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MANAGEMENT PLAN 2011
UNDERGROUND SYSTEM

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1. PURPOSE

The purpose of this document is to describe, for Underground and related network assets:

- Aurora's approach to asset management, as reflected through its legislative and regulatory obligations and Network Management Strategy;
- The key projects and programs underpinning its activities for the period 2012/13 –2016/17; and
- Forecast CAPEX and OPEX, including the basis upon which these forecasts are derived.

2. STRATEGY

The objective of the Network Management Strategy is:

To minimise cost of supply to the customer whilst:

a. Maintaining network performance;

b. Managing business operating risks; and

c. Complying with regulatory, contractual and legal responsibilities.

3. SCOPE

The assets covered by the Underground System Management Plan are underground cables, associated joints and terminations and any associated underground furniture.

4. DESCRIPTION OF THE ASSETS

4.1 Asset Family

The underground system asset group consists of:

- **Underground Cables** to transport electricity at both high voltage (HV) and low voltage (LV) levels, including the cable fittings, easements and earthing systems;
- **Joints and terminations** both outdoor and indoor to connect cables to each other and to other components of the distribution system including the LV cable terminations in wide based street light poles; and
- **Underground Furniture** including turrets, cabinets, pillars, link boxes and service posts etc. to provide a safe and secure place for cable terminations and fittings, both above and below the ground.

The following assets are excluded from the underground system asset group:

- All control and metering cables;
- All streetlight cables from turret to streetlight poles and to the street lighting head; and
- Wide based poles.

4.2 Underground Cables

There are several different types, sizes and makes of underground cable within the distribution system. They operate at voltages of 33 kV, 22 kV, 11 kV and 400 V and are installed predominantly in the urban areas throughout the distribution system. There are several submarine cables located throughout the state crossing waterways or rivers of varying widths.

Table 1 details the cables installed for different voltage levels in Aurora's distribution system as per G-Tech records at June 2010.

Table 2 details further classification of cables according to type of cables in HV and LV categories. This data is only approximate and derived (matched to G-tech records in June 2010) mainly from historical data in Aurora's WASP asset database.

Table 3 details the 33 kV oil-filled cables in Aurora's distribution system from WASP as at Dec 2009.

Table 1: Cables installed in Aurora's distribution system

Description of cables	Installed length (km)
33 kV cables (Sub Transmission Cables)	16
22 kV cables	447
11 kV cables	615
Total Length HV Cables (Including submarine cables)	1078
LV cables	1077
Total Length LV cables	1077

Table 2: Cables installed in Aurora's distribution system by type (WASP)

Description of cables	Voltage	Installation period	Installed length (km)
Paper insulated, oil draining (Age profile: Appendix A.1)	HV	1920-1960	30
Paper insulated, Oil-filled Cable (Sub-transmission only) (Age Profile: Appendix A.2)	HV	1964-1971	16 (Refer to Table 3)
Paper insulated, mass impregnated non-draining (MIND) (Age Profile: Appendix A.3)	HV	1960-1992	505
Submarine cable (Age Profile: Appendix A.4)	HV	1949 - Current	30
XLPE insulated, PVC/HDPE sheathed (Age Profile: Appendix A.5)	HV	1992- 2010	447
XLPE-TR insulated, PVC/HPDE sheathed (Age Profile: Appendix A.6)	HV	2007 - Current	50

Description of cables	Voltage	Installation period	Installed length (km)
Paper insulated, oil draining (Age Profile: Appendix B.1)	LV	Pre-1960	15
Paper insulated, mass impregnated non-draining (MIND) (Age Profile: Appendix B.2)	LV	1960-1978	207
CONSAC (Age Profile: Appendix B.3)	LV	1971-1980	189
XLPE insulated, PVC sheathed (single to four core) (Age profile: Appendix B.4)	LV	1978-current	666

Table 3: 33 kV Oil-filled cable details

Feeder	Installation Year	Length (m)
East Hobart 4	1964	1,834
East Hobart 5	1964	3,656
East Hobart 6	1964	3,146
Sandy Bay 8	1967	1,122
Sandy Bay 22	1967	372
New Town 23	1967	1,443
New Town 24	1967	468
Claremont 26	1967	2,109
Bellerive 305	1971	1,219
Bellerive 310	1971	685
Total Length		16,054

4.2.1 CONSAC Cables

Concentric Neutral Solid Aluminium Conductor (CONSAC) cables are LV cables with the neutral conductor in the form of concentric aluminium sheath acting as a combined neutral and earth connection (Figure 1). They are paper insulated and covered with bitumen corrosion proof coating and PVC over-sheath.

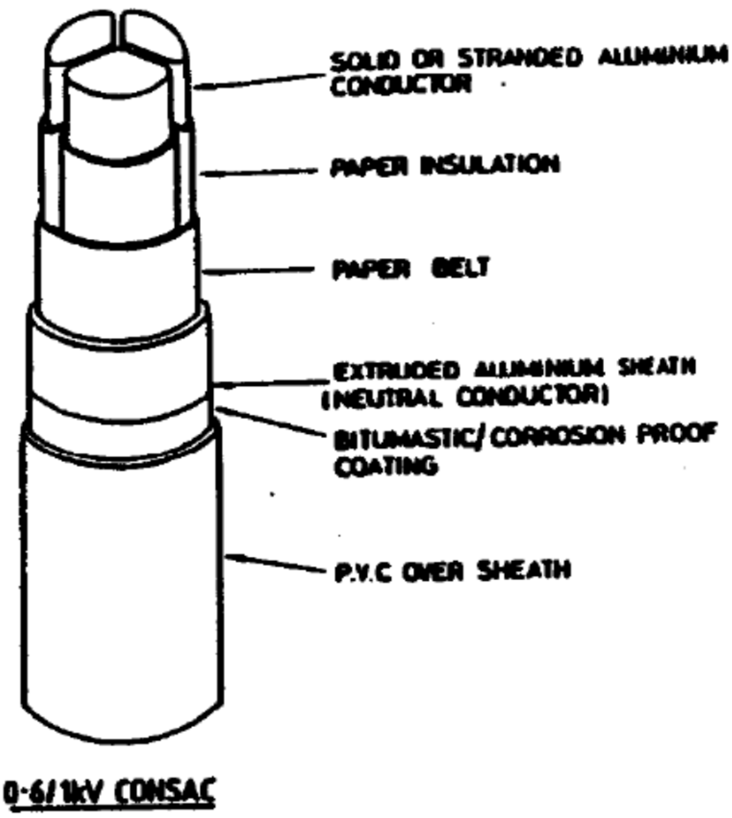

Figure 1: CONSAC Cable Construction

Aurora installed these cables in underground residential subdivisions from 1971 until 1980. Current asset records (G-Tech data June 2010) indicate 189 km of CONSAC cable in the system.

4.2.2 Oil Filled Cables

Oil-filled cables were introduced into the sub-transmission system in the early 1960s to supply a number of Aurora's zone substations.

Oil filled cables have a corrugated aluminium metallic sheath to contain the oil within the cable and PVC over-sheath.

Oil filled cables are highly efficient and can operate at much higher temperatures (85ºC) than solid paper type cables (65ºC). This is due to the oil in the cables being maintained under a constant pressure so that it totally impregnates the cable paper insulation and fills any voids with oil so that ionisation is suppressed.

The cables, joints, terminations and tanks collectively contain approximately 26,000 litres of oil. Approximately 20,000 litres of spare oil is stored at Aurora's Oil Farm to meet the emergency needs of both Aurora and Transend Networks.

New oil cannot be used directly from the drums it is supplied in because it may have unacceptable levels of moisture and gases. Aurora maintains two mobile oil treatment plants for the purpose of treating any oil prior to use.

The cables are divided into sections based on the gradient of installation and length of the section, so that the pressure in each section is within controlled limits. Each section is fitted with its own oil tank that is specifically designed for that section. Further information can be found in reference 1.

The oil pressure is monitored in each tank through oil pressure gauges with a low-pressure alarm system. The alarm circuits are also monitored to ensure they are operational. These alarms are connected to Aurora's Supervisory Control and Data Acquisition (SCADA) system via pilot wires.

Although there is a relatively small number of these cables in Aurora's network and oil-filled cables have a low failure rate, the consequence of failure of these cables is significant because:

1. The cables supply zone substations, so failure of a cable may result in large system outages;
2. Failure of oil-filled cables pose an environmental hazard because of the volume of oil they contain;
3. Repairs of failed oil-filled cables are expensive and time consuming requiring specialised skills (including freezing of the cables).

Oil-filled cables pits have been identified as a confined space. Any work requiring entry to the pits has to follow the procedures for working in a confined space in compliance to AS 2865: 2009, Confined spaces and Workplace Health and Safety Regulations 1998 (references 1 and 2).

4.2.3 Cable Accessories, Easement and Earthing Systems

Cable fittings such as saddle plates, stand off brackets, breakout boots, end caps and heat shrink sleeves are used to secure the cables at poles and for cable terminations. Surge arresters are also installed on HV cable poles to prevent damage to equipment in the event of a lightning strike to assets through overhead wires.

Aurora installs visual and mechanical protection for its cables to reduce the risk associated with inadvertent digging up of cables. Although AS 3000: Electrical Installations/ Wiring Rules (reference 3) deems marker tape and cable covers as sufficient protection for cables and mitigation of public risks, Aurora also installs above ground cable markers and signs in limited areas. The aboveground signage is restricted to only where the cable installation is not obvious or to cover any special circumstances, such as railway property easements, submarine cables, oil-filled cables or in the case of special installation methods such as the plough-in of cables.

Aurora maintains easement records for locations where cables pass through a customer's private property in order to provide electricity supply to other customers in the area. No easement records are maintained if a cable is installed through a customer's private property to supply electricity to that single customer.

Earthing systems are installed at cable ends to earth the cable screens for safety and correct protection operation purposes in accordance to relevant Australian standards and Electricity Network Association (ENA) guidelines.

4.3 Joints and Terminations

All underground cables have joints and terminations associated with the installations. Joints are used for connecting sections of underground cable together. Terminations are used for connecting the underground cable to other parts of the distribution network (for example to the overhead system or to ground mounted switchgear).

Table 4 details the types of terminations and joints installed in Aurora's distribution system as per G-Tech records at June 2010.

Table 4: Joints and terminations installed in Aurora's distribution system

Description	Voltage	Installation period	Number installed
Cast iron potheads (Age Profile: Appendix D.1)	HV	Pre-1973	165
Heat Shrink terminations (Age Profile: Appendix D.2)	HV	1973 - Current	1819
Total cable termination poles	HV	Current	1984
Cable termination poles without surge arrestors	HV	Pre-2004	1084
Cable termination poles connected to ground mounted substations	HV		1719

4.4 Underground Furniture

Underground cables are joined or terminated in various above- and below-ground enclosures collectively known as underground furniture. Underground furniture (HV and LV) is designed to provide a safe, secure and weatherproof environment for cable terminations, joints and associated equipment. The majority of LV enclosures contain LV switching devices, circuit breakers or service fuses for customer installations.

Table 5 details the types of underground furniture installed in Aurora's distribution system as per WASP at Dec 2009.

Table 5: Underground furniture installed in Aurora's distribution system

Description	Voltage	Number installed
HV Pillar (introduced 2006)	HV	<10
Cabinets (200 A and 400A) (Age Profile: Appendix C.1)	LV	2,513
Turrets (PE, HDPE, Fibreglass) (Age Profile: Appendix C.2)	LV	11,855
Service posts (metallic)	LV	193
Distribution pillars and switching devices	LV	192
Underground link boxes (UGLB)	LV	20

Most of the underground furniture is earthed or incorporates earthing systems to provide safety and protection as per relevant Australian standards.

5. FACTORS INFLUENCING ASSET MANAGEMENT STRATEGIES

The principle factors influencing asset management strategies are classified as per objectives set out in Section 2.

5.1 Minimising Cost of Supply to the Customers

- Ensuring cost effective trade-offs are made between pro-active and reactive maintenance practices;
- Ensuring maintenance activities are managed cost effectively to achieve a reasonable service life from the asset; and
- By capturing adequate information on the assets to facilitate informed decision making.

5.2 Maintaining Network Performance

- Targeting asset management activities appropriately to the different parts of the network that have varying impacts on consumer service levels to ensure that the most cost effective solution is achieved;
- Ensuring contingency procedures (system reconfiguration, portable generation) are in place to cater for any asset failure events, as failure of this asset class is difficult to predict; and
- Identifying trends in asset performance to highlight and target future areas of likely failure.

5.3 Managing Business Operating Risks

- Ensuring that all exposed cables have adequate mechanical protection to 2 m above the ground (cable guard) and burial depths that comply with legislation;
- Ensuring failure of underground assets does not create a safety risk for members of the public;
- Ensuring all underground furniture is suitably secured and earthed in compliance to relevant standards for safety of public and operating staff;
- Ensuring adequate monitoring and inspection activities cover legislative compliance requirements and duty of care safety obligations; and
- Ensuring all risks are identified and have adequate management plans integrated into the business' practices.

5.4 Complying with Regulatory, Contractual and Legal Responsibilities

- Ensure adequate monitoring and inspection activities cover regulatory, contractual and legislative compliance requirements and duty of care safety obligations. Some of the identified compliance requirements are:
  - Ensuring adequate monitoring and inspection is in place to protect oil filled cables and to contain the environmental risk (oil spills with or without Polychlorinated Biphenyl (PCB)) as per Aurora Safety, Health and Environment (SHE) policy (reference 4);
  - Ensuring confined space entry signage and records are (refer Section 4.2.2) in accordance to AS2865: 2009, Confined spaces,

and Workplace Health and Safety regulations 1998 (references 1 and 2); and
  - Ensuring above ground signage are in good condition to contain the risk of inadvertent digging or anchoring.
- Ensuring all reasonable precautions are taken at installation (including earthing) to protect the asset for the duration of its service life and compliant to relevant standards such as:
  - AS3000: Electrical Installations/ Wiring Rules (reference 3;
  - AS2067: Substation and high voltage installations exceeding 1 kV a.c (reference 5); and
  - ENA guidelines.

6. SPECIFIC ISSUES AND MANAGEMENT PLAN

6.1 Treatment Trade-Offs

6.1.1 Inspection and Monitoring

Options for the inspection of cable systems are limited due to the fact they are installed underground, but can be undertaken at terminations and shorelines for submarine cables. Thermal scanning is a viable option to check pole top terminations. Whilst monitoring techniques are available (for both thermal and partial discharge), these systems are generally very expensive and often reserved for only the higher voltage cables (33 kV and above) and key circuits.

6.1.2 Preventative versus Corrective Maintenance

There is minimal preventative maintenance that can be undertaken on underground cables due to the nature of the assets. Corrective maintenance of underground cables normally involves new cable joints to replace a section of cable after failure. HV jointing in particular is a skilled activity and reliability of the joint is highly dependent on the skills of the jointer.

Preventative measures to identify movement in soil levels or excavations by third parties can be proactively identified and remedied.

6.1.3 Refurbishment

Whist there are some life extending technologies currently available on the market to restore (refurbish) dielectric strength in HV XLPE cables, these assets have not demonstrated any performance issues to date.

As no performance issues are foreseen in the near future given the relatively young age of the assets, historically good installation practices and relatively cold weather conditions in Tasmania, this activity does not form part of Aurora's management plans.

6.1.4 Planned versus Reactive Replacement

Due to the difficulty predicting the remaining life of cable assets, a large proportion of replacement work tends to be reactive after failure of the asset. This is also driven by the time frames needed to plan a cable replacement and secure appropriate road opening permits etc. from councils and other affected parties. In some cases, particular classes of cable assets can be identified as a high likelihood of failure (such as CONSAC cables) so replacement can be planned to minimise disruption to the consumer.

6.1.5 Non Network Solutions

Cables are a fundamental requirement of the network with no viable non-network alternatives.

Use of a temporary mobile generation substation while an asset is out of service is possible, but generally a high level of redundancy is built into the network to allow load shifting around a failed asset until it is able to be repaired/replaced. Aurora currently has one mobile generator and has leasing arrangements in place to source additional units as required.

The provision of Cable PI to the consumer population to allow customers to check for faulty neutrals is a significant non-network initiative to drive an improvement in the condition monitoring of network assets.

6.2 Preventative Maintenance

6.2.1 Visual Inspection Program

Due to the high cost of repair for submarine cables, an annual visual inspection of the cable entry and exit points is performed. This activity checks all signage is in place to deter civil works, fishing or anchoring activities and checks the general condition of the submarine cable termination.

6.2.2 Oil Cable Monitoring Program

Due to the catastrophic consequences of operating oil filled cables when they have suffered a pressure loss (refer Section 4.2.2), monthly monitoring of pressure gauges is performed on all HV oil filled circuits, with some being monitored with a low-pressure alarm warning system. The alarm circuits are also monitored to ensure they are operational. These alarms are connected to Aurora's SCADA system via pilot wires.

In addition, annual testing of the cable sheaths is performed to pre-emptively detect any deterioration of the outer cable layers (corrosion of the outer metallic sheath) that may lead to oil loss. Operational testing of the two oil treatment plants to ensure the smooth running of the plants is also completed quarterly.

All the maintenance activities are performed as per Aurora's underground manual DSD UG2 Aurora manual for Low Pressure Oil Filled Cables (reference 6).

6.2.3 Ad-hoc Monitoring Programs

From time to time, thermal scans of cable terminations are performed to address specific issues such as hot spots or overloading conditions that may arise (refer Section 6.2.6). Pothole digging on specific circuits is also commissioned from time to time (refer Section 6.2.4).

Cathodic protection (CP) issues with cables and earthing are also sometimes identified during installation of cathodic protection systems on steel infrastructure (such as steel pipelines and bridges) by other utilities. On identification specialised testing is required to make sure that Aurora assets are not affected adversely (refer Section 6.2.8).

LV distribution pillars (or boxes) are above ground link boxes used for switching and reconfiguration of LV circuits. The metal enclosures for some of these boxes, although small in number, are in poor condition due to rust and corrosion. When found these are flagged and targeted for replacement in the near future.

6.2.4 Pot Holing

On identification of a substandard cable installation, an audit is conducted to establish the extent of the substandard installation. Substandard cable installations can be found during various excavation activities or other works, related to cables or near the cables, for different purposes from Aurora or any other contractors or customers.

These audits are conducted by potholing and exposing the cables at intervals along the route. Rectification and risk treatment work is then planned based on the outcomes of the audits.

Historically, four to five investigations are completed each year for substandard depths. Each incident generally requires auditing of around 200 m of cable (approximately 15 to 20 potholes). Therefore, Aurora proposes approximately 1 km (75 to 100 potholes) of cable inspection through these audits.

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6.2.6 Thermal Inspection

Thermal inspections of cable terminations are performed to locate hot spots and overloaded or overheated assets. Thermal inspections are triggered by load monitoring system information and the criticality of the cables in the system.

This program mainly covers thermal imaging of submarine cable poles and some other indoor and outdoor terminations.

No change is proposed to the current volumes or strategy.

6.2.7 Condition Monitoring Program

The conditions of the HV and LV cables are, in general, unknown due to the prohibitive costs associated with proactive condition monitoring. Therefore, it is very hard to define any prudent cable replacement program or strategy in the absence of any historical condition information other than failure rates.

To overcome this difficulty Aurora proposes a condition monitoring trial or condition assessment program on some of its critical cables with the potential to extend the program to other cables based on outcome of the trial. The proposed condition monitoring methods will involve partial discharge and dielectric loss angle testing.

The main aim of this program will be to accurately (as much as practically possible) assess the remaining age of the old and critical cables using the information from the trial in conjunction with historical failure and load data. This program is expected to identify some of the relatively bad condition cables and hence feed into a more reasonable and prudent condition based cable replacement program in future.

This work shall be contracted out to an external service provider, as Aurora does not have the resources required to conduct the specialised testing.

An initial budget of $30k per annum has been proposed for this program. Based on the outcome of the condition monitoring trial, a long term testing policy and the HV cable replacement program shall be decided.

6.2.8 Cathodic Protection Issues

Cathodic protection (CP) is used to protect critical steel infrastructure, such as bridges and steel pipelines (water and gas), from electrical interference or minor electrical currents through earthing systems. These systems are used mainly by other utilities, however, these CP systems can affect the earthing systems installed by Aurora and hence can affect the equipment enclosures (including cable metallic sheaths and armouring) attached to these earthing systems.

Aurora is approached by other utilities from time to time to install these CP systems and uses these opportunities to conduct a specialised test to check the effect of the CP on Aurora's infrastructure or vice versa. The testing is conducted in consultation with external assistance, as Aurora does not have the expertise and resources.

Aurora is also required to cooperate in the restriction and monitoring of possible CP issues by actively participating in statewide corrosion committee meetings run by Workplace Standard Tasmania (WST).

6.2.9 Cable Marking

Above ground cable route signage is installed in situations where the consequence of third party damage to the cable is significant (for example, oil filled cables and submarine cables) and in situations where under ground cables may not be expected (such as railway property easements and plough-in cables).

Signage is also installed as a temporary risk treatment measure on cable routes or sections where a cable has been identified at substandard depths. The signage has to be maintained at the site until the rectification work is completed to bring the installation to the acceptable standard.

6.2.10 Dial Before You Dig

Dial Before You Dig (DBYD) is a free national community service that connects users involved in all forms of excavation with the infrastructure owners of underground services to prevent the incidence of third party damage to underground infrastructure. Aurora is a member of this service and provides asset information and cable location marking on request through DBYD.

As an addition to the normal DBYD services, Aurora also provides a cable watcher to supervise any excavation activity within 2 m of any oil-filled cables due to the criticality of these assets (refer Section 4.2.2).

The main aim of the program is to avoid costly damage. No change is proposed in current strategy or volumes.

6.3 Corrective Maintenance

Corrective maintenance programs consist of the rectification of faulty assets caused by cable failures, joint and termination failures, third party damages and other defects identified during various inspections. Aurora has experienced a significant increase (Table 7) in expenditure due to an increase in some of the activities as per description in following sections.

6.3.1 Cable Failure (Insulation Failure)

The number of cable failures has progressively increased over the last four years as illustrated in Figure 2.

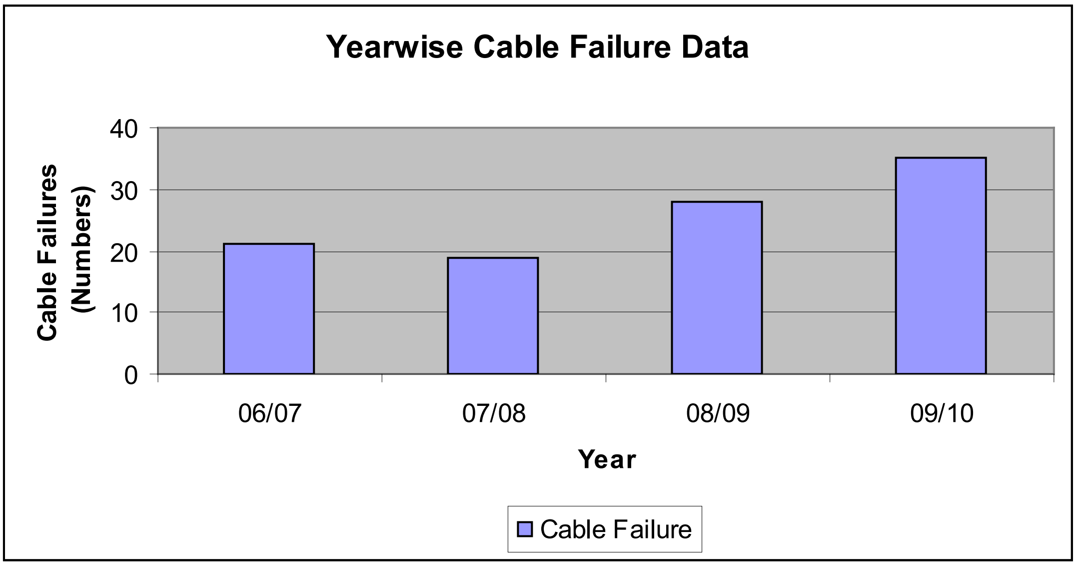

Figure 2: Year wise Cable Failure Numbers in Aurora

6.3.2 Third Party Damage

Each year Aurora experiences approximately 20 incidents where third party excavation contractors dig up Aurora's cables. Excavation activities are on the rise due to the introduction and expansion of the natural gas network in the state. In addition to this there are on average 30 incidents per annum of accidental damage or vandalism to Aurora's underground furniture reported in Aurora's Outage Management System.

6.3.3 Oil filled Cable Accessories

In recent years Aurora has experienced a rise in the number of minor (but expensive) failures due to normal ageing of oil filled cable accessories (currently at least two failures per year). Therefore Aurora has proposed a new repair work category (ARUOS) to capture the ongoing repair cost of oil filled cables to assess the cost effectiveness of the current strategy and assist in decision making with regards to future of these cables.

All the repair works are contracted out to external service provider, as Aurora does not have the special skills and resources required for these jobs.

6.4 Asset Replacement

The key driver to non-demand replacement is condition. There are some specific issues that are also considered for a replacement decision:

6.4.1 CONSAC Cables

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Another common point of failure along CONSAC cables is at joints. Bopole joints are a type of LV underground T-joint used in Aurora's distribution system from 1971 to 1973. These joints were mainly installed with CONSAC cables. Installation of these joints was discontinued as a result of high failure rates attributed to moisture ingress into the joint over time and is another driver for this program.

Aurora implemented a proactive replacement program of CONSAC cables in 2008 after analysis revealed that over 70% of LV cable failures were directly related to CONSAC cables, despite being only 17% of the total LV cable population.

This proactive replacement program targets CONSAC cable replacement in areas where failures had been experienced in the past, as the failures appear to be clustered in geographical areas. It is thought that local jointing practices, soil type and other environmental conditions are contributing to the failures.

Aurora's asset records indicate, as at August 2010, there are 189 km of CONSAC cable in the system. Approximately 30 km of CONSAC cable remains to be replaced within the high failure areas. Aurora proposes to remove the CONSAC cable from these areas by 2017.

The program is also coordinated with other programs for the replacement of distribution assets which are connected to CONSAC cables, such as ground mounted distribution substations, LV switchgear in ground mounted substations and wide based streetlight poles.

The CONSAC cable is replaced from the substation to the first turret or LV cabinet out of the substation during a substation replacement. Similarly, while renewing a streetlight, the associated CONSAC cable shall be replaced at least up to first turret or cabinet.

6.4.2 Oil-filled Cable Replacement Program

Currently, oil-filed cables are replaced when they fail, are damaged or major repairs are required to address oil leaks. The strategy is to replace the damaged cable with XLPE cables to the nearest appropriate jointing location such as another joint or a termination to the overhead system.

The aim of this strategy is to gradually remove oil-filled cable from the system, removing the environmental risk and eventually reducing the maintenance costs and restoration times.

There is no fixed replacement plan or program currently in place due to the generally good condition of the cables. The current ad hoc replacement volumes are based on the assumption that Aurora will experience one major failure of an oil-filled cable or submarine cable section per year. Aurora has experienced one oil-filled cable failure (two hits on same cable in 2005) and one submarine cable failure in 2009. Consequently 0.700 m of oil filled cable was replaced and 0.600 m of submarine cable was abandoned after reconfiguration with newly installed land cables.

Replacement of these cables could have some marginal reduction in inspection and maintenance of oil filled cable in proportion to replaced volumes, however any major reduction in expenditure is possible only after the full length of cable is replaced.

6.4.3 Cast Iron Potheads

A cast iron pothead is a cast iron box fitted to a multi-core cable in which the cores pass through porcelain bushings and enable the cable to be connected to the overhead system.

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Cast iron pothead replacement is prioritised as per Table 6.

Table 6 Pothead Prioritisation Table

Condition	State	Rating
Voltage	22 kV	3
	11 kV	2
	LV	1
Proximity	Within 100 m of schools	5
	Within 15 m of high pedestrian areas	3
	Other urban areas	1
	Remote area	0

High risk 22 kV potheads located near schools and high pedestrian areas have already been removed or scoped for removal from the system.

Aurora's strategy is to have all high-risk cast iron potheads removed from the distribution network by 2017.

6.4.4 Underground Furniture Replacement

Assets in poor condition are identified and targeted for replacement via inspection programs, but often these assets are renewed as a result of other activities (such as CONSAC cable replacement and wide based poles replacement). Accordingly budgeted replacement rates are low for non-demand replacement and based on historical rates.

6.4.5 Underground Link Boxes (UGLB) Replacement

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Aurora has a replacement program to replace all the UGLBs in the system with modern cabinets by 2017.

Currently there are 20 units left in the system and Aurora is replacing 6 units each year. Aurora proposes to continue the program with reduced replacement rate of three units per year for the 14 remaining units so that they will all be replaced by 2017.

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6.4.7 General Cable Replacement Program

Currently Aurora considers the non-demand replacement of cables based on their condition.

Based on current performance levels and low failures, Aurora is not proposing any major cable replacement program (except CONSAC cables) although some provision has been made to replace a few lengths (less than 1 km) of HV and LV cables.

6.4.8 Lightning Arrestors

In recent years, Aurora has experienced substantial damage from lightning strikes. Although the majority of damage has been to pole-mounted transformers, damage has also been sustained to cables and associated ground mounted substations and switchgear. Such events drive early replacement of the asset due to failure. Installation of additional protection in the form of lightning arrestors on every HV cable pole in future has already been incorporated in Aurora design and construction standards for underground systems.

Due to the increase of lightning activity across the state and corresponding increase in the damage to assets, Aurora introduced a program in the 2012 pricing determination to retrofit lightning arrestors on critical HV cable termination poles. The aim of the program is to retrofit lightning arrestors on HV cable poles linked to costly assets such as ground mounted substations and to ensure compliance to Aurora current strategy in regards to installation of lightning arrestor.

Currently approximately 87% of total HV cable poles are linked to the ground mounted substations (Table 4). Approximately 55% of total HV cable poles do not contain lightning arrestors. This indicates that there is large number of HV cable poles connected to ground mounted substations that are not protected by lightning arrestors and hence carry a higher risk of damage.

In the south, this program is coordinated with the cast iron pot head replacement program but only if a lightning arrestor is not already installed. This coordination maximises the efficiency of this program.

In North and North West the program is coordinated with replacement of the associated assets i.e. substation or pole termination. In this way Aurora plans to retrofit lightning arrestors on approximately 20 HV cable poles each year.

This program is also expected to reduce the operational expenditure (asset repair in Underground Systems and Ground Mounted Substations Threads), as Aurora experiences approximately one incident every second year.

6.5 Undergrounding of Special Areas

On 20 July 1988 as part of the bicentennial celebrations in conjunction with past Local, State and Federal Governments, the Hydro-Electric Commission agreed to contribute to the undergrounding of reticulation in areas of significant heritage, scenic or tourist appeal. Following agreements with subsequent Governments, Aurora has continued with this scheme provided that Aurora's contribution was limited to:

- One third of the total cost of each project; and
- The availability of funds for the purpose.

Aurora proposes to contribute $125k per year to the undergrounding of reticulation in special areas. The expenditure is based on historical values.

Although the main aim of the program is aesthetic value, a very minor reduction in operational expenditure could be expected in proportion to the replaced overhead system by undergrounding.

7. REVIEW OF HISTORICAL PRACTICES

Aurora is satisfied that its expenditure on inspection and monitoring is prudent to manage the risk around oil and submarine cables as per current industry practices.

Consideration has been given to investigate some of the new technologies now on the market in an attempt to fill the void of condition monitoring for cable assets, but it is acknowledged that this is not an easy exercise.

A considerable increase in reactive repairs and replacement is expected from the CONSAC cables until they are removed from the network. The level of consumer disruption is currently at a tolerable level (as per trend of contribution to System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI), but if this increases during the period of the program, the replacement program may require acceleration.

A need to improve the decision making data for earthing installation upgrades has been identified as an area that requires additional focus.

8. PROPOSED OPEX PLAN

It is proposed to continue the current asset management practices without any significant changes (Table 7) in practice or frequency. The sustained initial increase in repair activities is as a direct consequence of the deteriorating performance of CONSAC cables and other ageing cables. Also third party damages incidents (refer Section 6.3.2) are on rise due to increased gas reticulations activities in state. This increase shall be offset with replacement of CONSAC cables.

Marginal increase in asset inspection and monitoring program is attributed to new condition monitoring program (refer Section 6.2.7) and earth testing (refer Section 6.2.5) programs.

Table 7: OPEX for period between 2007/08 and 2016/17 financial years ($)

Work Program	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Inspection	62,373	47,102	51,765	98,361	98,361	156,578	152,569	150,735	148,045	146,789
Repair	482,573	268,044	367,484	362,513	362,513	440,477	427,885	421,171	412,065	406,755
Actual $$	544,946	315,146	419,249							
Proposed	423,222	437,092	424,578	460,874	460,874	597,054	580,454	571,906	560,110	553,544

9. PROPOSED CAPEX PLAN

The following values were obtained using Aurora's Capex Model (reference 7). Using the estimated life expectancy feature of the model for this asset category, the following envelope of renewal investment is required over the following 20 years to maintain the asset class at a stable Remaining Life Expectancy (RLE).

Figure 3 shows the outputs of Aurora's capital expenditure model for underground assets, taking into account condition, risk and age. The model forecasts capital investment of $28.1m over the next regulatory period, with an average spend of $5.6m per year.

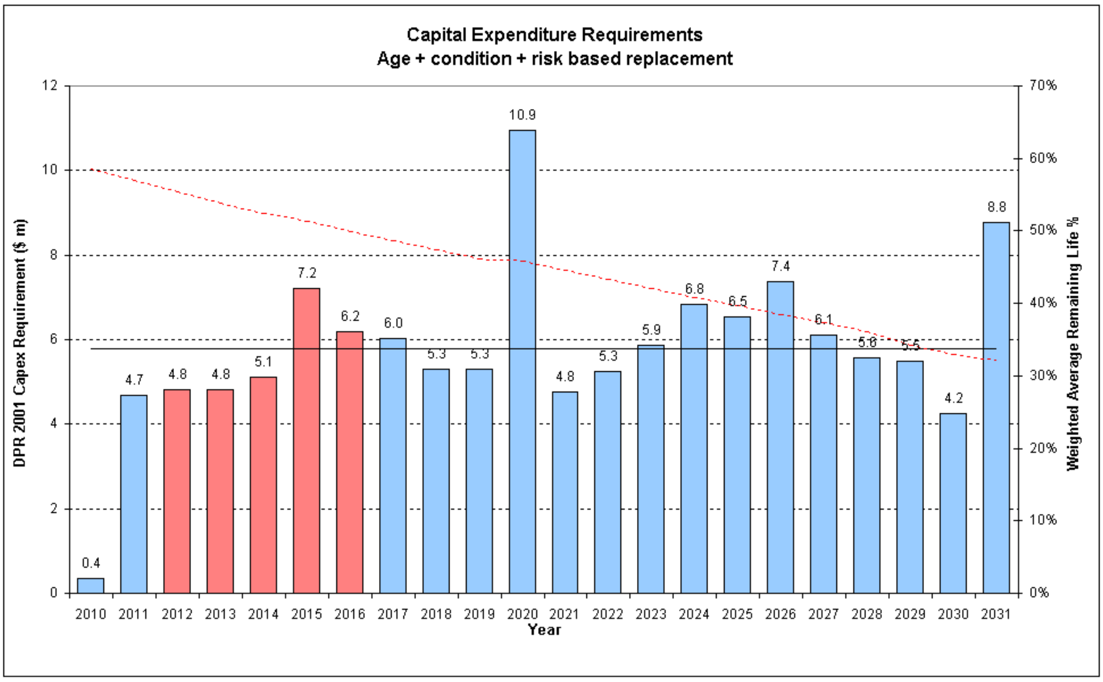


Figure 3: Forecast CAPEX Expenditure from PB Model

Aurora proposes a total capital expenditure of $17.7m over the next five years, with an average spend of $3.6m each year. The proposed capital expenditure takes into consideration the safety risks associated with CONSAC cables (refer Section 6.4.1), cast iron potheads (refer Section 6.4.3) and UGLBs (refer Section 6.4.5)

Table 8: Proposed CAPEX Expenditure for 2012 to 2017

Work Program	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Non Demand Replacement	728,874	1,113,386	2,537,029	1,182,274	2,318,131	3,510,093	3,442,690	3,451,586	3,424,356	3,412,380
Specific Issues	0	0	112,115	33,070	113,076	125,000	125,000	125,000	125,000	125,000
Actual $$	728,874	1,113,386	2,649,144							
Proposed	1,177,822	1,814,072	2,826,110	1,215,344	2,431,207	3,635,093	3,567,690	3,576,586	3,549,356	3,537,380

10. CAPEX–OPEX TRADE OFFS

Due to the nature of underground assets and the current lack of asset condition information, the inspection programs are essential for monitoring the condition of underground assets that can be easily inspected above ground, such as UGLB and cable terminations and the condition of the critical HV cables that supply Aurora's zone substations as best as possible.

A number of the operating expenditure programs are also in place as preventative safety measures to reduce the risk of third party interaction with Aurora's underground assets and an attempt to mitigate the amount of reactive repair that Aurora is required to undertake outside of in service failure.

There is a positive relation between capital and operational expenditure in that the operational programs (asset repair) can defer asset replacement and assist in the targeting of capital replacement works for safety and environmental drivers such as CONSAC cable replacements, substandard underground cable sites and damaged oil filled cables.

11. ASSET MANAGEMENT INFORMATION

Aurora maintains records of underground assets through the periodic routine testing and inspection programs providing the following information. The equipment details and attributes are predominantly recorded within FRAMME / WASP. These being the two integrated asset management systems, however there are smaller data-sets in MS Access and Excel that currently store other information relating to the asset and its condition.

Recorded information includes:

- Identification number (unique identifier);
- Location / site / geographical details;
- Asset / equipment, terminations and jointing details (size, make, model, type, rating, installed date);
- Equipment attributes and operational numbering;
- Operational details (connectivity, protection & equipment settings / ratings, etc);
- System performance details (reliability, causes, power quality recorded data etc);
- System monitoring information / data (load – cyclic, maximum demand, load balance);
- Asset condition data and remaining residual life (general and limited);
- Oil condition, contamination levels;
- Age of asset and components, installed / refurbished date;
- Age of related equipment;
- Unit rates or agreed costs i.e. inspection, treatment refurbishment and replacement costs;
- Maintenance details / action;
- Maintenance program progress; and
- Maintenance history (general and limited).

12. RESPONSIBILITES

Maintenance and implementation of this management plan is the responsibility of the Asset Engineer – Substations and Underground.

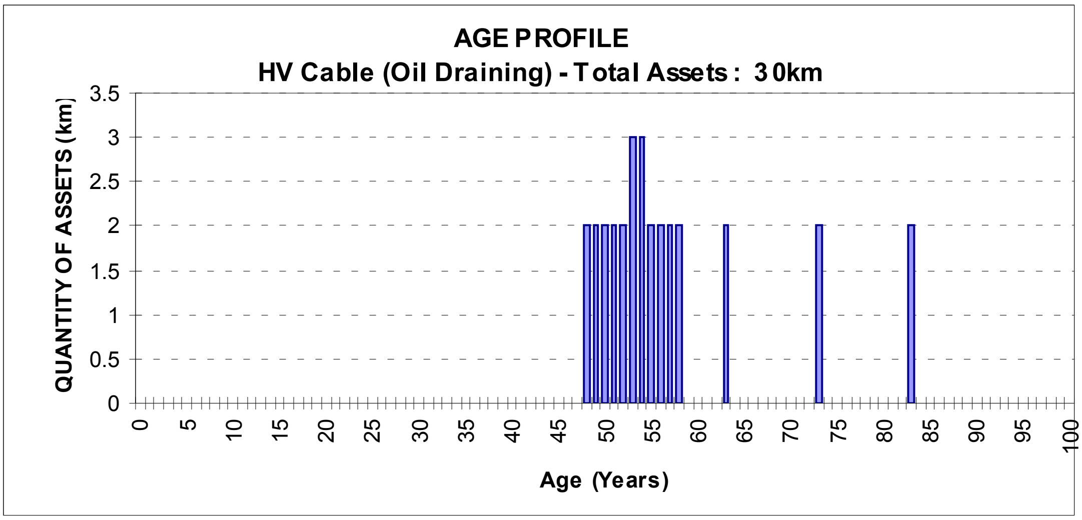
Approval of this management plan is the responsibility of the Asset Performance and Information Manager.

13. REFERENCES

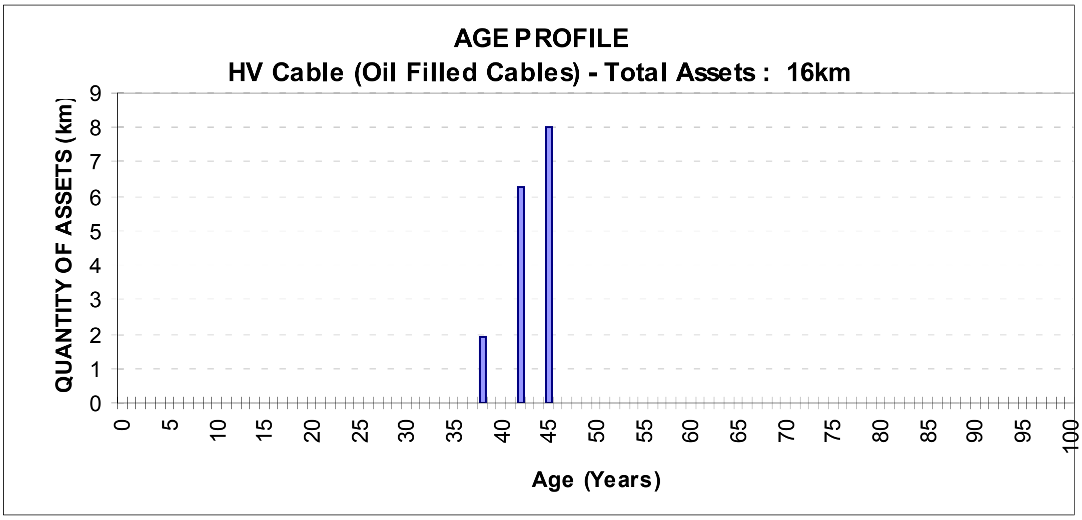
1. AS 2865:2009, Confined spaces
2. Workplace Health and Safety Regulations 1998
3. AS 3000: Electrical Installations/ Wiring Rules
4. Aurora Safety, Health and Environment Policies
5. AS2067: Substation and high voltage installations exceeding 1 kV a.c
6. Aurora Manual for Low Pressure Oil Filled Cables (DS D UG 02)
7. PD 20 12 C APEX Model – Dollars: U nderground S ystems (DM # 30182407)

Appendix A HV Cable Age Profiles (WASP Data Dec 2009)

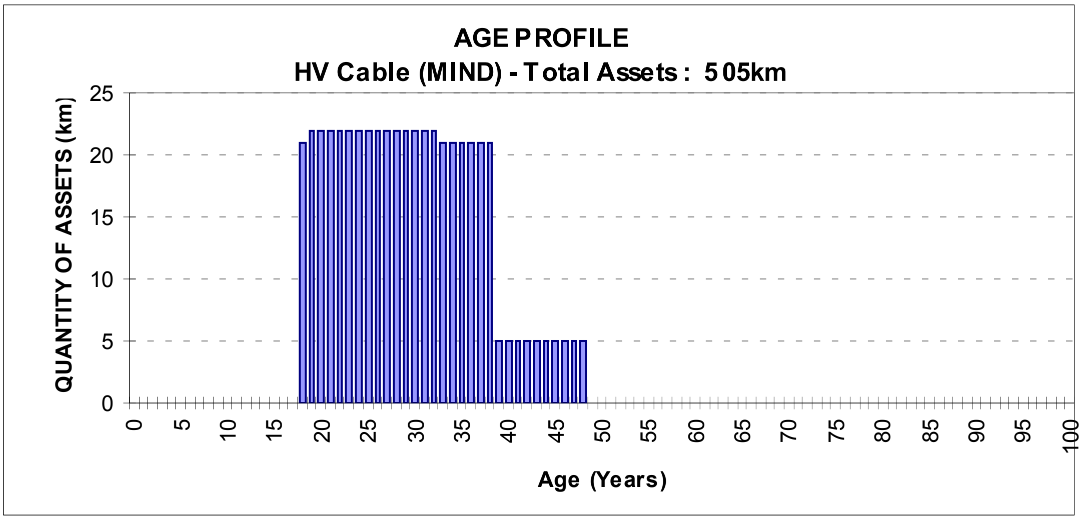
A.1 HV Oil Draining Cable Age Profile



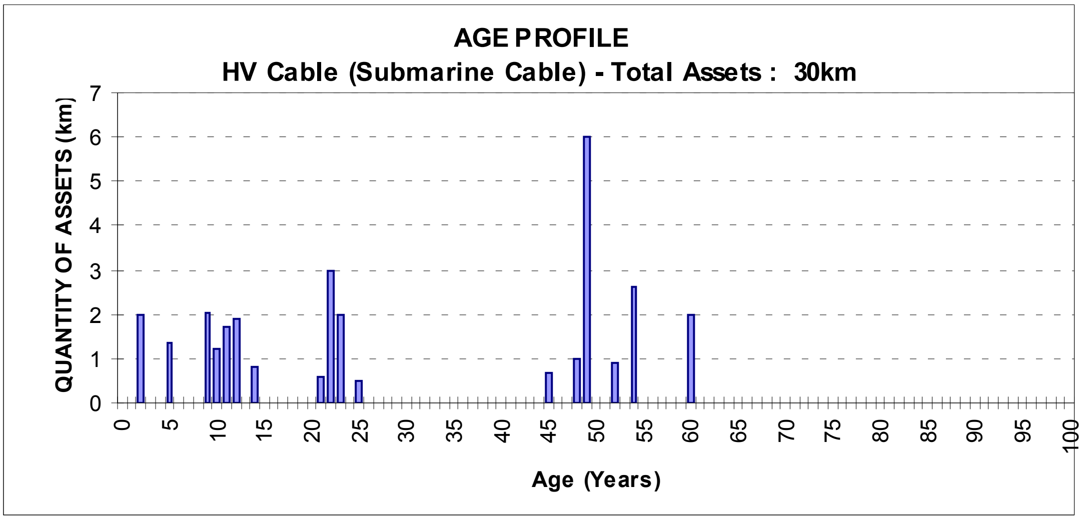
A.2 HV Oil-Filled Cable Age Profile



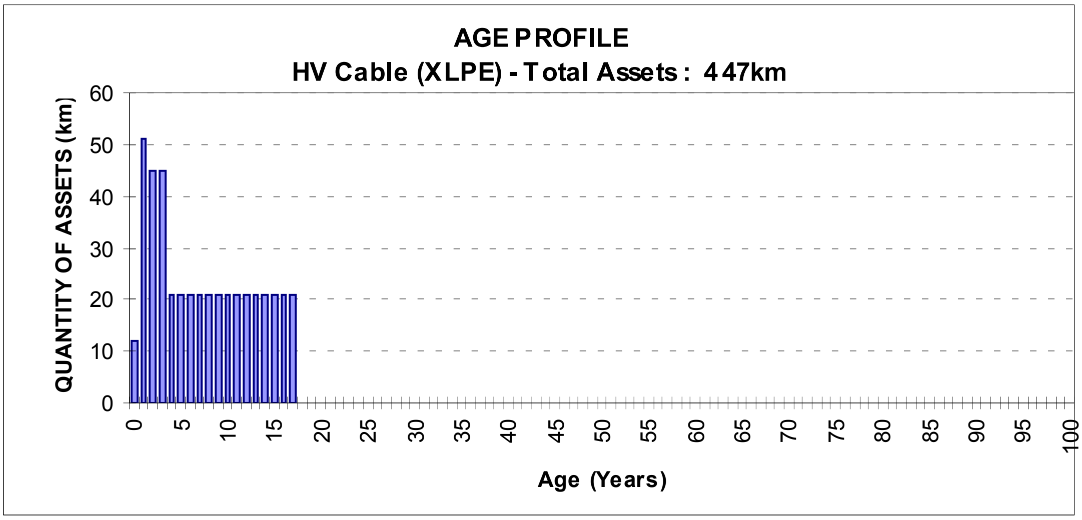
A.3 HV MIND Cable Age Profile



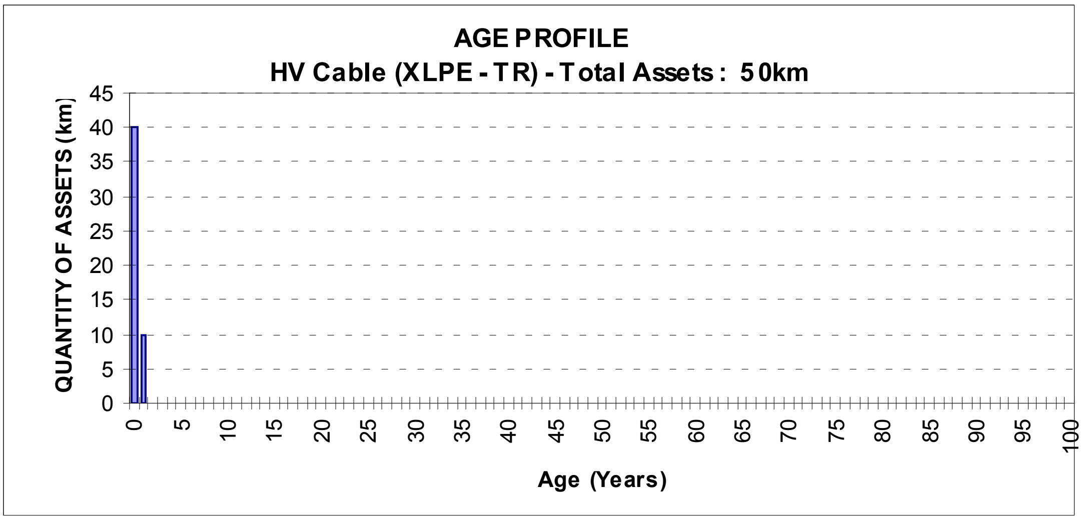
A.4 HV Submarine Cable Age Profile



A.5 HV XLPE Cable Age Profile

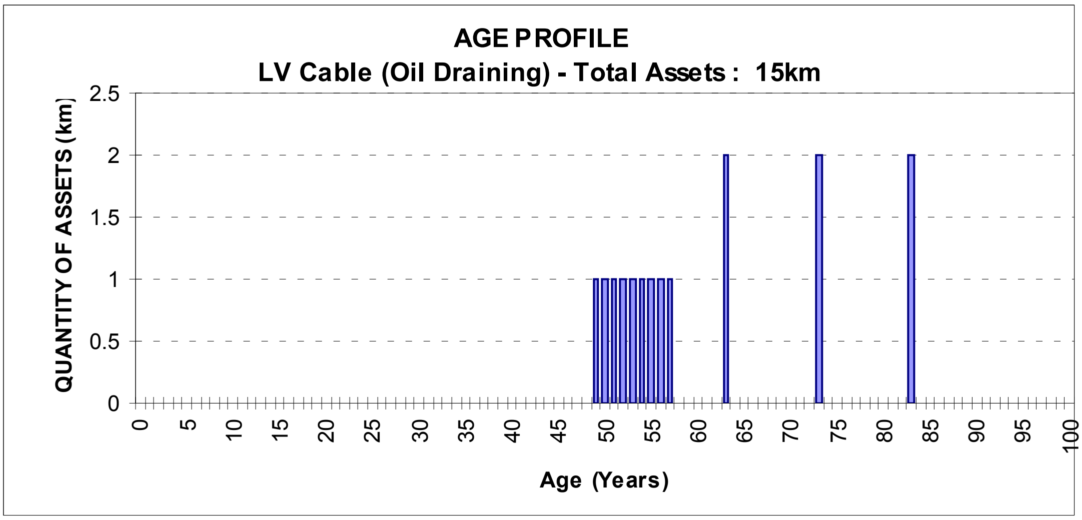


A.6 HV XLPE-TR Cable Age Profile

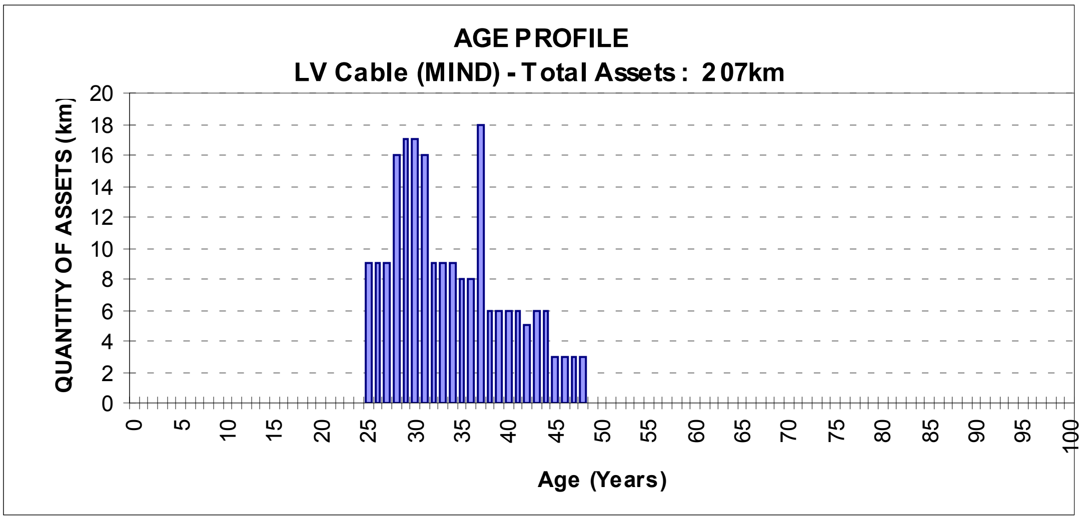


Appendix B LV Cable Age Profiles (WASP Data Dec 2009)

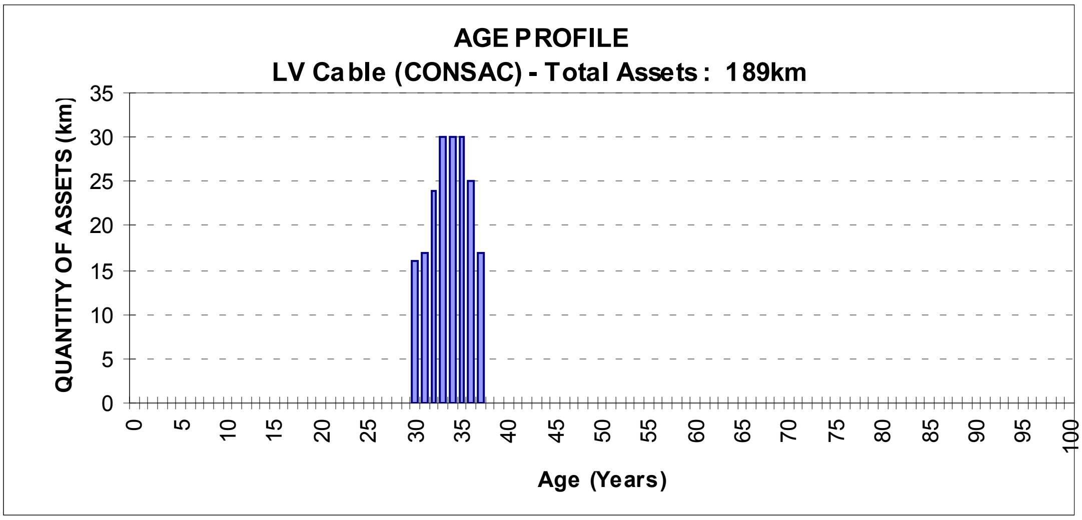
B.1 LV Oil Draining Cable Age Profile



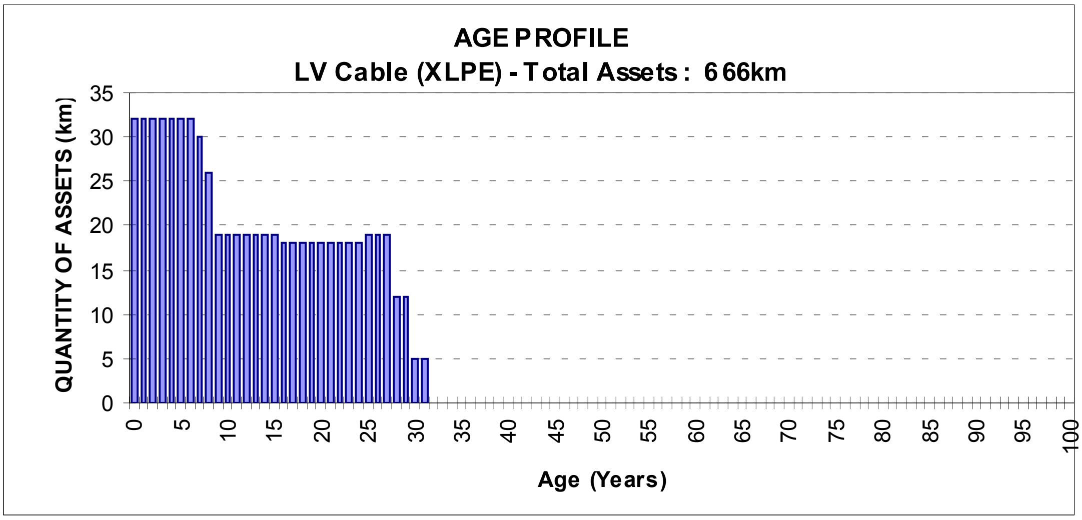
B.2 LV MIND Cable Age Profile



B.3 LV CONSAC Cable Age Profile

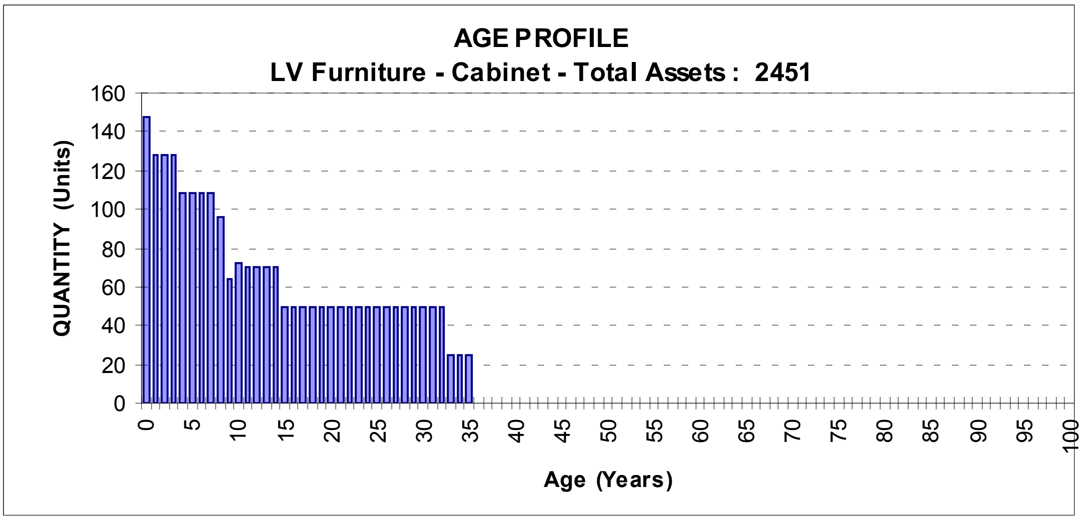


B.4 LV XLPE Cable Age Profile

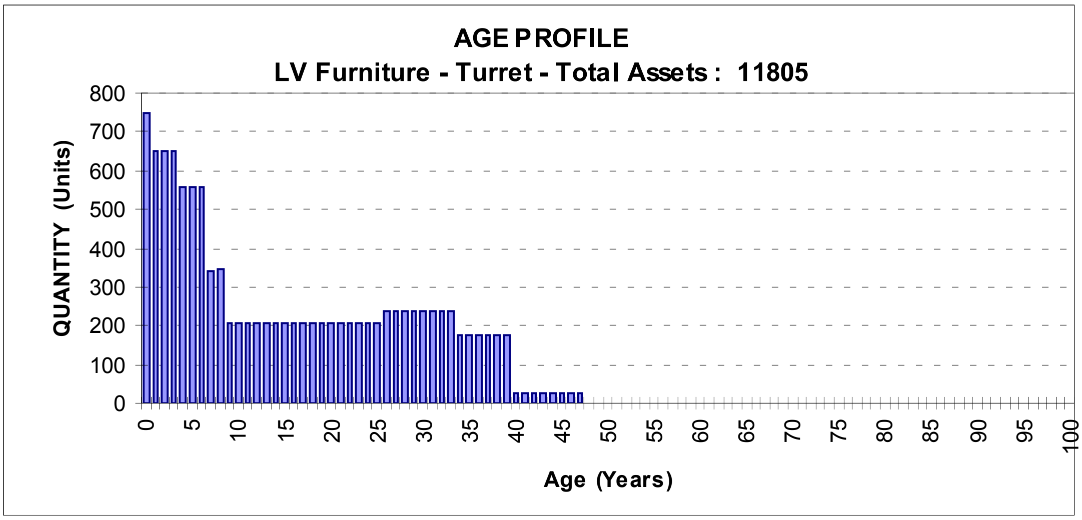


Appendix C Street Furniture Age Profiles (WASP Data Dec 2009)

C.1 Cabinet Age Profile

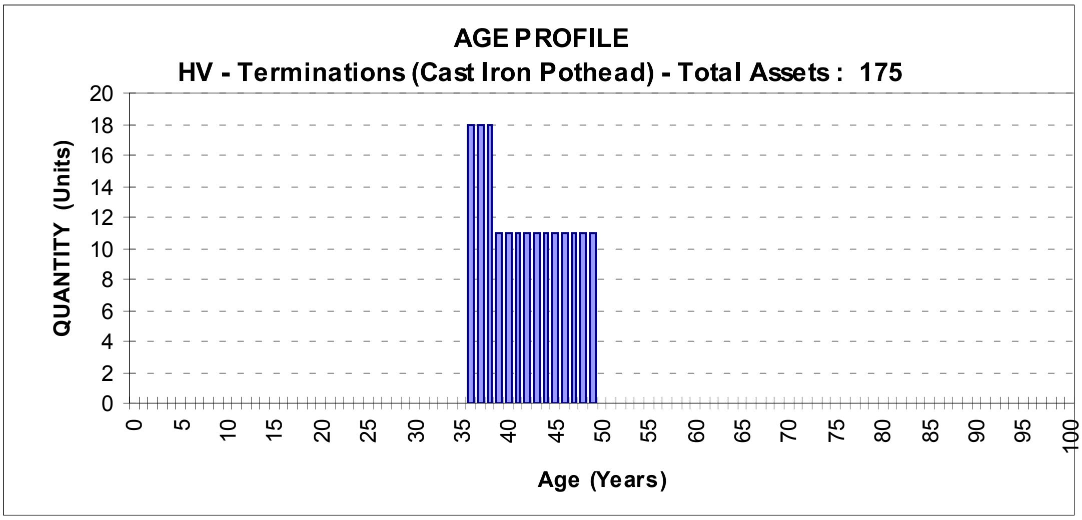


C.2 Turret Age Profile

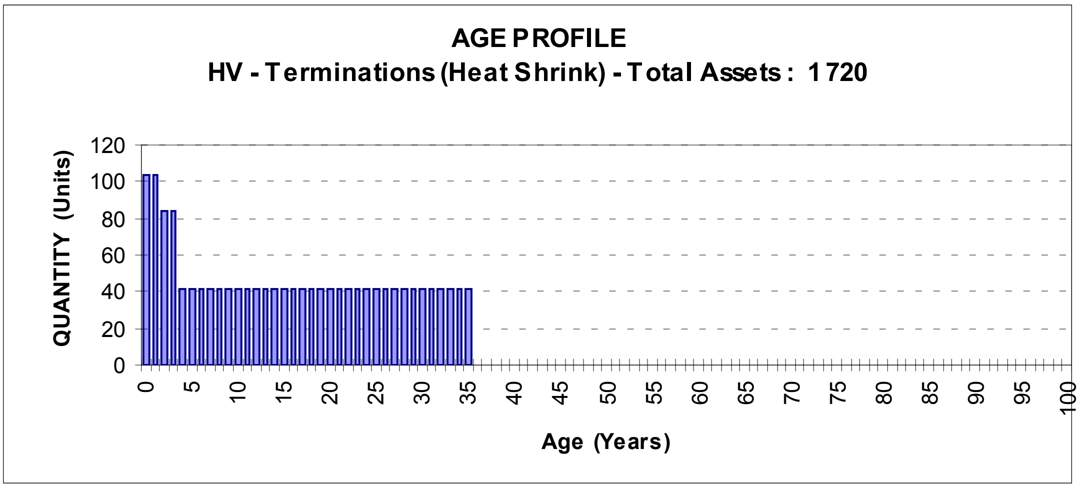


Appendix D Terminations Age Profiles (WASP Data Dec 2009)

D.1 HV Cast Iron Pothead Age Profile



D.2 HV Heat Shrink Termination Age Profile



Appendix E Failed CONSAC Cable Pictures

Figure 4: Cable sheath near failed joint

Figure 5: Corrosion under 'Ozokerite' sealing tape