fed from 27.6 to 13.8 kV step-down transformers. The equipment associated with this new ring bus will eventually be included in Section 3, "Substations," but it is new and not currently discussed in the ASP.

6.1 Network Transformers

6.1.1 Age and Life Expectancy

The ratings of the 78 transformers on the two network systems are as follows:

- 37 are 750 kVA,
- 32 are 500 kVA,
- 4 are 1000 kVA and
- 5 are 1500 kVA.

Network transformers have a stacked core design, which allows them to fit efficiently in vaults under sidewalks. The design of the older units in particular has contributed to their longevity. In fact, London Hydro has a number of transformers that were rebuilt in the 1950s and are still in service (making the age of some components much older than that). In this Asset Sustainment Plan a typical lifespan of 40 years is used.

Figure 6-1 below shows the age distribution of all the network transformers on London Hydro's system.

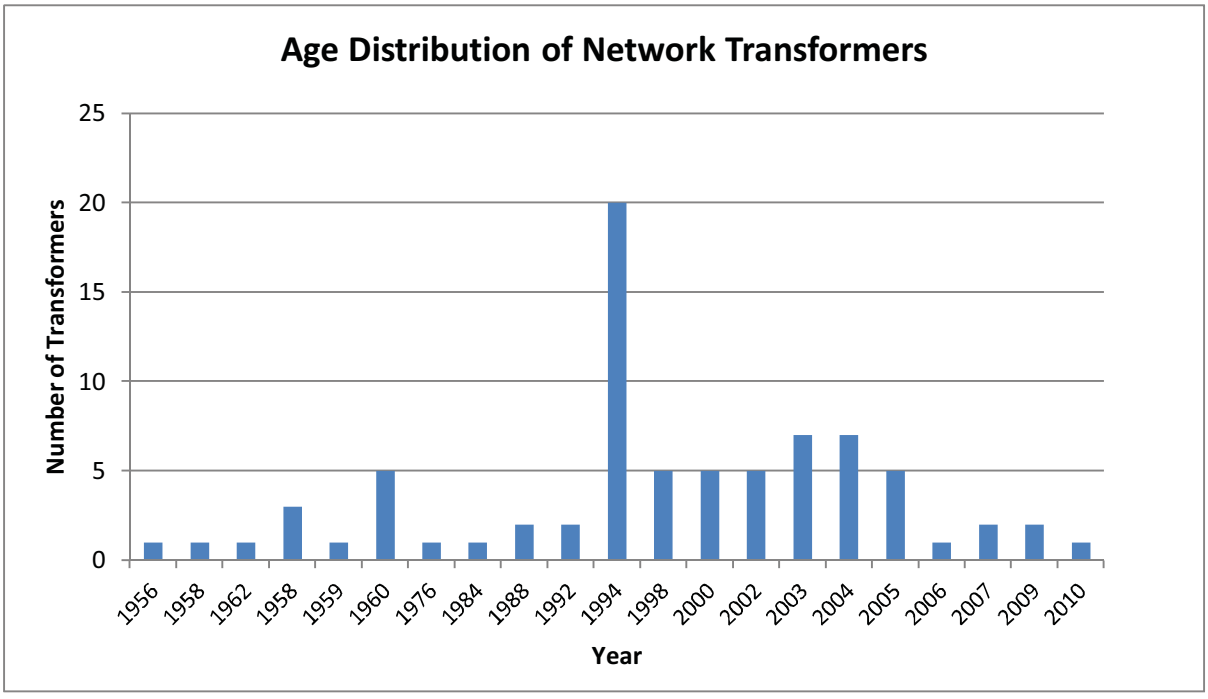


Figure 6-1 - Age Distribution of Network Transformers

It is important to note that the network system will not be expanded. Over the next 15 to 20 years the plan is to eliminate the network entirely and replace it using current standard designs supplied at 27.6 kV. However, it may be necessary to install new transformers to sustain the network as plans are developed to eliminate the network entirely.

6.1.2 Condition

London Hydro has proactively replaced all of its PCB-filled transformers, and as a result 40 of the 78 transformers in service are less than 15 years old and are in excellent condition. Twelve transformers are nearing their end of life and have been in service for approximately 50 years and can be considered in poor condition. The remaining transformers range in condition from fair to poor. All transformers are monitored and inspected frequently.

6.1.3 Inspection Plan

The OEB's Distribution System Code (DSC) requires all customer specific substations to be inspected on an annual basis and otherwise requires all distribution transformers to be inspected once every three years in urban areas. Since London Hydro's network systems feed critical core areas of the city, inspections are performed more frequently, typically once every two months. The checklist below is used for these inspections and includes inspection of not only the transformer itself, but also of the integrity of the vault and access systems.

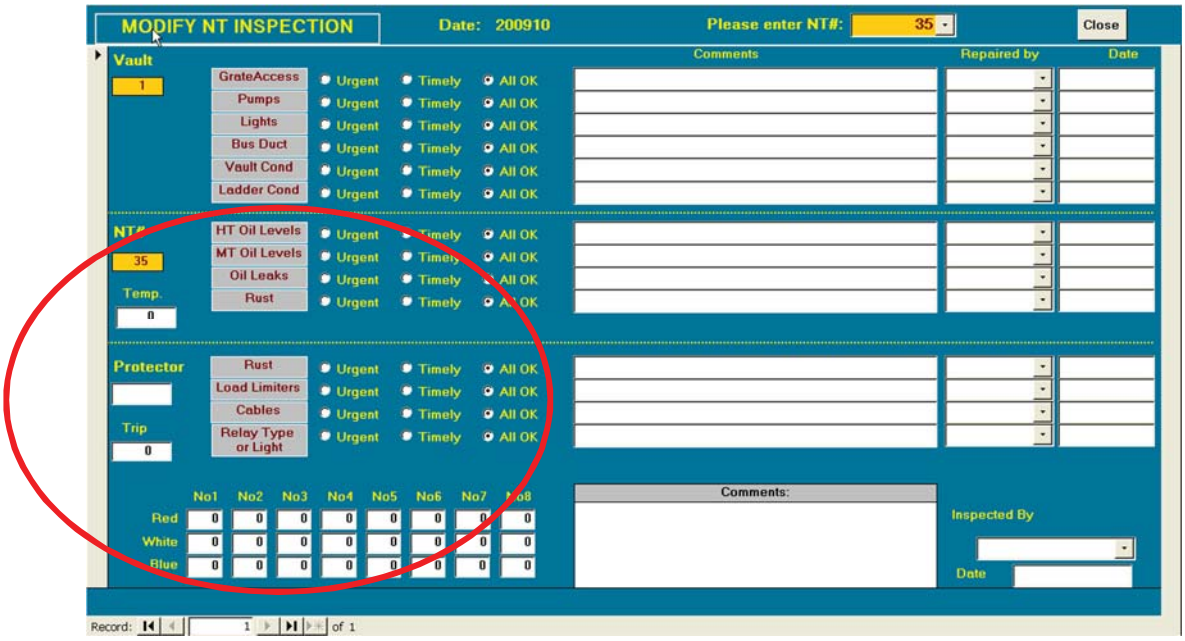


Figure 6-2 - Inspection Checklist – Network Transformers

When problems are found they are ranked and progress on their repair is tracked on a monthly basis. When urgent repairs are required they are addressed as soon as possible and longer term problems are forwarded to the Engineering Department to be included in refurbishment and replacement plans.

London Hydro also takes oil samples from its network transformers annually since they can be a useful indicator of incipient faults. London Hydro uses infrared inspection equipment to look for overheated connections and components.

6.1.4 Risk Assessment

Since network transformers are interconnected on the low voltage secondary side, the failure of an individual transformer rarely results in a power outage. However, within the general network system there are a number of spot networks that are isolated from the main interconnected secondaries. If a transformer or protector fails on a spot network at the same time that one of the primary feeder cables is out of service, an outage can result. All of London Hydro's spot networks have been connected to the SCADA system to relay the status of all the protectors and loads in real time to minimize the chance of an outage.

The failure of a network transformer poses a minimal risk to reliability; however, due to their unique location under sidewalks with open grates these transformers could pose a serious safety hazard to employees or the public if their failure involves a fire or explosion.

Although the vaults that house the network transformers have sump pumps that were originally installed to expel rain water, the risk of simultaneously discharging oil as the result of an oil leak has led to the disabling of all sump pumps on the network system. While this minimizes the risk to the environment, it can result in water accumulation and corrosion. Following heavy rain falls, London Hydro staff will confirm that standing water is oil-free before activating the sump pump to drain the vault.

6.1.5 Asset Sustainment Plan

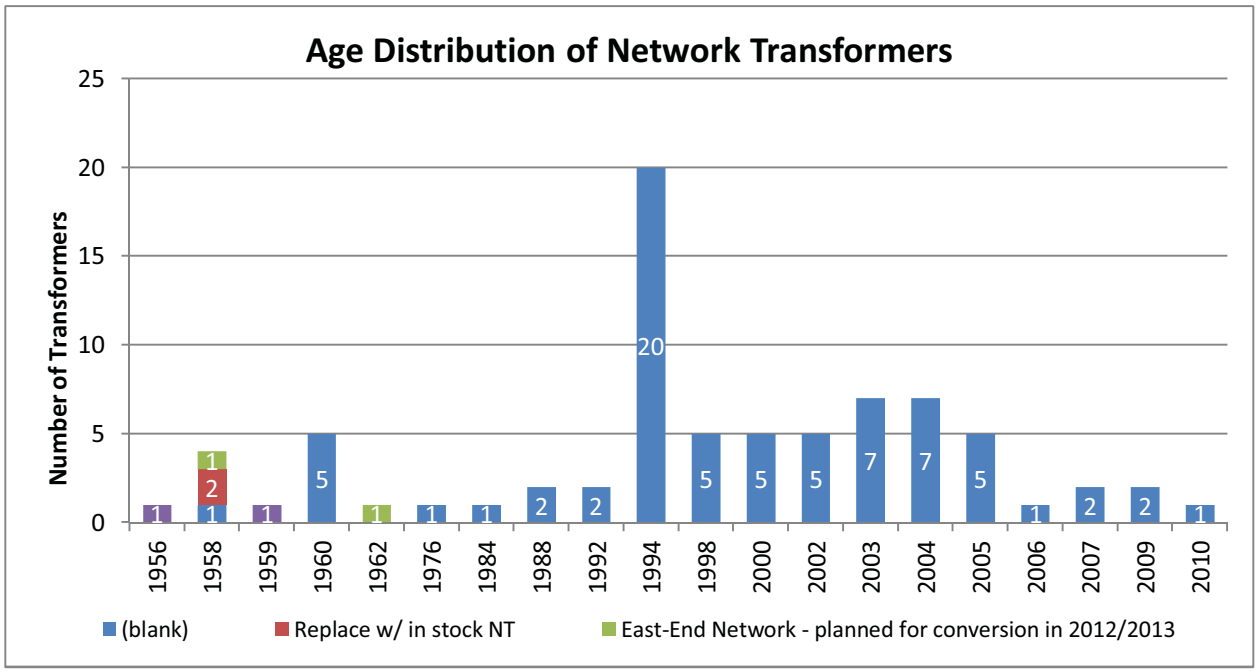


Figure 6-3 - Age distribution and present and future replacement plans

Over the next 15 years, fourteen network transformers will reach 40 years of age; however, twelve of them are already over 40 years old. Corrosion and oil leaks are the main problems that are encountered as network transformers age. But as mentioned previously, the Network Transformers are inspected and

maintained frequently and any problems that are found during inspection are forwarded to the Engineering Department to feed into capital replacement plans. Privileged

The majority of London Hydro's Network Transformers and Protectors are relatively new and will not need to be replaced over this planning horizon. The 14 transformers that are near their theoretical end of life will be addressed in one of the following manners:

- Replaced with recovered transformers from other customer voltage conversions;
- Eliminated due to customer voltage conversion plans,
- Or in some cases, London Hydro will need to acquire new transformers to replace the depreciated ones.

Fortunately, London Hydro has six relatively new (4-10 years old) network transformers that are available in stock to replace aging transformers since the voltage conversion of a large network customer was completed in 2011. For capital planning purposes, the most depreciated network transformers are scheduled to be replaced with these newer transformers.

New installations of refurbished network transformers will be terminated with EPR cables at the high voltage chamber. This will result in the need for added cable transitions to connect to the existing high voltage PILC Cable. The costs of laying the new cable will depend on the nearest available manhole where a PILC-EPR transition can be installed. Furthermore, there will be additional capital cost associated with refurbishing the high voltage chamber to accommodate an EPR cable termination. It is uncommon for London Hydro to remove multiple network transformers (see above discussion) from service before they reach their end of life. London Hydro will seize this opportunity and replace older in service transformers with the newer ones over the next two years. Although the cost of the network transformer has already been paid for, there will be additional capital expenditure related to the installation of the new EPR cable, cable transition splices, and retrofitting of the high voltage chamber of the transformer. The four remaining transformers will need to be replaced with new units.

The elimination of the East End Network has been ongoing for several years and more work will be required over the next two years to complete the project.

6.2 Network Protectors

6.2.1 Age and Life Expectancy

Protectors are required on network systems to prevent backfeed from the meshed secondary during primary cable or transformer faults. They contain sophisticated relays that can sense the direction of current and small variations in voltage to ensure that primary cable faults are isolated from all sources of power and backfeed.

The protector itself is similar to a circuit breaker and can last almost indefinitely as long as spare parts are available and housings are maintained to prevent rust. Most of London Hydro's protectors are now housed in waterproof enclosures, but London Hydro is still using a handful of drip-proof and dust-proof covers that are not as effective at keeping the units dry.

Protectors that are not in waterproof enclosures are expected to last only 40 years and protectors in waterproof enclosures should last at least 50 years. Over the past 10 years London Hydro has replaced most of the mechanical relays with electronic relays, and as of the end of 2009, only 8 protectors still have mechanical relays, which will need to be replaced over the next few years.

Some of the electronic relays have failed prematurely for unknown reasons, so it is uncertain as to how long they will last. For the purpose of this plan, the assumption will be made that no other electronic relays will need to be replaced over the next 15 years.

London Hydro does not have accurate records on ages of the protectors themselves. Protectors get moved around and refurbished and have not been accurately tracked over time. For now, it can be assumed that the age of the protectors matches the age of the transformers. As part of the GIS enhancements project, London Hydro should include protectors as a new field device in the system so the age, location and maintenance history of individual protectors can be more easily tracked.

The following table shows how many of each size of protector London Hydro has on the two network systems.

Table 6-1 - Size and Quantity of Protectors on London Hydro's Network System

Size	Quantity
1200	3
1500	1
1600	37
1875	3
2500	34
Total	78

6.2.2 Condition

London Hydro has replaced or refurbished over 50 of its protectors in the last 10 years. At least this many protectors are, therefore, in excellent condition. Assuming that the remaining protectors are the same age as their associated transformer, London Hydro can surmise that 15 protectors are in fair to poor condition and will reach end of life over the next 15 years.

6.2.3 Inspection Plan

During the inspection of network transformers, London Hydro performs a cursory inspection of network protectors. This inspection typically occurs once every two months and involves checking that the protector is in the closed position and that the cables and load limiters associated with the protector are in good condition. The housing is inspected for rust, but the cover is not actually opened unless the protector will be undergoing its regularly scheduled maintenance, as described below.

Protectors will sometimes open automatically under light load conditions, but if inspections reveal that a protector is regularly found to be in the open position, it might indicate the need for calibration.

6.2.4 Risk Assessment

Similar to network transformers, the failure of a single network protector rarely results in a power outage, so the risk to reliability is low. The greatest risk posed by network protectors is due to the arc flash hazard they present to employees. Fault currents can exceed 100,000 amps on the network system and employees are required to remove bolts, fuses and links from protectors while they are energized.

To help mitigate the arc flash hazard, London Hydro has committed to eliminating all GE protectors on its system because the design of these protectors makes them especially prone to accidental contact during routine isolation work. London Hydro is planning to have all 208V GE protectors removed from the system; only one remains in service and is located in the east end network which will be eliminated as part of the final phase of the east end network elimination project (apprx. 2-5 years). Since an outage can always be obtained before working on 600V GE protectors, staff can obtain a Work Permit to establish a safe work area so these protectors will remain in service.

6.2.5 Asset Sustainment Plan

London Hydro has a maintenance program that involves the regular testing and calibrating of the relays. During this testing, the protectors' moving parts are cleaned, lubricated and tested. Although relays will sometimes fail to operate properly, a complete protector failure is rarely experienced. Therefore protectors are not replaced on their own as they age; the transformer and protector are replaced together as a unit (with the exception of the 208V GE protectors described above).

Many protectors have been refurbished or replaced in the last 10 years and only very a small number will need to be considered for replacement in the next 15 years. If it is assumed that the protectors are the same age as their associated transformers, 14 protectors will likely need to be refurbished or replaced over the next 15 years. This should also address the remaining drip-proof and dust-proof enclosures. As discussed in section 6.1.5 six relatively new transformers and their protectors are available to replace 6 older installations and an additional 4 transformers and protector units will be eliminated through customer conversions. The remaining 4 older transformers planned for replacement in the coming years will need to have their protectors replaced as well.

7 - Maintenance Holes, Concrete Encased Ducts and Vaults

7.1 Maintenance Holes

7.1.1 Age and Life Expectancy

London Hydro has 1,099 maintenance holes on its system, and Figure 7-1 below shows their age distribution. The life expectancy of maintenance holes is estimated at 70 years, but depending on their location and exposure to corrosive salts and mechanical loads the life expectancy can vary.

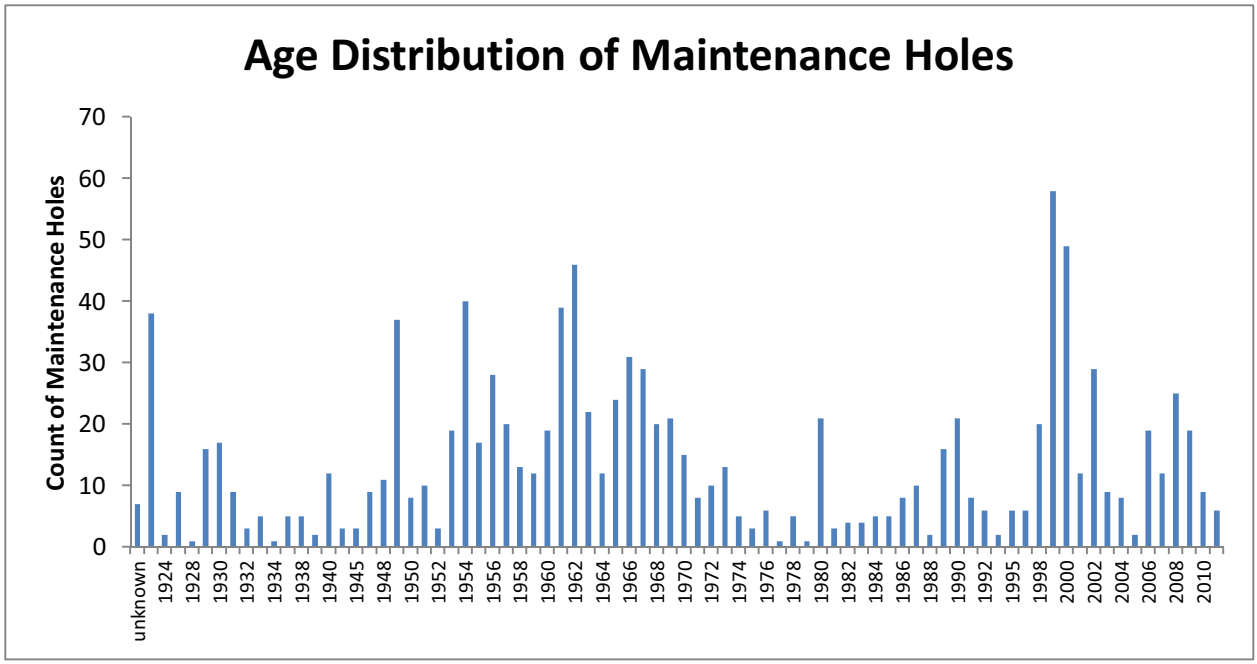


Figure 7-1 - Age Distribution of Maintenance Holes

The roof slabs and chimneys associated with maintenance holes do not last as long as the maintenance hole itself. Their estimated life span is 40 years.

As of today, 128 maintenance holes (11.8% of the total population) are over 70 years old and another 185 (28% of total population) will be over 70 years old by the year 2026. London Hydro does not have

complete records of when the roof slabs were replaced on its maintenance holes, although it is known that many roof slabs have been replaced over the decades. Based on the differential in life span, London Hydro will need to budget for the replacement of a greater number of roof slabs than maintenance holes since they have a shorter lifespan.

7.1.2 Condition

Of the 200 maintenance holes scheduled to be inspected each year, London Hydro's staff normally identify anywhere from 2 to 10 maintenance holes that are deemed to be in sufficiently poor condition to warrant inspection by a civil engineer. Table 7-1 illustrates the general condition of the maintenance holes inspected each year. The table below was generated based 2008-2010 inspection data; hence, it does not reflect the condition of the entire maintenance hole population but provides a proxy of the general condition of the overall asset. As of the end of 2010, 30 maintenance holes were on London Hydro's list for study, prioritization and ongoing monitoring.

Of the maintenance holes inspected in the last three years, 90% scored OK in all areas of inspection, 9% required non-urgent maintenance, and 1% required urgent attention.

Table 7-1 – Condition of Maintenance holes based on general inspection (2008-2010)

	Manhole Ring and Lid			Roof			Condition of Floor		Condition of Wall	
	Level with Road?	Dished or Cracked	Condition of Asphalt	Rebar showing?	Concrete crumbling ?	Condition of Riser/Bricks	Cracked or crumbling?	Does it need cleaning?	Cracked or crumblin	Does it need cleaning?
Y	87%	8%	89%	20%	19%	94% Good	6%	59%	8%	26%
N	13%	92%	7% Fair	80%	81%	5% Fair	94%	41%	92%	74%
			4% Poor			1% Poor				

7.1.3 Inspection Plan

There is no OEB requirement to inspect maintenance holes; however, London Hydro has developed an inspection program to visit each of these maintenance holes at least once every five years. The inspection checklist that is used when inspecting maintenance holes follows and includes a thorough inspection of the condition of the walls, floor, and roof slab as well as the riser for the maintenance hole ring and lid. The checklist also includes room for comments on the condition of the cables and limiters and a record of whether or not standing water is present. In addition to the five year cycle, these checklists are also completed periodically as crews visit maintenance holes for other purposes.

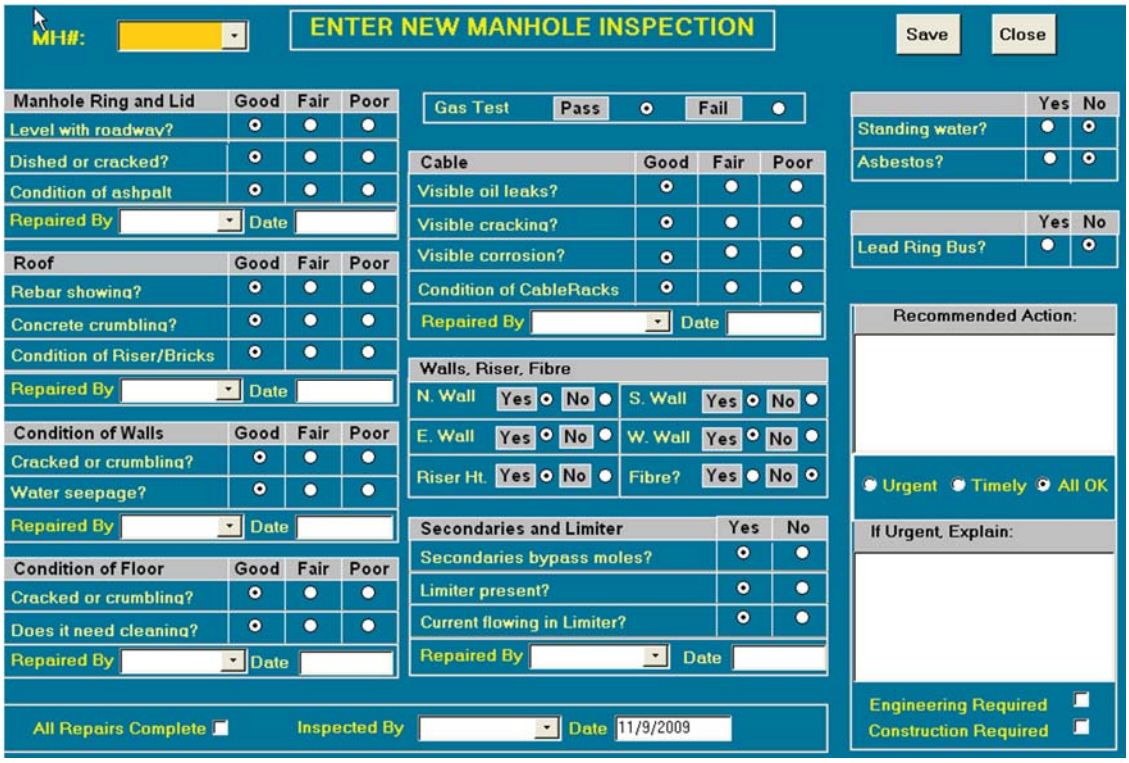


Figure 7-2 - Inspection Checklist - Maintenance Holes

Structures that are identified as needing attention during inspections are reviewed by a civil engineering firm and recommendations for repair or replacement are acted upon as required.

London Hydro has also developed a method for making panoramic movies of the interior of its maintenance holes. A new movie is created after each inspection or whenever major cable changes are

made. These movies are linked to the GIS system and are useful for confirming existing feeder routes or planning new routes and can also be used to provide a general impression of the condition of the structure.

7.1.4 Risk Assessment

As maintenance holes age they can pose a risk to public or employee safety if they collapse. Although this is not common, such an incident occurred recently when a bus caused a collapse of a City of London sewer maintenance hole. Generally, however, any problems found in maintenance holes do not lead to problems in system reliability. London Hydro has experienced outages in the past when failed watermains have undermined maintenance holes or vaults, and, theoretically, maintenance holes that are in better condition would be less likely to collapse under the pressure of a watermain break than those that are fully depreciated. In order to manage the risk associated with the depreciation of maintenance holes, London Hydro will occasionally 'condemn' a hole to ensure that workers are not put at risk until repairs can be made.

7.1.5 Asset Sustainment Plan

As described above, London Hydro has a regular program to identify maintenance holes that need reinforcement or rebuilding. Each year London Hydro retains a civil engineer to assess the holes that have been identified as being in poor condition during inspection. An amount is budgeted each year to replace roof slabs, repair walls, or completely rebuild maintenance holes as required.

Relative to the cost of building a maintenance hole in a new location, rebuilding a manhole in the same location can cost two-to-six times the cost of new construction. In some cases, London Hydro can find a new location for both the maintenance holes and the associated ducts and can replace depreciated structures at a lower cost in the new location. This typically occurs when the City of London is replacing the deep services under the roadway and London Hydro can seize this opportunity to jointly rebuild the

entire affected infrastructure at once. In most cases, however, maintenance holes are rebuilt one at a time and have to be constructed around the existing cables while the old structure is removed.

London Hydro has spent little over the years replacing concrete encased ducts. Although ducts will occasionally collapse and become unusable, most of the concrete encased ducts, even those installed in the 1920's, are still providing reliable service. Therefore, for the purpose of this ASP, it will be assumed that large scale duct replacement works will not be required. However, as the ducts age, duct replacement plans will eventually be required, and at approximately $300/m, replacement will be costly.

Figure 7-1 illustrates that 313 maintenance holes will reach 70 years of age over the next 15 years. It is assumed that the seven maintenance holes for which there is no age data are likely old and will also need to be addressed; this brings the total to 320 maintenance holes. This is equivalent to rebuilding 21 maintenance holes per year over the next 15 years. This is considerably more than the rate London Hydro is currently rebuilding manholes and notwithstanding the above, it is not intuitive given the yearly inspections and maintenance plans conducted by London Hydro staff that 28% of all manhole structures are at end of life and hence at risk of failure.

At this point it seems unreasonable that over 20 manhole rebuilds per year are immediately necessary. This will need to be studied in more detail to determine if a 70 year life expectancy is an appropriate indication of the useful life of maintenance holes on the London Hydro system. London hydro has engaged an external Civil Engineering firm to study this issue in 2012 so London Hydro can have a well-documented strategy for addressing its aging duct and maintenance hole structures.

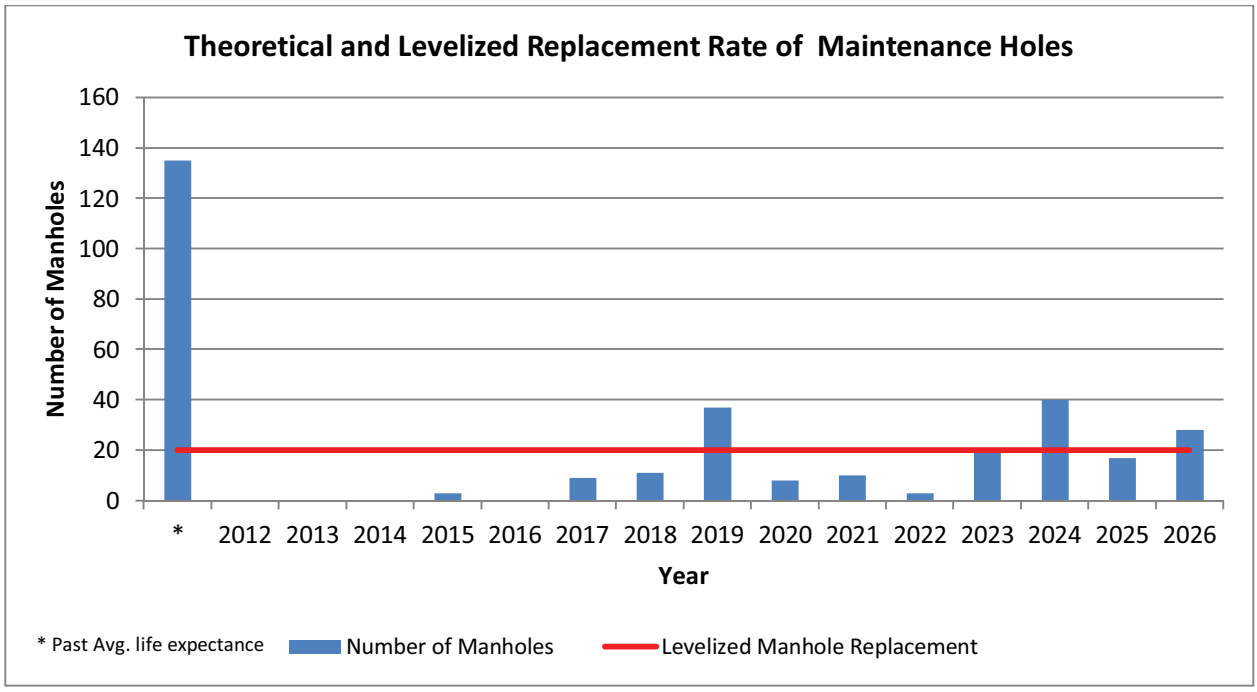


Figure 7-3 - Maintenance holes reaching 70 years of age over the next 15 years

7.2 Vaults

7.2.1 Age and Life Expectancy

London Hydro has 67 vaults on its system, and Figure 7-4 below illustrates their age distribution. The main structure of vaults is expected to last 70 years, whereas their roof slabs have a shorter life expectancy of approximately 40 years. Vault components also include access and ventilation grates, ladders, lighting and sump pumps, and although these have a shorter life span, they aren't material enough to be included in this ASP.

From the age distribution of vaults below, 7 vaults will reach 70 years towards the end of this planning horizon. For the purpose of this planning document it will be assumed that the 7 vaults will reach end of life by the year 2026; unless inspection by a civil engineer suggests otherwise.

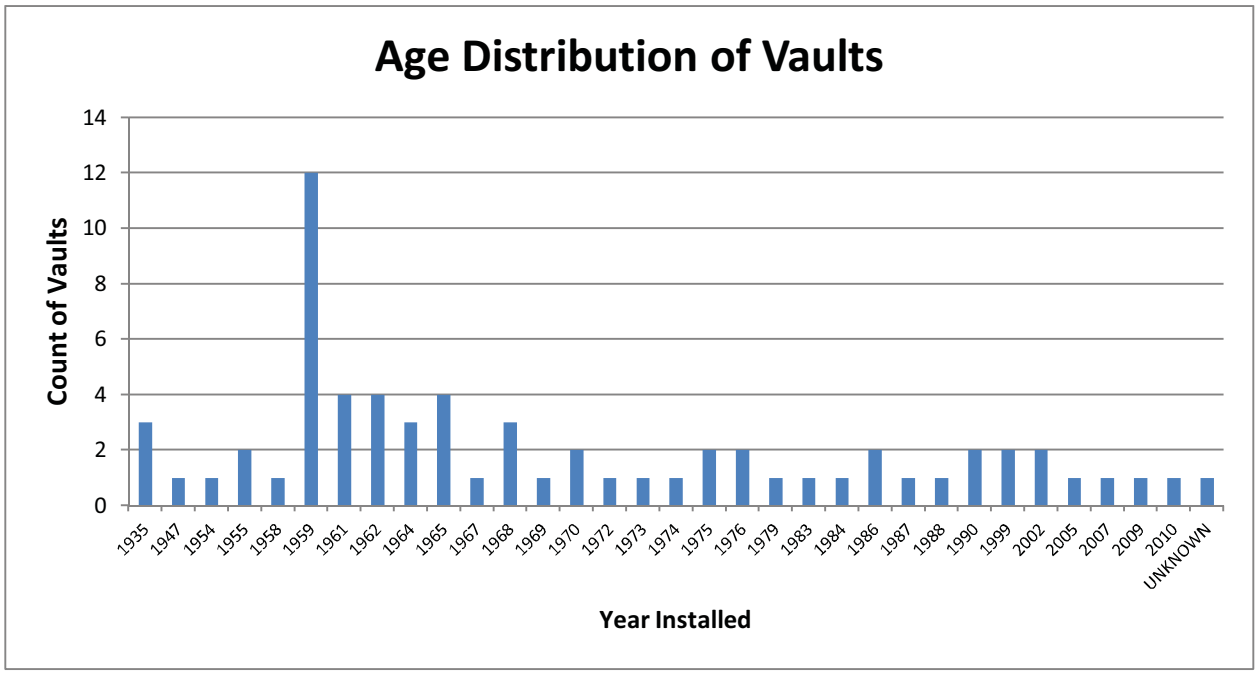


Figure 7-4 - Age Distribution of Vaults

7.2.2 Condition

In 2011, nine network vaults (including seven of the oldest vaults on the system) have been escalated to be inspected by a civil engineer. According to the inspection results, five of the vaults were recommended for refurbishment within the next two years and the remaining were recommended for further monitoring and re-inspection in 5 years.

Depending on the type of concrete used in the past, some vaults are more susceptible to spalling and deterioration, but the majority of London Hydro's vaults can be considered to be in fair to good condition. Based on London Hydro's inspection reports, approximately 25% of the roof slabs can be considered to be in poor condition with the remainder in fair to good condition.

7.2.3 Risk Assessment

As vaults age they can pose a risk to public or employee safety if they collapse, similar to maintenance holes. Unlike maintenance holes, however, vaults are never installed in the travelled portion of the road so they are less subject to deterioration due to the repetitive loading and vibration of vehicles. The roof slabs, however, span a larger area and are fully exposed to weather and the detrimental effects of salt. The slabs are typically in sidewalks and they can pose a risk to pedestrians if they become spalled or if the sidewalk shifts relative to the vault. When staff identify a vault that may need attention, it is put on a list for annual inspections by a structural engineer and, occasionally, if the deterioration might pose a risk to staff working inside, the vault is condemned until repairs can be made.

7.2.4 Inspection Plan

The OEB does not specify an inspection regime for non-electrical components, but London Hydro has developed an inspection checklist for staff to complete while they perform inspections on network transformers; once every two months on average. Besides noting the condition of the vault's walls and

roof slabs, the access grates, ladders, pumps and lighting system are also inspected. A copy of the inspection checklist can be seen below.

At times, London Hydro would abandon a vault by removing the electrical components while keeping the civil structure in place. The civil structure would still pose a risk on public safety if left without inspection or refurbishment, and therefore the vault needs to continue to be inspected unless it is filled or fully removed.

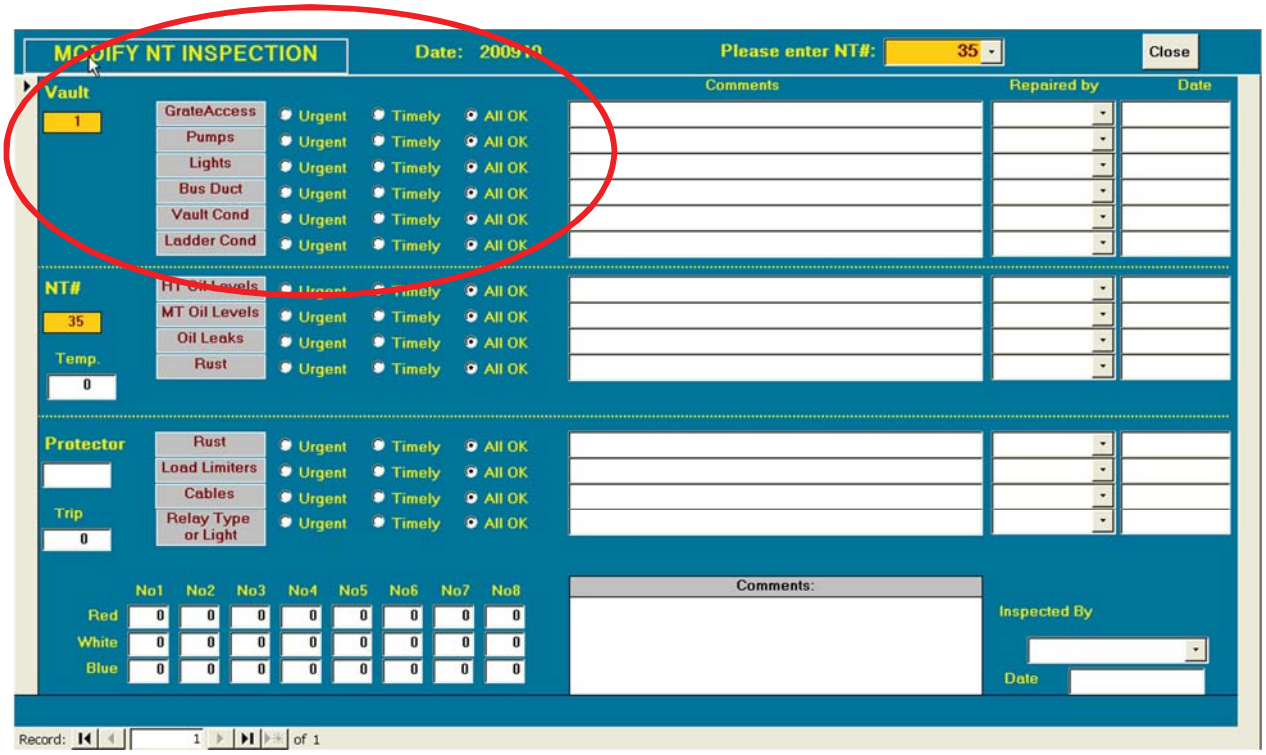


Figure 7-5 - Inspection Checklist for Vaults

7.2.5 Asset Sustainment Plan

Similar to the case of maintenance hole rebuilds, the cost of rebuilding an existing transformer vault in same site can be twice the cost of building a vault in a new location. However, most vaults need to be rebuilt in the same location. This rebuilding requires temporary removal and subsequent installation of the transformer and all the associated cables. The majority of vaults house a single network transformer whereas some can house up to four transformers. On occasions, the rebuilding of vaults may not be necessary and the vault condition can be improved by simply refurbishing it at a lower cost.

As discussed in Condition 7.2.2 five network vaults have been inspected and have been recommended for replacement/refurbishment within the next two years. Three vaults will be addressed in 2012 and 2 more vaults in 2013. London Hydro has plans to complete a detailed audit of the civil component of all maintenance holes and network vaults on the system in 2012, and until the audit is London Hydro will be have a better long term approach to address the aging civil structure on its system. For now, the 15 year proposed rebuild rate of transformer vaults is nominally shown in Figure 7-6 below.

As noted in subsection 7.2.1, vault roof slabs have a life expectancy much shorter than the vault itself, and a separate replacement schedule is required to address the roof slab replacements. Unfortunately, London Hydro does not have adequate age data on vault roof slabs, but for the purpose of this planning document, and until the engineering civil inspection is complete, it can be assumed that the slabs have been installed at the same time the vault was constructed. Based on the age of the vaults, 47 roof slabs will theoretically reach their end of life in the next 15 years. Taking into account the five vaults planned for full refurbishment, and assuming that 20% of those slabs have been previously addressed, approximately 30 vault roof slabs will need to be addressed over the next 15 years.

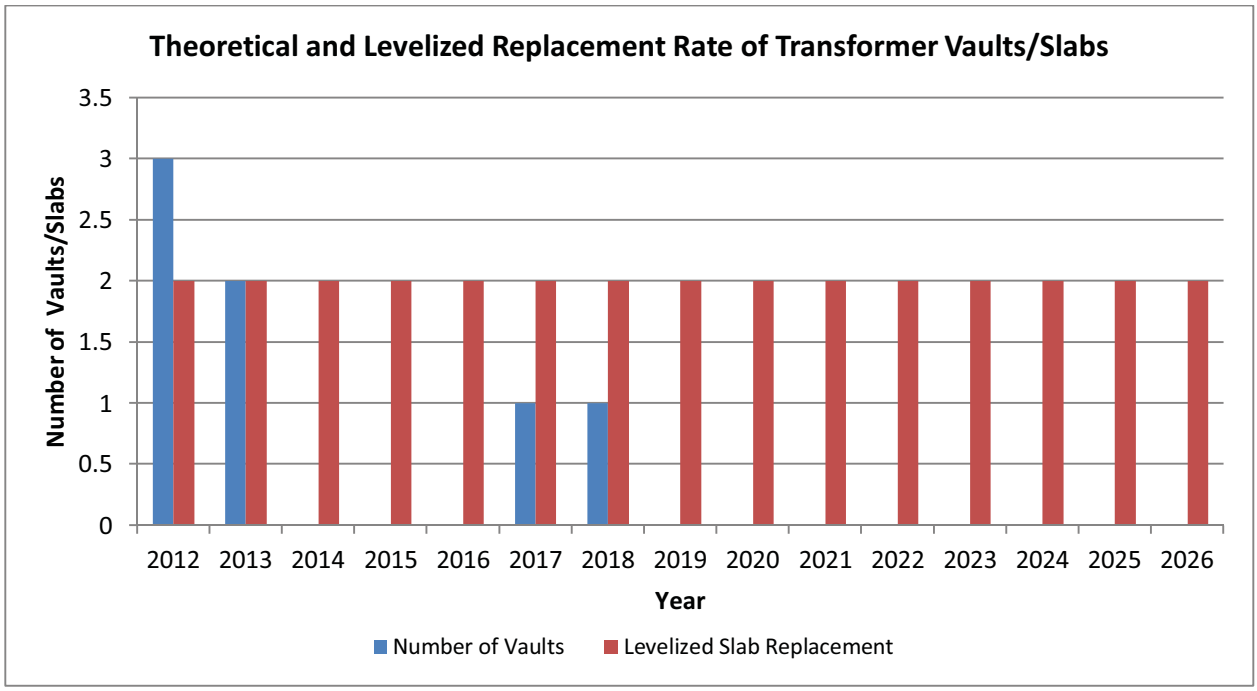


Figure 7-6 - Theoretical and Levelized Replacement Rate of Vaults and Roof Slabs

8 - Transformers in Customer-Owned Vaults

8.1 Age and Life Expectancy

In the 1950's, London Hydro introduced a style of construction that involved the installation of dry-type transformers inside customer-owned vaults at schools and in apartment buildings. Under dry conditions, the transformers are expected to last 50 to 60 years, but most of the vaults are underground and some have problems associated with water ingress. Under wet and damp conditions the life expectancy is only 40 to 50 years.

Of the original installations, 63 still have dry-type transformers and 16 have been converted to transformers filled with flame resistant R-Temp or FR3 fluid. One installation contains pole-type transformers filled with oil, but this installation is essentially outside because it is under a grate in front of the building (100 Ridout St. South). There are also two oil filled transformers. Whenever possible, when a dry-type installation reaches its end of life, London Hydro attempts to completely decommission it and replace it with a padmounted transformer external to the vault. When it is not practical to install a padmounted transformer outside, an alternative is to replace the dry-type transformers inside with new transformers filled with R-Temp or FR3 fluid. Transformers filled with flame resistant fluid are expected to last 50 years. Figure 9-1 below shows all of the transformers in London Hydro's customer-owned vaults by age and type.

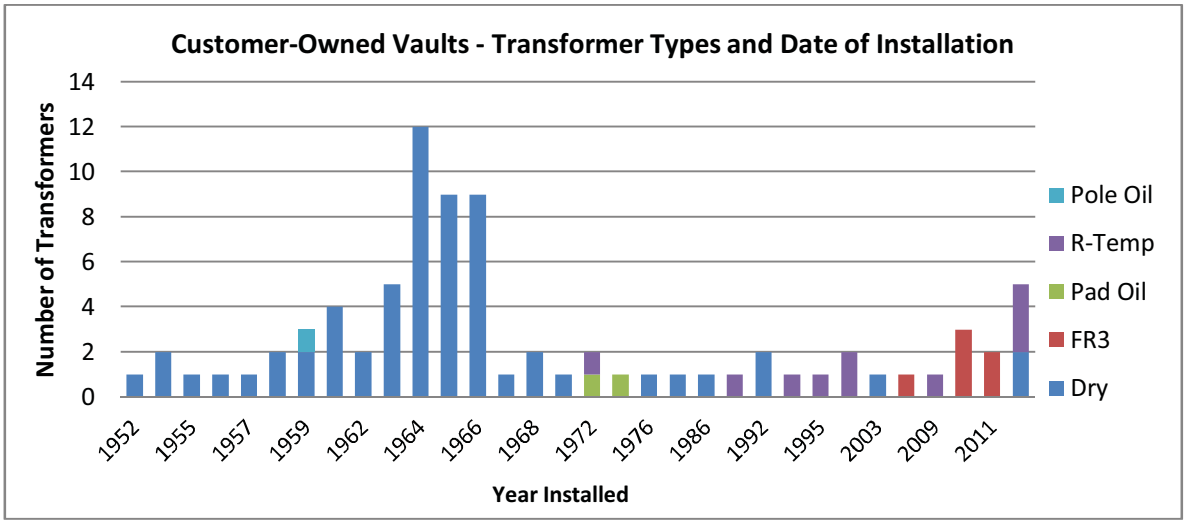


Figure 8-1- Customer-Owned Vaults - Transformer Types and Date of Installation

8.2 Condition

The 16 fluid-filled transformers are relatively new and are in good condition, but most of the dry-type transformer installations will reach 50 years of age over the next ten years with the exception of a handful of newer dry-type transformers that were used in the past to replace failed units.

Apart from the transformers themselves, some of the vaults are underground and located in forgotten corners of basements where there are ongoing problems with security, signage, water ingress and access. Given their age, it can be concluded that most of the dry-type transformers are likely in poor condition. London Hydro does not own the vaults themselves, but, in some cases, problems with the vault accelerate the need to address the electrical components owned by London Hydro.

8.3 Inspection Plan

The Distribution System Code requires utilities to inspect their customer-specific substations on a three-year cycle if they are located indoors.

London Hydro's inspection confirms that the site is still secure, properly signed, well-lit and accessible. Since these are often in basements it is an ongoing task to keep the sites clean and safely secured. The inspection also checks for blown arresters and any damage to cables, connections or grounding.

8.4 Risk Assessment

The largest risk posed with these installations in the past involved the vaults that housed oil-filled transformers. Although the vaults were theoretically fire-rated, it was always a concern that if an oil-filled transformer caught fire, especially in a school, there would be a potential risk to safety. Currently, there are two remaining indoor oil-filled installation in schools and they should be prioritized for conversion first.

An additional risk that is always present is that since these transformers are housed inside customer-owned vaults, London Hydro has little control over site security and the structural condition of the installation. Some are separated from the rest of the basement by only a chain-link fence and some also house customer-owned equipment in various states of repair.

Whenever practical, London Hydro tries to eliminate the entire installation and replace it with an outdoor padmounted transformer.

8.5 Asset Sustainment Plan

During inspections London Hydro will often vacuum the electrical components to ensure there is adequate ventilation for the dry-type transformers. Staff will also repair and/or replace signage and lighting as required.

There are currently two remaining oil filled padmounted transformer installed inside customer owned vaults. One is located at a public school and is scheduled for replacement in 2012.

London Hydro needs to budget a regular amount and make plans to replace, and whenever possible, eliminate, the older installations. Over this planning horizon 60 more transformers in customer owned vaults will be in service for over 50 years and will need to be replaced/or eliminated over the next 15 years. The majority of these units are dry-type transformers and are primarily installed on the 4kV system. Figure 8-2 shows how recent developments in long term plans to phase out the use of the 4kV primary voltage supply will help accelerate the replacement/elimination of these Transformer Vault installations.

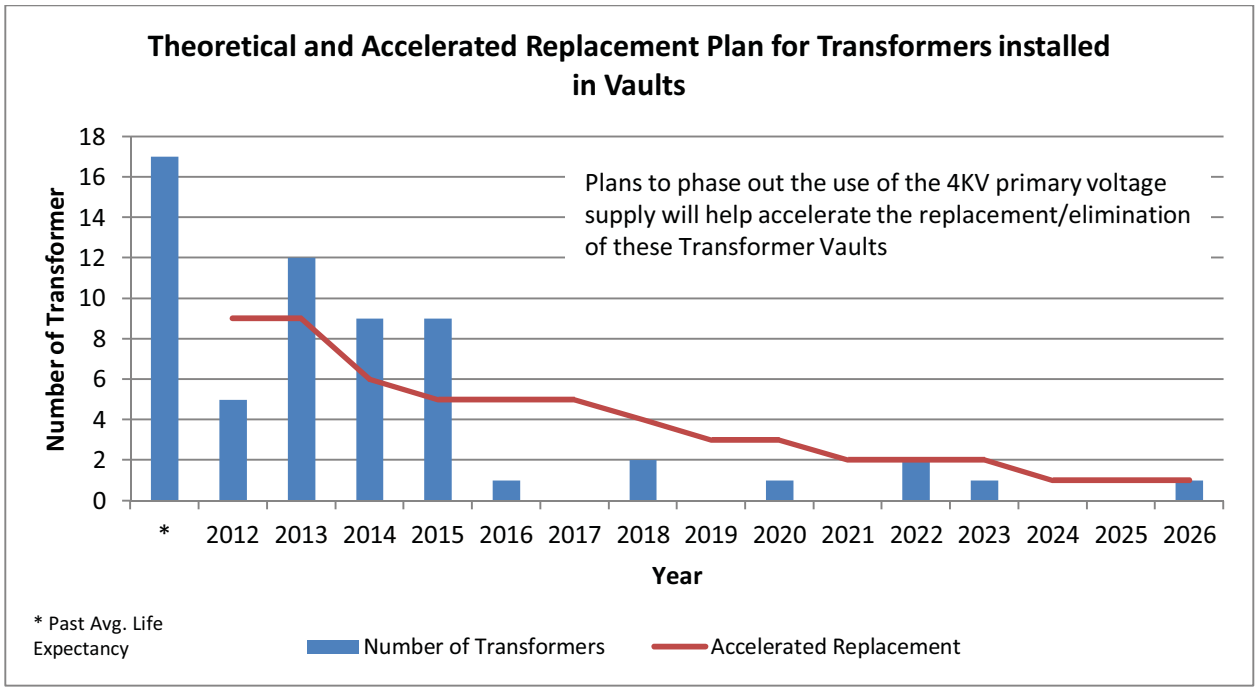


Figure 8-2 - Theoretical and Levelized Replacement Rate of Transformers Installed Vaults

9 - Residential and Network Secondary Cables

9.1 Residential Secondary Cables

Background

London Hydro started installing underground cables in subdivisions in the early 1960's. Although, residential secondary cables are shown on the UD (underground distribution) drawings, they were mot modeled physically in the GIS system until 2008. As a result it is difficult to obtain detailed length and age information. In some instances, the age can be inferred from the recorded age on the primary cable; in subdivisions where the primary cable is still in service, the secondary cables would be the same age. Wherever the primary cable has been replaced, the original secondary cables are usually still in service and hence the inference would not hold.

9.1.1 Age and Life Expectancy

In the Cost Allocation Study Summary (February, 2007), the Engineering Department estimated that there were 75,150 residential underground services. Extrapolating to 2011, this number has likely increased to 76,000. If the average length of an underground service is assumed to be 65 meters, and hence it is estimated that there is approximately 5,000 km of direct buried secondary residential cable in service.

The average lifespan of underground secondary service cable is 60 years, which means that the vast majority of these cables will still have useful life over the 15 year horizon of this current year plan.

9.1.2 Risk Analysis

When a secondary service fails, it usually affects only one customer so the impact on reliability is very low. Consequently, London Hydro's current practice is to replace these cables only when they fail. In 2010, there were 169 failures that needed to be repaired. This represents only 0.2% of the estimated

number of cables in service. If the age profile of these cables was evenly distributed, one could expect that 1/60th of all cables (1,283) would fail in any given year. Since the age profile is not evenly distributed, one could reasonably estimate that at some point in the future twice as many or 2,600 would fail in a year.

Currently, the method for repairing a failed underground service cable is to locate the fault, dig down and replace the failed section with a small piece of cable and two splices. It is cost- prohibitive to trench a new cable all the way from the transformer to the customer's meter when the faulted section can be simply repaired. Also, in the right-of-way along the roadway, multiple secondary cables are direct buried in the same trench making it very difficult to bore or trench in just one new cable.

As more failures occur many cables will eventually end up having multiple splices with no easy strategy presenting itself for replacing the entire service cable. Even if a spare duct was installed next to new cables or if new cables were installed directly in the duct, it is debateable whether it's cost effective given that the duct will not be called into service for at least 60 years and even then, may not be useable. It would also be very difficult to manage the multiple ducts that would be required to run in parallel along the right of way and then enter under the transformer foundation. Nevertheless, these are some of the options London Hydro needs to consider going forward when installing new or rebuilding old subdivisions. [13]

9.1.3 Asset Sustainment Plan

The cost to repair failed residential underground secondary cable is captured in the Operating and Maintenance budget and this area will need to be monitored as the cables age and more failures start to

13 This looming issue will likely manifest itself over the next 20 to 30 years as underground residential distribution systems age around the world. With finished roadways, driveways and landscaping in place, utilities may one day be spending two to five times more each year replacing old buried residential systems than they will be spending on new. London Hydro currently spends approximately $3 million each year on new underground residential distribution systems; in the future this number could rise to $8 million each year to rebuild the existing ones as they age.

occur. For the purpose of this ASP, no major capital activities are envisioned in this area over the next 15 years.

London Hydro has a large number of single phase low voltage junction pedestals that connect multiple residential services to one common low voltage bus. Some of these units are reaching their end of life. They are in excess of 30 years old and the enclosures are starting to corrode. It has been also been found that the connections and barriers within the existing units are beginning to fail.

The replacements will be prioritized based on the findings from OEB audits conducted by field staff and also to address areas where problems have been experienced in the past. Again, repair costs of failed residential underground secondary cables are captured under the Operating and Maintenance budget.

9.2 Network Secondary Cables

Background

The network system comprises the 13.8kV system feeding residences and businesses in the core area of the City. The uniqueness of this system stems from the fact that the 120/208 volt secondary cables are interconnected such that the loss of any one supply transformer does not result in the interruption of supply.

9.2.1 Age and Life Expectancy

London Hydro has approximately 22 km of network secondary cables in service. London Hydro has had an ongoing program for many years to replace all the older lead covered - paper insulated secondary cables on the network system, and, as of 2011, almost all the cable in service is XLPE insulated. The majority of this cable is in very good condition.

Associated with the secondary cables are all the ‘moles’ that are used in each maintenance hole to interconnect the secondaries into a meshed network and to provide tap off locations for individual services. It is estimated that there are approximately 1,500 moles installed in the maintenance holes and

vaults in the downtown area. It is further estimated that there are approximately 3,500 fuse limiters on the system. These fuse limiters are installed at strategic locations and limit the amount of fault current that flows in network. This is especially important because of the high fault current made available as a result of the interconnection of the supply transformers.

Similar to underground residential secondary cables, secondary components on the network have an estimated life span of approximately 60 years. Moisture and corrosion are the main factors that can limit the life of network systems, and replacements and repairs are occasionally required in wet maintenance holes.

9.2.2 Risk Analysis

Unlike residential cables, network failures can result in more significant consequences. In the least destructive case, the cables will short violently and burn clear. In the more severe cases, the cables will fault and begin to arc resulting in a fire which can potentially spread to other cable.

A network secondary cable can fail in several ways. The insulation can be damaged by the impact of adjacent faults or through mechanical wear from the cable supports. In most instances when a fault occurs, the fuse limiters will operate and isolate the faulted section. However, there are times when the fault impedance is such that the resultant fault current is below the limiter's operating threshold. In these instances the cables can start to burn and a fire can be initiated.

9.2.3 Asset Sustainment Plan

London Hydro does not expect that any large scale replacements of secondary components will be required over the next 15 years. Typically if a maintenance hole is rebuilt for structural reasons, all the network secondary components inside will be replaced at the same time if they are showing signs of

deterioration. The average historical rate of work in this area can be used a proxy to estimate future work over the next 16 years.

10 - SCADA

London Hydro's SCADA system is made up of three major elements:

- The master station
- The communications hardware
- The electronic map board

These are discussed separately below.

10.1 Master Station

The master station includes all the SCADA computer hardware and software in the Control Room. The original master station was purchased in 1985 and was completely replaced in 1993, 2002 and 2009. Replacement is generally required because the computer hardware and operating system become obsolete and difficult to support. New versions of application software also provide enhanced functionality with each replacement. For planning purposes, London Hydro anticipates to replace the master station in 2017 and again in 2024.

10.2 Communication Hardware

A number of elements make up the communication system between the master station and field devices. London Hydro has 141 overhead switches/reclosers, 32 substations and 7 network vaults that are equipped with RTU's (Remote Terminal Units), which serve as data collection devices in the field that can communicate with the master station. A collection of modems, data concentrators and repeaters at 111 Horton St. and at Springbank Reservoir make up the communication hardware at the master station.

Much of the communication hardware at the master station dates back to 1993 and plans are being formulated to replace this equipment in the coming years. As the communication backbone for smart meters is developing, strategic decisions will need to be made to determine if, and how extensively, the SCADA and smart meter communication systems should be integrated. Currently, London Hydro's field devices communicate via UHF radio or dedicated leased line with a few devices also using London

Hydro-owned fibre optic lines. For planning purposes London Hydro should anticipate needs for capital resources to replace the aging elements of the master station communication hardware within the first five years of this planning horizon in 2014.

RTU's are expected to last approximately 30 years – much depends on whether spare parts are available. To accommodate those RTU's that might need to be replaced over the next 15 years and, to purchase equipment to possibly integrate with the smart meter communication system, London Hydro should allocate capital resources to keep up with the replacement of aging RTU units.

10.3 Electronic Mapboard

London Hydro purchased its large electronic map board in 2004. This map board consists of nine large DLP displays to create a seamless 8' x 12' electronic display of London Hydro's distribution map and SCADA interface. Currently, London Hydro is upgrading its GIS and preparing for OMS (Outage Management System). These tools will provide enhanced functionality in the Control Room to allow the System Operators to visualize and operate switches on the distribution network. We envisage the solution encompassing a combination of desktop displays and the map board. London Hydro plans to upgrade the map board server and software in 2012 and replace the display units in 2015.

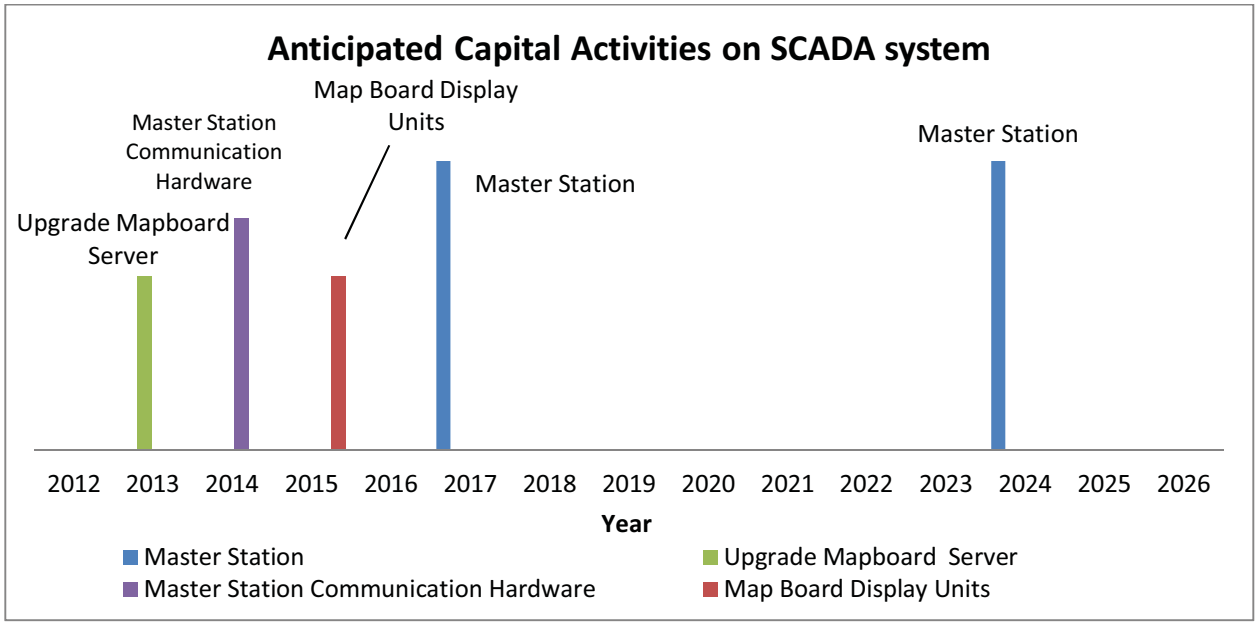


Figure 10-1 - Projected Spending on SCADA System

11 - Miscellaneous Switches

London Hydro owns and operates a number of miscellaneous switches that are included here for completeness. Although in total they do not represent a major asset in terms of cost, they do present some risks and liabilities that should be identified.

11.1 27.6 kV SF_6 Insulated Vacuum Switching Units

London Hydro owns four large SF_6 switching units (three, 5-way and one, 6-way) that are housed in customer-owned vaults in the downtown area. These units were installed in the 1990s and, due to rust problems, two of them were refurbished with stainless steel tanks (Galleria and Old Oak are stainless and Decade and One London Place are original mild steel). The spare unit is also stainless steel. It is expected that these units will continue to provide good service over the next 15 years.

An additional eight, 3-way 27.6 kV SF_6 insulated vacuum switching units are also in service in customer-owned vaults in various locations throughout the city. These stainless steel units have been installed over the past ten to fifteen years and will not likely require attention over the time horizon of this Asset Sustainment Plan.

11.2 13.8 kV Oil Filled Switches

London Hydro owns fourteen above-ground oil filled switches that are used to terminate and switch PILC cables on the 13.8 kV system. These switches are estimated to be 50 to 60 years old or perhaps even older, but they are never operated under load and can be considered to be in fair to good condition. The System Planning Department is working on an overall plan for the non-network 13.8 kV

distribution system over the next few years. This plan, together with the new network ring bus, will likely make these switches obsolete in the near future.

11.3 In/Out Switchgear Cells in Customer-Owned Equipment

In the 1960's and 1970's, London Hydro allowed its large customers in the downtown area to purchase 13.8 kV switchgear. As part of the arrangement, London Hydro agreed to own and maintain two of the switchgear cells. The two cells were used to terminate PILC cable – one cell to feed the customer and another to loop back out again to feed another customer's similar switchgear. Ten of these installations remain on the system and with the exception of one new unit, they range in age from 40 to 50 years old.

When customers with this type of installation decide it is time to replace their switchgear line-up, London Hydro can either maintain the in/out ownership arrangement (e.g., City Centre) or they can negotiate for space with the customer to install a new 3-way switch or loop-through padmounted transformer that would be owned entirely by London Hydro. Now that many of these installations are aging, the difficulty in maintaining them has become apparent. The switchgear is unique for each customer, and in the event of a failure, there is the risk that London Hydro will be unable to repair and maintain the existing arrangement properly as it does not carry the necessary spare parts. The solution can sometimes be fairly simple (a loop through padmounted transformer), or it could be complex if there is limited space for new equipment. Since only ten of these installations remain, the financial impact is not large, but the risk and consequences of failure are fairly high; therefore, addressing these installations should be made a priority. Three of the ten installations have been replaced in 2010.

12 - SUMMARY AND FORECAST OF ANNUAL ASSET SUSTAINMENT PLAN

London Hydro has a mature and well developed process in place to create both short and long-term maintenance, refurbishment and/or replacement plans for all of its major assets. These processes include regular inspections and testing, where appropriate, and the formal documentation of equipment age, life expectancy, condition and the risks associated with each type of asset as it ages.

The foregoing sections have provided a fifteen year forecast of the level of replacement of major assets that will be necessary to maintain the assets in good working order. It is important to note that the forecast is not a defined replacement plan. Instead, it is one of several inputs on which annual capital works programs are developed within the overarching Asset Management Plan.

When applicable, the following table provides the theoretical, levelized or accelerated long term replacement rates of major asset groups.

Anticipated Level of Asset Replacement/Refurbishment to Sustain All major Assets for the Next 15 Years

Asset Group		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Overhead - Poles	1															
London Hydro poles		704	704	704	704	704	704	704	704	704	704	704	704	704	704	704
Circuit on non London Hydro owned poles [1]		90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
Primary Underground Cable	2															
Residential / Commercial - Km's of Cable		44.8 km	44.8 km	44.8 km	44.8 km	44.8 km	44.8 km	44.8 km	44.8 km	44.8 km	44.8 km	44.8 km	44.8 km	44.8 km	44.8 km	44.8 km
Downtown / Station Egress - Km's of Cable		4.5 km	4.5 km	4.5 km	4.5 km	4.5 km	4.5 km	4.5 km	4.5 km	4.5 km	4.5 km	4.5 km	4.5 km	4.5 km	4.5 km	4.5 km
Substation	3															
Substation Transformers		← 8-10 year plan →										The 8-10 year 4 kV conversion plan will replace 15 transformers over 10 year and this will address 11 of the oldest substation transformers and switchgear. The final 5 years of the ASP will need to address, at minimum, the remaining 4 depreciated transformer units.							
		Facilitate the removal of 5 station transformers				Facilitate the removal of 5 station transformers				Facilitate the removal of 5 station transformers						
Switchgear Lineup		Eliminate 3 air insulated switchgear lineups, and one oil filled switchgear lineup				Eliminate 2 air insulated switchgear lineups, and one padmounted style of switch gear lineup				Eliminate 2 air insulated switchgear lineups, and 2 padmounted style of switches						
T1-L Switches		Replace 4 T1-L switches in substations				Eliminate 1 SF6, 2 polemounted, and 1 padmounted T1-L switches				Eliminate 1 SF6, 1 polemounted, and 2 padmounted T1-L switches						
Padmounted Transformers	4															
Single Phase - number of units		94	94	94	94	94	94	94	94	94	94	94	94	94	94	94
Three Phase- number of units		21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Padmounted Switching Enclosures	5															
27.6kV - 8yr plan - number of units (Air Insulated)		9	9	9	8	8	8	8	8	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4.16kV - number of units (Air Insulated)		5	4	4	3	0	0	0	0	0	1	N/A	N/A	N/A	N/A	N/A
16kV - number of units (Air Insulated)		4	4	2	2	1	1	2	1	2	0	0	0	0	0	0
Network Transformers & Protectors	6															
Network Transformers and Protectors		The majority of London Hydro's Network Transformers and Protectors are relatively new and will not need to be replaced over this planning horizon. 14 transformers, however, will reach their end of life during this planning horizon. These units will be addressed in one of the following manners: 1. Replaced with recovered transformers and protectors from other customer voltage conversions; 2. Eliminated due to customer conversion plans, 3. and in some cases, London Hydro will need to acquire new transformers and protectors to replace the depreciated ones.														
Maintenance Holes and Vaults	7															
Maintenance Holes and Concrete Ducts [2]		20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Vaults (Main structure)		3	2	0	0	0	1	1	0	0	0	0	0	0	0	0
Vaults (Roof slabs)		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Transformers in Customer-owned Vaults	8															
Number of Units		9	9	6	5	5	5	4	3	3	2	2	2	1	1	1
Secondary Cables	9															
Network Secondaries Residential Secondaries (Pedestal)		London Hydro does not have capital plans to proactively replace residential and network secondary cables. Refer to sections 9.1 and 9.2 for details														
SCADA	10															
Master Station							Replace							Replace		
Communication Hardware				Replace												
Map Board			Upgrade		Replace											

1 - Levelized number of Bell owned poles with LH circuit requiring replacement

2 - Theoretical number of replacement based on age. Once the civil engineering audit is complete, London Hydro will have a more accurate plan.

Appendix

Abstracts of Engineering Reports

that Supplement the Asset Sustainment Plan

Throughout this document reference has been made to various internal reports and other relevant sources of information. These reports have been used to develop the Asset Sustainment Plan for 2012-2026. It is recognized that these reports are highly technical in nature and may contain proprietary information and therefore, are not included in the Asset Sustainment Plan for general distribution. For convenience the following abstracts have been prepared.

Rehabilitation of Aging Underground Residential Distribution Systems Update

This report analyzes the typical life cycle of underground residential cables, discusses the causes and general timeline of cable deterioration and uses that information to give a comprehensive assessment of London Hydro's residential cable assets in terms of age and reliability. This information forms the basis of a long-term Reliability-Centred Maintenance cable replacement plan that ranks subdivisions in need of cable replacement based on a number of factors including impact on reliability.

Rehabilitation of Aging Underground Residential Distribution Systems Addendum

The addendum to this report discusses London Hydro's continued use of its proprietary methodology (SPOORE) to prioritize those subdivisions with cables that are at risk of failure due to their age and past performance. The continually updated addendum records the previous rebuild initiatives and lists subdivisions based on the SPOORE analysis for the following year.

4kV Aging Infrastructure System Planning Report (2011)

This report studies London Hydro's 4kV system and applies reliability centered maintenance to identify dominant areas requiring permanent solution. The goal of this report is to address existing and potential system deficiencies over the course of the decade- in terms of priority zone instead of individual substations. Several criteria including: visual audits, test data, and system performance are used to evaluate the condition of the plant resulting in a quantified classification of the network's condition. The results are used to support the need of capital expenditures required to maintain the integrity of this system.

Quality of Supply Report 2010

This report provides a high level overview of the system reliability metrics reported to the OEB at the end of 2008. The report evaluates the factors that contributed to unreliability, describes past efforts to reduce system deficiencies and makes recommendations for future investment to improve London Hydro's reliability performance.

EDRO: An Innovative Approach in Performance Benchmarking for Better Asset Management (May 2008)

EDRO stands for Equipment and Design Related Outages. This report supplements the Quality of Supply Report since it analyzes only those outages that are within London Hydro's control. It was prepared to develop benchmarks and analyze trends to monitor the effectiveness of London Hydro's capital investment programs.

Safe Work Practices Manual

This manual is a compendium of all of London Hydro's safety rules and work procedures pertaining to work performed on the electric distribution system by front line staff. Pertinent sections of the manual are reviewed regularly with employees not only to ensure employees follow standard safety procedures, but also to encourage employees to improve the way work is completed and to identify assets that are either deteriorating or that could pose a risk to safety or reliability.

Conditions of Service

All LDC's require a formal document that describes their conditions of service as defined by the OEB. Our Conditions of Service document describes London Hydro's operating practices and the types and levels of service available to customers within our service area in addition to the service charges and circumstances under which customers can obtain and maintain their electric service from London Hydro.

Mitigating Pole Fires on London Hydro's Distribution System

This report addresses issues associated with the number of increased wooden pole fires caused by the flow of uncontrolled electrical current through the pole. A background of the contributing factors relating to the modes of failure and their impact on reliability of supply are provided. The extent and impact of the failures are quantified and solutions involving available technology and practices are provided for the purpose of identifying capital expenditures.

Refurbishment of the Electric Supply to London's Core Network System

This report was produced by London Hydro Network Planning Department and outlines an integrated plan to refurbish the supply to the downtown core in conjunction with the addition of 27.6kV supply capacity at Nelson T.S. These interdependent projects occurring over the next four years will result in the replacement of a significant amount of sixty-year-old end of life infrastructure. The existing single source 13.8kV supply to the downtown core network will be replaced with an interconnected 27.6kV system that will allow London Hydro to meet the future needs of downtown London.

Performance Review and a New Perspective of In-Service 27.6kV Three-Phase Air Insulated Sectionalizing Enclosures" report, 2006

This report is intended to address the poor performance of one of the most critical pieces of London Hydro's 16/27.6Y KV medium voltage distribution system which can have a large impact on safety and reliability: air insulated sectionalizing enclosures (SEs). The advantages and drawbacks of its utilization are presented to emphasize that their use is still significant in order to provide reliable power to London Hydro's Customers

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APPENDIX 2D – EI-31 ASSET MANAGEMENT POLICY AND PROCEDURES

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Engineering Instruction EI-31

Asset Management Policy & Procedures
Electric Distribution System

Instruction Number: **EI-31**	Revision: **R0**
Original Release Date: **November 2011**	Revision Date: **--**
Written By:	**Reviewed By:**
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Overview

This document describes the policies and procedures used by London Hydro to manage its electrical distribution system assets. It also defines the decision making roles and responsibilities that lead to the preparation and review of the Asset Sustainment Plan and the yearly Capital Budget.

❖ ❖ ❖

Revision Index

Changes from previous editions of this Engineering Instruction are listed below. Relocations of paragraphs or editorial changes are not shown.

Revision Number	Issue Date	Section	Description of Revision
R0	November 2011		Original Issue

London Hydro

Asset Management Policy & Procedures

Electric Distribution System

Policy

London Hydro manages the electrical distribution system within the City of London and is responsible for building, maintaining and operating the system in a safe, efficient and sustainable manner in order to meet the requirements of its regulators, customers, shareholders and employees.

To fulfill this mandate, London Hydro has developed a long term Asset Sustainment Plan that covers the full lifecycle continuum of its distribution assets. The plan is reviewed and updated annually.

The annual Capital Works Program uses the Asset Sustainment Plan as one of the inputs and sets out the work to be completed in the current budget year.

Objectives

London Hydro balances the competing needs of its stakeholders by striving to meet the following objectives:

Safety – ensuring that London Hydro's distribution system assets are maintained in a safe condition so they never cause injuries to employees or the public;

Regulatory – ensuring that London Hydro complies with all legislative requirements;

Environmental – ensuring that the distribution assets are managed in an environmentally responsible manner by meeting and, where practical, exceeding all environmental regulatory requirements;

Capacity – ensuring that the distribution system has sufficient capacity to supply both new and existing customer loads and, where appropriate, connect new generation facilities;

Reliability – ensuring that London Hydro's reliability performance meets or exceeds OEB requirements and equals or is above the average of its LDC peer group;

Losses – ensuring that the distribution system's technical losses are effectively minimized through the introduction of changes in system design or operating practices; and

Costs – ensuring that the lifecycle costs of the electric distribution system are optimized while meeting the above objectives.

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Introduction

Purpose

This Asset Management Policy and Procedures document describes how London Hydro balances the competing needs of its stakeholders to meet the objectives described in the Asset Management Policy. It works in tandem with the Asset Sustainment plan that documents the age and condition of our existing distribution assets so we can anticipate potential performance problems and plan strategies and spending programs to manage our risks within acceptable levels. The goal is to meet the objectives described in the Asset Management Policy at the lowest life cycle cost. With well-managed procedures and plans we are able to make informed decisions about when to build assets and then, as they age, whether and when to maintain, refurbish or replace them.

Scope

This document and the accompanying Asset Sustainment Plan cover only the Electric Distribution System; other major assets, such as London Hydro's vehicles and power operated major equipment, buildings and office equipment, including furniture and computer hardware and software, are covered in separate management plans.

In particular, these documents cover the following assets:

1. Overhead Circuits
    - Poles
    - Crossarms
    - Insulators
    - Transformers
    - Overhead Switches
    - Conductors
    - Wooden Pins and Hardware
2. Primary Underground Cable
    - Residential / Commercial Underground Cable
    - Downtown / Station Egress Cable

3. Substations
    - Transformers
    - Switchgear
    - 4 kV and 8 kV Substation T1-L Switches
    - Relays
    - Buildings
    - Batteries

4. Three Phase Padmounted Transformers

5. Single Phase Padmounted Transformers

6. Padmounted Switching Enclosures

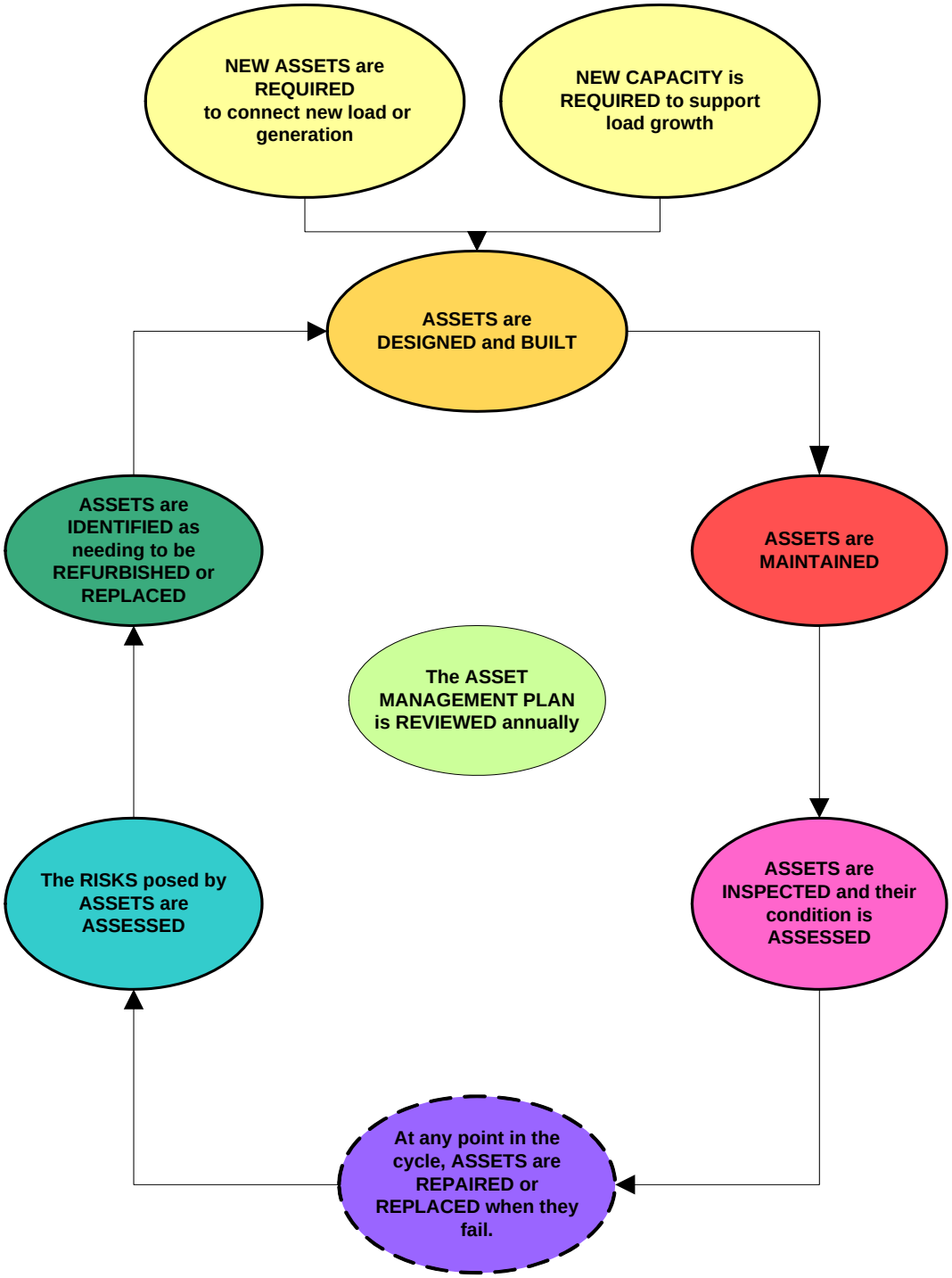
7. Network Transformers and Protectors

8. Maintenance Holes, Concrete Encased Ducts and Vaults

9. Transformers in Customer-owned Vaults

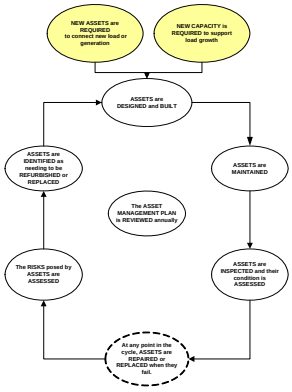
10. Miscellaneous Assets
    - Residential Secondary Cables
    - Network Secondary Cables and Accessories
    - Meters
    - SCADA
        - Master Station
        - Communication Hardware
        - Electronic Mapboard
    - Miscellaneous Switches
        - 27.6 kV SF_6 Insulated Vacuum Switching Units
        - 13.8 kV Oil-Filled Switches
        - In/Out Switchgear Cells in Customer-Owned Equipment

The Asset Management Lifecycle



Responsibilities

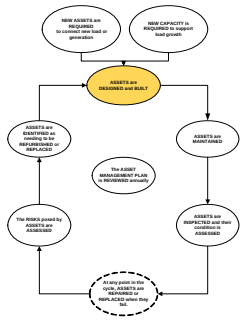
Step 1



1. **New assets are required to connect new load or generation.**
2. **New capacity is required to support load growth.**

Element	Responsibility
System Expansions	The *Director of Engineering* is responsible for • Analyzing customer trends and budgeting for new growth.
System Planning	The *Director of Network Planning* is responsible for • Ensuring that the capacity within the distribution system is adequate to accommodate new customer load and generation and to provide optimum operating flexibility; and • Preparing a planning document to predict future load growth and determine where future transformer station and feeder capacity will be required.

Step 2

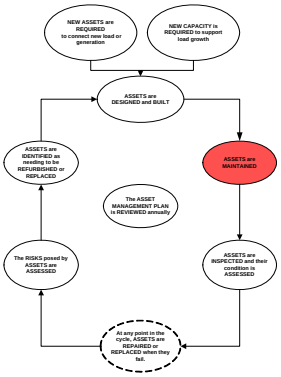


Assets are designed and built.

Element	Responsibility
Engineering Design	The *Director of Engineering* is responsible for • Preparing engineering designs for the construction of new assets; • Keeping the design standards up-to-date; • Preparing Engineering Instructions as required to formalize engineering design principles; • Consulting Operations, Reliability, Network Planning and CDM staff to prepare designs that will best meet London Hydro's Asset Management Policy objectives; and • Ensuring that key staff in the design department receive ongoing training to keep up-to-date with best practices. The *Standards Engineer* is responsible for • Ensuring that the Equipment Approval Process is followed whenever new equipment is introduced to London Hydro. *All Engineers* are responsible for • Ensuring that the "Procedure for the Implementation of New and Revised Standards" is followed whenever design changes are made. The *Director of Operations* is responsible for • Collecting revisions and clarifications for the Conditions of Service document and • Arranging to have it updated to ensure that it addresses the evolving needs of customers and continues to meet the objectives outlined in the Asset Management Policy.
Material Resources	The *Director of Logistics and Support* is responsible for • Administering London Hydro's purchasing and materials management practices to ensure that materials are available when required and can be purchased at the lowest possible cost.
Project Scheduling	The *Project Scheduler* is responsible for • Working with the Engineering, Operations, Materials Management and Finance Departments to schedule and track projects to ensure they are completed on time and on budget.

Labour Resources	The *Director of Operations* is responsible for
	• Managing the construction and refurbishment of assets
	  ○ to meet regulatory obligations for connecting new customers within 5 or 10 days,
	  ○ to provide timely construction services for developers, and
	  ○ to build and maintain distribution assets as efficiently as possible;
	• Ensuring that a proper balance between the use of internal resources and external contractors is maintained to permit London Hydro to meet its Asset Management Policy objectives; and
	• Developing an annual succession plan for each major department to ensure that there is an adequate complement of Apprentices and trades people to meet future needs.

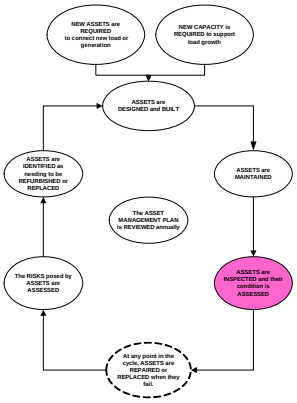
Step 3



Assets are maintained.

Element	Responsibility
Preventative Maintenance Plans	The *Director of Operations* is responsible for • Developing preventative maintenance plans for overhead lines, underground residential, and underground commercial systems; • Establishing and documenting the Safe Work Practices to ensure that no employee or member of the public is injured or suffers harmful health effects from any of London Hydro's assets; and • Ensuring that the appropriate staff receive training and keep up-to-date with leading maintenance practices and technologies. The *Director of Network Planning* is responsible for • Developing preventative maintenance plans for substations, downtown network, metering and SCADA assets; and • Ensuring that the appropriate staff receive training and keep up-to-date with leading maintenance practices and technologies.

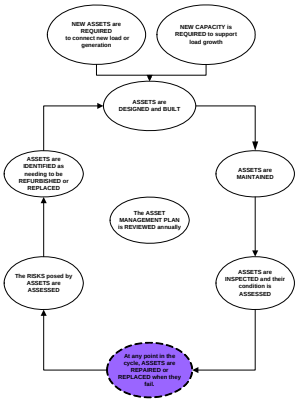
Step 4



Assets are inspected and their condition is assessed.

Element	Responsibility
Inspections	The *Directors of Operations* and *Network Planning* are responsible for • Ensuring that London Hydro's assets are regularly inspected as required by the OEB Distribution Code or more frequently as described in the Asset Sustainment Plan. *Individual Supervisors* are responsible for • Scheduling the inspections and analyzing the results to make recommendations about asset maintenance and replacement; and • Revisiting the field when necessary to audit the accuracy of the data.

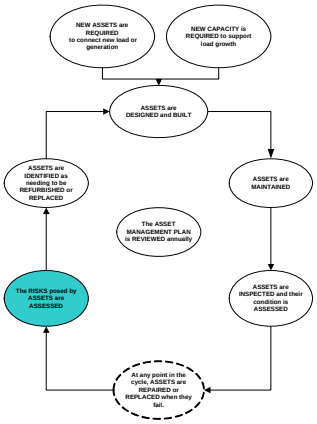
Step 5



At any point in the process, assets are repaired or replaced when they fail.

Element	Responsibility
	The *Directors of Operation* and *Network Planning* are responsible for • Developing procedures to respond to equipment failures as quickly as possible at a reasonable cost. *Immediate Supervisors* are responsible for • Ensuring that serious deficiencies found during inspections are repaired as soon as possible; and • Identifying emergent issues that require large scale repair or replacement plans.

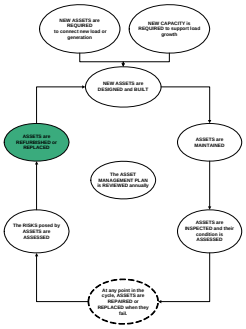
Step 6



The risks posed by assets are assessed.

Element	Responsibility
Reliability	The *System Control Supervisor* is responsible for • Documenting the cause and duration of every outage in the electric system. The *Reliability Engineer* is responsible for • Analyzing and reporting on London Hydro's reliability performance and creating a yearly "Quality of Supply Report;" and • Recommending maintenance, refurbishment or replacement plans to address reliability issues.
Safety and Environmental	The *Director of Operations* is responsible for • Identifying safety and environmental issues related to the performance of London Hydro's distribution assets and ensuring those issues that need attention are addressed. All *employees* are responsible for • Reporting to their supervisor any perceived safety or environmental hazards related to London Hydro's distribution assets.

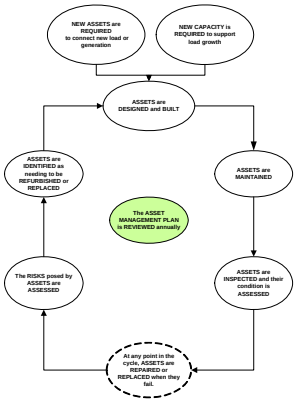
Step 7



Assets are identified as needing to be refurbished or replaced.

Element	Responsibility
	The Director of Engineering is responsible for • Working with representatives from Engineering and Operations Departments to develop a proposed capital budget that addresses the risks that have been identified with existing assets while balancing the need to fund the building of new assets. The *Chief Engineer and Vice President of Operations* is responsible for • Balancing the Engineering and Operations capital budget proposal with other corporate needs and then obtaining Board approval.

Step 8



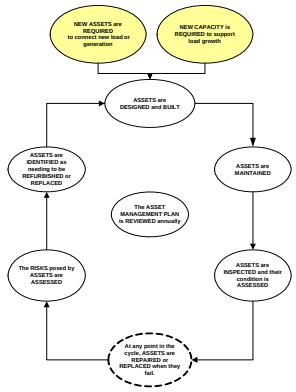
The Asset Sustainment Plan is reviewed annually.

Element	Responsibility
	The *Chief Engineer and Vice President of Operations* is responsible for • Reviewing the Asset Sustainment Plan on an annual basis to ensure that it continues to meet London Hydro's strategic objectives and to confirm that all of the processes and procedures described are being followed. The *Director of Operations* is responsible for • Reviewing London Hydro's Asset Sustainment Plan every year to update the details regarding the life expectancy and condition of existing assets as well as any additional risks identified in the past year. The *Director of Engineering* is responsible for • Revising the short and long-term capital spending requirements described in the Asset Sustainment Plan on an annual basis.

Procedures

The following section describes the procedures that are followed for each step of the asset management process.

Step 1



1. New assets are required to connect new load or generation.
2. New capacity is required to support load growth.

System Expansions

As a licensed LDC serving the municipality of the City of London, London Hydro has a regulatory obligation to connect new customers within its service territory. The Director of Engineering develops procedures to ensure that requests for new service are responded to in a timely manner. In order to ensure sufficient funds are available, the Director of Engineering works with the City of London's Planning Department and developers to budget for new subdivisions, commercial/industrial connections and expansions and line relocations due to road widenings.

System Planning

The Director of Network Planning develops system planning criteria for total system, transformer and feeder loading to ensure that adequate system capacity is available to meet the needs of new customer load and generation.

The Director of Network Planning also works with the Operations Departments to plan the system so that it provides optimum operating flexibility and system reliability. The plan determines where future transformer stations, feeders and switching equipment will be required.

London Hydro has a detailed forecasting methodology that includes land use projections developed by the City of London. The criteria and methods currently used by London Hydro to plan its distribution system are detailed in the engineering report entitled, "Recommendations for New Supply Capacity [2010]."

As a general philosophy, London Hydro prefers to delay the construction of new transformer stations as long as possible to make the best use of existing assets and to accumulate enough load to reduce the capital contribution required by Hydro One. Ideally, if enough load exists in the area of the new station, the station will 'pay' for itself and the CCRA (Capital Cost Recovery

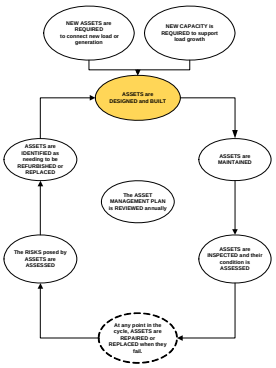
Allowance) calculation will show that no capital contribution is required. Waiting until there is enough load eliminates the risk that a new transformer station will be built and the load never materializes. However, delaying the construction of a new station also carries some reliability risk if existing stations exceed their LTR (Limited Time Rating) on a frequent basis before the new station can by put into service.

To help mitigate this risk, London Hydro has embarked on a GIS Enhancements Project to integrate its GIS system with CYME's Load Flow Analysis Program to allow for better load forecasting and planning for 'what if' switching scenarios. This project will give planners and operating staff more confidence that there are sufficient feeder ties on the distribution system to manage contingencies when transformer stations are purposely delayed to reduce CCRA contribution costs. The GIS Enhancements Project will allow alternatives to be analyzed to weigh the tradeoffs between constructing additional ties, if necessary, or advancing the in service date for a new station.

London Hydro has developed a general philosophy on redundancy and alternate feeds as follows. For general commercial and residential loads, once a radial feed reaches 1 MW of load, the Engineering Department will analyze alternatives for providing a backup tie to the load. Where costs are not prohibitive, backup distribution feeds will generally be provided as a matter of course to reduce lengthy outages due to a single point of failure on a radial feed. When a large commercial/industrial customer requests an alternate redundant feed, a number of different scenarios and consequences need to be analyzed and costed out. A full description of these scenarios is provided in London Hydro's Conditions of Service document.

Finally, London Hydro's load growth has not been sufficiently high in recent years to warrant a formal process for reviewing previous load forecasts for accuracy. In the future, we should determine if a periodic formal review of forecasting methods will provide sufficient benefits.

Step 2



Assets are designed and built.

Construction of Assets

Engineering Design

London Hydro has a comprehensive set of Engineering Design Standards certified by professional engineers that form the basis of the design of our distribution system. The Director of Engineering keeps the design standards up-to-date and ensures that when changes are made, copies are sent to all the registered holders of the Design Standards binder. In order to ensure a consistent methodology is used for the introduction or revision of standards at London Hydro, we have developed a “Procedure for the Implementation of New and Revised Standards.” All engineering staff adhere to this procedure to ensure that important changes are vetted by and communicated to all stakeholders.

London Hydro has a number of Engineering Instructions that outline the correct procedures for a number of processes, such as

- Approving plans, designs and specifications;
- Integrating electrical civil works into City projects;
- Sharing costs with the City and other utilities for bridge structures;
- Relocating electrical plant for third parties; and
- Approving equipment acquisitions.

The Director of Engineering ensures that all Engineering Instructions are kept up-to-date and are circulated to all stakeholders.

London Hydro has developed a Conditions of Service document that, in addition to addressing the OEB’s minimum requirements, describes in considerable detail the policies and procedures for connecting and sharing costs with new customers. Having these guidelines documented ensures that policies and procedures are applied consistently.

The Director of Operations collects revisions and clarifications for the Conditions of Service document and arranges to have it updated to ensure that it addresses the evolving needs of customers and continues to meet the objectives outlined in the Asset Management Policy.

The Director of Engineering ensures that key staff in the design department receive ongoing training and periodically attend industry conferences and seminars to keep up-to-date with best practices. When new assets are designed, various design options are considered and factors that affect reliability (increased automation for example), operational flexibility (such as redundancy and alternate feeds) and future capabilities (such as Smart Grid) are balanced with cost to select the best option. The Director of Engineering solicits input from Operations, Standards, Reliability and Network Planning staff as well as from those involved in CDM programs to facilitate their joint agreement on new design features that will best meet London Hydro's Asset Management Policy objectives.

The Director of Engineering occasionally uses the services of external Engineering Design firms to assist with workloads. The use of external resources also permits the Director to benchmark London Hydro's design methods and efficiency and to keep London Hydro up to date with best design practices. London Hydro uses design specialists for all of its civil engineering work since the volume of this type of work does not warrant having staff designated for this purpose.

London Hydro has a Standards Department whose function it is to keep up-to-date with new products and to ensure that the designs we create use equipment that is safe and effective for the job. The Standards Engineer works closely with the Reliability Engineer to identify equipment problems as early as possible and to implement mitigation measures that may be required.

Staff in the Standards Department regularly attend equipment trade shows and conferences, participate in industry committees and subscribe to trade publications to keep up-to-date with new equipment trends and standards.

London Hydro has developed a formal Equipment Approval Process to comply with the Electric Safety Authority's requirement to use only approved equipment in electric distribution systems. The Approval Process defines how London Hydro uses certified tests, approvals by professional engineers, trial periods and good utility practices to ensure that equipment does not pose a safety hazard to the public. The Standards Engineer ensures that the Equipment Approval Process is followed whenever new equipment is introduced to London Hydro. By following all these processes, London Hydro ensures that the equipment and designs it uses provide the best long term value for stakeholders.

Material Resources

The Director of Logistics and Support is responsible for administering London Hydro's purchasing practices to ensure that materials meeting our specifications are available when required and can be purchased at the lowest possible cost. A secondary objective is to maintain an optimal level of inventory to manage overall inventory costs. The Materials Management Department needs to ensure that appropriate amounts of material are available for maintenance, customer and capital works as well as for emergency safety stock while also following effective inventory practices, procedures and controls. Staff from the Operations Department are consulted on a regular basis to adjust safety stock levels for major items such as transformers and cable. Engineering staff are consulted to develop an annual schedule of deliveries for cable and transformers to meet projected developer demand.

Supplier Alliances have been established with six vendors, representing a substantial percentage of the product being used in our distribution system. The material supplied by these vendors covers most categories of inventory including Transformers, Concrete Products, Cable and Wire, Utility Electric and Miscellaneous Electric. The Alliances have resulted in lower costs due to volume purchasing over a long period of time, reduced administrative efforts, and lower inventory carrying costs. In addition, Supplier Alliances provide improved security of supply for critical materials and improved supplier relationships by allowing information to be shared regarding historical and projected volume requirements. When appropriate, some of the vendors also store safety stock (for certain SKUs) for London Hydro, which allows for a further reduction of inventory on hand.

London Hydro uses a customized work order commitment database (WOCOMM) to match future material requirements (which are described in Bills of Material) with Capital Project Schedules to determine when and if materials need to be ordered. This process supports the 'Just-In-Time' approach to inventory control.

The Director of Logistics further enhances these material management efficiencies by working with staff from Engineering and Operations Departments to standardize products where possible to minimize the need for inventory and safety stock and to develop internal processes for material quality assurance.

Project Scheduling

London Hydro has a dedicated full-time Project Scheduler who is responsible for working with Engineering, Operations, Materials Management and Finance to schedule and track projects to ensure they are completed on time and on budget.

The Project Scheduler meets with Engineering, Operations and Materials Management staff every two weeks to discuss the progress of all Engineering Capital Projects budgeted and Work Orders in progress for that year. When appropriate, a Gantt chart is created to coordinate the allocation of resources and to determine as early as possible if and when external resources will be required to ensure that work can be designed and constructed when needed. All participants receive a list of every work order with an up-to-date status (Engineering Only, Preliminary, Issued, In Progress, etc.) and an up-to-date costing. Any projected cost overruns or emergent issues are discussed, and, when necessary, a report is submitted to the Chief Engineer and Vice President of Operations to obtain approval to make adjustments to the annual budget such as adding, removing or revising the scope of projects.

Engineering Instruction EI-21, "Engineering and Operations Capital Program Project Cost Control Requirements," describes the procedures in place for identifying and reporting on project cost overruns or under-spending and the procedure for obtaining approval for scope changes or new projects that are not in the Board approved capital budget.

Labour Resources

It is London Hydro's philosophy that a proper balance between cost and customer service is best achieved by using a combination of internal staff and external contractors. When staff and contractors work together or observe each other's work, both can learn from the other to develop

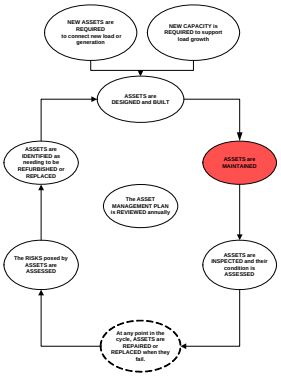
best practices. However, relying too much on external contractors can result in the loss of internal expertise and can leave us overly dependent on third parties for critical response during storms or emergency events. Although internal staff can generally respond more quickly to customer requests for new service, the presence of external contractors in the workplace can serve as a useful benchmark for marketplace standards and efficiencies.

The Director of Operations is responsible for ensuring that a proper balance is maintained between the use of internal resources and external contractors to permit London Hydro

- to meet its regulatory obligations for connecting new customers within 5 or 10 days,
- to provide timely construction services for developers, and
- to build and maintain distribution assets as efficiently as possible.

Each year the Director of Operations develops a succession plan for each major department and submits an internal staffing plan with the Operations Budget to ensure that an adequate complement of Apprentices and Tradespeople is available to meet the objectives of London Hydro's Asset Management Policy. As a result, London Hydro is confident that its hiring practices will continue to ensure we have enough qualified and trained staff on hand to meet all of our stakeholders' electric distribution system needs.

Step 3



Assets are maintained.

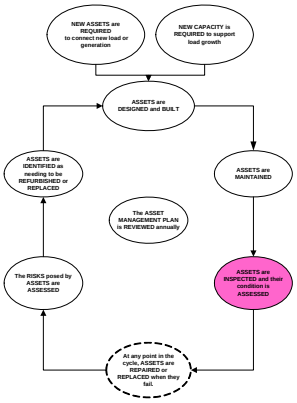
Maintenance of Assets

The ‘Electric Distribution System Asset Sustainment Plan’ describes the current maintenance and testing activities performed on all of London Hydro’s major assets and also describes how the work is recorded and how decisions are made regarding when assets need to be refurbished or replaced. The Asset Sustainment Plan replaces the Operations Inspection and Maintenance Plan that was last updated in 2006. The Directors of Operations and Network Planning work with their supervisors to develop preventative maintenance plans. They also ensure that the appropriate staff receive training and participate in industry committees, equipment shows, conferences and seminars as required to keep up-to-date with leading maintenance practices and technologies.

Currently, when maintenance and repair activities are recorded, they are described in separate Word documents (e.g. Substation Maintenance) or they appear as updates to the MS Access OEB inspection databases. As part of the 2010 and 2011 GIS Enhancements project, we plan to develop methods to store all maintenance and repair activities in either the GIS or SAP database to make the information more readily accessible and easily transportable when assets are moved or retired.

The Director of Operations works with the Joint Health and Safety Committee (JH&SC) and staff in individual departments to establish and document the policies and procedures related to live line work, work permits, outage planning, etc. to ensure that the maintenance and construction of London Hydro’s electrical assets can be completed in a safe manner so no employee or member of the public is injured or suffers harmful health effects from any of our assets. These policies and procedures are documented in London Hydro’s ‘Safe Work Practices’ manual.

Step 4



Assets are inspected and their condition is assessed.

Inspection and Condition Assessment

The Directors of Operations and Network Planning ensure that London Hydro's assets are inspected as required by the OEB Distribution Code or more frequently as described in the 'Electric Distribution System Asset Sustainment Plan.' Individual Supervisors are given areas of the city or lists of equipment that need to be inspected each year.

London Hydro staff currently use paper forms to record the condition of assets during their inspections, and copies of each form can be found in the Asset Sustainment Plan. The individual Supervisors responsible for scheduling the inspections collect the paper forms and enter the data into MS Access databases. They ensure that serious deficiencies are repaired as soon as possible and revisit the field when necessary to audit the accuracy of the data.

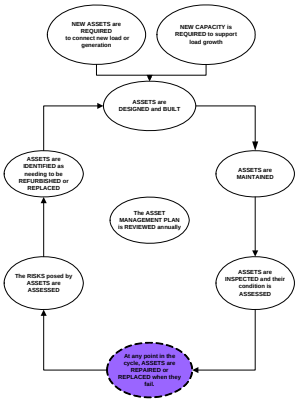
The Supervisors responsible for each area use the information from the inspection audits to determine what work needs to be completed immediately, what work can be scheduled in a timely manner, what work can be deferred until the next inspection or is not required at all, and when the scope of work required needs further Engineering study. All deficiencies that require further study from the Engineering Department are forwarded to the Director of Engineering. When repairs are made, those who performed the work and the date the work was completed are entered into the database.

The Operations Technical Supervisor works with the Access database to create monthly reports to track the progress of all of London Hydro's inspection and preventive maintenance programs. Each month the 'Electric System Inspection & Maintenance Audit Report' shows what percentage of each year's scheduled work has been completed to date and tracks in detail the number and status of all the deficiencies found during inspection. If deficiencies are carried over from one year to the next, this too is tracked to ensure that all problems found during inspections are eventually remedied.

Individual inspection reports are created for every municipal substation, every padmounted, network and dry-type transformer and every underground switching enclosure or load center. Individual inspection reports are currently not collected for every pole on the system since the volume of paper would be difficult to manage; instead, reports for the overhead system are

created only when deficiencies are found. As part of our GIS Enhancements project, we plan to provide field staff with tablet computers to enable direct entry of inspection information into the GIS system to facilitate the collection of more detailed information on the inspection of every pole on the system.

Step 5

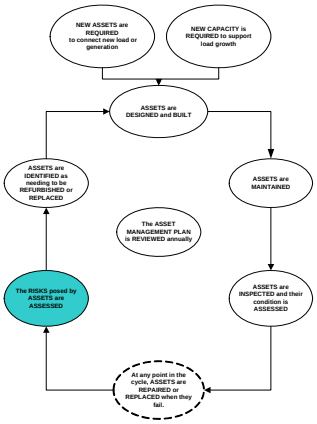


At any point in the process, assets are repaired or replaced when they fail.

When assets fail, Supervisors work with their staff to determine the cause of the failure and make judgements about whether the failure is routine or requires further investigation. If, during the repair, serious deficiencies or emergent issues are discovered that could affect other similar assets, Supervisors will bring this information to the attention of the Director of Operations, who will involve the Engineering Department and other resources, as required, to develop an action plan.

The Reliability Engineer analyzes all of London Hydro's outages on a regular basis and makes note of how long it typically takes to make repairs. If improvements can be made in repair times by modifying response methods or procedures, these suggestions are brought to the attention of the Director of Operations who convenes meetings and revises procedures in the Safe Work Practices Manual as required to ensure that the appropriate practices are in place to keep outages as short as possible.

Step 6



The risks posed by assets are assessed.

Managing System Reliability

London Hydro has a Reliability Engineer who is dedicated to analyzing and reporting on London Hydro's reliability performance. The System Control Supervisor updates an MS Access database to record the cause and duration of every outage in the electric system. Momentary outages are also recorded. This tracking system is complemented by our SCADA system which also logs all breaker operations.

The Reliability Engineer analyzes all of London Hydro's outages and creates a monthly 'Reliability Incident Summary Report' to describe the root cause and recommended action plans for all outages that caused 25,000 or more customer outage minutes that month. Meetings are held with Operations or Engineering staff to discuss performance issues and to develop action plans when required. Failure trends are thereby analyzed and reported on and this information forms one of the resources for the Asset Sustainment Plan. Reliability Centered Maintenance (RCM) techniques are the main driver for determining where and when our maintenance and refurbishment or replacement activities should be targeted. Many of our current and past programs such as Underground Residential Cable Rebuilds, Pole Fire Mitigation, Porcelain Insulator Replacement and SE Refurbishment and Replacement have originated as a result of the application of RCM techniques. Targeting maintenance and rebuild plans where they will do the most good is the best way to ensure they are efficient and cost effective. The Asset Sustainment Plan describes our RCM programs in more detail.

The Reliability Department also creates a yearly 'Quality of Supply Report' to summarize reliability performance for the previous year and to identify the top 10 worst performing feeders. Action plans are recommended when appropriate and it is an ongoing objective to prevent the same feeder from appearing repeatedly in the top 10 list. To select the worst performing feeders, London Hydro weighs the feeder performance with the number of customers affected to ensure that even feeders with few customers but many outages get the attention needed despite having little impact on overall system reliability.

Limitations in our GIS connectivity model currently require us to estimate how many customers are affected by each outage, but the GIS Enhancements Project, which is scheduled to be completed in 2011, will enable us to obtain more accurate counts. In addition, London Hydro's GIS system is not yet sophisticated enough to enable reliability data to be stored and attributed directly to each customer, but it is part of the GIS Enhancements Project to improve our capability in this area. London Hydro's goal is to be able to represent our reliability performance on maps to the customer level to enable us to identify those customers who experienced the worst reliability over any given period of time. We can then target specific action plans to improve the reliability for individual customers even if London Hydro's overall system reliability is on target. The GIS enhancement will also allow us to represent all outage cause types geographically and to segregate them by their impact on both individual customers and overall reliability. This information will refine our ability to target asset management spending as efficiently as possible.

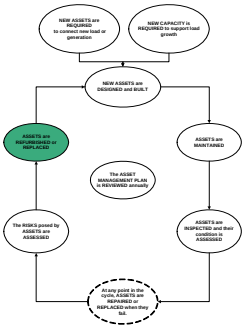
Assessing Risks to Safety and the Environment

The Asset Sustainment Plan describes how risks to safety, reliability and the environment are assessed for each major asset and how this information is used to develop maintenance, refurbishment and replacement plans.

Throughout the year, as field staff routinely identify equipment problems that could pose risks to safety or the environment, Operations Supervisors bring these matters to the attention of the Director of Operations, who involves the appropriate departments to ensure immediate issues get resolved and non-urgent issues get included for consideration in the following year's budget.

As a regular feature of safety meetings, Supervisors are responsible for reviewing pertinent sections of the Safe Work Practices Manual with their staff. The purpose of this review is not only to ensure that employees know London Hydro's standard procedures, but also to encourage them to develop better procedures and to identify assets that are either deteriorating or that could pose risks to safety or reliability. As part of its Health and Safety Management System annual audit, the JH&SC confirms that these Safe Work Practice reviews are conducted.

Step 7



Assets are identified as needing to be refurbished or replaced

Capital Planning Process

Every year the Director of Engineering meets with representatives from relevant Engineering and Operations Departments to discuss proposed projects for the upcoming year to develop a list of specific capital projects for the following year's budget.

The capital budget planning team works together to balance the need to refurbish or replace existing assets with the need to fund the building of new assets.

The Director of Engineering submits the proposed capital budget to the Chief Engineer & Vice President of Operations, who works with other VPs to balance the Engineering and Operations capital budget proposal with other corporate needs and then obtains Board approval.

Engineered capital programs can be divided into two basic categories:

- Infrastructure related projects that result from engineering and planning studies and operational issues, and
- City and Developer works that are externally driven and are generally growth related.

The City and Developer works that are driven by external requirements are, for the most part, outside of London Hydro's control. These projects include connecting new services, extending the grid to service new developments, and relocating plant to accommodate City and Provincial works associated with road, water, and sewer improvement programs. The Provincial Acts and associated regulations, codes and requirements stipulate that these are part of the regulated business and must be provided.

Infrastructure related programs are driven by internal engineering studies and operational reports that detail the requirements for expansion, reinforcement and refurbishment. A number of factors are considered in determining a particular year's capital program, but they can be summarized into the following three criteria:

1. Safety
2. Reliability
3. Capacity

Safety is the highest-level criteria and covers both people (staff and public) and equipment safety. Engineers look for a variety of factors in this area, including:

- Compliance with codes and regulations,
- Possibility of destructive failure jeopardizing equipment, personnel and the public, and
- Antiquated equipment and/or installations that make them unsafe to operate or maintain.

These situations, while not frequent, occur because the equipment has aged beyond its useful life or because circumstances such as overloading or environmental conditions have adversely altered the life cycle.

Reliability analysis provides an indication of how well a system is performing. The statistics provide a relative evaluation in that they look at service levels in comparison to the total customer base. Step 6 above (Procedures) discusses how London Hydro tracks and manages system reliability, and at London Hydro the capital program is designed to maintain reliability at or slightly above the average of other large utilities. Reliability levels that are too low will, in future, probably result in a financial penalty from the regulator and can damage London Hydro's reputation. Reliability levels that significantly exceed the average might signal unnecessary costs and 'gold plating' of the system.

In addition to meeting the requirements set forth by the regulator, the need to manage system reliability is also driven by other factors, including

- the increasing sensitivity of customer loads, especially those with digital processes,
- the recognition that customers link reliable service to service quality, and
- the increasing costs of distribution systems.

Capacity refers to the ability of the system to meet the requirements of servicing general load growth and its reserve capacity to handle contingency situations. The ability to handle capacity is extremely important in terms of improving the attractiveness of the City's economic development initiatives.

Each year as the Capital Budget is planned, every project is assigned a class code to identify its main driver:

- SAF = Safety
- REL = Reliability
- COL = City of London
- DEV = Developer
- RNF = Capacity Reinforcement
- SRV = Enhancing service (automation, telemetry)

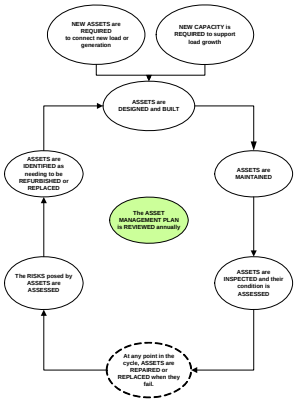
This coding assists all those involved in coming to a consensus regarding which projects will be included each year. Projects proposed from previous years are reviewed and each year those projects that are deferred in order to accommodate higher priority projects are reevaluated. Once a manageable list of projects has been defined, engineers are assigned to prepare a description/justification for each project. The justification will include any supporting reference material and will discuss any alternatives that have been considered (more maintenance as

opposed to replacement, refurbishment instead of replacement, etc.). Each project is also assigned a ranking according to an Engineering Ranking Index (ERI) as described in London Hydro's reference document entitled, *Reliability and Safety Correlation: An Analytical Ranking Model for Engineering Capital Projects*. The ranking is used to prioritize infrastructure related projects that are not driven by system capacity needs or City and Developer works.

A budget estimate is prepared for each project as well as a monthly cost and timing estimate, and the Chief Engineer and Vice President of Operations presents the draft list of work to the Executive Committee for consideration. Other projects from the IT department, Facilities, CDM, etc. are also brought forward and a final list of capital projects is established to meet London Hydro's asset management and financial objectives.

Once the final list of Engineering and Operations projects is defined, a complete Capital Budget binder is presented to the Board for approval. The binder includes an overview and review of London Hydro's asset management principles, a section on current and past system reliability performance, a detailed description and class code for each project, a three year capital spending forecast and a list of all the supporting reports and documents that are available. Once a complete list of projects is approved by the Board, all Supervisors in the Engineering and Operations Departments are given a copy of the Capital Budget binder for reference so they can understand the entire scope of the following year's work.

Step 8



The Asset Management Plan is reviewed annually.

Asset Management Review

The Chief Engineer and Vice President of Operations reviews the Asset Management Policies and Procedures document on an annual basis to ensure that it continues to meet London Hydro's strategic objectives and to confirm that all of the processes and procedures described in it are being followed.

The Director of Operations reviews the Asset Sustainment Plan annually to update the details regarding the life expectancy and condition of existing assets as well as any additional risks identified in the past year.

Every year the Director of Engineering revises the short and long-term capital spending requirements described in the Asset Sustainment Plan.

The Asset Sustainment Plan is distributed to all Engineering and Operations management staff after each annual update to ensure that information relating to the age and condition and the associated assessment of risk for each asset is transparently communicated throughout the organization.

Background

Approaches to Asset Sustainment

The failure rate of most major assets can be shown using a **bathtub curve (Figure 2),** which illustrates three potential stages of asset failure:

The first stage represents a decreasing failure rate, often described as infant mortality. This failure rate is initially high but quickly decreases within hours or days of installation and can be accounted for by defects in the equipment itself or errors in handling or installation.

The second stage represents a relatively constant failure rate. At this stage, after the equipment is installed properly and well before its designed life time limit, the failure rate is low and constant. When failures do occur, they are generally of a random, unpredictable nature.

The third stage sees an increasing failure rate. In the late life of the asset, the failure rate increases, as age and wear or original design defects take their toll on the product.

An Asset Sustainment Plan must anticipate the third stage of escalating failure rates to determine when refurbishment and/or replacement are necessary. Some assets can be run to failure with minimal risk whereas others need to be replaced before failures start to escalate.

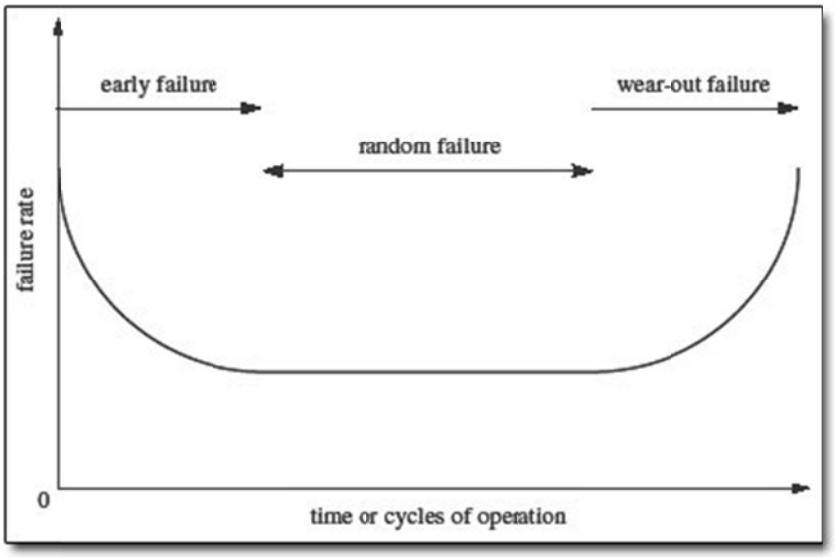


Figure 2 – The Bathtub Curve

Besides determining when each asset should be refurbished and/or replaced, the Asset Sustainment Plan needs to determine and record which assets require regular inspection, testing and/or maintenance.

There are two main approaches to asset maintenance: Corrective Maintenance (CM) and Preventative Maintenance (PM).

The Corrective Maintenance approach focuses on reacting to problems when they occur. It involves no inspection, testing or maintenance until the equipment breaks down. In some cases, this method may result in reliability issues as well as higher costs because by the time the problem is found, refurbishment or replacement may be the only options left. This approach is only suitable if the equipment is non-critical and if the consequences of failure are not serious. In distribution networks this method is widely used for low voltage secondary cables, for example, where no cost effective preventative maintenance measures are available.

Preventative Maintenance takes a proactive approach to maintaining equipment before it breaks down and causes problems with safety or system reliability. PM can be further divided into Time-Based Maintenance (TBM) and Condition-Based Maintenance (CBM). TBM, which is the more traditional approach, follows a set maintenance schedule at fixed time intervals. CBM involves continuous monitoring and inspection or testing to determine when maintenance is required based on the condition of the equipment.

Timed-Based Maintenance, with its fixed time intervals for inspection and maintenance, is the easiest and most widely used PM method. Time intervals are either given by the manufacturers or are based on the judgement and experience of those who work with the asset, and the intervals may be shortened or lengthened depending on the history of problems with that asset. London Hydro uses this method, for example, to perform regular maintenance on breakers, protectors, relays and batteries.

In Condition-Based Maintenance, maintenance activities are triggered by the estimated or measured condition of certain properties that reach a predetermined threshold. When the condition of an asset can be estimated or measured directly, CBM can lead to more effective decisions that can improve reliability and/or lower costs compared to TBM. London Hydro uses this method for managing its poles. London Hydro uses various testing methods to determine whether a pole has started to deteriorate and the results are used to determine when poles should be retested or replaced. This practice increases reliability by ensuring that poles are replaced on a planned schedule before they fail, and it lowers costs by ensuring that poles that are in good condition are not replaced prematurely simply based on their age.

Reliability-Centered Maintenance (RCM) is an approach focused on identifying and establishing the operational, maintenance, and capital improvement policies that will manage the risks of equipment failure most effectively. RCM involves both Corrective Maintenance and Preventative Maintenance approaches, but evaluates the priorities for maintenance and ranks replacement and refurbishment activities based on the impact of failure. The result is a program that focuses scarce economic resources on those items that would cause the most disruption if they were to fail. For many of London Hydro’s assets, (for example, underground cables and small distribution transformers), no cost effective maintenance activities can be performed, so London Hydro uses a RCM approach to develop refurbishment and replacement schedules.

Ideally, London Hydro should be using some form of RCM for each asset, and where we do not, the Asset Sustainment Plan will identify this gap.

Summary

The purpose of the Asset Sustainment Plan is to optimize the life cycle value of the physical assets in our Electric Distribution System in order to ensure safe and reliable service to our customers at the lowest long-term cost.

The main task in the Asset Sustainment Plan is to determine which assets have the greatest impact on safety, reliability and cost in the event of failure and to focus our greatest efforts on those assets. Once those assets are identified, key decisions need to be made using Reliability Centred Maintenance techniques on how often to maintain them, and whether to refurbish or replace them and when.
London Hydro recognizes the importance of using some form of RCM for each asset. An asset without a sustainment plan will eventually fail and this could cause reliability problems. Asset failure has cost implications since repairing a failed asset in an emergency is usually more costly than maintaining the asset or replacing it as part of a scheduled replacement plan. Unplanned failures can also pose a safety hazard for the public and London Hydro's employees. In addition, when planning and budgeting for the management of our assets, it is essential to understand the difference between book value and the replacement cost to ensure that enough capital funds are set aside. It is also recognized that over-maintaining or replacing assets too early can be costly. London Hydro's Electric Distribution System Asset Sustainment Plan aims to find the balance while levelizing year-to-year capital spending.

Finally, by defining the overall responsibilities and procedures for the Asset Management Lifecycle and by documenting the current condition and asset sustainment strategy for each asset, London Hydro can demonstrate where its Asset Sustainment Plan is well-defined and defensible and, also, where it needs improvement.

APPENDIX 2E – INFRASTRUCTURE & DEMAND PROJECT SHEETS (2010 & 2011)

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Engineering & Operations
2010 Gross Capital Budget

Project Code	Project Description/Scope	TOTAL BUDGET
A Substation Rebuilds		
10A1	Downtown Network Supply Upgrade	1,375,000
10A2	T1-L Switch Replacements	180,000
10A3	Substation Battery Bank Replacement	25,000
A Substation Rebuilds Total		**1,580,000**
B Subdivision Rebuilds		
10B1	Silicone Injection of Underground Cable	1,080,000
10B2	Nelson Park Transformer Replacement and Voltage Conversion	800,000
10B3	Replacement of Air Insulated Sectionalizing Enclosures	100,000
10B4	Leaking Transformer Replacement	620,000
10B5	Residential Secondary Pedestal Replacements	25,000
10B6	Vault Transformer Replacements	135,000
10B7	Installation of Underground Backup Supply	55,000
10B8	Installation of Fault Indication on Padmounted Transformers	10,000
B Subdivision Rebuilds Total		**2,825,000**
C Main Feeder		
10C1	Ridout St 13.8 kV Conversion	450,000
10C2	King Street 4.16 kV Conversion	360,000
10C3	26M11 & 26M56 Egress Installation	700,000
10C4	Sub 97 Voltage Conversion Phase 1	320,000
C Main Feeder Total		**1,830,000**
D City Works		
10D1	City of London (Road authority) Relocations	1,395,000
D City Works Total		**1,395,000**
E Developer Projects		
10E1	Developer Driven Distribution Circuits Expansions and Relocations	4,060,000
10E2	Residential Secondary Service Upgrades	260,000
10E3	New Single Family Residential Underground Distribution	1,900,000
10E4	New Multi-Housing Underground Distribution	700,000
10E5	New Commercial Distribution Services	2,300,000
E Developer Projects Total		**9,220,000**
F Network		
10F1	Replacement of Network Vaults/Manholes/Transformers	870,000
10F2	Replacement of Primary & Secondary Cables	250,000
10F3	Eliminate East End Network - Phase 1	240,000
10F4	Replacement of Low Voltage GE Protectors	80,000
10F5	Refurbishment of Low Voltage Network Grid	50,000
F Network Total		**1,490,000**
G Overhead Line		
10G1	Replacement of Fully Depreciated Poles	400,000
10G2	Replacement of Poles Susceptible to Poles Fires	375,000
10G3	Rebuild of Fully Depreciated Overhead Areas	2,290,000
10G4	Implementation of Lightning Study Results	25,000
10G5	Porcelain Insulator Replacement	50,000
10G6	Removals & Restoration of Overhead Plant	30,000
G Overhead Line Total		**3,170,000**
H Automation		
10H1	Automation Visibility to Substations	150,000
10H2	Automation on Feeders - Recloser Installations	260,000
10H3	SCADA New Functionality	100,000
10H4	Installation of Network Temperature Monitoring Devices	10,000
H Automation Total		**520,000**
TOTAL ENGINEERING AND OPERATIONS CAPITAL BUDGET		**22,030,000**

2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10A1
Project Name:	Downtown Network
Project Objective:	REL

Project Title:	Downtown Network Supply Upgrade	BJC- C/PC-10

Project Manager:	Ysni Semsedini	**Project Tech.:**	Rolf Reiners

Supporting Reference Material

Refurbishment of the Electric Supply to London's Core Network System, Issued July 31, 2008

Description/Justification

London Hydro had previously identified the need to make alterations and improvements to the 13.8kV network. This work was scheduled over 3 years (2008 - 2010). In the first two years the detailed engineering was completed, transformers, switchgear, protections, controls and neutral grounding resistors were procured and civil works were installed. The final year's work will involve the completion of interstation wiring, the installation and integration of new network dash cables and the commissioning of the entire installation.

COST and TIMING ESTIMATES

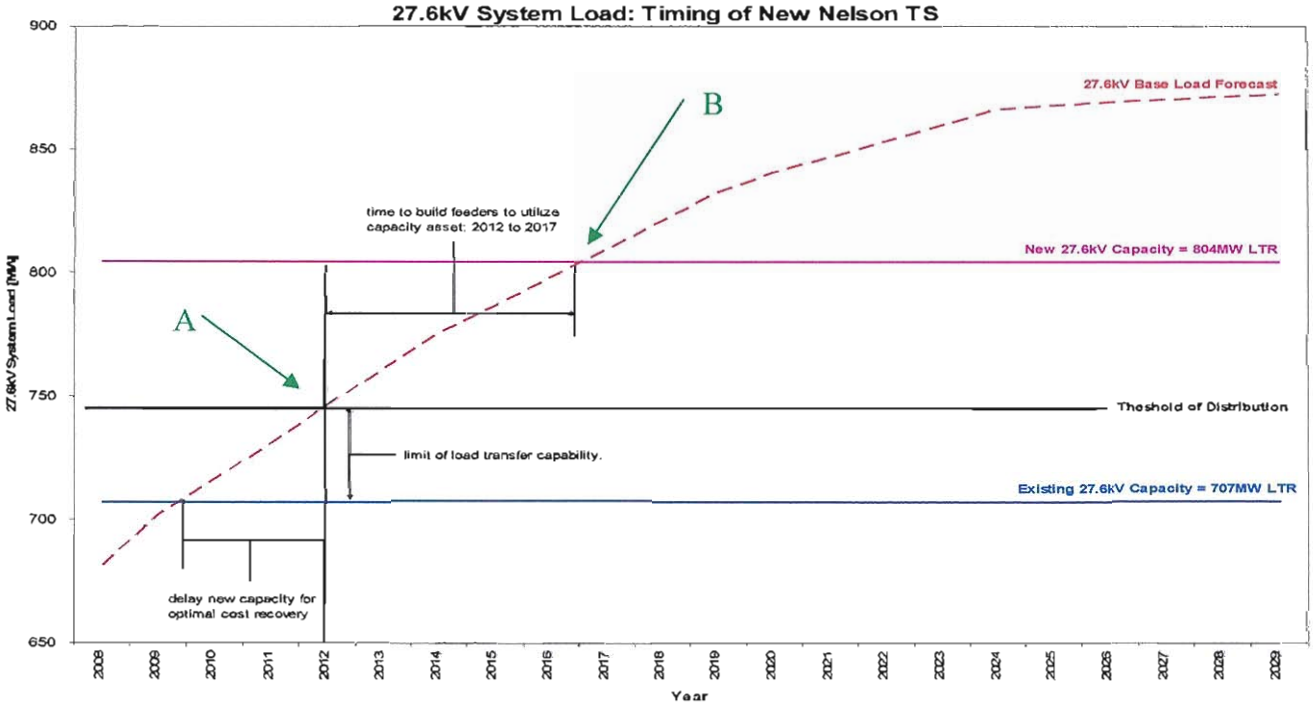
Section - 110	Cost
Jan	$ 268,000.00
Feb	$ 169,000.00
March	$ 134,000.00
April	$ 134,000.00
May	$ 201,000.00
June	$ 134,000.00
July	$ 134,000.00
August	$ 67,000.00
Sept	$ 134,000.00
Oct	
Nov	
Dec	$ -
TOTAL	$ 1,375,000.00

Estimated Completion Date:	September, 2010
Prepared By:	Ysni Semsedini, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Downtown Network Supply Upgrade
Project 10A1

The April 2008 London Hydro load forecast confirms that London Hydro will require new 27.6kV capacity in 2012. (A) Based on spatial load analysis and a review of available transmission capacity it has been determined that the new transformer station capacity is required at Nelson T.S.

Construction of a new 27.6kV transformer station at the Nelson location will require that an existing aging 13.8kV transformer station be decommissioned. In order to maintain 13.8kV reliability and to facilitate continued 13.8kV load transfer capability within the city of London, modification to the supply of the 13.8kV downtown network system is required.



27.6kV Base Load Forecast:
Is London Hydro's projected load growth on the 27.6kV distribution system. This information is primarily based on The City of London's land use projections for the next 20 years.

New 27.6kV Capacity = 804 MW:
Is the aggregated 10-day LTR for London Hydro's 27.6kV system after a new Nelson TS. (B)

Existing 27.6kV Capacity = 704MW: Is the aggregated 10-day LTR for London Hydro's 27.6kV system before new capacity at Nelson TS.

Threshold of Distribution:
Is the feeder transfer capability limit for optimal asset utilization. Transfer capability allows loads to be moved between stations.

10 day LTR: A Station's capacity is determined by the "10-day Limited Time Rating" (LTR) of one of the two transformers. This based on the assumption that one line or transformer could be forced out of service at any time leaving the remaining transformer to carry the entire load. These ratings are very aggressive and when used stress the transformer to point where its life will be shortened.

London Hydro has a limited amount of transfer capability through its distribution system beyond the existing 707MW system capacity. By the year 2012, London Hydro will have exhausted its 27.6kV system 10-day LTR and transfer capability of its distribution system; thus, requiring new capacity.

2010 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	10A2
Project Name:	T1-L Switch Replacements
Project Objective:	REL

Project Title:	T1-L Switch Replacements	BJC- C/PC-9
Project Manager:	Ysni Semsedini	**Project Tech.:** Rolf Reiners
Supporting Reference Material	2008 Substation Deficiency Report	

Description/Justification

As part of London Hydro's continuous substation assessment process, it was found that a number of T1-L switches, which are the primary side station transformer switch, have developed considerable amounts of rust, holes, and/or are collecting water. Previous corrective measures such as paint, sealant and tar to protect the metal structure's surface have prolonged the in-service life of these devices, but have not provided a permanent solution.

The purpose of this capital plan is to begin a phased replacement of all identified depreciated T1-L switches. Specifically, we will be replacing the following substation T1-L switches in 2010: Subs 21, 29, and 39.

COST and TIMING ESTIMATES

Section - 110	Cost
Jan	
Feb	
March	
April	
May	
June	
July	
August	$ 59,400.00
Sept	$ 59,400.00
Oct	$ 61,200.00
Nov	
Dec	
TOTAL	$ 180,000.00

Estimated Completion Date: October, 2010

Prepared By: Ysni Semsedini, P.Eng.
Distribution Engineer

Approved By: Ken Walsh, P.Eng.
Chief Engineer &
V.P. of Operations

Tl-L Switch Replacement
Project 10A2

T1-L is the designations provided to primary side substation transformer switches.
London Hydro through its continuous substation assessment process has determined that
A particular style of T1-L switch (S&C) is susceptible to considerable amounts of rust, holes, and/or collecting water. These defects pose potential safety and reliability issues that must be addressed. The problem with the identified switches is a ledge design on the incoming chamber. The current London Hydro standard T1-L switch does not contain a ledge and therefore should not suffer from the above mentioned defects. Below are two pictures: one illustrating the defective T1-L switches with an incoming ledge chamber design(1) and the second showing the current London Hydro standard T1-L switch.

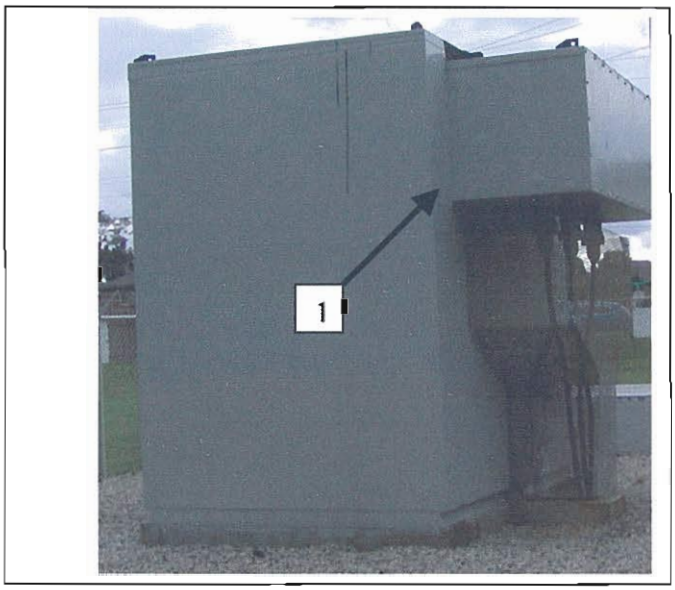


Figure 1 – Identified Defective T1-L Switch


Figure 2 – Replacement T1-L Switch

2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10A3
Project Name:	Substation Enhancements
Project Objective:	REL

Project Title:	Substation Battery Bank Replacement	BJC-C/PC-9

Project Manager:	Ysni Semsedini	**Project Tech.:**	Rolf Reiners

Supporting Reference Material: 2008 Substation Deficiency Report

Description/Justification

All 48 vDC battery controlled substations have had their batteries replaced within the last 10 years. The 128 vDC battery controlled substations had their batteries replaced between 1982 - 1985 and are now due for replacement. The 128 vDC controlled substations include Substation No. 2, 6 & 8.

Substation No 2 was completed in 2009.
Substation No. 8 is scheduled for replacement in 2010.

This budget section will also cover the costs to order and install new 128 vDC charger and batteries.

COST and TIMING ESTIMATES

Section - 110	Cost
Jan	
Feb	$ 5,000.00
March	$ 20,000.00
April	
May	
June	
July	
August	
Sept	
Oct	
Nov	
Dec	
TOTAL	$ 25,000.00

Estimated Completion Date:	March, 2009
Prepared By:	Ysni Semsedini, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Substation Battery Bank Replacements
Project 10A3

London has over forty substations. The relays and the protection systems in the stations operate on d.c. voltage and are backed up by batteries so that the station can still be operated in the event of a power failure. Batteries are maintained and inspected as part of the London Hydro routine maintenance program. They are replaced at stations on a routine basis dependent on age and condition to ensure that the protection systems operate when needed.



Figure 1: Picture of the cabinet housing the batteries and battery charger. The charger is on the top while the batteries are located in the bottom cabinet.



Figure 2: Bottom cabinet opened to show the station batteries.

2010 ASSET MANAGEMENT PLAN
Project Sheet

London Hydro

Project Number:	10B1
Project Name:	Cable Silicone Injection
Project Class:	REL

Project Title:	Underground Residential Rehabilitation of 27.6 kV system (Silicone Injection of Underground Cable)	BJC-C/PC-9

Project Manager:	Cristina Terek	**Project Tech.:**	Jamie MacPherson

Supporting Reference Material

1. Engineering Report Update 2009, ***Rehabilitation of Aging Underground Residential Distribution Systems*** - November 2009
2. ***2009 SPOORE Geo Media Implementation*** - June 2009 Presentation

Description

The newly augmented, in-house SPOORE analysis carried out in 2009 made use of the GIS-based engineering analysis tool *GeoMedia*. While the main selection criteria continues to be cable 25 years and older, and a minimum of two faults in the past five years, other realities such as defective or leaking transformers supplement the performance ranking of subdivisions with decreased reliability.

This item covers rehabilitation of underground aged cable by means of silicone injection. This will be performed in three areas of the city which ranked highly unreliable. While the infrastructure is mostly 25 to 30+ years old, numerous failures have been experienced (on cable and transformers) over the last five years. The silicone injection technology increases the lifespan of the polymeric cable, adding up to another 40 years of service.

While over $13M dollars have been spent replacing approximately 130 km of underground cable in total, a much larger amount of aged cable remains in-service today that will eventually need to be replaced. Cable aging is a constant phenomenon that can be overcome only through a consistent and adequate rehabilitation program. Without proper budget allocation, more failures can be expected from the aged cable that is past its life expectancy. Cable investment will need to ramp up significantly in future years in order to reverse the under-performance trend.

COST and TIMING ESTIMATES

Section - 145	Cost
Jan	
Feb	
March	
April	
May	
June	$ 200,000.00
July	$ 200,000.00
August	$ 230,000.00
Sept	$ 250,000.00
Oct	$ 200,000.00
Nov	
Dec	
TOTAL	$ 1,080,000.00

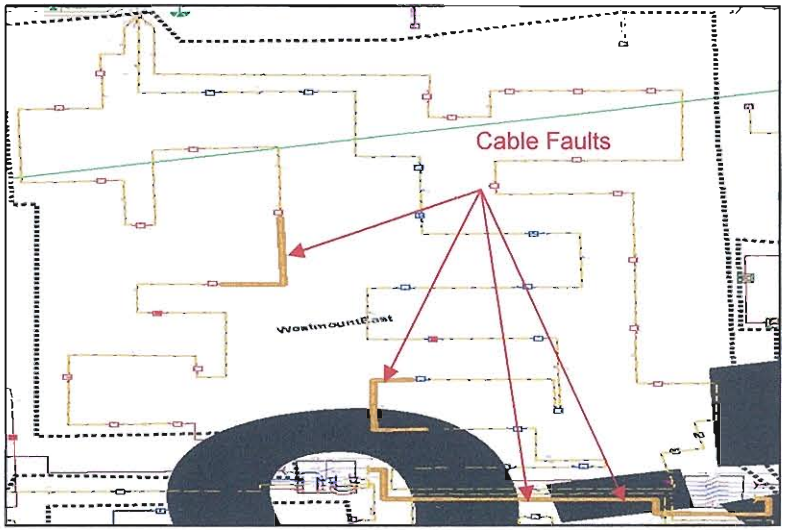
Estimated Completion Date:	October, 2010
Prepared By:	Cristina Terek, P.Eng. Distribution Reliability Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Westmount East (27.6 kV supply)

The past five years of historic outage data in this 30+ years old subdivision ranks it as the most unreliable underground residential area at this time. Failures of cable have escalated to a total of four in five years; added to that, defective transformers brought its ranking in the SPOORE analysis even higher.

After first considering a complete rebuild, another option was sought due to budget constraints. As such, this budget item proposes silicone injection to rejuvenate the polymeric insulation of 28 kV rated cable which is past its life expectancy. Silicone injection on cable of younger age was carried out in 2002 covering Westmount West with no cable failures experienced since.

The silicone injection process fills in the voids in the cable insulation (including water trees whose formation is lessened by this process), which proliferate in time leading to dielectric breakdown. It is hoped that this proposal, while considerably more economical, will provide success in mitigating continuous failures in this area supplied by an estimated 9.6 km of cable. However, depending on field conditions such as backyard construction, the costs may go higher. Many more kilometers of aged cable (approx. 330 km) remain in-service today with a high probability of decreased performance.



Westminster Park East (Phase 1)

This large area known as Westminster Park East is in urgent need of rehabilitation. The reliability of supply has been in decline. Both the duration and frequency of outages has worsened due to equipment failure combined with single supply source for many customers.

While attention has been paid to the entire subdivision which is over 30 years old, seven new risers were added in 2009 to increase the ability to backfeed customers in the event of a failure.

Due to the extent of the cable length in the entire subdivision (approximately 20 km), the area has been subdivided into two (Phase 1 and Phase 2); only Phase 1 (the east side) will be completed at this time. This will address up to 10 km of aged cable and will require replacement of eight live-front transformers. The rehabilitation will be done by means of silicone injection of the cable insulation, similar to the proposed item for Westmount East subdivision.

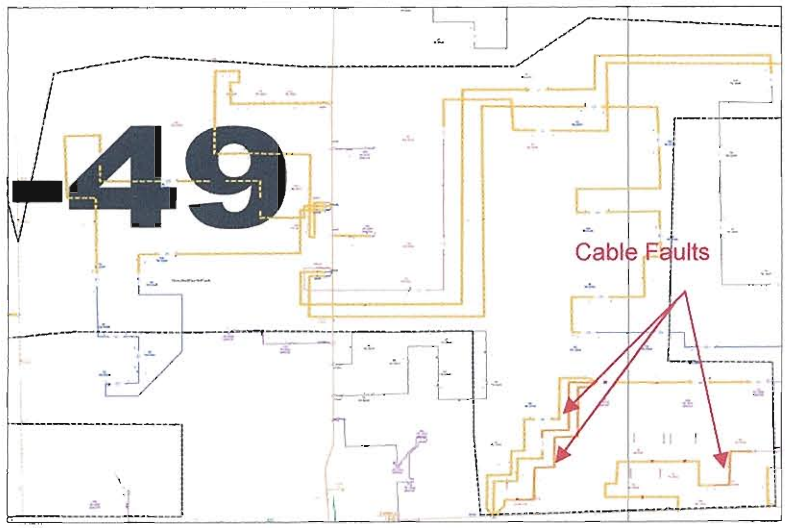


Grenfell North Park

This subdivision ranks as one of the most unreliable supply areas, for criteria similar to the other two projects proposed for 2010.

While some cables that supply the overall Grenfell North Park area are barely 25 years of age, there still are an estimated 10 km of polymeric cable which is past the end of its lifetime. Failures on both cable and transformers have proliferated in the last several years. Transformers leaking oil severely were also found during the 2008 OEB audit. The area ranks poorly in reliability; the need of rehabilitation is not questionable.

A recommendation was made that the cable replacement program should intensify its pace. As such, to minimize the existing gap between cable that needs replacement and kilometers completed every year, silicone injection will be performed on old cable in this area as well. It is expected that this technology, while achieving good results in prolonging the life of cable insulation is considerably more economical, thus addressing a larger amount of old cable under the same budget allocation.



2010 ASSET MANAGEMENT PLAN
Project Sheet

London Hydro

Project Number:	10B2
Project Name:	Nelson Park UG Rebuild
Project Class:	REL

Project Title:	Nelson Park Transformer Replacement and Voltage Conversion	BJC-C/PC-8
Project Manager:	Jagoda Borovickic	**Project Tech.:** Jamie MacPherson
Supporting Reference Material	OEB Audits Conducted by Field Staff	

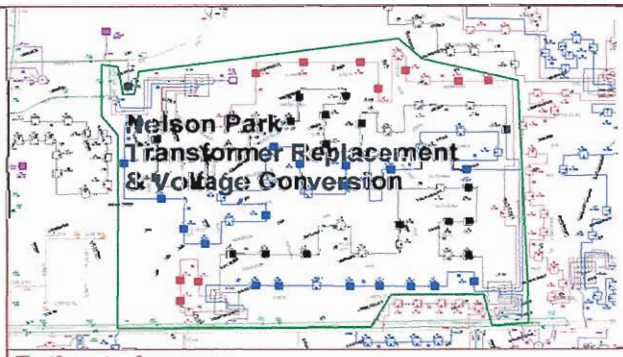
Description

This budget item includes the replacement of approximately 72 transformers, many of which are live front units that are 40 to 45 years old and have started to leak oil. The existing 28 kV rated cable is presently operating at 4.16 kV. By replacing these transformers and converting the voltage from 4.16 kV to 27.6 kV we can achieve the following:

- Resolve the environmental concern relating to leaking transformers
- Improve operability of the area by replacing non-switchable live front transformers with deadfront switchable transformers
- Provide adequate voltage support during peak loading conditions
- Facilitate the future removal of Sub 48 (on Trafalgar Street) from service
- Use components of Sub 48 for the future rebuilding of Sub 92 on Clarke Road

COST and TIMING ESTIMATES

Section - 145	Cost
Jan	
Feb	
March	$ 200,000.00
April	$ 280,000.00
May	$ 320,000.00
June	
July	
August	
Sept	
Oct	
Nov	
Dec	
TOTAL	$ 800,000.00



Estimated Completion Date: May, 2010

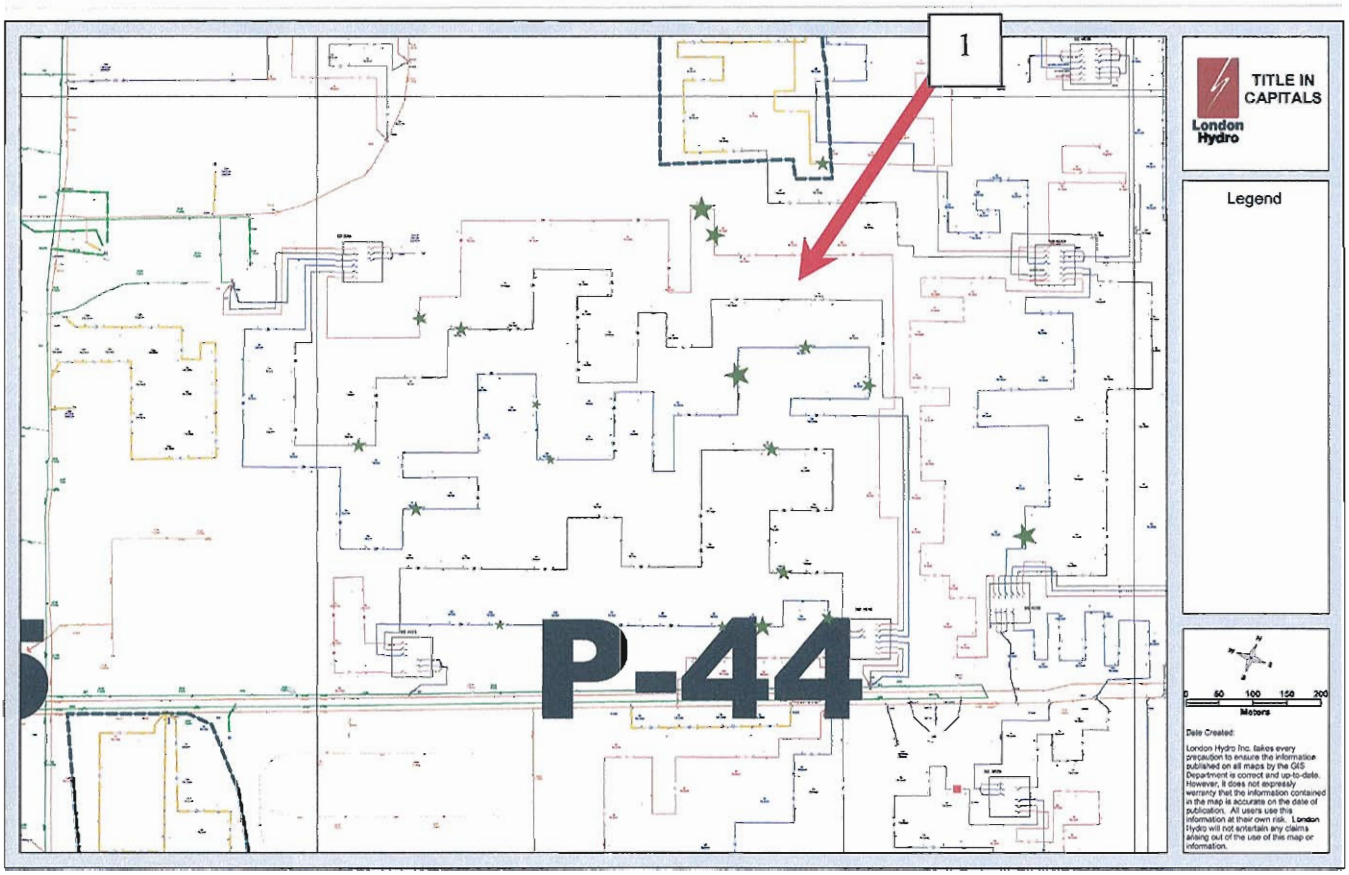
Prepared By: Allan Van Damme, P.Eng.
Manager of Engineering

Approved By: Ken Walsh, P.Eng.
Chief Engineer &
V.P. of Operations

Nelson Park Transformer Replacement and Voltage Conversion
Project 10B2

London Hydro performs OEB audits on the condition of aged padmounted transformers in our system. These audits help us identify potentially defective/end of life transformers for replacement. London Hydro takes it's environmental responsibilities seriously and as such continues to invest capital dollars into the identification and removal of these suspect transformers. Nelson Park has a high concentration of transformers that are reaching their end of life. The transformers are 40 to 45 years old on average. The voltage conversion of this area will result in several benefits outlined on the front page of this budget item.

1) Leaking transformers in area indicated by stars



2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10B3
Project Name:	Replacement of SE's
Project Objective:	REL

Project Title:	Replacement of Air Insulated Sectionalizing Enclosures (SE's)	BJC-C/PC-8

Project Manager:	Cristina Terek	**Project Tech.:**	Jamie MacPherson

Supporting Reference Material

Distribution Reliability Report, ***Performance Review and a New Perspective for In-service 27.6 kV Three-Phase Air Insulated Sectionalizing Enclosures,*** May 2006
Reliability In Review for the 2007 Operating Year, September 2007

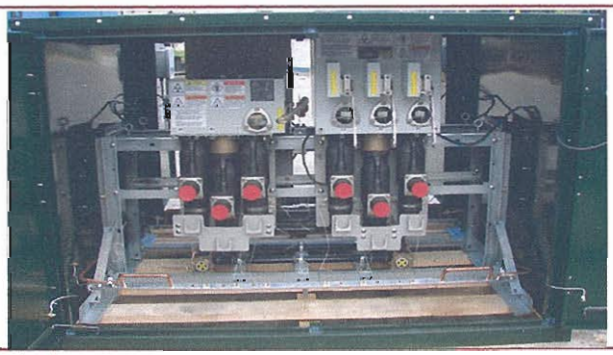
Description/Justification

Year 2010 will be the fifth year into this long-term project intended to eliminate air-insulated switchgear from our 27.6 kV distribution system. The most critical units were targeted at the initial stage and the effect has been extremely positive. After several years with no in-service failures of air-insulated switchgear, almost a third of the original subject population has been dealt with. Of these, about two thirds of the units have been phased out while the remaining old units (over 20) have been replaced by our standard solid-dielectric enclosures.

This budget item has been reduced from previous years; it is believed that an aggressive program is no longer essential to maintaining the reliability of the system. It will take up to ten years of future work to accomplish the final goal of decommissioning the entire population of air-insulated switchgear.

COST and TIMING ESTIMATES

Section - 145	Cost
Jan	
Feb	
March	$ 20,000.00
April	$ 20,000.00
May	
June	$ 20,000.00
July	
August	
Sept	$ 20,000.00
Oct	$ 20,000.00
Nov	
Dec	
TOTAL	$ 100,000.00



Estimated Completion Date: October, 2010

Prepared By: Cristina Terek, P.Eng.
Distribution Reliability Engineer

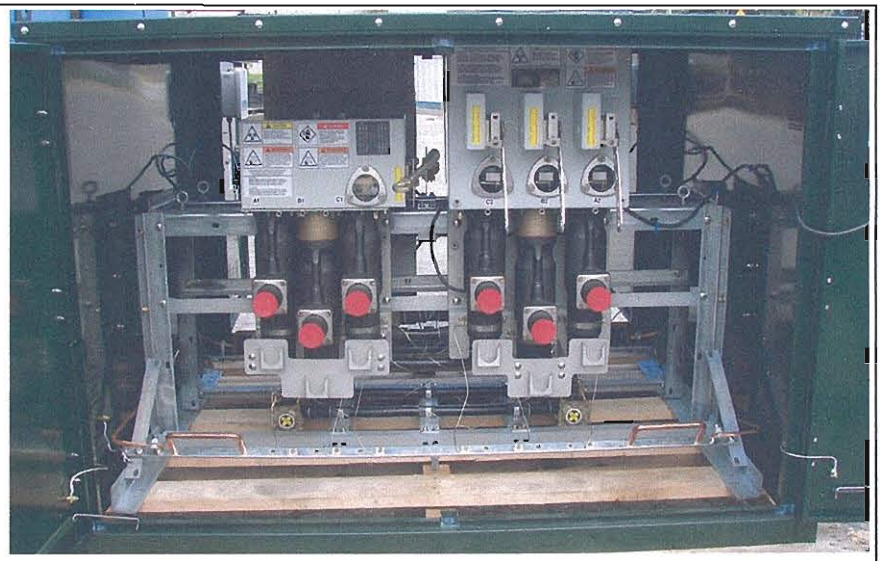
Approved By: Ken Walsh, P.Eng.
Chief Engineer &
V.P. of Operations

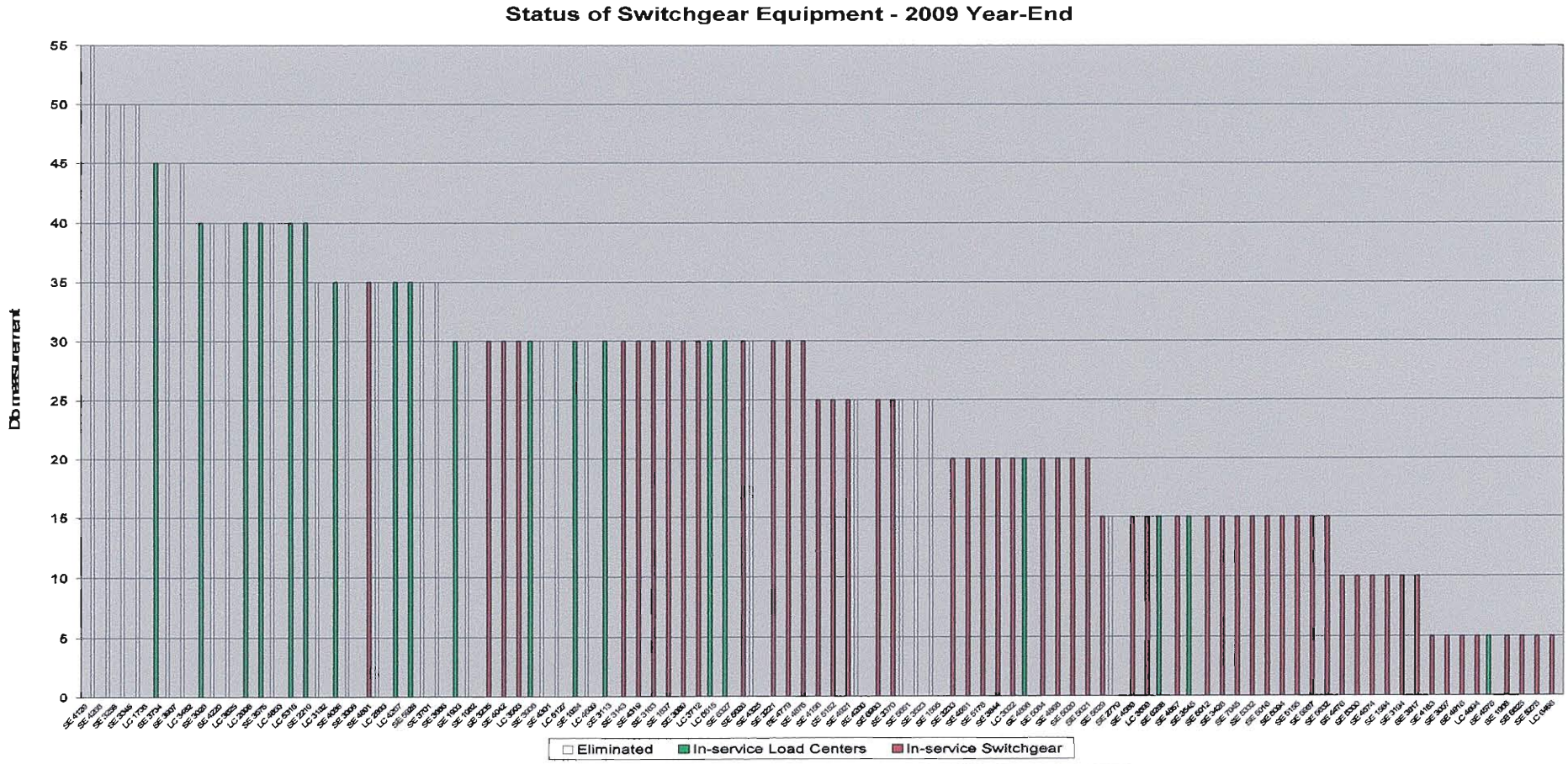
Replacement of deteriorated air-insulated switchgear (Project 10B3)

Air-insulated switchgear was introduced in the underground electrical system in the mid 70's; they were used as load distribution centres at medium voltage. However, failures in recent years were frequent. Following vigorous field inspection of all in-service units, it was concluded that the under-rated insulation degrades over time and they become prone to flashovers, resulting in failures. It was discovered and documented that dielectric breakdown of the insulation leading to premature failure was caused by severe air ionization combined with humidity within a high voltage enclosed space. Research and analysis helped prioritize the units as displayed in the graph below; replacement with solid-dielectric switchgear was recommended on the higher-risk units, it began in 2006. The progressive work during the following three years showed a remarkable positive impact.

The chart below indicates that of the equipment that was found at risk (approximately 100 units, 3-phase, 27.6 kV), many have been dealt with: either by replacement with the new standard solid dielectric switchgear (photo to the right) – the green bars, or by elimination where the configuration made it redundant – the transparent bars.

Since approximately 50 of the most critical units were replaced during the first three years, the on-going program is no longer as aggressive; the risk was mitigated and the remaining population will be replaced in due time.





2010 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	10B4
Project Name:	Leaking Transformers
Project Objective:	SAF

Project Title:	Leaking Transformer Replacement	BJC-B/PC-10
Project Manager:	Jagoda Borovickic	**Project Tech.:** Fernando Depierro
Supporting Reference Material	OEB Audits conducted by field staff	

Description/Justification

London Hydro field staff conduct annual audits of padmounted transformers in accordance with the requirements of the Ontario Energy Board. These audits are meant to identify transformers which may be weeping oil around the primary and secondary bushings. This matter is usually caused by the degradation of the sealing gaskets.

This project covers the cost to identify and replace the above mentioned transformers.

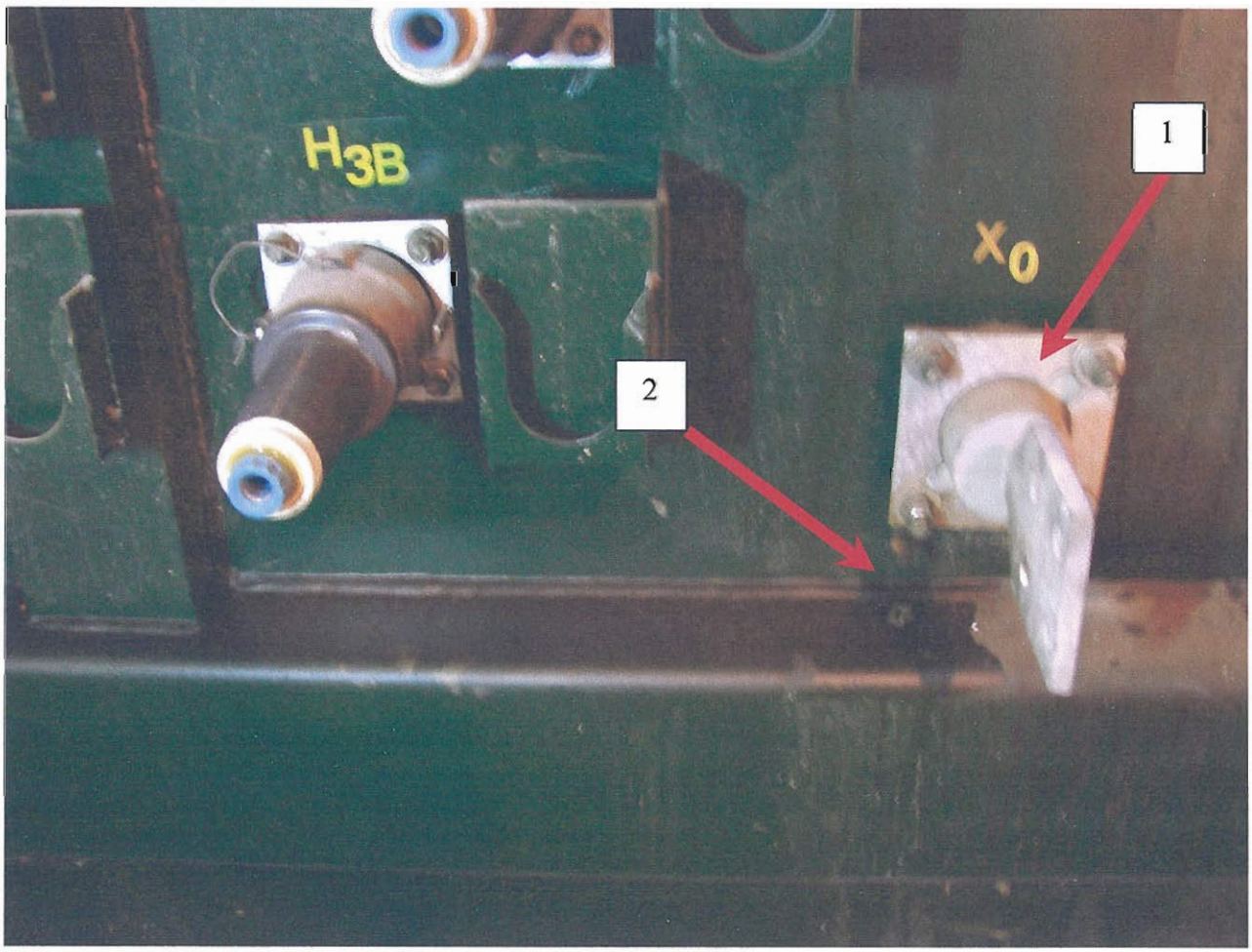
COST and TIMING ESTIMATES

Section - 145	Cost
Jan	$ 12,000.00
Feb	$ 18,000.00
March	$ 30,000.00
April	$ 60,000.00
May	$ 80,000.00
June	$ 90,000.00
July	$ 90,000.00
August	$ 60,000.00
Sept	$ 60,000.00
Oct	$ 60,000.00
Nov	$ 60,000.00
Dec	
TOTAL	$ 620,000.00

Estimated Completion Date:	November, 2010
Prepared By:	Allan Van Damme, P.Eng. Manager of Engineering
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Leaking Transfomer Replacement
Project 10B4

London Hydro performs OEB audits on the condition of aged padmounted transformers in our system. These audits help us identify potentially defective/end of life transformers for replacement. London Hydro takes its environmental responsibilities seriously and as such continues to invest capital dollars into the identification and removal of these suspect transformers. Historically, we have been identifying 65 suspect transformers per audit year. The cost to replace a typical suspect transformer ranges between $7500 - $15,000 depending on Transformer type. The allocated amount for this project is $620,000.



1) Neutral Bushing
2) Oil Leak

2010 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	10B5
Project Name:	Secondary Pedestal Replacement
Project Objective:	REL

Project Title:	Residential Secondary Pedestal Replacement	BJC-C/PC-8
Project Manager:	Jagoda Borovickic	**Project Tech.:** Fernando DePierro
Supporting Reference Material	OEB Audits conducted by field staff	

Description/Justification

London Hydro has a large number of single phase low voltage junction pedestals active in our system. These units are typically used in residential areas. They allow one common bus cable to be divided into several service cables to feed multiple meters. Some of these units are reaching their end of life. They are in excess of 30 years old and the enclosures are starting to corrode. It has also been found that the connections and barriers within the existing units are beginning to fail.

This budget targets the replacement of these existing units with our new non-metalic units shown below. The replacements will be prioritized based on the findings from our OEB audits conducted by field staff and address areas where problems have been experienced in the past.

COST and TIMING ESTIMATES

Section - 145	Cost
Jan	
Feb	
March	$ 6,250.00
April	$ 6,250.00
May	
June	
July	$ 6,250.00
August	
Sept	$ 6,250.00
Oct	
Nov	
Dec	
TOTAL	$ 25,000.00

New replacement unit shown to right



Estimated Completion Date: September, 2010

Prepared By: Rick Stainthorpe
EUS Supervisor

Approved By: Ken Walsh, P.Eng.
Chief Engineer &
V.P. of Operations

2010 ASSET MANAGEMENT PLAN
Project Sheet

London Hydro

Project Number:	10B6
Project Name:	Vault Rebuilds
Project Class:	SAF

Project Title:	Vault Transformer Replacements	BJC-B/PC-10

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Jamie MacPherson

Supporting Reference Material

OEB Audits conducted by field staff

Description

Through the course of their regular inspections, London Hydro staff have identified various indoor transformer vaults that require attention. These vaults include two school locations: Westmount Senior Public School and Manor and Highland Park Public School. We also need to rebuild the apartment vault located at 1 Fontenac Road.

Westmount Senior Public School and Manor and Highland Park Public School
These two public school vaults contain oil filled transformers (non-PCB). These transformers will be replaced with padmounted transformers that are mounted external to the building or transformers that are filled with a non-flammable fluid that is also environmentally friendly.

1 Frontenac Road – Apartment Vault
This indoor transformer vault contains dry-type transformers that are more than forty years old. Our operation staff have identified this location as having chronic water problems that could result in equipment failure. This budget item will allow for the replacement of this transformer with a padmount unit outside the vault. It will also allow for the installation and termination of secondary cables from the new padmount location to a new disconnect inside the vault.

For illustrative purposes, a picture of the dry type transformers at 1 Frontenac Road has been provided on the back of this page.

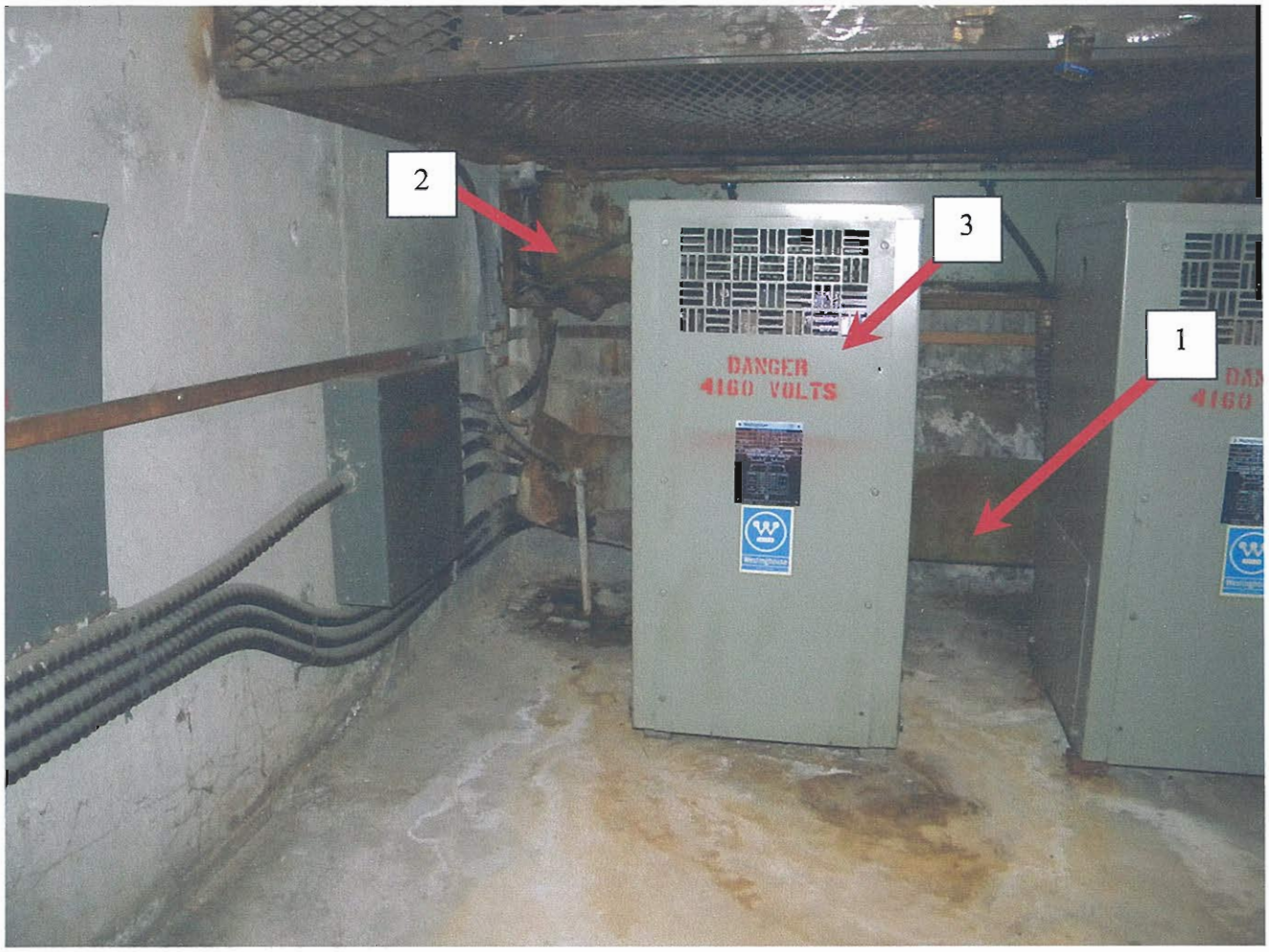
COST and TIMING ESTIMATES

Section - 145	Cost
Jan	
Feb	$ 6,750.00
March	
April	
May	
June	
July	$ 40,500.00
August	$ 40,500.00
Sept	$ 47,250.00
Oct	
Nov	
Dec	
TOTAL	$ 135,000.00

Estimated Completion Date:	September, 2010
Prepared By:	Allan Van Damme, P.Eng. Manager of Engineering
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Apartment Vault Replacements
Project 10B6

1 Frontenanc Road



1) Shows water tracking down wall
2) Advanced Corrosion due to moisture
3) Dry Type transformer

2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10B7
Project Name:	Backup Supply Installation
Project Objective:	REL

Project Title:	Installation of Underground Backup Supply	BJC-C/PC-8
Project Manager:	Jagoda Borovickic	**Project Tech.:** Fernando DePierro

Supporting Reference Material

Description/Justification

London Hydro has started to experience outages in the Meadowbrook and Scenic View underground subdivisions. Both of these areas were serviced approximately 30 years ago with a radial underground system. This configuration leaves London Hydro's control room operators with no options to restore power quickly during outages resulting from equipment failure.

This budget item provides for these systems to be "looped" thereby providing our operators with an alternate source from which they can restore power. This work will greatly improve the speed that power can be restored to these areas and enhance the reliability of supply.

COST and TIMING ESTIMATES

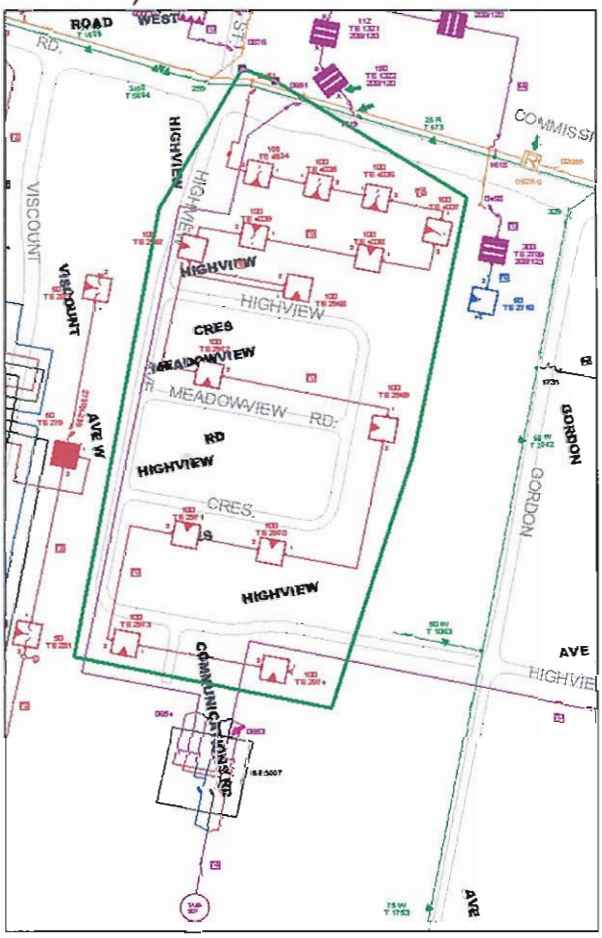
Section - 145	Cost
Jan	
Feb	
March	$ 19,250.00
April	
May	
June	
July	
August	$ 24,750.00
Sept	$ 11,000.00
Oct	
Nov	
Dec	
TOTAL	$ 55,000.00

Estimated Completion Date:	September, 2010
Prepared By:	Allan Van Damme, P.Eng. Manager of Engineering
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

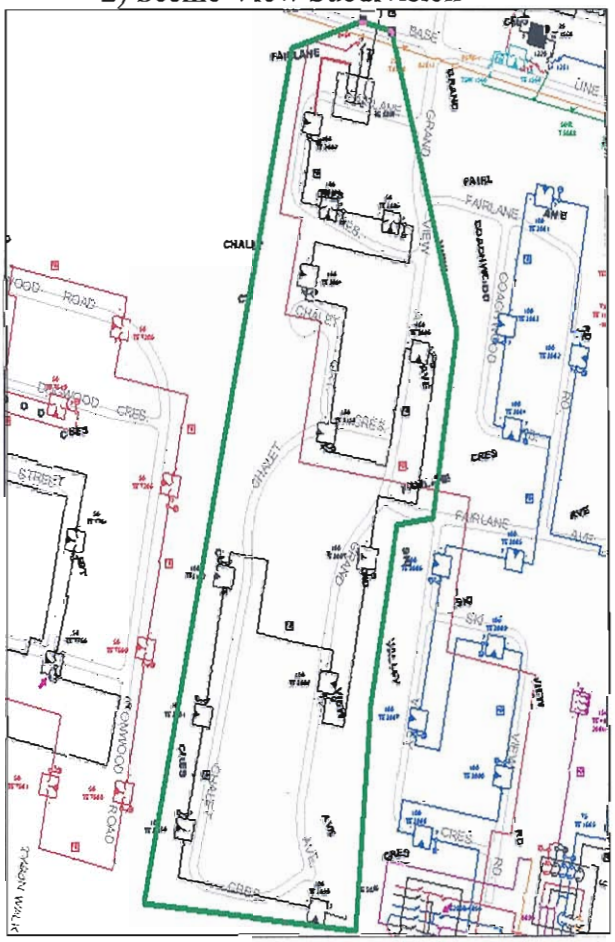
Installation of Underground Backup Supply
Project 10B7

London Hydro has started to experience outages in two underground areas that were installed approximately 30 years ago without a looped supply arrangement. As a result, cable faults within these radially supplied systems lead to prolonged outages due to the absence of switching or reconfiguration options. Each area supplies approximately 180 customers and approximately 500 kW's of load. This budget item will correct the situation by completing the loop and providing an alternate source of supply to these subdivisions. The two areas are highlighted below and are located in the Meadowbrook Subdivision and Scenic View Subdivision.

1) Meadowbrook Subdivision



2) Scenic View Subdivision



2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10B8
Project Name:	Fault Indicator Installations
Project Objective:	REL

Project Title:	Installation of Fault Indication on Padmounted Transformers	BJC-C/PC-8

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Fernando DePierro

Supporting Reference Material

Description/Justification

Fault locating of long underground systems can lead to extended outages in the absence of strategically placed fault indicators. In areas without fault indicators, our crews must open each transformer and test the cable in order to determine the location of the fault. Fault indication technology allows for fault assessment from outside of the transformer allowing our crews to quickly locate the fault, isolate the faulted cable and return power to the affected customers quickly.

This item includes the installation of fault indicators in areas with complex or lengthy underground distribution systems.

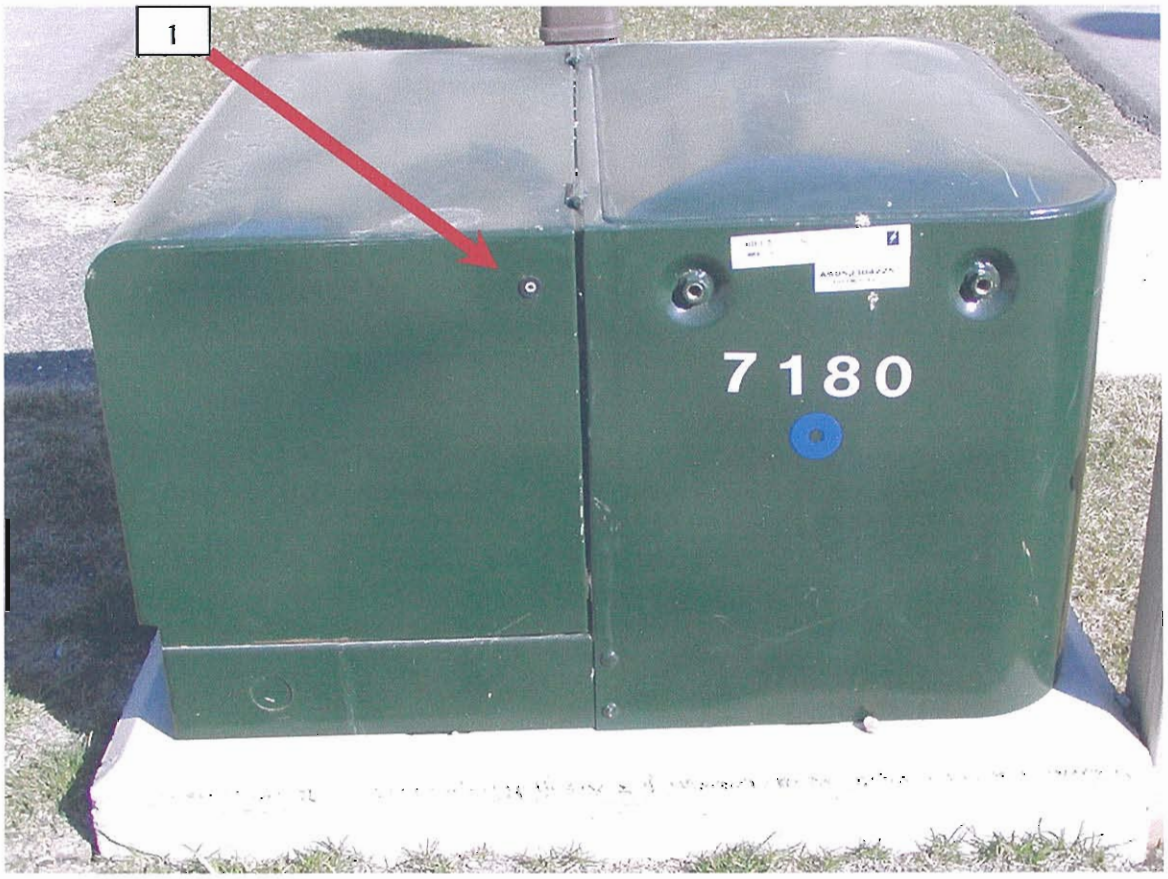
COST and TIMING ESTIMATES

Section - 145	Cost
Jan	
Feb	
March	$ 5,000.00
April	$ 5,000.00
May	
June	
July	
August	
Sept	
Oct	
Nov	
Dec	
TOTAL	$ 10,000.00

Estimated Completion Date:	April, 2010
Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Installation of Fault Indication on Padmounted Transformers
Project 10B8

As was mentioned prior, the installation of fault indication in areas with lengthy and complex circuit arrangements has the ability to decrease both outage duration and cost of repair. The average underground subdivision contains 16 transformers on a feeder loop. These loops are segmented into two radial sections of 8 transformers to minimize the effects of an outage. Through the installation of fault indication it was found that the average time required to locate a faulted section of cable could be reduced by 1.25 hrs. This translates into a savings of roughly 9600 customer minutes per outage.



1) Fault Indicator – Led lights red when transformer has witnessed fault current.

2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10C1
Project Name:	Ridout 13.8 kV Conversion
Project Objective:	RNF

Project Title:	Ridout Street 13.8 kV Conversion	BJC-E\PC-9
Project Manager:	Allan Van Damme	**Project Tech.:** Jamie MacPherson

Supporting Reference Material

Description/Justification

London Hydro's 13.8 kV 1K4 feeder supplies several customer owned substations along Ridout Street from Dundas Street to King Street. These customer owned substations are supplied through London Hydro owned high voltage metal clad switches that are located within the customer's building. These switches are approximately 30 years old and are difficult to maintain or replace in the event of a failure. Recent developments such as the Rennisance appartments have extended our 27.6 kV system along Ridout Street. This extension has provided us with an opportunity to replace these customer owned substations and switches with standard 27.6 kV padmounted transformers. This reduces our risk of a prolonged outage on this feeder. The reduction of 13.8 kV load in this area is consistent with the long range plans for Nelson TS. It may be possible to recover spare parts from these switches so that they can be used for emergency purposes at other locations on our system.

It is noted that there are several details associated the customer owned equipment within the buildings that must be verified during the detailed design phase of this project. This will be done with the use of external consulting engineers. In absence of this detail we have used all available information to produce this budget value.

COST and TIMING ESTIMATES

Section - 131	Cost
Jan	
Feb	$ 22,500.00
March	
April	
May	
June	
July	
August	$ 67,500.00
Sept	$ 135,000.00
Oct	$ 157,500.00
Nov	$ 67,500.00
Dec	
TOTAL	$ 450,000.00

Estimated Completion Date:	November, 2010
Prepared By:	Allan Van Damme, P.Eng. Manager of Engineering
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

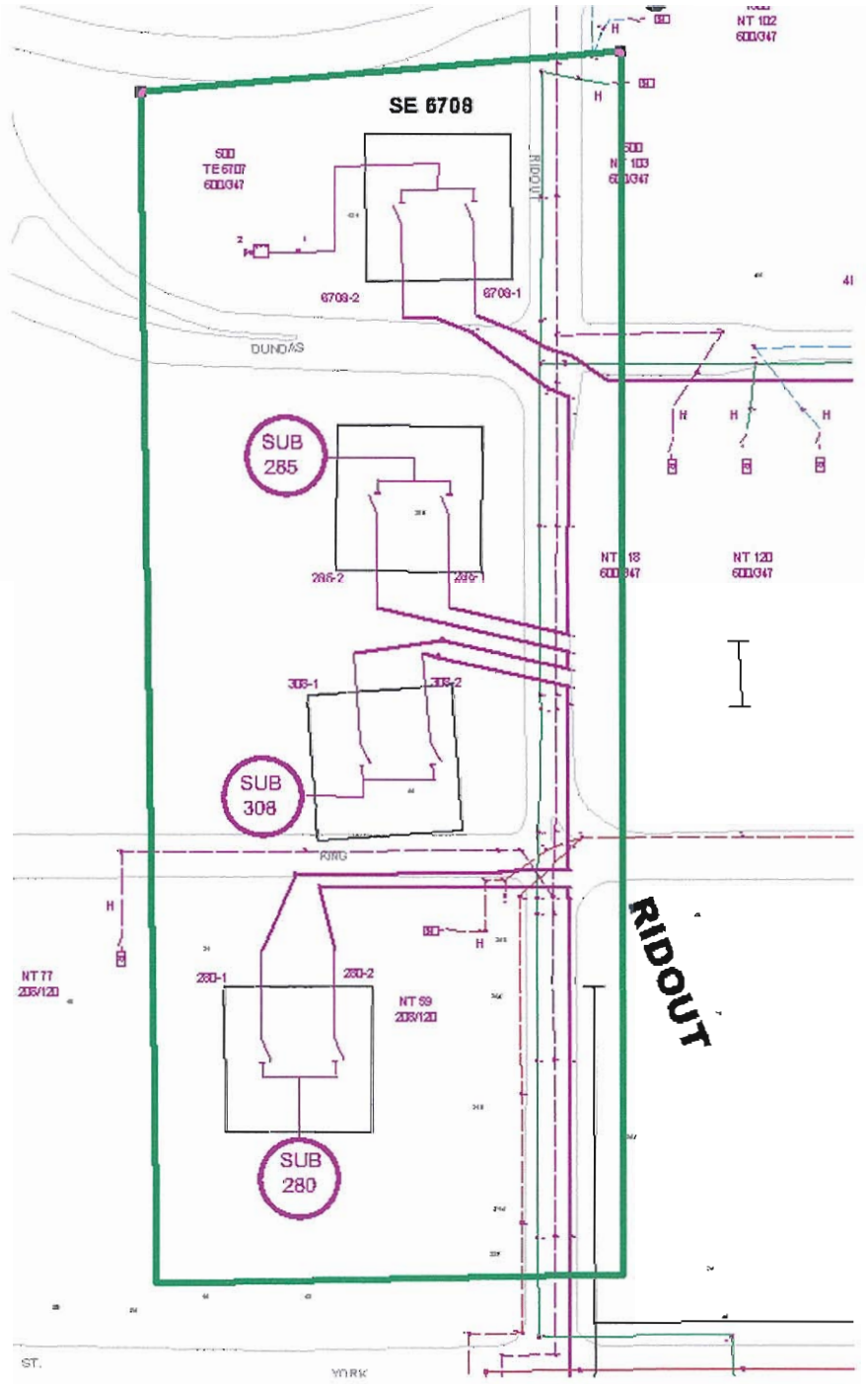
Ridout Street 13.8 kV Conversion
Project 10C1

The area targeted conversion includes the London Art Gallery, the Middlesex County Court House Restoration, Middlesex-London District Health Unit building and the Peter McGregor Apartments building.

The reduction of 13.8 kV in this area is consistent with the long range plans for Nelson TS. This project will also help to facilitate the future elimination of an obsolete oil switch located at Bathurst and Ridout Streets along with two 13.8 kV station breakers.

This conversion will transfer all load that is directly supplied by the 1K4 feeder to the 27.6 kV system. The overall area being converted is illustrated below and represents approximately 1.5 MW of load.

Conversion Area Along Ridout Street



2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10C2
Project Name:	King St. 4.16kV Conversion
Project Objective:	RNF

Project Title:	King St. 4.16kV Conversion East of Adelaide St.	BJC -E/PC-8
Project Manager:	Rod Doyle	**Project Tech.:** Hank Bonnar

Supporting Reference Material

Description/Justification

This project will convert the 4.16kV along King Street between Adelaide Street to Rectory Street and on Rectory Street from Dundas Street to Florence Street to the 27.6kV system.

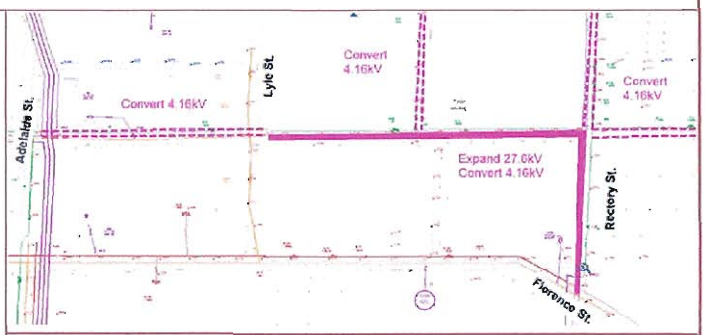
The primary factor driving this project is to coordinate with a new customer load developing in this area (2 new residential high-rises). A number of factors are driving this project to expand the 27.6kV system and convert the 4.16kV system:

1. The 4.16kV system cannot support the new customer load expanding in this area.
2. The 4.16kV three-phase customers on Rectory Street experience low-voltage problems.
3. The elimination of the 4.16kV system will save on long term maintenance costs.
4. The conversion of the 4.16kV will place 27.6kV on the east end of the East Network, which will assist with the East Network conversion plan; thus, offloading Nelson TS.
5. The conversion of the 4.16kV offloads Substations 2 and 28, which offloads Nelson TS.

The 4.16kV will be converted to 27.6kV that is already in place on King Street from Adelaide Street to Lyle Street. A 27.6kV system expansion will convert the remaining 4.16kV along King Street from Lyle Street to Rectory Street and along Rectory Street from Dundas Street to Florence Street. King Street east of Lyle Street is already insulated and conductor sized for 27.6kV.

COST and TIMING ESTIMATES

Section - 131	Cost
Jan	
Feb	
March	
April	$ 90,000.00
May	$ 90,000.00
June	$ 90,000.00
July	$ 90,000.00
August	
Sept	
Oct	
Nov	
Dec	
TOTAL	$ 360,000.00



Estimated Completion Date: July, 2010

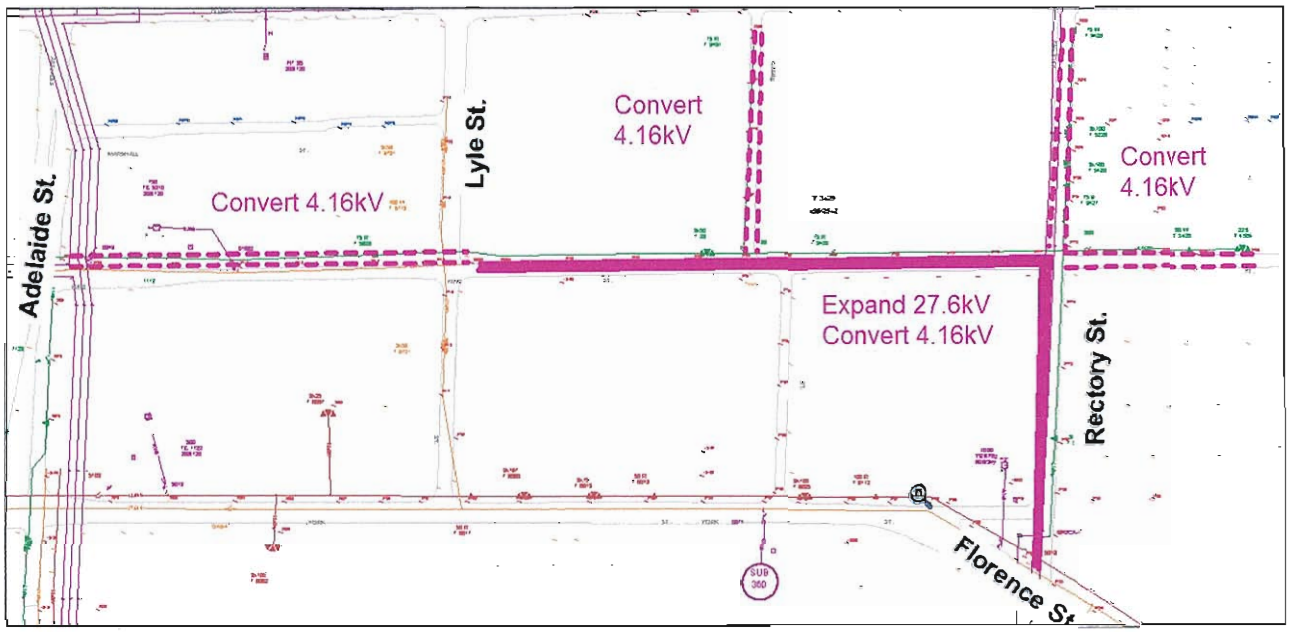
Prepared By: Rod Doyle, P.Eng.
Distribution Engineer

Approved By: Ken Walsh, P. Eng.
Chief Engineer &
V.P. of Operations

Convert 4.16kV on King Street east of Adelaide Street
Project 10C2

The 4.16kV will be converted to the 27.6kV circuitry that is already in place on King Street from Adelaide Street to Lyle Street. A 27.6kV system expansion will convert the remaining 4.16kV along King Street from Lyle Street to Rectory Street and along Rectory Street from Dundas Street to Florence Street.

This conversion will take place to co-ordinate with the large new residential project being built by Medallion Properties Incorporated. This development will be located on King Street between Lyle and Hewitt Streets. The area identified for conversion is shown below.



Convert 4.16kV on King St. to 27.6kV

2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10C3
Project Name:	26M11 Feeder & 26M56 Egress
Project Objective:	RNF

Project Title:	26M11 Feeder and 26M56 Egress Installation	BJC -E/PC-8

Project Manager:	Rod Doyle	**Project Tech.:**	Jim Soetemans

Supporting Reference Material

New Supply Capacity for London - 2006 to 2010
2008 Addendum to New Supply Capacity for London 2006-2010

Description/Justification

System Planning has identified the need to increase load transfer capability between Talbot Transformer Station and Clarke Transformer Station and to provide load relief in the northeast part of the city by constructing the 26M11 feeder.

Currently, the 26M11 breaker is supplying the former 26M56 feeder. The scope of project will include installing a new egress feeder cable to connect the 26M56 breaker to the former 26M56 feeder and construct a new circuit route for the 26M11 feeder to supply the northeast part of the city and load relief for Clarke Transformer Station.

Clarke Transformer Station presently operates above the station's 10-day LTR rating. The 26M11 feeder will offload Clarke's 70M4, 70M5 & 70M7 feeders.

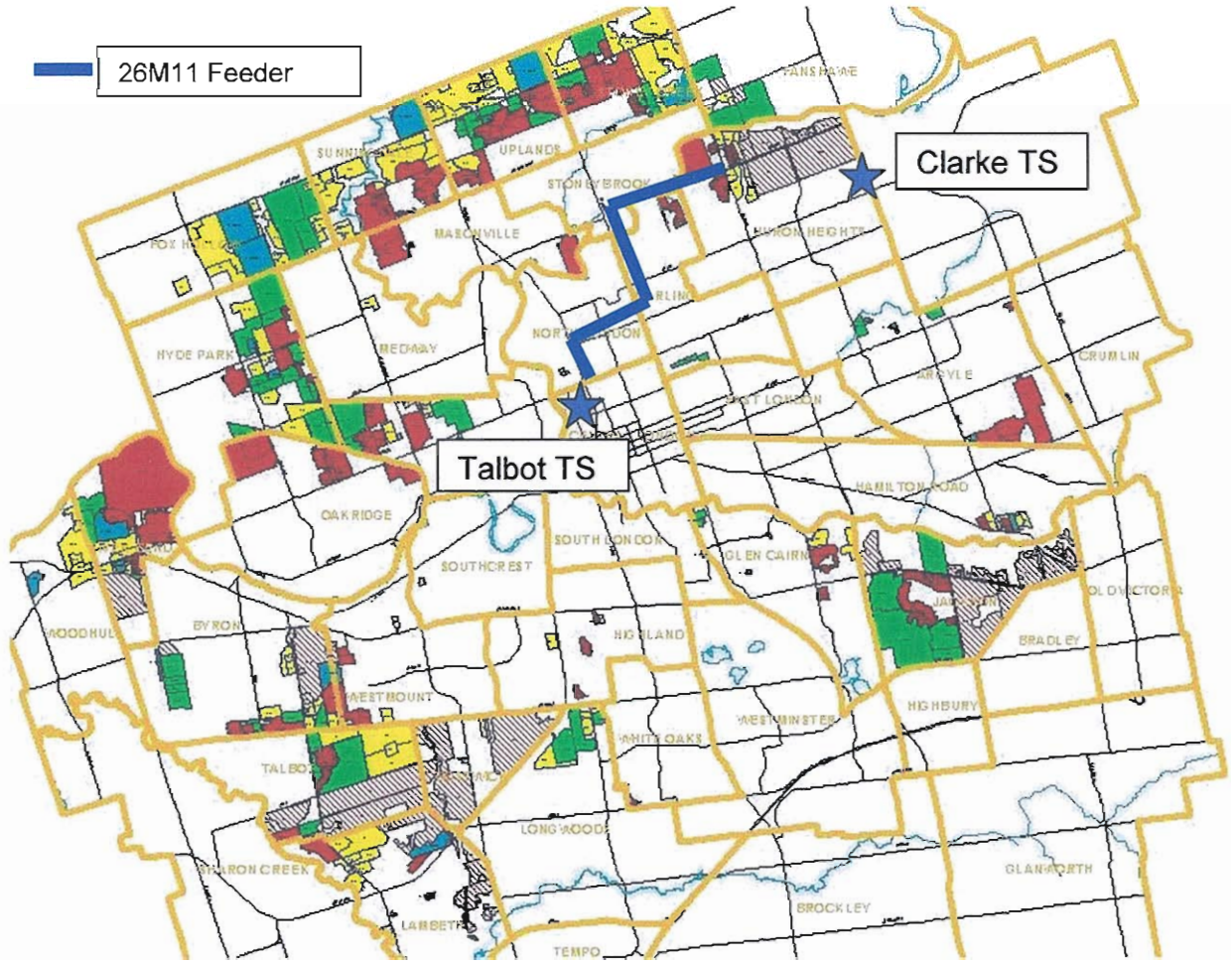
COST and TIMING ESTIMATES

Section - 140	Cost
Jan	
Feb	
March	$ 88,000.00
April	$ 204,000.00
May	$ 136,000.00
June	$ 136,000.00
July	$ 136,000.00
August	
Sept	
Oct	
Nov	
Dec	
TOTAL	$ 700,000.00

Estimated Completion Date:	July, 2010
Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P. Eng. Chief Engineer & V.P. of Operations

Construction of 26M11 Feeder and New Egress for 26M56 Feeder
Project 10C3

London Hydro will construct the 26M11 feeder from Talbot TS to supply load relief in Clarke TS service area. This project will also utilize the 26M56 breaker from Talbot TS.



Feeder Route for the 26M11 Feeder

2010 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	10C4
Project Name:	Sub 97 Conversion
Project Objective:	RNF

Project Title:	Sub 97 Voltage Conversion - Phase 1	BJC- E/PC-9

Project Manager:	**Project Tech.:**

Supporting Reference Material

2008 Substation Deficiency Report

Description/Justification

This project will soft convert two of three Sub 97 8.32 kV feeders (97F1 and 97F3) to the 32M1 and 32M6 27.6 kV Wonderland feeders using pairs of stepdown transformers.

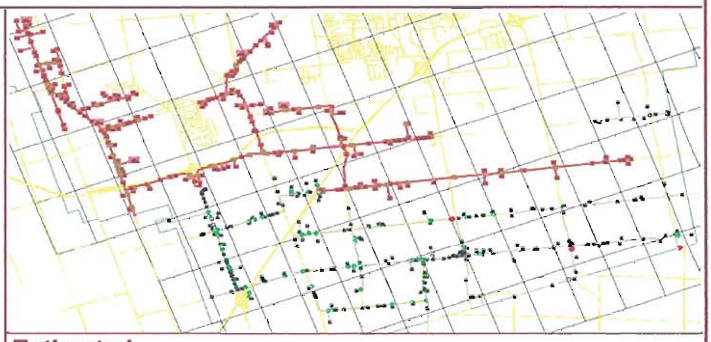
The primary factor driving this project is the 2008 Substation Deficiency Report which identified Sub 97 as the most deficient substation at London Hydro. This conversion will be the first step in the complete decommissioning of Sub 97.

Also, this conversion will allow for one of the station transformers to pickup the entire system load. Currently, if one of the Sub 97 station transformers is lost on the system peak day the other transformer would be unable to support the entire 8.32 kV system load. This would cause extended outages to many of the customers on the 8.32 kV system. Going forward with the soft conversion of two of the three feeders from Sub 97 will allow for one transformer to pickup the remaining load in the case the other transformer is lost, increasing system reliability in the process.

Over the next couple of years proposed distributed generation projects will make it possible to soft convert the remaining 97F2 feeder to Wonderland feeders using distributed stepdown transformers and allow for the complete decomissing of Sub 97.

COST and TIMING ESTIMATES

Section - 131		Cost
Jan	$	1,000.00
Feb	$	2,000.00
March	$	-
April	$	-
May	$	50,000.00
June	$	67,000.00
July	$	150,000.00
August	$	50,000.00
Sept	$	-
Oct	$	-
Nov	$	-
Dec	$	-
TOTAL	$	320,000.00



Estimated Completion Date: August, 2010

Prepared By: Ysni Semsedini, P.Eng.
Distribution Engineer

Approved By: Ken Walsh, P.Eng.
Chief Engineer &
V.P. of Operations

Substation 97 Conversion Phase 1
Project 10C4

As part of London Hydro's continuous substation assessment process, substations deficiencies are ranked based on a number of criteria including: age and condition of transformation, age and condition of switching equipment, ability to secure replacement parts and the ability to backup the station in case of a failure. Sub 97 is the second oldest substation by transformer age in London Hydro service territory and was deemed the most deficient station in a 2008 report. Sub 97 supplies power to the city's south end (south of the 402 and 401 to the city boundary and the city boundary from east to west). This station was originally owned by Hydro One and was transferred to London Hydro after annexation. Sub 97 currently has no means of backup and contains an exposed overhead bus structure. This project would look to soft convert 2 of the 3 8.32 kV Sub 97 feeders to Wonderland 32M1 and 32M6 feeders. This work is the first step in a complete decommissioning of Sub 97.



Figure 1 – Sub 97 Station



Figure 2 – Sub 97 Overhead Bus

2010 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	10D1
Project Name:	City Requested Relocations
Project Objective:	COL

Project Title:	City of London (Road Authority) Relocations	BJC-F/PC-10
Project Manager:	Rod Doyle	**Project Tech.:** Jim Soetemans

Supporting Reference Material

Description/Justification

This project comprises of the relocation of London Hydro Infrastructure located on the road allowance. These relocations are initiated by the Road Authority (City of London) and are necessary in order to accommodate planned modifications to the roadway.

The terms and conditions under which these relocations occur are specified in the Public Service Works on Highways Act enacted by the Provincial Government. The Act gives a Road Authority the power to ensure that all operating corporations entitled to the use of the road allowance cooperate with the Road Authority to execute any required modifications to the profile of the road allowance in a timely manner. The Act states that an Operating Corporation (London Hydro Inc) must modify or relocate their plant on the road allowance to accommodate the Road Authority's improvements or alterations within a specified time period. The Act also outlines the mechanism for the apportionment of costs for these required works. Typically the Operating Corporation is permitted to recover 50% of the labour and vehicle costs from the Road Authority.

Some of the larger relocation projects for 2010 include:
- Wonderland Rd. widening between Gainsborough Rd. to Fanshawe Park Rd.
- Hale St. and Trafalgar St. rail overpass
- Fanshawe Park Rd. and Highbury Ave. intersection widening

COST and TIMING ESTIMATES

Section - 133	Cost
Jan	$ 200,000.00
Feb	$ 206,250.00
March	$ 200,000.00
April	$ 200,000.00
May	$ 101,250.00
June	$ 81,250.00
July	$ 81,250.00
August	$ 81,250.00
Sept	$ 81,250.00
Oct	$ 81,250.00
Nov	$ 48,750.00
Dec	$ 32,500.00
TOTAL	$ 1,395,000.00

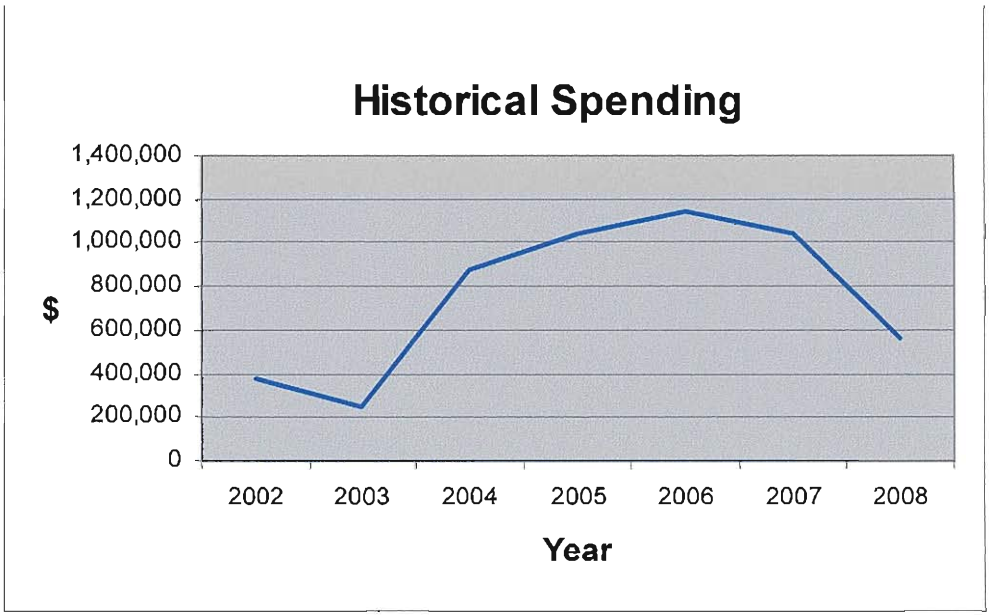
Estimated Completion Date:	December, 2010
Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

City of London (Road Authority) Relocations
Project 10D1

London Hydro works closely with the City of London to try and determine which of their projects will affect London Hydro's infrastructure. Unfortunately, the City has not defined all their projects for 2010; therefore, the annual expenditures are estimated based on a combination of known projects and base historical spending. Spending in this area has ranged from $249,000 to $1,140,000 in the last six years depending on the projects that were identified by the City of London as being required.

The City of London has identified two large relocations for 2010 and the completion of a third relocation carried over from 2009:

1. Wonderland Rd. widening between Gainsborough Rd. to Fanshawe Park Rd. (carry over from 2009)
2. Hale St. and Trafalgar St. rail overpass
3. Fanshawe Park Rd. and Highbury Ave. intersection widening



Note: As is evidenced in North America and particularly in Canada, there is an increased emphasis on municipal infrastructure improvements. For instance, road way enhancements and other sub service utilities i.e. Water mains and sewers.

2010 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	10E1
Project Name:	Expansions and Relocations
Project Objective:	DEV

Project Title:	Developer Driven Distribution Circuit Expansions and Relocations	BJC-F/PC-10
Project Manager:	Jagoda Borovickic/Rod Doyle	**Project Tech.:** Hank Bonnar

Supporting Reference Material

Description/Justification

This budget item includes extension of the existing high voltage overhead or underground distribution system in order to accommodate new customer developments as they are added to London's service area. This budget item includes all costs associated with the construction of these extensions.

Some of the major expansions anticipated for 2010 include:
- 27.6 kV line extension on White Oak Road from Dingman Drive to Manning Drive to supply the W12A Landfill
- Innovation Park Phase 3 (underground)
- Innovation Park Phase 4 (underground)

This item also includes the relocation of existing London Hydro plant for accommodating new developments within the city limits. These relocations are required when items such as new proposed driveways and turn lanes for new developments are in conflict with the existing hydro plant. This budget item includes all costs associated with the relocation.

COST and TIMING ESTIMATES

Section - 131	Cost
Jan	$ 130,000.00
Feb	$ 310,000.00
March	$ 420,000.00
April	$ 525,000.00
May	$ 300,000.00
June	$ 205,000.00
July	$ 190,000.00
August	$ 205,000.00
Sept	$ 290,000.00
Oct	$ 625,000.00
Nov	$ 500,000.00
Dec	$ 360,000.00
TOTAL	$ 4,060,000.00

Estimated Completion Date:	December, 2010
Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

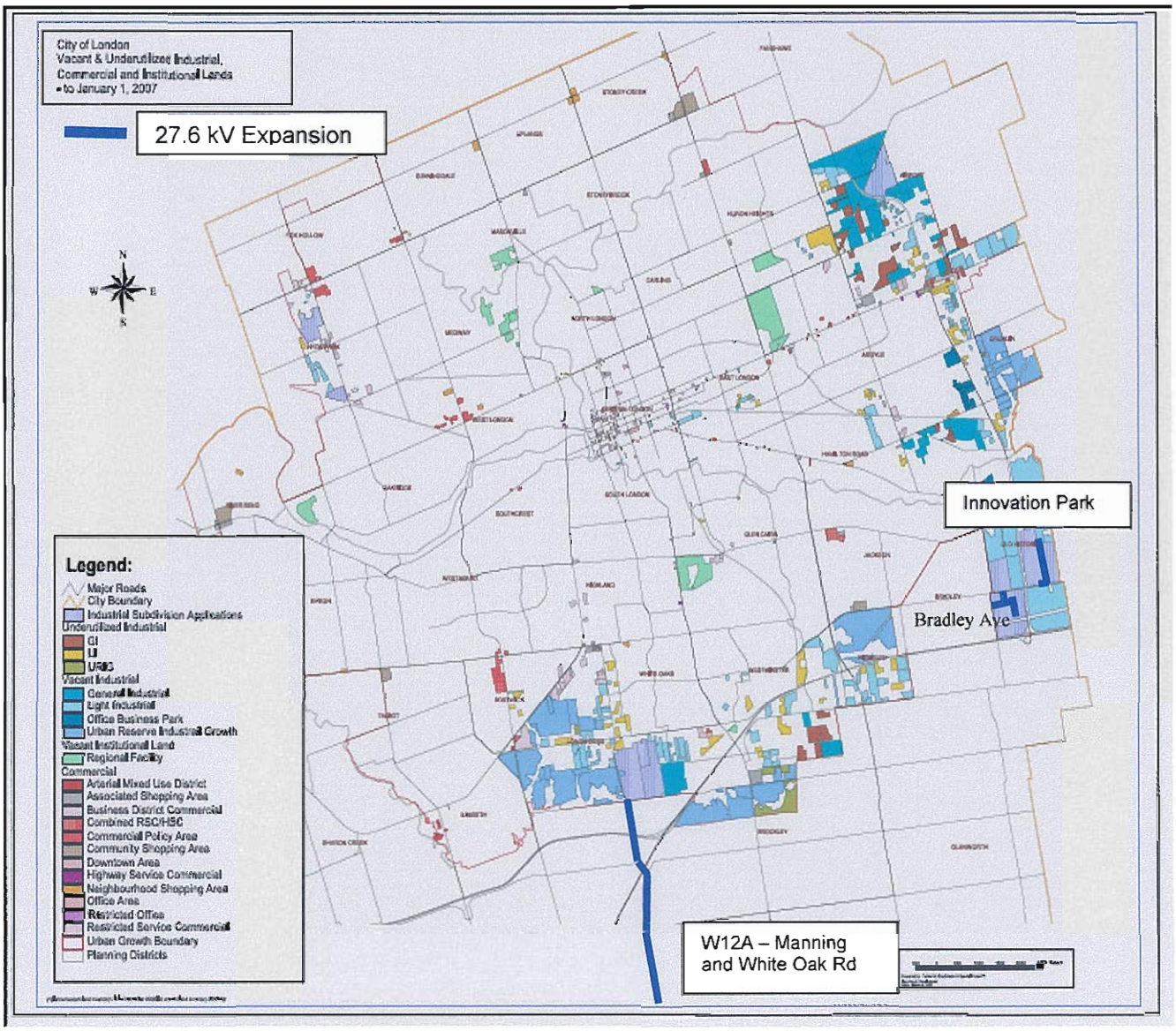
Developer Driven Distribution Circuit Expansions and Relocations
Project 10E1

This project comprises the installation and/or modification of electrical equipment that is used in supplying customers' installations. It also includes the work associated with upgrading existing installations.

The London Hydro Conditions of Service Document details how capital contributions are assessed for these installations.

From a budgeting perspective, the annual expenditures are estimated based on a number of factors including: City of London development forecasts and customer inquiries.

The three largest expansions that are proposed for 2010 include: Innovation Park Phase 3 and Phase 4 and an expansion of the City's W12A Material Recovery Facility located at Manning and White Oaks Road. These expansions are illustrated on the map below. These three expansions account for $3,760,000 of the $4,060,000 in this budget section and will require both overhead and underground plant to be extended. The remaining $300,000 allocated for expansions and relocations is yet to be determined by various developers.



2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10E2
Project Name:	Secondary Service Upgrades
Project Objective:	DEV

Project Title:	Residential Secondary Service Upgrades	BJC-F/PC-10
Project Manager:	Rod Doyle	**Project Tech.:** Jim Soetemans

Supporting Reference Material

Description/Justification

This budget item includes replacement of the existing low voltage conductors with conductors of increased size from the overhead transformer to the customers' electrical service stacks. These upgrades are often required when customers increase their electrical demands. This item involves all costs associated with these upgrades.

COST and TIMING ESTIMATES

Section - 131	Cost
Jan	$ 13,000.00
Feb	$ 13,000.00
March	$ 13,000.00
April	$ 26,000.00
May	$ 26,000.00
June	$ 26,000.00
July	$ 26,000.00
August	$ 26,000.00
Sept	$ 26,000.00
Oct	$ 26,000.00
Nov	$ 26,000.00
Dec	$ 13,000.00
TOTAL	$ 260,000.00

Estimated Completion Date: December, 2010

Prepared By: Jagoda Borovickic, P.Eng.
Distribution Engineer

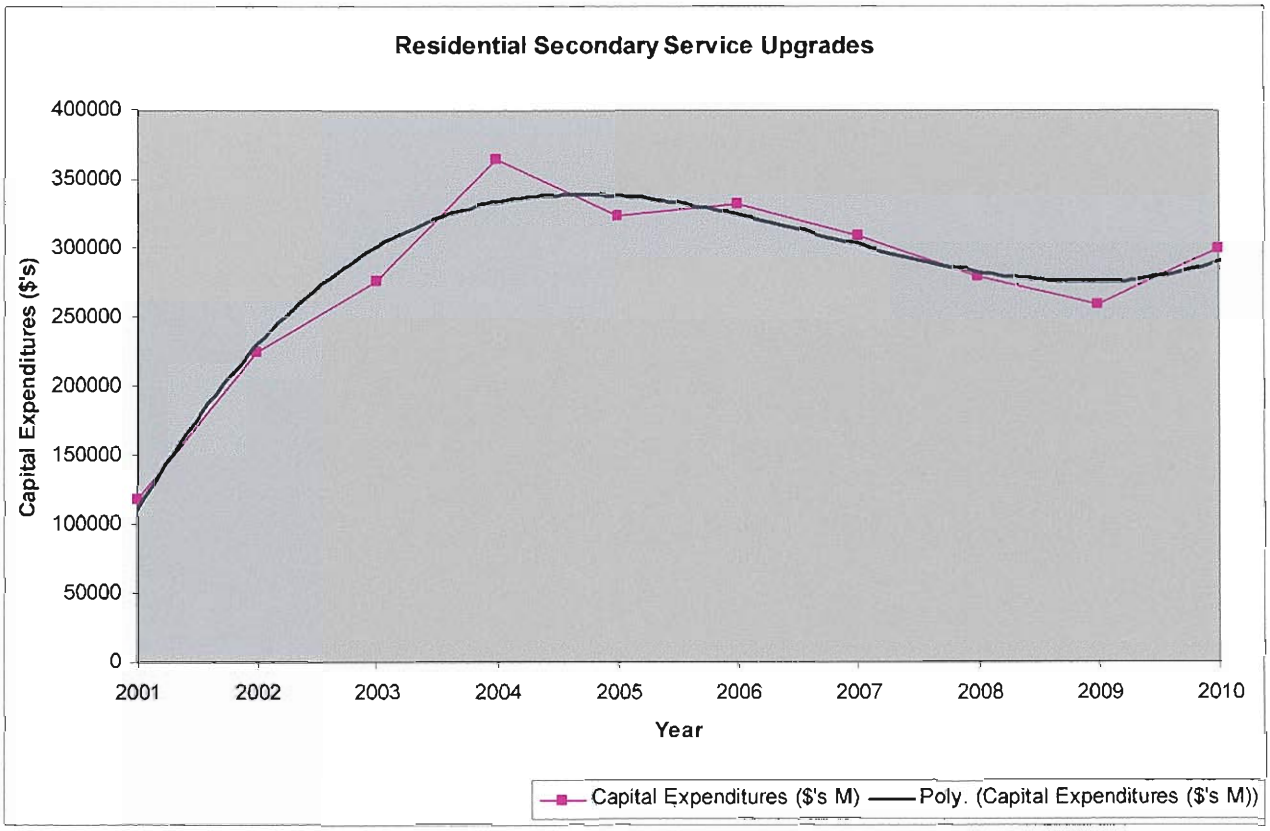
Approved By: Ken Walsh, P.Eng.
Chief Engineer &
V.P. of Operations

Residential Secondary Service Upgrades
Project 10E2

This project comprises the replacement of overhead low voltage electrical services to residential dwellings. There is no charge to customers for these upgrades as they are part of London Hydro's basic connection for overhead residential customers as defined in the Distribution System Code.

These upgrades are initiated by customers that require an increase to their electrical service size. These requests may be due to issues such as the addition of new load in their home or due to requirements of an insurance company that requires the service to be upgraded to a minimal size and configuration.

From a budgeting perspective, the annual expenditures are estimated based on past history. A graph has been provided below and illustrates the level of required expenditures within London Hydro's service territory.



2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10E3
Project Name:	Residential Underground
Project Objective:	DEV

Project Title:	New Single Family Residential Underground Distribution	BJC-F/PC-10
Project Manager:	Jagoda Borovickic	**Project Tech.:** Fernando DePiero

Supporting Reference Material

Description/Justification

This item involves the installation of single family residential underground distribution systems to provide service as needed to developers. We are budgeting $1,900,000 for 2010 based on a number of factors including the forecast by the Canada Mortgage and Housing Corporation, which indicates that for London there will be a moderate increase in total housing starts.

It is noted that market conditions can create large fluctuations in expenditures from year to year. This item is solely dependant on market conditions. This section will contain several different projects of varying magnitude depending on customer requirements.

COST and TIMING ESTIMATES

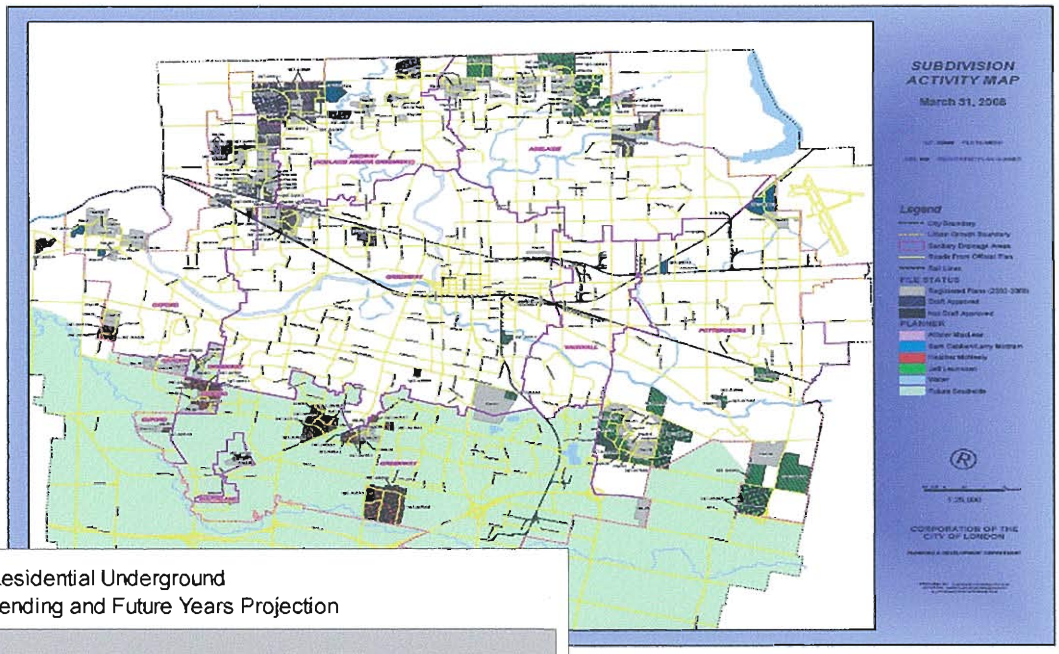
Section - 142	Cost
Jan	$ 95,000.00
Feb	$ 95,000.00
March	$ 190,000.00
April	$ 190,000.00
May	$ 190,000.00
June	$ 95,000.00
July	$ 190,000.00
August	$ 190,000.00
Sept	$ 190,000.00
Oct	$ 190,000.00
Nov	$ 190,000.00
Dec	$ 95,000.00
TOTAL	$ 1,900,000.00

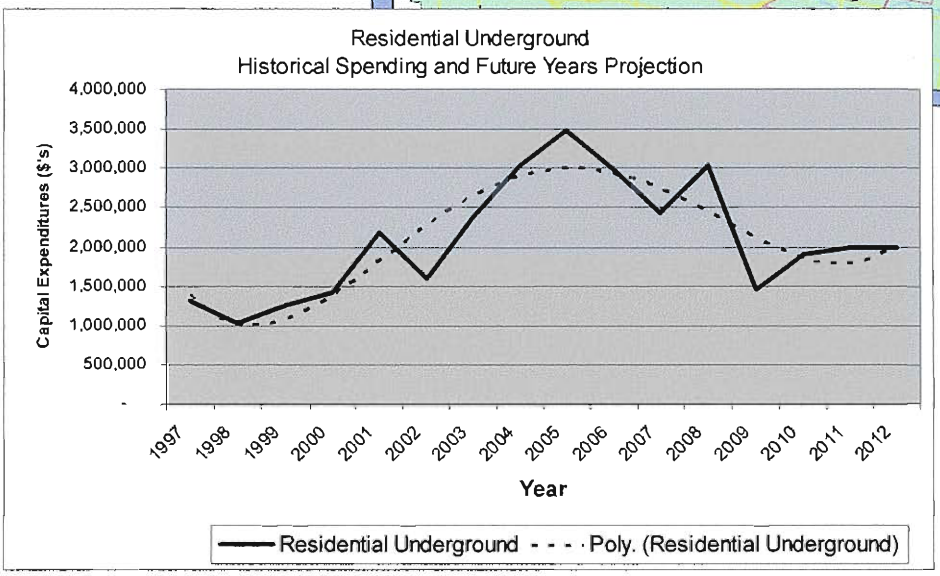
Estimated Completion Date:	December, 2010
Prepared By:	Jagoda Borovickic, P.Eng Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Residential Underground
Project 10E3

This project involves the installation of single family residential underground distribution systems to provide service as needed to developers.

The London Hydro Conditions of Service Document details how capital contributions are assessed for these installations.





From a budgeting perspective, the annual expenditures are estimated based on a number of factors including: past history, City of London development forecasts, market reviews including Canada Mortgage and Housing Corporation, and customer inquiries. Examples of the various documents created and reviewed are shown. This information is updated each year and the forecasts and budgets are adjusted accordingly.

This collection of information is part of a larger library that is used in the preparation of the 25 year load forecast.

Housing Market Outlook - Ontario Region Highlights - Date Released: Second Quarter 2009

Ontario Region Housing Forecast - New Construction

	Housing Starts	2008	2009(F)	% chg (2008/2009)	2010(F)	% chg (2009/2010)	YTD 2009	YTD 2008	% chg (2008/2009)
London	Single-Detached	1,369	650	-52.5	700	7.7	94	277	-66.1
	Multiple	1,016	850	-16.3	750	-11.8	211	240	-12.1
	Total	2,385	1,500	-37.1	1,450	-3.3	305	517	-41.0

Source: CMHC (Starts and Completions Survey)
(F) = CMHC Forecast

Apartment development at London Hydro is included 10E5 Commercial

2010 ASSET MANAGEMENT PLAN

E&O Department

Project Number:	10E4
Project Name:	Multi-Housing Servicing
Project Objective:	DEV

Project Title:	New Multi-Housing Underground Distribution	BJC-F/PC-10

Project Manager:	Jagoda Borovickic	**Project Tech.:**	Fernando DePiero

Supporting Reference Material

Description/Justification

This item is for the installation of multi-housing (primarily townhouses and condominiums) underground distribution systems to provide service as needed to developers. We have budgeted $700,000 *for 2010* based on a number of factors including the forecast by the Canada Mortgage and Housing Corporation which indicates that for London there will be a moderate decrease in housing starts.

This item is solely dependant on market conditions. This section will contain several different projects of varying magnitude depending on customer requirements.

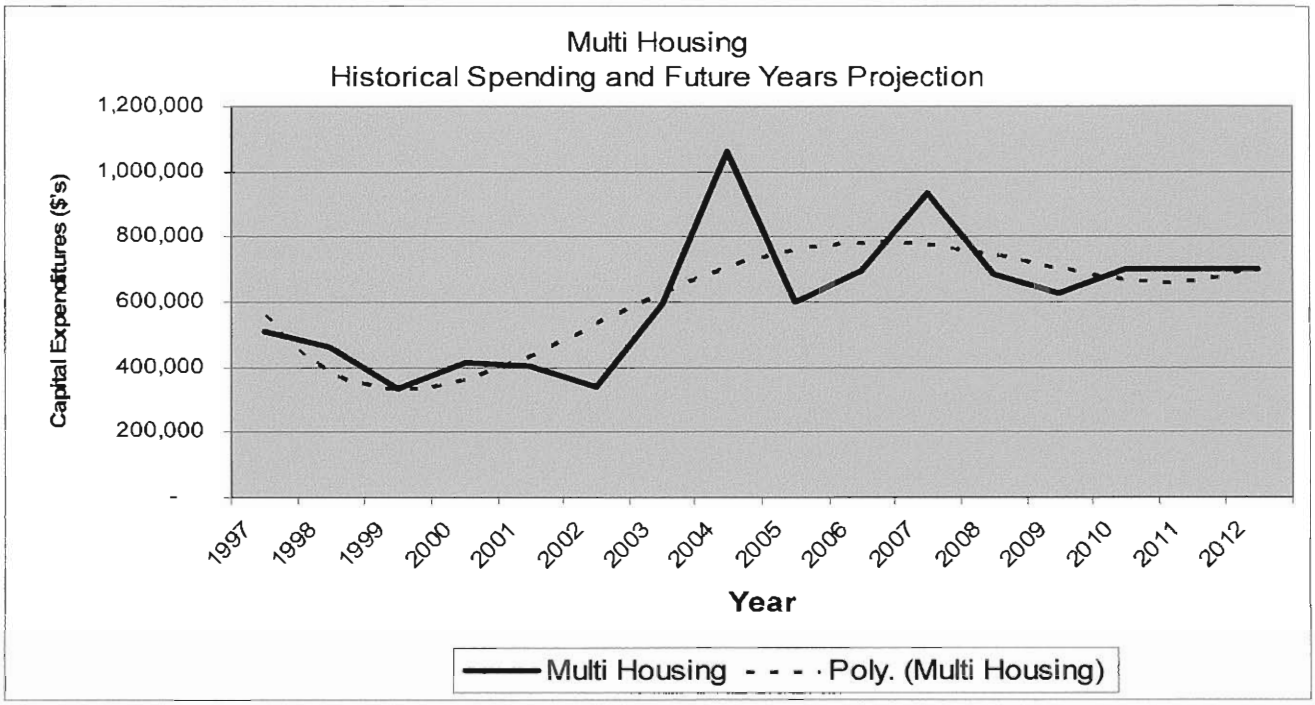
COST and TIMING ESTIMATES

Section - 143	Cost
Jan	$ 35,000.00
Feb	$ 35,000.00
March	$ 70,000.00
April	$ 70,000.00
May	$ 70,000.00
June	$ 35,000.00
July	$ 70,000.00
August	$ 70,000.00
Sept	$ 70,000.00
Oct	$ 70,000.00
Nov	$ 70,000.00
Dec	$ 35,000.00
TOTAL	$ 700,000.00

Estimated Completion Date:	December, 2010
Prepared By:	Jagoda Borovickic, P.Eng Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Multi Housing
Project 10E4

This project involves the installation of multi housing underground distribution systems to provide service as needed to developers.



The London Hydro Conditions of Service Document details how capital contributions are assessed for these installations.

From a budgeting perspective, the annual expenditures are estimated based on a number of factors including: past history, City of London development forecasts, market reviews including Canada Mortgage and Housing Corporation, and customer inquiries. Examples of the various documents created and reviewed are shown. This information is updated each year and the forecasts and budgets are adjusted accordingly.

This collection of information is part of a larger library that is used in the preparation of the 25 year load forecast.

Housing Market Outlook - Ontario Region Highlights - Date Released: Second Quarter 2009

Ontario Region Housing Forecast - New Construction

	Housing Starts	2008	2009(F)	% chg (2008/2009)	2010(F)	% chg (2009/2010)	YTD 2009	YTD 2008	% chg (2008/2009)
London	Single-Detached	1,369	650	-52.5	700	7.7	94	277	-66.1
	Multiple	1,016	850	-16.3	750	-11.8	211	240	-12.1
	Total	2,385	1,500	-37.1	1,450	-3.3	305	517	-41.0

Source: CMHC (Starts and Completions Survey)
(F) = CMHC Forecast

Housing Starts in London

2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10E5
Project Name:	Commercial Distribution
Project Objective:	DEV

Project Title:	New Commerical Distribution Services	BJC-F/PC-10
Project Manager:	Jagoda Borovickic	**Project Tech.:** Albert Kanters/Mike Geboers

Supporting Reference Material

Description/Justification

This item is for the installation of commercial overhead and underground distribution systems to provide service as needed to customers. We have budgeted $2,300,000 for 2010. This item is solely based on market conditions.

This budget is based on past historical expenditure patterns.

COST and TIMING ESTIMATES

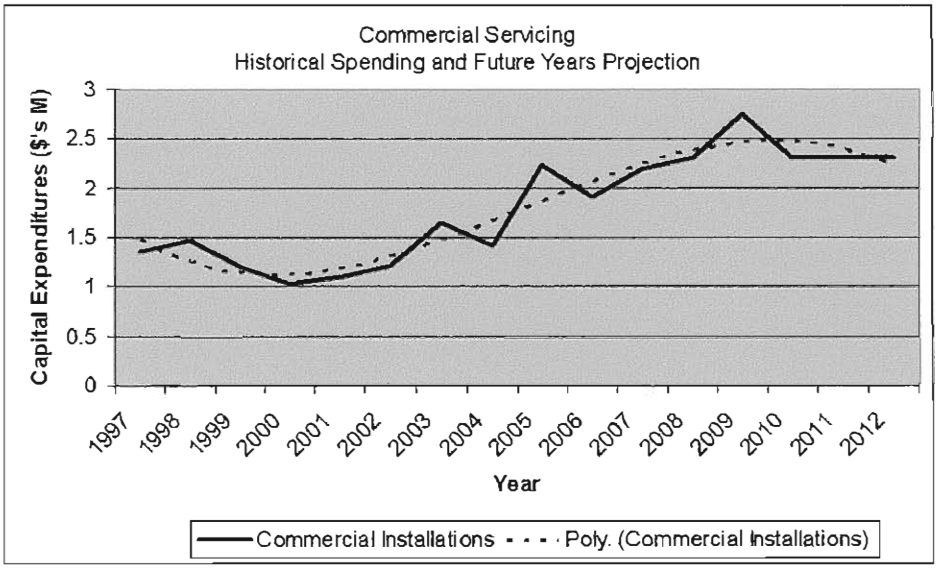
Section - 144	Cost
Jan	$ 115,000.00
Feb	$ 115,000.00
March	$ 230,000.00
April	$ 230,000.00
May	$ 230,000.00
June	$ 115,000.00
July	$ 230,000.00
August	$ 230,000.00
Sept	$ 230,000.00
Oct	$ 230,000.00
Nov	$ 230,000.00
Dec	$ 115,000.00
TOTAL	$ 2,300,000.00

Estimated Completion Date:	December, 2010
Prepared By:	Jagoda Borovickic, P.Eng Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Commercial Distribution
Project 10E5

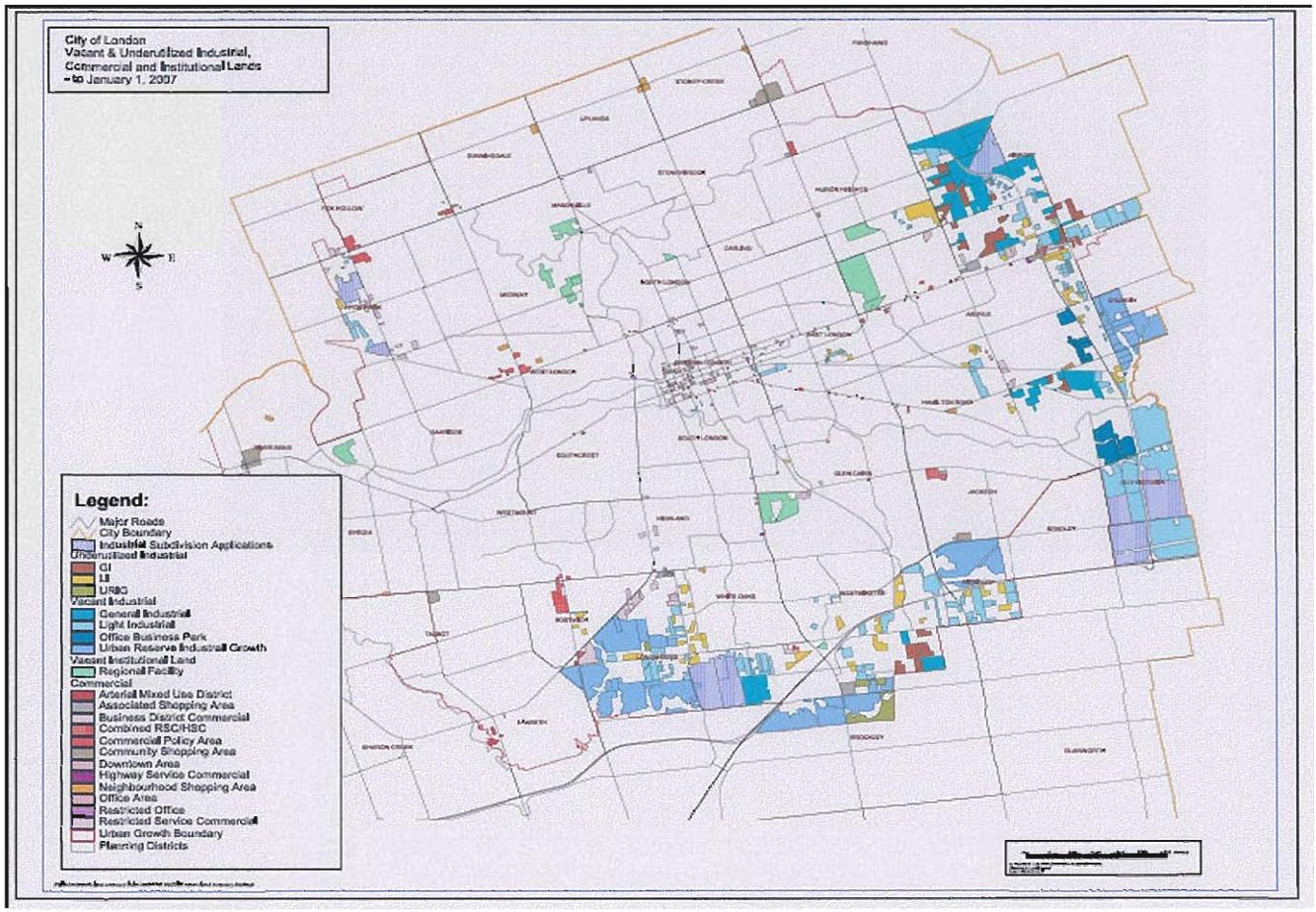
This project comprises the installation and/or modification of electrical equipment that is used in supplying commercial (including apartments) and industrial customers' installations. It also includes the work associated with upgrading existing installations.

The London Hydro Conditions of Service Document details how capital contributions are assessed for these installations.



From a budgeting perspective, the annual expenditures are estimated based on a number of factors including: past history, City of London development forecasts, market reviews, and customer inquiries. Examples of the various documents created and reviewed are shown. This information is updated each year and the forecasts and budgets are adjusted accordingly.

This collection of information is part of a larger library that is used in the preparation of the 25 year load forecast.



2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10F1
Project Name:	Network Vault/Manhole/Tx Replacements
Project Objective:	SAF

Project Title:	Replacement of Network Vaults/Manholes/Transformers		BJC-B/PC-10
Project Manager:	Jagoda Borovickic/Allan Van Damme	**Project Tech.:**	Jamie MacPherson

Supporting Reference Material

Description/Justification

This item involves the design and installation of structrual entities such as concrete manholes, vaults, roof slabs and steel vault grating at various locations.

The condition of the above items is monitored through inspections by a structural engineer and our operations staff. This item is used to resolve all safety and reliability issues resulting from these inspections.

COST and TIMING ESTIMATES

Section - 141	Cost
Jan	
Feb	
March	
April	
May	$ 85,000.00
June	$ 170,000.00
July	$ 170,000.00
August	$ 170,000.00
Sept	$ 212,500.00
Oct	$ 62,500.00
Nov	
Dec	
TOTAL	$ 870,000.00

Estimated Completion Date:	October, 2010
Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operation

Replacement of Network Vault/Manhole/Transformers
Project 10F1

Each year, London Hydro's operations staff conduct inspections of the London Hydro subsurface chambers on a scheduled basis. These inspections are carried out in compliance with the requirements of the Distribution System Code. During the course of these inspections, notes are made to identify all structures that require additional assessment by a Professional Structural Engineer. The structural engineer then provides direction on the appropriate course of action that is required (if any) to maintain the structural integrity and safety of the installation.

The structural engineer's findings are documented and then implemented within the timelines that are specified. Typical findings involve delamination of concrete roof slabs and walls. This can be due to numerous factors including aggregate composition, salt contamination, age and method of construction used at the time. The picture below illustrates a deteriorated roof slab of a network transformer vault.



Sample of a Vault Roof slab in need of Replacement

2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10F2
Project Name:	Primary/Secondary Cable Replacements
Project Objective:	REL

Project Title:	Replacement of Primary and Secondary Cables	BJC-C/PC-10
Project Manager:	Jagoda Borovickic	**Project Tech.:** Scott Lasseter

Supporting Reference Material

Description/Justification

Over the years some of the cables in our distribution system have lost their ability to carry full load current and in some cases their dielectric strength has been compromised. This is partially due to age and loading conditions. These sections are often hard to detect until the quality of power is compromised. The degree of the problems can range from low voltage problems to power outages.

When these cables are identified, they are replaced with cables that meets our present day specifications and standards.

This budget item will include the replacement of primary and secondary cables which have reached failure or are approaching the end of their useful service life.

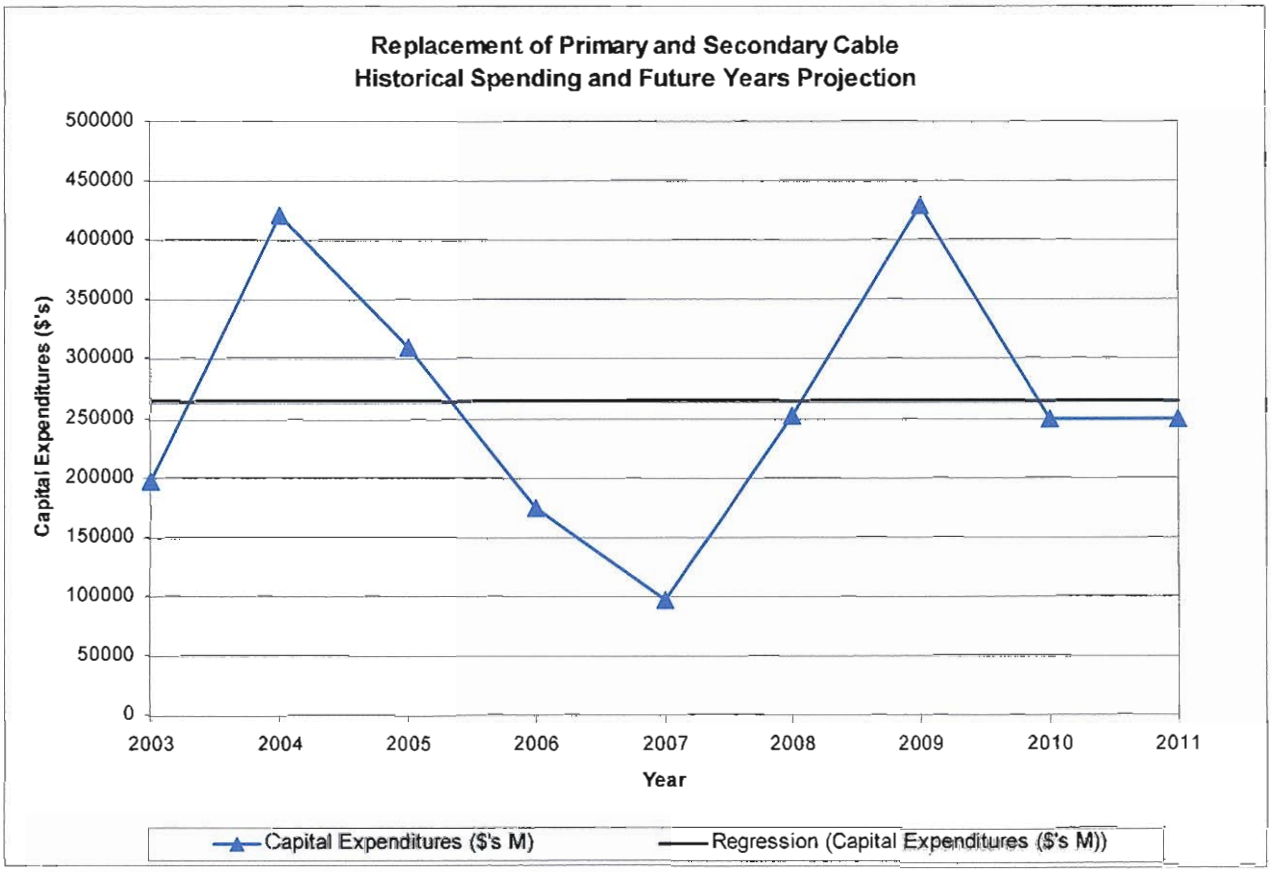
COST and TIMING ESTIMATES

Section - 150		Cost
Jan	$	12,500.00
Feb	$	12,500.00
March	$	25,000.00
April	$	25,000.00
May	$	25,000.00
June	$	25,000.00
July	$	25,000.00
August	$	25,000.00
Sept	$	12,500.00
Oct	$	25,000.00
Nov	$	25,000.00
Dec	$	12,500.00
TOTAL	$	250,000.00

Estimated Completion Date:	December, 2010
Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Replacement of Primary and Secondary Cables
Project 10F2

London Hydro has approximately 1700 km of primary cable in our distribution system and 25 km of low voltage main secondary cable in our downtown core. Although London Hydro is continuously assessing and replacing these cables through identified capital projects, some cables fail unexpectedly and require replacement. This budget item provides for replacement of these cables. Due to the fact that these failures are unplanned, a historical trend is used to estimate the required level funding for the replacements. The graph below illustrates that expenditures have been as high as $420,000 and as low as $100,000.



2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10F3
Project Name:	Eliminate East Network Ph 1
Project Objective:	REL

Project Title:	Eliminate East End Network Phase 1	BJC-C/PC-9
Project Manager:	Allan Van Damme	**Project Tech.:** Jamie MacPherson
Supporting Reference Material		

Description/Justification

In 2009, the London Police Department installed a customer-owned substation supplied off of the 27.6 kV distribution grid. This eliminated the need for the three transformer network vault that used to supply them along with the west portion of the east end network. These three network transformers were removed from service with the plan to replace them with a new 750 kVA padmounted transformer which will be placed on the Police Station's property. This budget item includes the installation of a new transformer that will provide long term supply to the former low voltage network grid in the area of Adelaide Street and Dundas Street. The result will be a smaller low voltage network in this area.

The long term plan is to continue this philosophy by replacing the network transformers with polemounted and padmounted transformers that will be supplied from the 27.6 kV system. The end product will be a less complicated system which is safer with lower available fault levels.

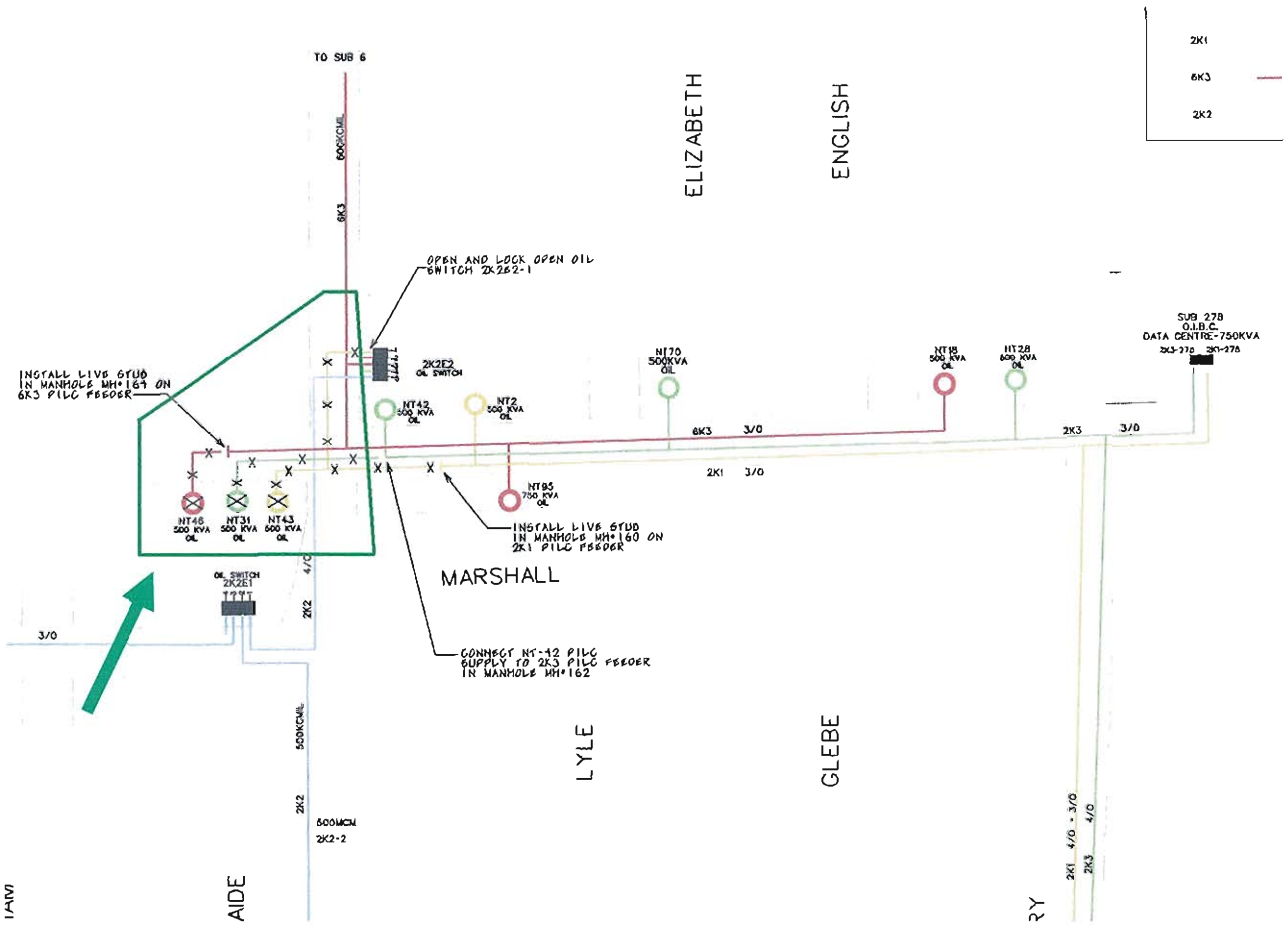
COST and TIMING ESTIMATES

Section - 150	Cost
Jan	
Feb	
March	
April	$ 120,000.00
May	$ 120,000.00
June	
July	
August	
Sept	
Oct	
Nov	
Dec	
TOTAL	$ 240,000.00

Estimated Completion Date:	May, 2010
Prepared By:	Allan Van Damme, P.Eng. Manager of Engineering
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Eliminate East End Network Phase 1
Project 10F3

This is the first phase of a multi-phase program to eliminate the east end network. The elimination of this network will provide a simpler and safer distribution system. The existing plant is approaching the end of it's useful life. The plan will integrate with the significant redevelopment that is occurring in the area bordered by Adelaide and Rectory Streets along Dundas Street. All load will be converted from the 13.8 kV distribution system to the 27.6 kV distribution system in line with our long term plans for Nelson TS. The first phase will address the area of Adelaide and Dundas Street as shown below.



Area Affected by Phase 1 of the East End Network Elimination

2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10F4
Project Name:	Replace Network Protectors
Project Objective:	SAF

Project Title:	Replacement of Low Voltage Network Protectors	BJC-B/PC-10
Project Manager:	Jagoda Borovickic	**Project Tech.:** Scott Lasseter

Supporting Reference Material

Description/Justification

The protectors at these locations are at end of life and are manufactured by General Electric. London Hydro staff have identified concerns that the units are difficult to maintain and operate. Recent best practices involve efforts by utilities to find and mitigate areas where arc flash energies are high and pose a risk to workers. Working on GE style network protectors poses one of the highest arc flash risks to London Hydro's staff.

This project proposes replacement of two of the three remaining General Electric protectors on our network system, with two refurbished Westinghouse protectors. The third remaining protector is proposed to be replaced in conjunction with the NT 38 network transformer replacement in 2010 under Project Code 10F1.

COST and TIMING ESTIMATES

Section - 150	Cost
Jan	
Feb	
March	
April	
May	
June	
July	
August	
Sept	$ 40,000.00
Oct	$ 40,000.00
Nov	
Dec	
TOTAL	$ 80,000.00

Estimated Completion Date:	October, 2010
Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Replacement of Protectors
Project 10F4

London Hydro has a regular maintenance and assessment program. Network protectors are maintained on a three year cycle and inspected monthly. The results of the program indicate that the network protectors manufactured by General Electric are at the end of life and operating them is becoming a safety concern.



Figure 1: The recent picture shown above illustrates the poor condition of the top of a network protector on our system.

2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10F5
Project Name:	Grid Refurbishment
Project Objective:	SAF

Project Title:	Refurbishment of the Low Voltage Network Grid	BJC-B/PC-9
Project Manager:	Jagoda Borovickic	**Project Tech.:** Mike Geboers

Supporting Reference Material

Description/Justification

The City of London's downtown core is largely supplied by an extensive low voltage network grid. High reliability and high fault energies are predominant characteristics of this type of network. The presence of high fault energies also translates into the probability of a catastrophic failure that creates a safety risk to those in close proximity to the failure.

In order to decrease the probability of a catastrophic failure, London Hydro is installing cable protecting fuses in the mains of the low voltage grid. These fuse elements limit the fault energy during the failure of a downstream device. The cable limiters can also serve to isolate the failed component and allow the system to continue operation. This item also includes the replacement of lead secondary cable and the reconfiguration of secondary cables within crowded manholes that are difficult to work in.

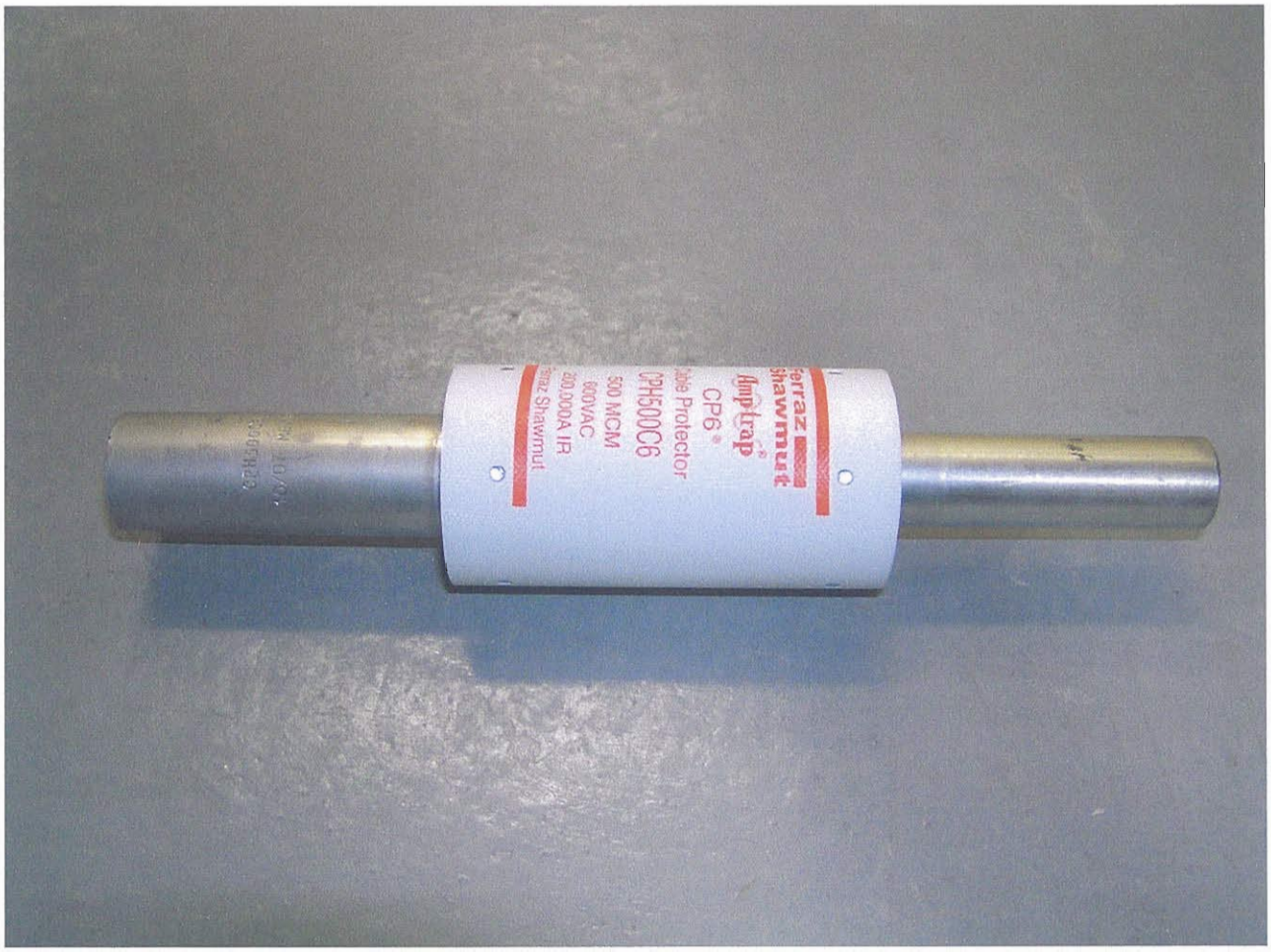
COST and TIMING ESTIMATES

Section - 150	Cost
Jan	
Feb	
March	
April	$ 7,500.00
May	$ 10,000.00
June	
July	$ 15,000.00
August	
Sept	$ 7,500.00
Oct	$ 10,000.00
Nov	
Dec	
TOTAL	$ 50,000.00

Estimated Completion Date:	October, 2010
Prepared By:	Jagoda Borovickic, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Refurbishment of Low Voltage Network Grid
Project 10F5

The City of London's downtown core is largely supplied by an extensive low voltage network grid. It is estimated that there is 22 km of copper secondary mains that are routed through the downtown duct and chamber system. London Hydro has installed approximately 3000 cable protecting fuses on this system over the last five years to address the safety issues that are inherent a system of this design. This budget item will allow us to continue with these installations, replacement of lead secondary cable and reconfiguration of congested manholes that are difficult to work in.



Low Voltage Cable Protecting Fuse used on Secondary Network

2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10G1
Project Name:	Replacement of Rotten Poles
Project Objective:	SAF

Project Title:	Replacement of Fully Depreciated Poles	BJC-B/PC-10
Project Manager:	Rod Doyle	**Project Tech.:** Jim Soetemans

Supporting Reference Material

Pole Test Records
Replacement of Fully Depreciated Overhead Distribution Areas Report

Description/Justification

In the last several years, London Hydro tested over 14,800 wood poles as part of our proactive maintenance approach. We have completed testing of all poles identified as being in poor and fair condition and poles identified in service for over 25 years or longer. Also, approximately 2,400 and 3,000 poles were retested in 2006 and 2009 respectfully as recommended in the previous year test results. The testing involves performing a visual check of the pole and its equipment, sounding the pole, obtaining a core sample from the base of the pole when required and recording all relevant information.

This budget item will replace the approximately 48 poles that were identified in the 2009 pole testing program as being fully depreciated and requiring immediate replacement.

COST and TIMING ESTIMATES

Section - 132	Cost
Jan	
Feb	
March	
April	
May	$ 100,000.00
June	$ 100,000.00
July	$ 100,000.00
August	$ 100,000.00
Sept	
Oct	
Nov	
Dec	
TOTAL	$ 400,000.00



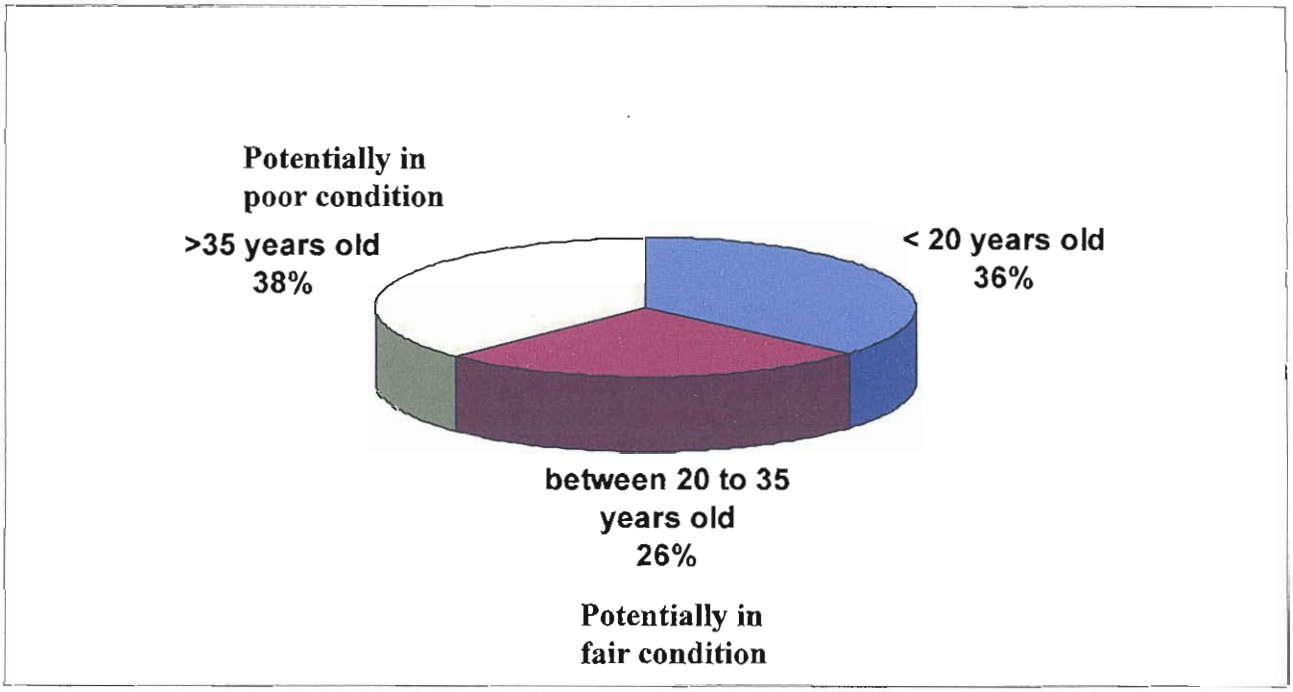
Estimated Completion Date:	August 2010
Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Replacement of Fully Depreciated Poles
Project 10G1

This project involves replacement of the fully depreciated (amortization period is 25 years) wooden poles that were tested and recommended for replacement.

London Hydro's system contains almost 29,000 poles. Approximately 95% of the poles on London Hydro's system are made of wood. In 1998 London Hydro introduced the pole testing program that was based on the results of the infrastructure audit conducted on London Hydro's overhead system in the same year. Since then, London Hydro tested all poles identified as being in poor or fair condition during the infrastructure audit, poles that supposedly migrated from good to fair condition since the audit, and all poles that were recommended to be revisited in the previous testings. Also, poles that are older than 25 years are tested every 5 years. Pole testing is done on annually basis and capital expenditures are based on the results of the inspections.

A graph showing the overall pole age on London Hydro's system is shown below. Poles greater than 35 years in service have the potential to be in poor condition.



Potential Condition of Poles (28,889 Poles in Total) based on age.
The pole age is based on the current GIS data. Some pole ages have been estimated.

2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10G2
Project Name:	Replacement of Pole Fire Poles
Project Objective:	REL

Project Title:	Replacement of Poles Susceptible to Pole Fires	BJC-C/PC-10
Project Manager:	Rod Doyle	**Project Tech.:** Hank Bonnar

Supporting Reference Material

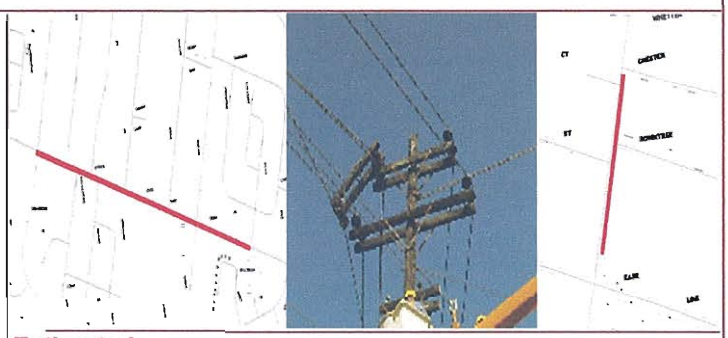
Mitigating Pole Fires on London Hydro's Distribution System Report
Acres Infrastructure Report

Description/Justification

The area designated for replacement consists of the plant built more that 40 years ago and is identified in the above reports as requiring replacement. This plant consists of outdated and aged materials and construction techniques that are more prone to failure than those used today. This budget item includes the pole lines on Byron Baseline Road from Colville Boulevard to Griffith Street and Wellington Road from Chester Street to Baseline Road.

COST and TIMING ESTIMATES

Section - 132	Cost
Jan	
Feb	
March	
April	
May	$ 37,500.00
June	$ 150,000.00
July	$ 150,000.00
August	$ 37,500.00
Sept	
Oct	
Nov	
Dec	
TOTAL	$ 375,000.00



Estimated Completion Date: August 2010

Prepared By: Rod Doyle, P.Eng.
Distribution Engineer

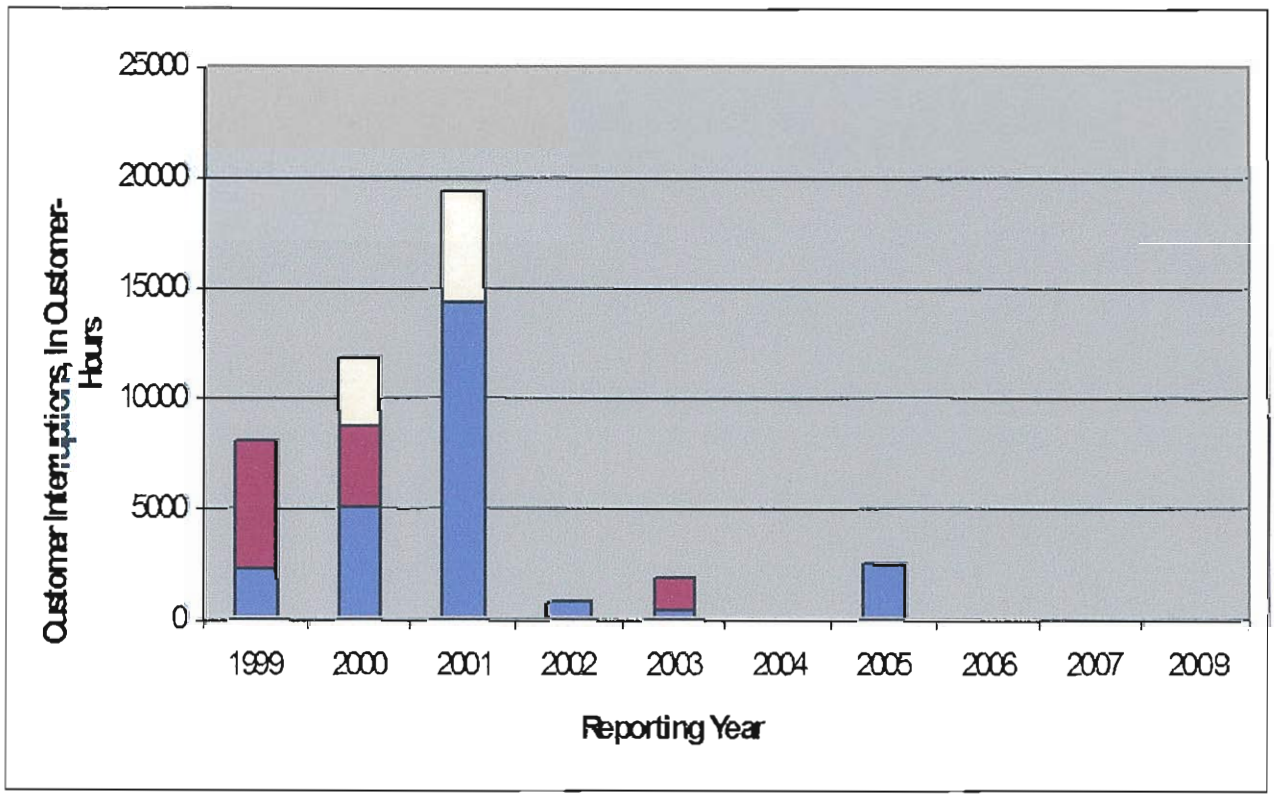
Approved By: Ken Walsh, P.Eng.
Chief Engineeri &
V.P. of Operations

Replacement of Poles Susceptible to Pole Fires
Project 10G2

The two projects scheduled for 2010 involve replacement of 28 poles susceptible to pole fires.

Pole fires occur in specific older types of overhead construction with wood crossarms and pin type insulators. In these types of construction, leakage current tracks over deteriorated insulators and becomes concentrated in places where bolts and steel brackets interface with the wood resulting in fires.

Several years ago London Hydro instituted the pole fire replacement program and to-date has replaced approximately 63% of the poles. This resulted in the significant improvement in the system performance as illustrated on the graph below. The replacement program will continue on an annual basis until the time that all pole fire prone poles are replaced.



Impact of Pole Fires on System Reliability

2010 ASSET MANAGEMENT PLAN

London Hydro

E&O Department

Project Number:	10G3
Project Name:	Rebuild Depreciated Areas
Project Objective:	REL

Project Title:	Rebuild of Fully Depreciated Overhead Areas	BJC-C/PC-10
Project Manager:	Rod Doyle	**Project Tech.:** Hank Bonnar
Supporting Reference Material	Acres Infrastructure Report Replacement of Fully Depreciated Overhead Distribution Areas Report	

Description/Justification

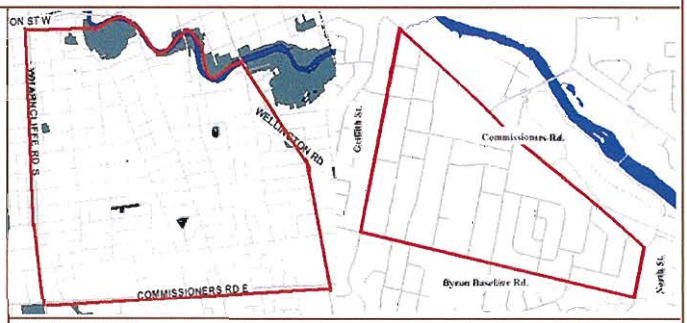
In 2010 we will continue rebuilding the depreciated plant in the Old South area, specifically the land mass bounded by Wharncliffe Road to the west, Commissioners Road to the south, Wellington Road to the east and Thames River to the north. In addition, we will start rebuilding depreciated plant in the Byron Area, specifically the land mass bounded by Commissioners Road to the north, Byron Baseline Road to the south, North Street to the east and Griffith Street to the west.

The Acres Infrastructure Assessment identified various parts of the system in this area as being in poor condition. Available pole testing data for the area show some poles as having pole top and surface decay. The deficiencies related to the age of the equipment may adversely impact the reliability of supply as well as public and employee safety.

The poles and associated hardware are approximately 50 years old. Many of the transformers in the area are operating in excess of their capacity due to load which has been added by customers over the years (i.e. air-conditioning and other appliances).

COST and TIMING ESTIMATES

Section - 132	Cost
Jan	
Feb	
March	
April	$ 270,000.00
May	$ 250,000.00
June	$ 270,000.00
July	$ 250,000.00
August	$ 250,000.00
Sept	$ 300,000.00
Oct	$ 300,000.00
Nov	$ 200,000.00
Dec	$ 200,000.00
TOTAL	$ 2,290,000.00



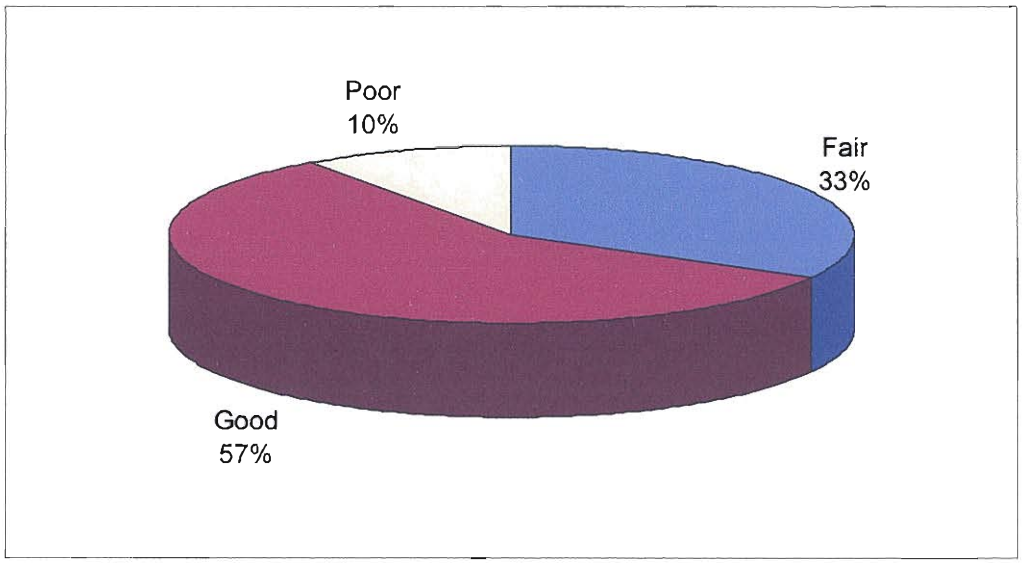
Estimated Completion Date:	December, 2010
Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Replacement of Fully Depreciated Areas
Project 10G3

London Hydro has established a set of criteria to be used when prioritizing which fully depreciated overhead areas are to be rebuilt. These include: results from the visual audit conducted on the overhead system in 1998, OEB infrastructure audit results, pole testing results, safety issues, system performance, accessibility and reliability.

London Hydro has 1323 km of overhead distribution circuitry within the City of London boundaries. The condition of the circuitry has been ranked good, fair or poor. It has been identified that 132 km of this circuitry is in poor condition. The depreciated plant is rebuilt on an annual basis by prioritizing area based on the plant condition. This year's budget will allow rebuilding of approximately 10 km of the fully depreciated overhead plant under this item.

The graph showing condition of the existing London Hydro's overhead plant has been created and is shown below.



Condition of London Hydro's existing Overhead Distribution System based on length

2010 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	10G4
Project Name:	Lightning Study
Project Objective:	REL

Project Title:	Implementation of Lightning Study Results	BJC-C/PC-9
Project Manager:	Cristina Terek	**Project Tech.:** Hank Bonnar

Supporting Reference Material

Kinectrics Report No. K-014857-001-RA-0001-R00
Lightning Protection Study for London Hydro - October 2009

Description/Justification

In 2009 Kinectrics was commissioned to study London Hydro's distribution system to determine:

- if the number of lighting related outages are normal compared to other utilities
- the ranking of the isokraunic level in London to the rest of Province
- our level of lightning protection practices in comparison to other comparable utilities
- make recommendations

Since this report has not been issued yet, this budget item is a place holder to start implementing some of the changes that will likely be recommended by the Kinectrics report. We anticipate the report might recommend additional lightning arrestors, improved grounding, increasing the BIL level on some feeders, etc. We also anticipate that the report might lead to a multiyear program to improve the lightning protection on vulnerable feeders or to change our Engineering Design Standards.

COST and TIMING ESTIMATES

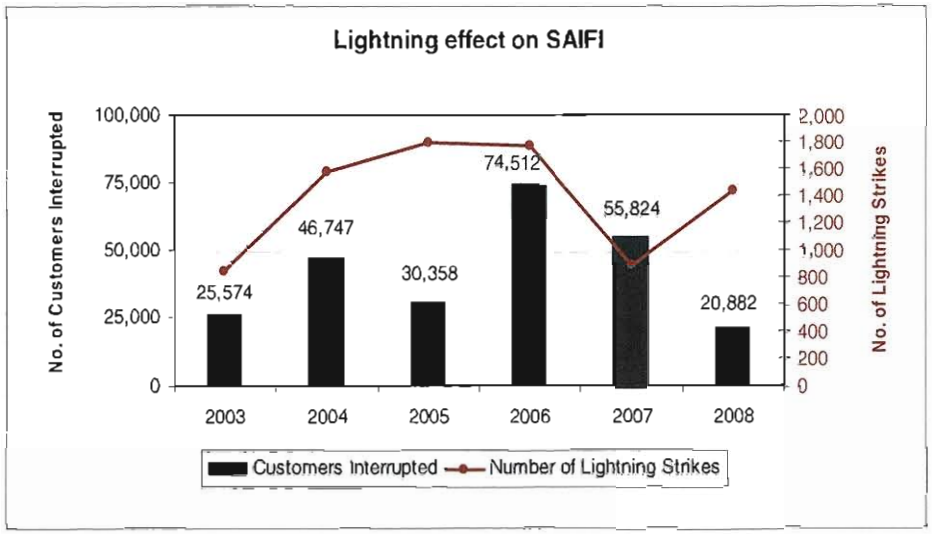
Section - 132	Cost
Jan	
Feb	$ 6,250.00
March	$ 6,250.00
April	
May	
June	
July	
August	
Sept	$ 6,250.00
Oct	$ 6,250.00
Nov	
Dec	
TOTAL	$ 25,000.00

Estimated Completion Date:	October, 2010
Prepared By:	Greg Sheil, P.Eng. Operations Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

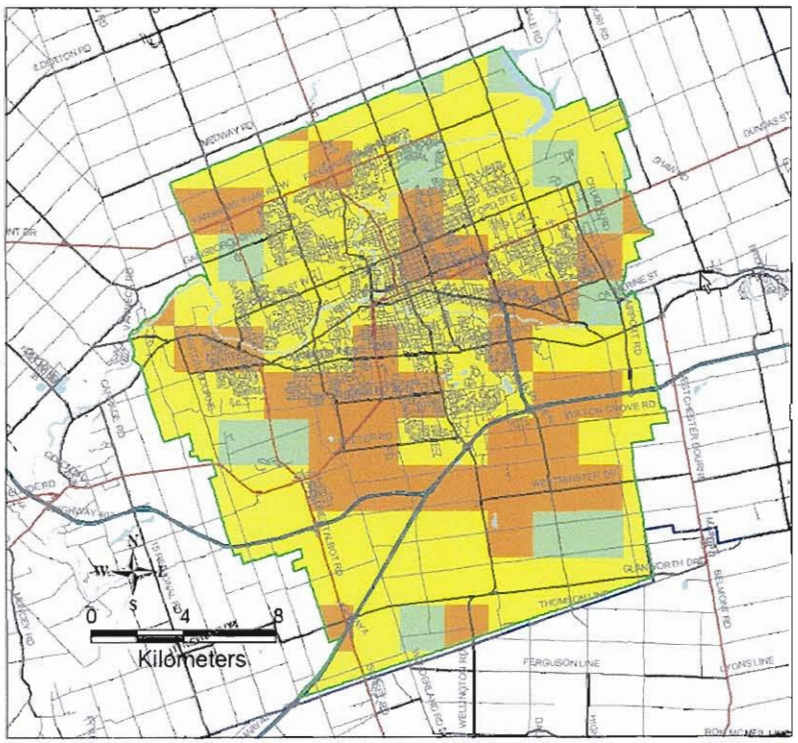
Implementation of Lightning Study Results (Project 10G4)

By the end of 2009, Kinectrics will deliver the results of a study on lightning protection practices on the London Hydro's distribution system. Implementation of any recommendations will take place in 2010. The analysis utilizes our historic outage data related to lightning as well as documentation obtained from Vaisala regarding lightning strikes in geographical correlation to London.

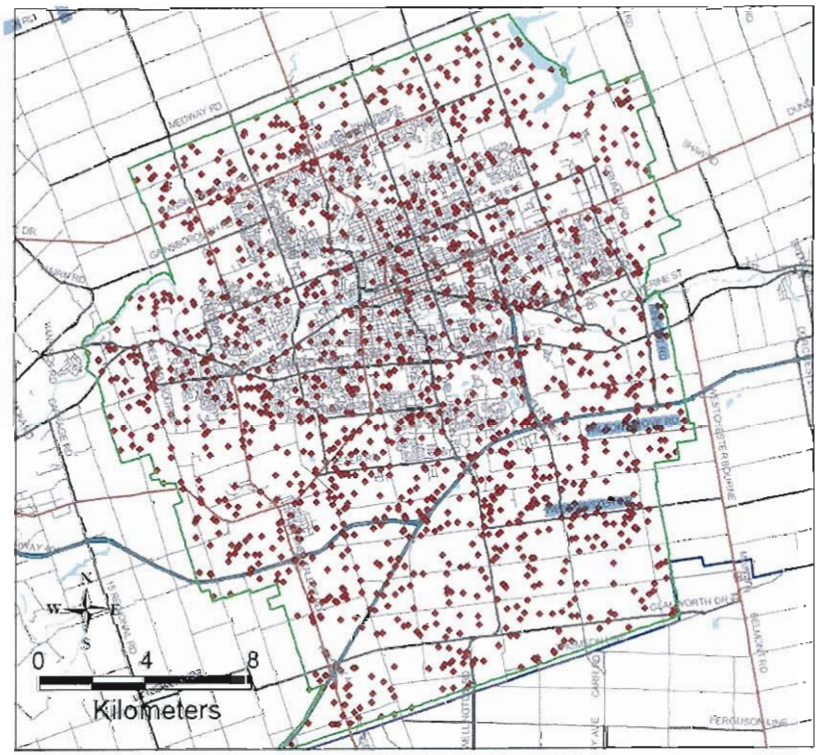
The graph and the two plots below illustrate some of the data made available to Kinectrics for the study.



Flash Density for London area in 2008



Flash Point for London area in 2008



2010 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	10G5
Project Name:	Porcelain Insulator Replacement
Project Objective:	REL

Project Title:	Porcelain Insulator Replacement	BJC-C/PC-10
Project Manager:	Rod Doyle	**Project Tech.:** Sherri Bechtel
Supporting Reference Material	Presentation on Mitigating In-Service Mechanical Failures of Porcelain Line-Post Insulators on Aerial 16/27.k kV Distribution Systems	

Description/Justification

London Hydro has experienced a large number of porcelain insulator failures on the 27.6 kV system. These failures have been analyzed and it has been determined that they relate to specific vintages and manufacturers. Many of these failures are related to the method of manufacture.

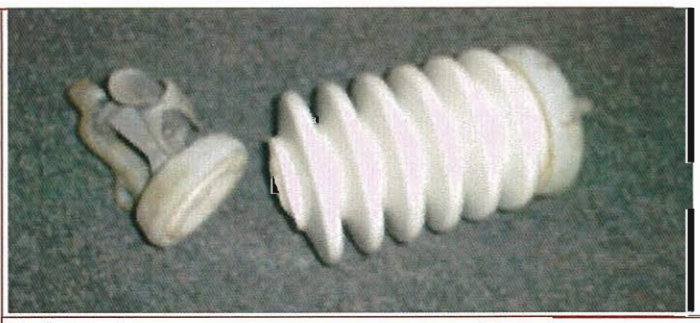
In 2001,when the replacement program was initiated there were 3,800 suspected insulators identified on our 27.6 kV system by using our purchasing and WO records. Meanwhile, an additional 1,800+ suspected insulators, mainly installed by Hydro One, have been identified bringing the overall number of identified suspected insulators to approximately 5,650+.

Out of 5,650+ identified insulators, approximately 5,600 have been replaced in the previous years, resulting in a significant decrease of the customer minutes of interruption caused by broken insulators. This budget item will allow us to replace a majority of the remaining suspect insulators and correct additional deficiencies within the same project area.

The remaining identified insulators will be proposed for replacement in 2011.

COST and TIMING ESTIMATES

Section - 132	Cost
Jan	$ 50,000.00
Feb	
March	
April	
May	
June	
July	
August	
Sept	
Oct	
Nov	
Dec	
TOTAL	$ 50,000.00



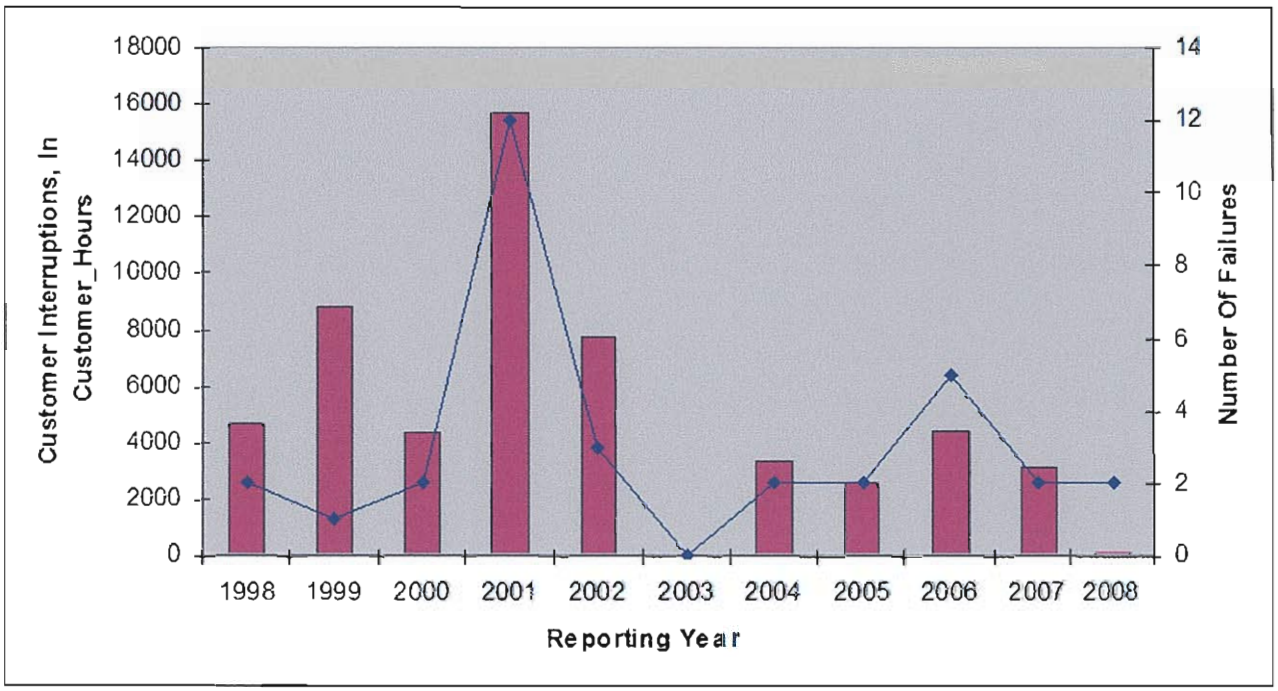
Estimated Completion Date:	January, 2010
Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Porcelain Insulator Replacement
Project 10G5

The projects identified for 2010 involve replacing porcelain line post insulators that are prone to mechanical failure. It will also address associated deficiencies that are associated with the existing plant at the project site.

Problem with these insulators was identified several years ago when certain brands and vintages of these insulators started to fail. All experienced failures were mechanical when insulators broke and enabled energized lines to fall and cause damage. The suspect insulators were identified and a program developed to change them out over several years.

The replacement program has been 99% completed resulting in significant improvement in the system performance as illustrated on the graph shown below. The replacement program will be completed in 2011.



Impact of Broken Insulator on System Reliability

2010 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	10G6
Project Name:	Removals and Restoration
Project Objective:	REL

Project Title:	Removal and Restoration of Overhead Plant	BJC-C/PC-8
Project Manager:	Rod Doyle	**Project Tech.:** Sherri Bechtel

Supporting Reference Material

Description/Justification

In 2010, London Hydro will be completing overhead pole line rebuilds in various areas within the city. These rebuilds involve many pole hole excavations and pole removals. This budget will be used to complete restoration in these areas. It is noted that these removals must be coordinated with our joint use partners such as Bell & Rogers and thus timing is dependent of external parties.

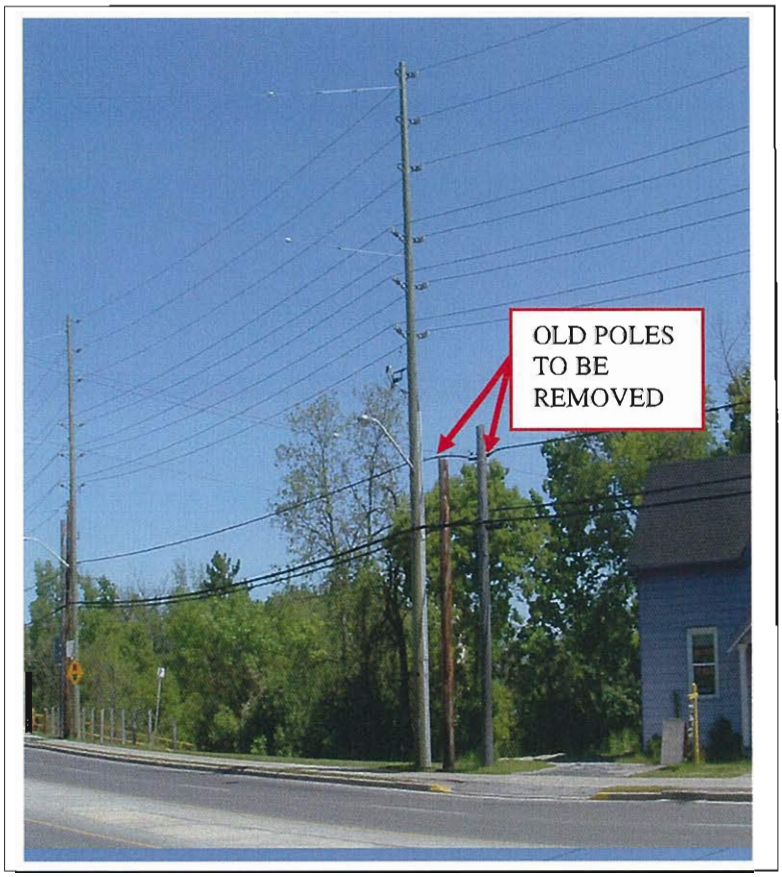
COST and TIMING ESTIMATES

Section - 132	Cost
Jan	$ 1,500.00
Feb	$ 3,000.00
March	$ 3,000.00
April	$ 3,000.00
May	$ 3,000.00
June	$ 3,000.00
July	$ 3,000.00
August	$ 3,000.00
Sept	$ 1,500.00
Oct	$ 1,500.00
Nov	$ 3,000.00
Dec	$ 1,500.00
TOTAL	$ 30,000.00

Estimated Completion Date:	December, 2010
Prepared By:	Rod Doyle, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Removals and Restoration
Project 10G6

The picture below is an example of new hydro pole construction, where the old structure is still supporting 3rd party attachments. The final phase of construction involves the removal of this structure, but must be co-ordinated with the 3rd party utilities (eg. Rogers Cable, Bell) still attached to our poles.



2010 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	10H1
Project Name:	Automation Visability to Substations
Project Objective:	REL

Project Title:	Automation Visability to Substation	BJC- C/PC-9
Project Manager:	Ysni Semsedini	**Project Tech.:** Rolf Reiners
Supporting Reference Material	2008 Substation Deficiency Report	

Description/Justification

As part of London Hydro's continuous substation assessment process, it was found that a number of substations do not provide SCADA telemetry back to the control room.

Having SCADA telemetry at substations provides the Control Room operators with real time status of all the station feeders. This information provides instant feedback that improves outage response time, reliability and will provide historical data on station loads for planning purposes

Currently the following stations do not provide SCADA telemetry

- Sub 97
- Sub 98
- Sub 50
- Sub 41

COST and TIMING ESTIMATES

Section - 250	Cost
Jan	
Feb	
March	
April	
May	
June	
July	
August	
Sept	$ 49,500.00
Oct	$ 49,500.00
Nov	$ 51,000.00
Dec	
TOTAL	$ 150,000.00

Estimated Completion Date:	November, 2010
Prepared By:	Ysni Semsedini, P.Eng. Distribution Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Automation Visability to Substations
Project 10H1

SCADA telemetry is a vital tool used by operators to determine the condition of the distribution system. Operators can monitor breaker positions(1), feeder loading (2) and receive status alarms at the touch of a button. This information allows the operators to anticipate potential power system disturbances and react to outages more swiftly then ever before. Operators can also use the SCADA interface to operate some devices remotely, which can eliminate the need to send out a crew to perform manual switching.

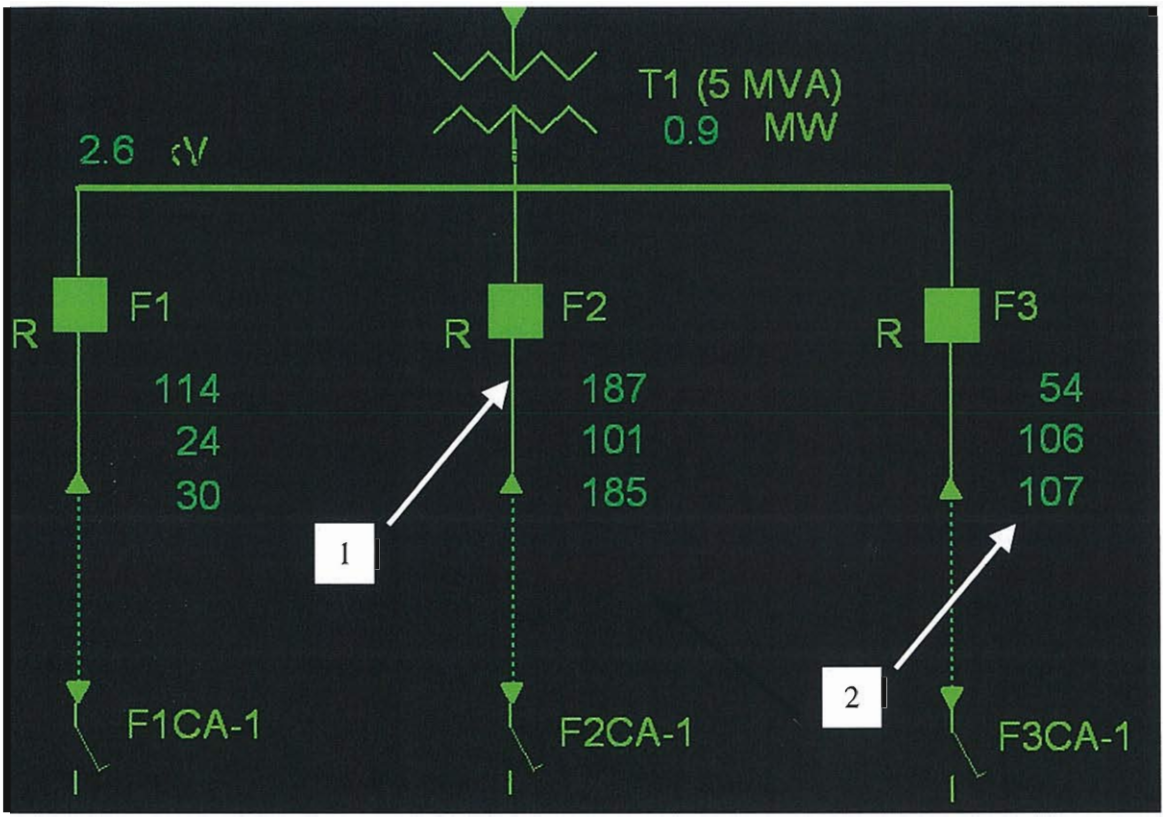


Figure 1 – Typical SCADA Station Screen

2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10H2
Project Name:	Install Reclosers
Project Objective:	REL

Project Title:	Automation on Feeders - Recloser Installations	BJC- C/PC-10
Project Manager:	Greg Sheil	**Project Tech.:** Hank Bonnar
Supporting Reference Material	Quality of Supply Report 2008	

Description/Justification

This project has been budgeted to install 4 reclosers over and above the reclosers included as part of the feeder builds occuring in 2010. There are still several 27.6 kV feeders that do not have any level of automation; reclosers will be installed on these feeders to augment our overall system automation.

COST and TIMING ESTIMATES

Section - 250	Cost
Jan	$ -
Feb	$ -
March	$ -
April	$ -
May	$ -
June	$ -
July	$ -
August	$ -
Sept	$ 130,000.00
Oct	$ 130,000.00
Nov	$ -
Dec	$ -
TOTAL	$ 260,000.00

Estimated Completion Date:	October, 2010
Prepared By:	Greg Sheil Operations Engineer
Approved By:	Ken Walsh, P.Eng. Chief Engineer & V.P. of Operations

Install Reclosers
Project 10H2

The installation of automated switches or reclosers on major feeders has had a very positive impact on the duration and frequency of outages on electric systems worldwide. London Hydro now has well over 100 automated devices in the field and plans to continue installing reclosers until there is an average of 2 1/2 reclosers on each major 27.6 kV feeder on the system.

The installation of reclosers is a very cost effective way of improving SAIFI reliability. (System Average Interruption Frequency Index). A report was developed into an industry paper entitled "Use of Reclosers on London Hydro's Electrical System" that examined various methods for evaluating the cost effectiveness of reliability improvement programs.

2010 ASSET MANAGEMENT PLAN
E&O Department

London Hydro

Project Number:	10H3
Project Name:	New SCADA Functionality
Project Objective:	REL

Project Title:	New SCADA Functionality	BJC-C:PC-9
Project Manager:	Greg Sheil	**Project Tech.:** Kim Franklin

Supporting Reference Material

Description/Justification

This is a result of the SCADA Windows Upgrade in 2009. The new functionality will include Fault Detection Isolation Restoration (FDIR). This application automatically isolates the faulted section and restores the unfaulted sections, if able (i.e. if there are available switching points, loading, etc.), within 60 seconds to reduce the impact on SAIDI and SAIFI. Another feature that we are buying allows realtime SCADA information to users via a web browser.

COST and TIMING ESTIMATES

Section - 250		Cost
Jan	$	-
Feb	$	50,000.00
March	$	50,000.00
April	$	-
May	$	-
June	$	-
July	$	-
August	$	-
Sept	$	-
Oct	$	-
Nov	$	-
Dec	$	-
TOTAL	$	100,000.00

Estimated Completion Date: March, 2010

Prepared By: Greg Sheil
Operations Engineer

Approved By: Ken Walsh, P.Eng.
Chief Engineer &
V.P. of Operations

2010 ASSET MANAGEMENT PLAN
E&O Department

Project Number:	10H4
Project Name:	Network Temperature Monitoring
Project Objective:	REL

Project Title:	Installation of Network Temperature Monitoring Devices	BJC-C:PC-8
Project Manager:	Greg Sheil	**Project Tech.:** Kim Franklin

Supporting Reference Material

Description/Justification

When network transformers or cables are taken out of service, network loads will shift in ways that are difficult to predict. Although we do our best to model the system and to provide reinforcements where required, parts of the system can still get overloaded during contingency conditions. Exactly how many cable half sections can be out of service without causing overheating of the remaining parts of the network is an ongoing question.

We experimented with a low cost temperature monitor in 2009 that has done a good job of keeping track of cable and mole surface temperatures. If enough of these are installed in key locations it will give us better information on how network loads shift during planned and emergency outages. This will allow us to provide reinforcements to help prevent future cable failures and network fires.

The money provided will allow for dozens of temperature monitors to be installed in key locations.

COST and TIMING ESTIMATES

Section - 250		Cost
Jan	$	-
Feb	$	-
March	$	-
April	$	1,000.00
May	$	1,500.00
June	$	5,000.00
July	$	2,500.00
August	$	-
Sept	$	-
Oct	$	-
Nov	$	-
Dec	$	-
TOTAL	$	10,000.00

Estimated Completion Date: July, 2010

Prepared By: Ed Jambor, P.Eng.
Director of Operations

Approved By: Ken Walsh, P.Eng.
Chief Engineer &
V.P. of Operations