EXECUTIVE SUMMARY

eThekwini Municipality is committed to developing and implementing an Integrated Infrastructure Asset Management (IAM) Business Plan so as to ensure that the infrastructural strategic assets of the various departments are planned, designed, acquired, constructed, maintained, operated, rehabilitated and disposed of, in a manner that provides a defined level of service to its communities and protects their health. To satisfy the requirements and recommendations of the eThekwini Municipality's IAM Business Plan, eThekwini Electricity has initiated an Asset Management Project and has engage the services of NETGroup South Africa and its sub-consultants to assist in achieving certain objectives and deliverables within this plan.

One of the strategic objectives of the Asset Management Projects deals with the long-term demand and energy forecast and the associated financial cash flow requirements to support the infrastructure strengthening and renewal and is defined as the eThekwini Transmission Network Master Plan study.

This study focuses on the eThekwini area of supply within the eThekwini municipal boundary with the objective of the study being to provide eThekwini municipality a clear view and plan to develop the electrical infrastructure to support the envisaged future demand.

In order to achieve this objective, the study was developed along a number of specific tasks. The high-level definition and objective of each task is provided below.

1. Information Gathering and Review

The objective of this task was to ensure that as much existing information as possible was gathered. Furthermore, this task entailed the review of all information obtained during previous projects and a review of existing eThekwini planning within the area to provide a solid platform on which this project could be based.

2. Geographical Load Forecast

The load forecast is a crucial input to the Network Master Plan. During this task a load forecast was developed that is based on regional demographic and historical load growth patterns. The aim of the load forecast was to determine the present and future electricity requirements of electrical end-users in the study area in order to reconcile this with the available resources and electrical services. Kayamandi Development Services was appointed by NETGroup to utilise regional information and their knowledge on demographics and economics of the study area, to develop an economic and demographic model which forecasts the expected population and economic growth in the study area. These results were then used by NETGroup as input to the load forecast to produce the expected electricity needs of the study area. The study presented a dynamic assessment in terms of historic and the most probable future trends. The anticipated long-term load forecast was directly used as an input to the long-term expansion plan.

3. Review Transmission and Distribution Plans

The expansion of Distribution networks bordering the study area as well as Eskom Transmission expansion within the region will have a direct effect on the planned future network. This task took into consideration these proposed expansions.

The objective of this task was to review and integrate the planned Transmission and bordering Distribution network expansion plans within the Network Master Plan for the Region.

4. Problem Statement, Strengthening Options and Technical Evaluation

This task clearly defined the network problems by assessing the existing network capability and analysing the shortcomings in a coordinated manner. In this way all the existing network problems were identified, along with any potential future problems, within the study area. Different networks to supply the expected load were identified and analysed and evaluated properly to ensure that each alternative network complies with required standards. Once this was achieved the alternatives were compared in terms of cost and technical feasibility.

The objective of this task was thus to review the adequacy of the eThekwini Transmission network through load flow and contingency analysis. The need for possible new transmission supply stations was also evaluated. This task was conducted through an iterative process of problem identification, modelling and analysis, discussion of result in a workshop environment and the rework and evaluation of possible solutions as identified through interaction of the planning team.

5. Environmental Assessment

The overall EA approach included the use of a multi-disciplinary team of experts including relevant specialists that assessed the environmental consequences of the proposed Network Master Plan on the environment, as well as formulated alternative plans and strategies where required. The project team focused on understanding the biophysical and economic environment and the values there-of. Opportunities, constraints and values of the study area, including the needs and wants of the relevant stakeholders, were assessed. This was formulated into a desired state of the environment that recognizes appropriate development options. The Network Master Plan was then evaluated against a set of sustainability criteria to ensure that it is a sustainable development.

A Participation Process formed part of the EA and allowed for the relevant stakeholders to contribute meaningfully during the development of the Network Master Plan. This included regular meetings with a steering committee as well as workshops with relevant parties, including Strategic Decision Makers and the Broader Public such as local authorities, service providers and the property and business sectors.

6. Recommendations for Expansion and Strengthening Requirements

The study has identified and documented expansion and strengthening projects to ensure the adequate performance of the eThekwini network within the short and long term. It is recommended that these projects be implemented in the phased manner as indicated.

7. Capital Program

The capital program was developed by using standard equipment cost, contained in an equipment library. The output from the various evaluation systems was used to set up the capital program for the preferred strengthening projects.

The network development capital program allows for:

- Sub-transmission network development,
- Reliability requirements, and
- Refurbishment requirements.

The total estimated capital expenditure to ensure the adequate functioning of the transmission networks within the Study Area is provided in the Figure 7-1A: The total cumulative capital amount to R 4,700 million rand over the 20 year period.

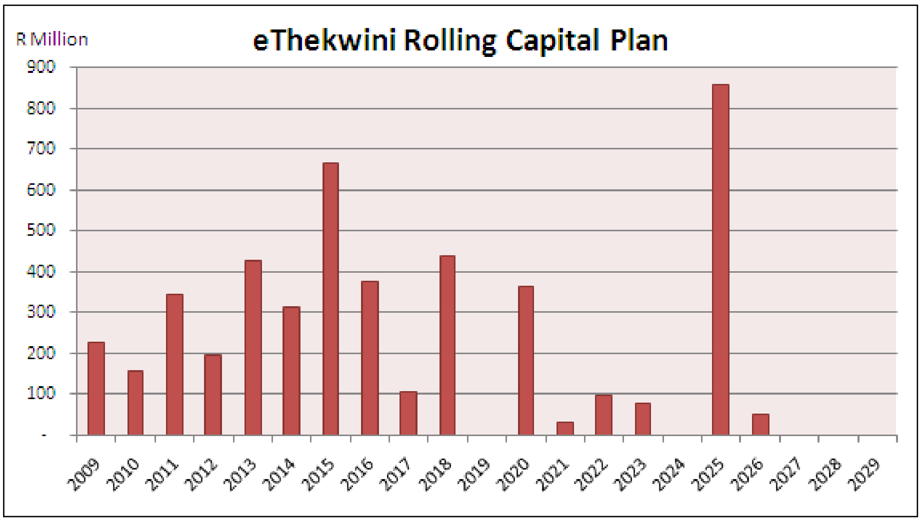

Figure A: Estimated Capital Expenditure / MTS Area

The current eThekwini capital rolling plan, including estimates for 2009 and 2010, amount to R 2,000 million and allow for capital project between 2009 and 2015. The Additional R2,700 million were developed from project plans that were identified during the master plan exercise. The expected capital expenditure from this exercise is provided in Figure 7-1B:

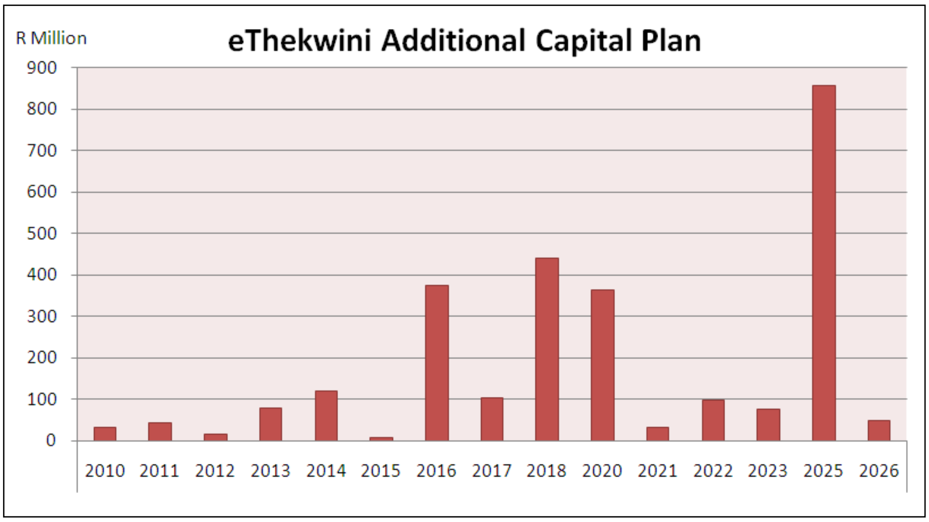

Figure B: Estimated Capital Expenditure from NMP

A significant amount (R 850 million) is scheduled for 2025 of which R 800 million is allocated for the development of the new Klaarwater 400/275/132kV intake station.

Document History

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1 INTRODUCTION AND BACKGROUND

1.1 Background

The study area for the eThekwini Electrical Network Master Plan encompasses the eThekwini Municipal boundary. As indicated in Figure 1-1, this study focuses on the eThekwini area of supply within the eThekwini municipal boundary

The municipal area is bounded on the south by Umdoni Municipality, Ndwedwe municipality to the north, Indian Ocean to the east, Mkhambathini Municipality to the west, Umshwathi Local Municipality to the north west and Vulamehlo Local Municipality to the south west. The electrical infrastructure within this area is owned by both the municipality and Eskom.

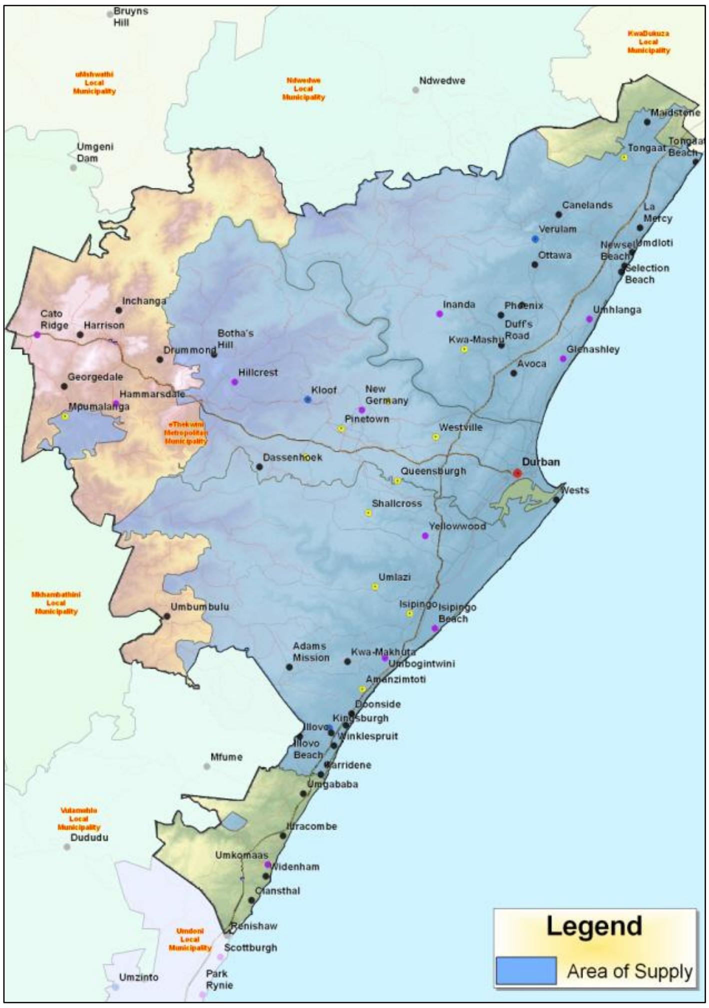


Figure 1-1: Study Area

The main objective of the study was to provide eThekwini with a clear view and long-term plan for the development of electrical infrastructure required to support the envisaged demand growth within the Study Area. The study further clearly identified where new infrastructure should be located and what components, either existing or new, will be required.

This document is structured in the following sections.

This document consists of two Volumes with Volume A consisting of the technical report providing fundamental methodology, data, analysis aspects, results and recommendations and Volume B providing a geo-schematic presentation of information supporting the study as well as recommendations to the study.

Volume A of this report consists of the following Sections:

Section 2: Provides background with regard to the Methodology and Data that was used during the study,

Section 3: Provides the Field Inspections summary,

Section 4: Covers aspects of the Electricity Demand Forecast, including Methodology and Results,

Section 5: Builds upon the Field Inspection of Section 3 to develop an Equipment Refurbishment Plan,

Section 6: Provides the Network Assessment and analysis framework for the Network Assessment. Aspects such as network performance under various loading scenarios and results and recommendations to proposed network strengthening strategies are dealt with,

Section 7: Provides the Capital Cost Estimate of the preferred alternatives.

Section 8: Reports on the Transmission Risk Assessment that was developed under the study.

Various Addendums are also provided to support the study document.

The Addendums to the document include:

Addendum A: Transmission Planning Code of Practice,

Addendum B: Network Assessment and Recommendations (Presentation Format),

Addendum C: Socio-Economic Development,

Addendum D: Environmental Assessment (EA) of the Study Area,

Addendum E: Substation Audits Summary (Presentation Format),

Addendum F: Supporting Electronic Information,

- ArcGIS Dataset,
- Demand Forecast within PowerGLF,
- Cost Estimates within MS Excel, and
- PSS/E case files,

Volume B provides a set of geographical diagrams that systematically portrays the network development for the eThekwini Transmission network.

2 METHODOLOGY AND DATA

2.1 Methodology

The long-term expansion and strengthening plan followed the basic process as outlined in Figure 2-1. The Sections below provide a high-level description of the objective for each task displayed in the process.

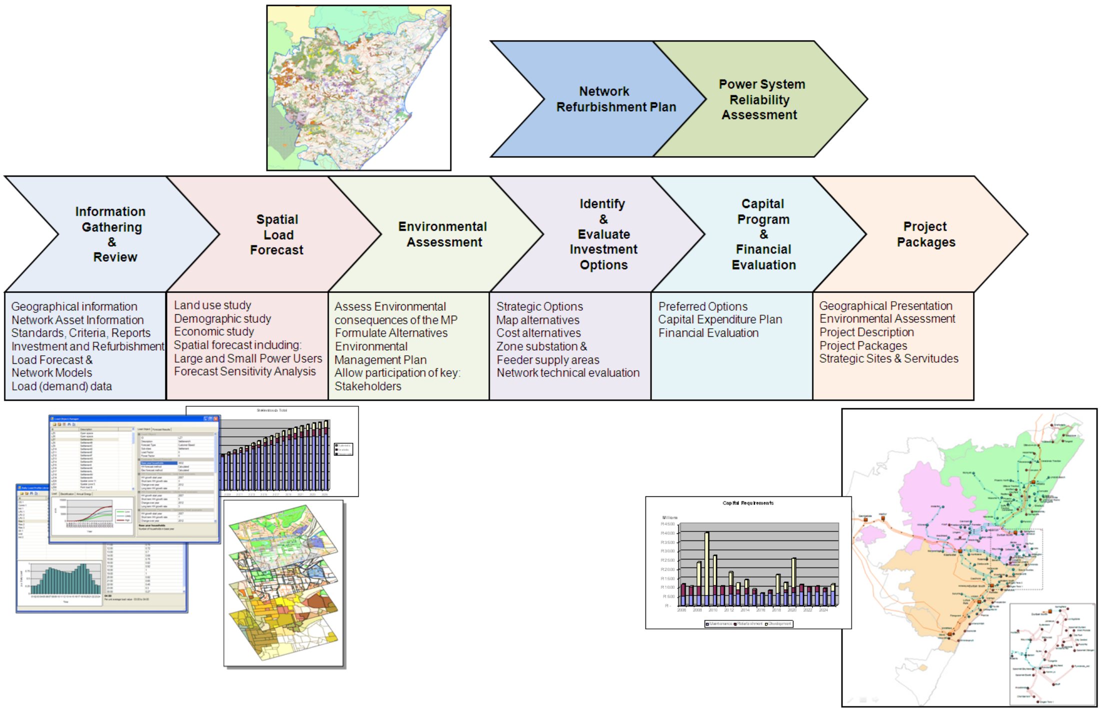


Figure 2-1: Network Master Plan Approach

For the purpose of this study the following definitions applied.

- **Transmission Networks:** Transmission networks in the context of this report are defined as all those substations and associated Transmission lines within the study area that connect and transmit energy directly from the Eskom transmission network (MTS) to distribution zones. The stud specifically deals with the identification, sizing and timing of new, high voltage 275/132kV, 132/88kV, 132/11kV, 33/11/6.6kV and 33/6.6kV substations and associated high- voltage cables and lines within the study area.
- **Network Master Plan:** Network Master Planning, in the context of this report is defined as the identification, sizing and timing of the sub-transmission infrastructure as defined above.

A simplified geographical presentation of the eThekwini Transmission network is provided in Figure 2-2.

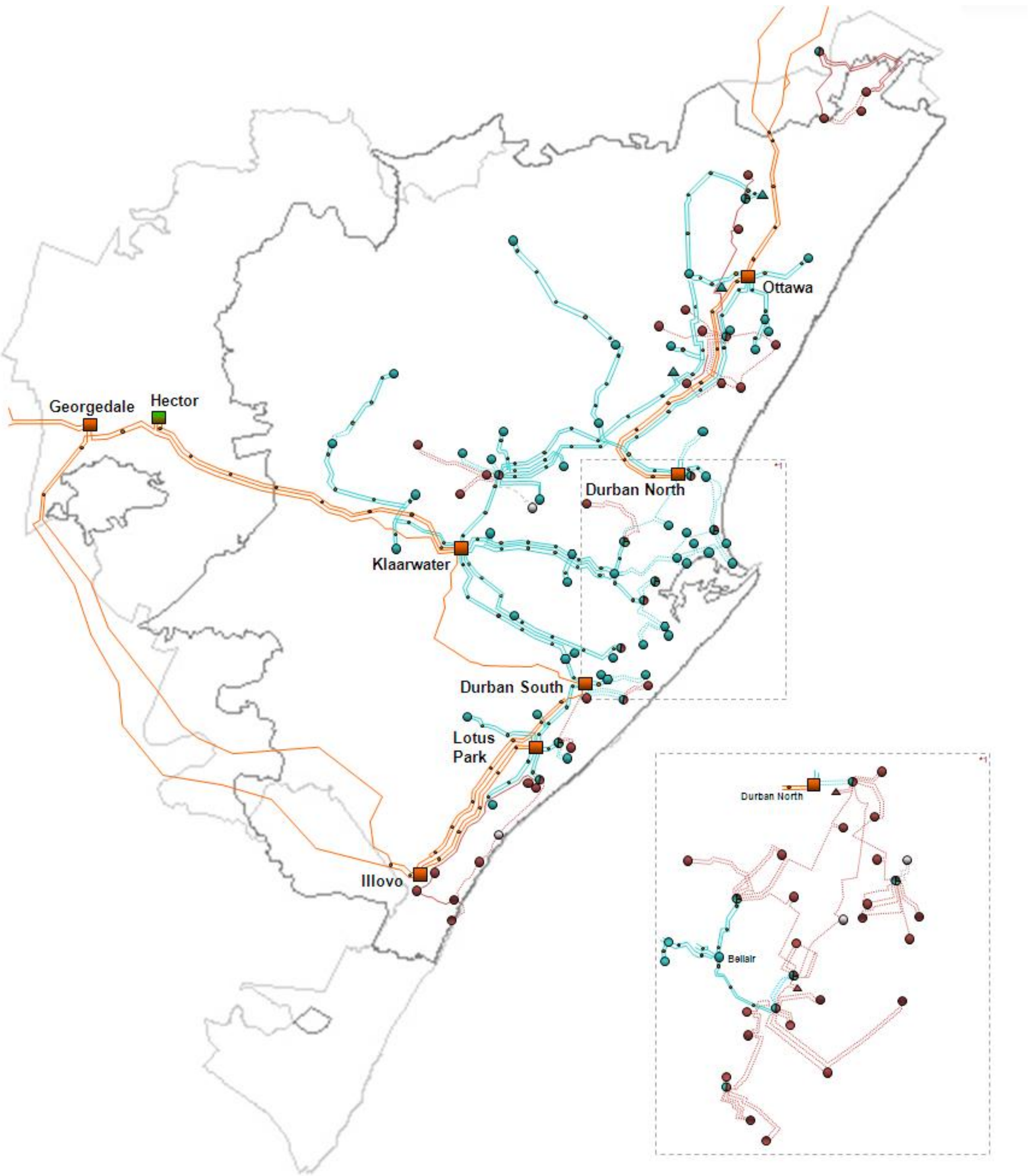


Figure 2-2: Study Area (Network Presentation)

The objectives and basic description of tasks to support the Network Master Plan study are provided in the following sections: The breakdown of these tasks corresponds to the process provided in Figure 2-1:

2.1.1 Information Gathering and Review

The objective of this task was to ensure that as much existing information as possible was gathered. Furthermore, this task entailed the review of all obtained information during previous projects studies, done by others, to provide a solid platform on which this project was based.

2.1.2 Substation Field Inspection

The objective of this task was to conduct high-level field inspections to familiarize the team with the general layout and condition of selected infrastructure where expansion or reconfigurations were proposed. The main objective of the field team was to assess:

- The general condition of equipment within the substation, and
- To assess the expandability of the existing infrastructure.

2.1.3 Equipment Refurbishment Plan

This task focused on the development of a long-term equipment refurbishment and renewal plan and the integration of this plan with the long-term Network Master Plan.

2.1.4 Electricity Demand Forecast

The load forecast is a crucial input to the Network Master Plan. During this task a load forecast was developed that is based on regional demographic and historical load growth patterns. The aim of the load forecast was to determine the present and future electricity requirements of electrical end-users in the study area in order to reconcile this with the available resources and electrical services. Kayamandi Development Services was appointed by NETGroup to utilise existing information and their knowledge on demographics and economics of the study area, to develop an economic and demographic model which forecasts the predicted population and economic growth in the study area. These results were obtained and used by NETGroup as input to the load forecast to produce the expected electricity needs of the study area. The study presented a dynamic assessment in terms of historic and the most probable future trends. The anticipated long-term load forecast was directly used as input to the long-term expansion plan.

2.1.5 Review Transmission and Distribution Plans

The expansion of Distribution networks bordering the study area as well as Transmission expansion within the region will have a direct effect on the planned future network. This task took into consideration these proposed expansions and reviewed its impact on the study area.

2.1.6 Problem Statement, Strengthening Options and Technical Evaluation

This task clearly defined the network problems by assessing the existing network capability and analysing the shortcomings in a coordinated manner. In this way all the existing network problems were identified, along with any potential future problems, within the study area. Different networks to supply the expected load were identified within a workshop environment and analysed and evaluated properly to ensure that each alternative network complies with required standards. Once this was achieved the alternatives were compared in terms of cost and technical suitability.

The objective of this task was to review the adequacy of the Eskom Sub-transmission network through load flow and contingency analysis. The need for possible new transmission supply stations was also evaluated. This task was conducted through an iterative process of problem identification, modelling and analysis, discussion of results in a workshop environment and the rework and evaluation of possible solutions as identified through interaction of the planning team.

2.1.7 Environmental Assessment (EA)

The Environmental Assessment (SEA) formed part of this study to ensure the development of a plan that aligns with environmental practices. The EA approach included the use of a multi-disciplinary team of experts including relevant specialists that assessed the environmental consequences of the proposed Network Master Plan on the environment, as well as formulated alternative plans and strategies where required. The project team focused on understanding the biophysical environment and the values thereof. Opportunities, constraints and values of the study area, including the needs and wants of the relevant stakeholders, were assessed. This was formulated into a desired state of the environment that recognizes appropriate development options. The Network Master Plan was then evaluated against a set of sustainability criteria to ensure that it is a sustainable development.

A Participation Process formed part of the EA and allowed for the relevant stakeholders to contribute meaningfully during the development of the Network Master Plan. This included Strategic Decision Makers such as local authorities, service providers and the property and business sectors.

2.1.8 Cost Estimates and Financial Evaluation

The objective of this task was to perform cost estimates of the technically successful alternatives and to develop a 20 year capital program (CAPEX).

2.1.9 Transmission Risk Assessment

The Transmission Network Risk assessment focused on developing network reliability models for representative network configurations and to assess the loss of load expectation for each configuration in an attempt to assess the impact of these interruptions of connected customers. The approach that was followed modelled and evaluated the reliability of typical eThekwini substation configurations and assessed the expected impact of specific substations of connected customers.

2.2 Project Data

2.2.1 Documentation

The following information was received, reviewed and used in support of the study:

- **Electrical supply system information:** Electrical network information (Single line diagrams, substation diagrams, layout diagrams where applicable); Network analysis files (PSS/E Case Files);
- **Existing standards and reports:** Existing studies and reports (Including load forecast, Previous Network Master Plans); General existing planning related information; Rehabilitation / Refurbishment reports.
- **Capital Program:** Standard item costs (e.g. Transformer & Cables); Standard building block costs; Existing capital plan,
- **Generation & Transmission Master Plans:** Existing Eskom Transmission expansion plans for integration with the Network Master Plan for the study area,
- **Historic Load Information:** Historical substation loading information,
- **Future Development Information:** Existing and future developments from eThekwini planning and housing departments. Spatial development frameworks and housing developments, and

- **Satellite Imagery:** Satellite imagery for the study area.

2.2.2 Other Information

The following is a list of information that was sourced by NETGroup or obtained from other organisations that was used to develop portions of the Geographical Load Forecast:

- Cadastral information, and
- Basic topological information.

2.3 Software

2.3.1 Mapping Software

All mapping and geographical presentation of information and data was done using ESRI ArcMap 9 and Microstation CAD Ver8.0.

2.3.2 Network Analysis Software

The PSS/E Version 32.0.3 was used throughout the analysis.

3 SUBSTATION FIELD INSPECTION

3.1 Background and Objective

A technical field inspection was conducted, obtaining basic equipment information and evaluated equipment status and condition on site of all HV assets. A second phase allowed a design engineer to evaluate this basic information and photos to provide a technical perspective of the state and suitability of the equipment.

Three qualified inspection teams visited 104 substations between the 4th of May and the 15th of June 2009. A preparation exercise to exhaust readily available information prior to the site visit was also conducted to enhance the quality of the technical inspection (Substation Single Line diagrams and an existing Equipment dataset).

The substation inspections focused on primary equipment within all sub-transmission substations (275/132kV, 132/88kV, 132/33kV, 132/11kV, 88/33kV, 33/11kV, 33/11/6.6kV and 33/6.6kV substations) as well as the substation yard, land and buildings, batteries and battery chargers. Substation equipment included:

- Power and Auxiliary Transformers,
- Neutral Earthing Transformers,
- Instrument Transformers,
- Surge Arrestors,
- Indoor and Outdoor Circuit Breakers,
- Isolators,
- Reactors and Capacitors, and
- Standby Generators.

3.2 Inspection Summary

The inspection revealed a need for equipment upgrades which could pose a problem during fault / switching conditions. The following are general findings and comments regarding the substations that were inspected:

- In most cases enough space is available for extensions to the existing infrastructure and will not be problematic. In some cases overhead line configurations will require innovative solutions for infrastructure extensions.
- Transformers are generally in a good condition.
- Some parts of the network are ageing and this is evident by the old equipment and protection schemes still in use especially in the 44kV yards.
- Some station equipment (line isolators and breakers) shows signs of ageing like oil leaks.
- Maintenance is of an acceptable level and this was evident during the inspections with the exception of one or two cases.
- Control buildings are generally well kept.
- Indoor switchgear is in good condition and battery chargers and batteries are in good condition.
- Some oil filled equipment oil levels are low and in some cases it is unclear.
- Access is good in most stations.
- Stone cover is good in most stations.

Detail comments and findings to the field inspection are provided under Addendum C of this report.

4 ELECTRICITY DEMAND FORECAST

4.1 Background

A comprehensive Demand- and Energy forecast was required to establish the demand basis for the Network Master Plan. The purpose of a spatially based demand forecast was to derive a realistic prediction of the electrical load for the eThekwini area of supply, over a medium to long term period (5-20 years).

Spatially-based demand forecasting is regarded as the most suitable method for long term electrical load forecasting. Although research has proved that probabilistic methods provide better results than deterministic methods, the data to support such an approach normally takes years to collect. A practical compromise is followed where a computerized deterministic model was used. The input data needed is realistically obtainable and the model allows for "what if" studies to be performed easily (in the case of eThekwini 3 major Industrial scenarios were developed with land-use sectors following these major scenarios). This approach allows system planners to develop a feel for the sensitivity of certain input parameters and typical pessimistic, realistic and optimistic scenarios can be analyzed.

As the name suggest the demand prediction is done on a spatial basis – both using geographical data as backdrop information and input data as well as geographically predicting load growth e.g. where the load will increase and how the load increase will occur over the forecast horizon.

Although not an exact science, demand growth can be forecasted to a reasonable degree of accuracy. By analysing the area of load growth in terms of the type of load (industrial, commercial, residential etc.), the current loading, historical loading where available, it is possible to make reasonable assumptions in terms of future load growth for the area.

The eThekwini demand forecast did exactly that. It combined available load information from, as an example, the billing system with the geographical data that will influence the way in which the load will develop. Geographical information further provided information with relation to potential boundaries for load growth (e.g. mountains, developable terrain, environmental constraints, etc.), load classification of current load (e.g. large power users such as industrial, commercial, farmland), future areas earmarked for development, green zones (no development), etc.

The aim of the Electricity Demand Forecast is thus to determine the present and future electricity requirements of electrical end-users within eThekwini in order to reconcile this with the available resources and electrical services. The Demand Forecast presents a dynamic assessment in terms of historic and the most probable future trends.

The focus throughout the forecast falls on the electricity needs and requirements of the various user sectors as determined by the characteristics and trends of each. The forecast therefore highlights where and when imbalances between electricity requirements and supply are most likely to occur.

The primary input that drives the various load growth scenarios is the Development perspective. The following sections provide a high-level summary of the eThekwini development perspective.

4.2 Demand Forecast Approach and Methodology

The load forecast is deterministic in nature and was performed within the NETGroup PowerGLF application where the loads were summated, taking load diversity into account, for each uniquely defined load zone.

The load forecast used as a basis:

- Forecasted economic information,
- Demographic trends,
- Existing and predicted future land-use data, and
- Future development initiatives.

4.2.1 Base Load Set-up

The base development consisted of creating a data set and associated geographical presentation of the existing network topology and associated loads.

Historical statistical meter, Large Power User (LPU) information and transformer and feeder loading schedules were assigned to feeders zones to represent the base load.

4.2.2 Forecast Development

Once the base load was established, the load forecast was developed with the results obtained from the Development- and Socio Economic study providing the basis of the forecast. The primary drivers for load growth were:

- Economic growth parameters per sub-place level,
- Actual Development initiatives, and
- Electrification load as provided by the Universal Access Program (adjusted to new backlog eradication target of March 2015).

The above drivers were captured geographically and assigned to load zones.

4.2.3 Base Information

The following sections provide background and supporting information to the data and methods that was used to develop the base load.

4.2.3.1 Set-up Load Forecast Database

All load zones were entered into PowerGLF and linked to the GIS. This enabled reporting on maps, providing a visual perception of growth areas. Load profiles per load classification were further linked and calibrated to load zones.

The summation hierarchy used to complete the Geographical Load Forecast is shown below:

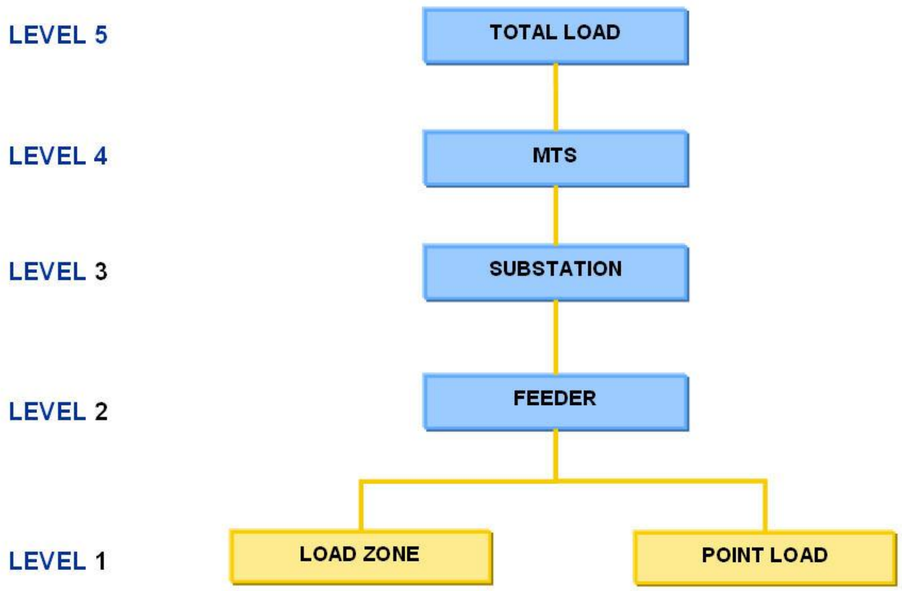


Figure 4-1: Summation Hierarchy

The sub-place information was used as a basis for the creation of load zones. The study Area was sub-divided into 5034 Load Zones and 520 Point Loads (LPU's) were identified. The load zones include 1700 developments that were identified. Figure 4-2 below shows the demand forecast zones.

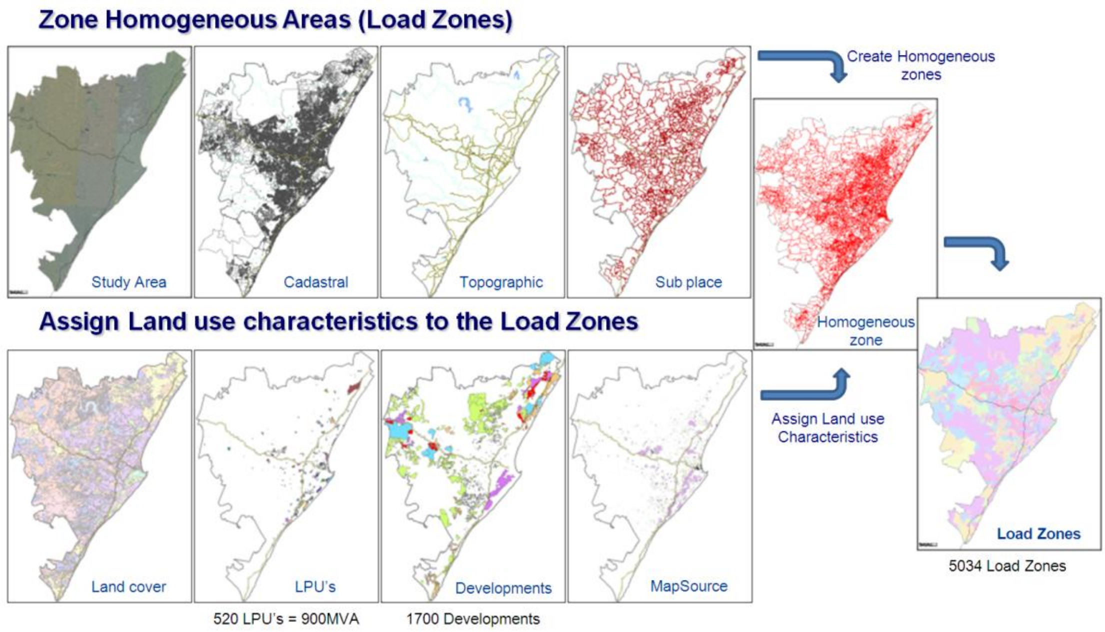


Figure 4-2: Demand Forecast Zones

4.2.3.2 Land-use Characteristics

The number of load classifications that was used in the load forecast was determined in consultation with the Development Economist and eThekwini. The Table below shows the definitions for the various classifications that were used.

Land Use ID	Description
Agricultural	Farmland used for any agricultural or related use.
Commercial	Businesses (neighbourhood centre, corner shop, etc.)
Casino	Casinos
Cemetery	Cemeteries
Educational	All schools, crèches, Technikons, Universities, Colleges, etc.
Government	All government uses or land earmarked for government use, i.e. State/Departmental buildings, stores/workshops, etc.
Golf Coarse	Golf coarse
Hospital	All health facilities
Industrial	Industries (i.e. service industries, light industries, etc.)
Institutional	Churches, Post Offices, Police Stations etc.
Mining & Quarrying	Land used for quarrying or extracting of minerals (mines) and include both underground and surface mining operations.
Municipal	All municipal and related land or uses such as sewerage farm, reservoir, dumping site, cemetery, airfield / aerodrome or land earmarked for municipal use.
Nature Reserve	Declared nature reserves by means of some outstanding ecosystem/s, geological features, etc. undisturbed by man.
Private open space	Open space not accessible to the general public (i.e. Security Villages, etc.)
Public open space	All open spaces accessible to the public (not agricultural land)

Table 4-1: Land Use Categories

Figure 4-3: provides a typical view of the application of the land-use within GIS.

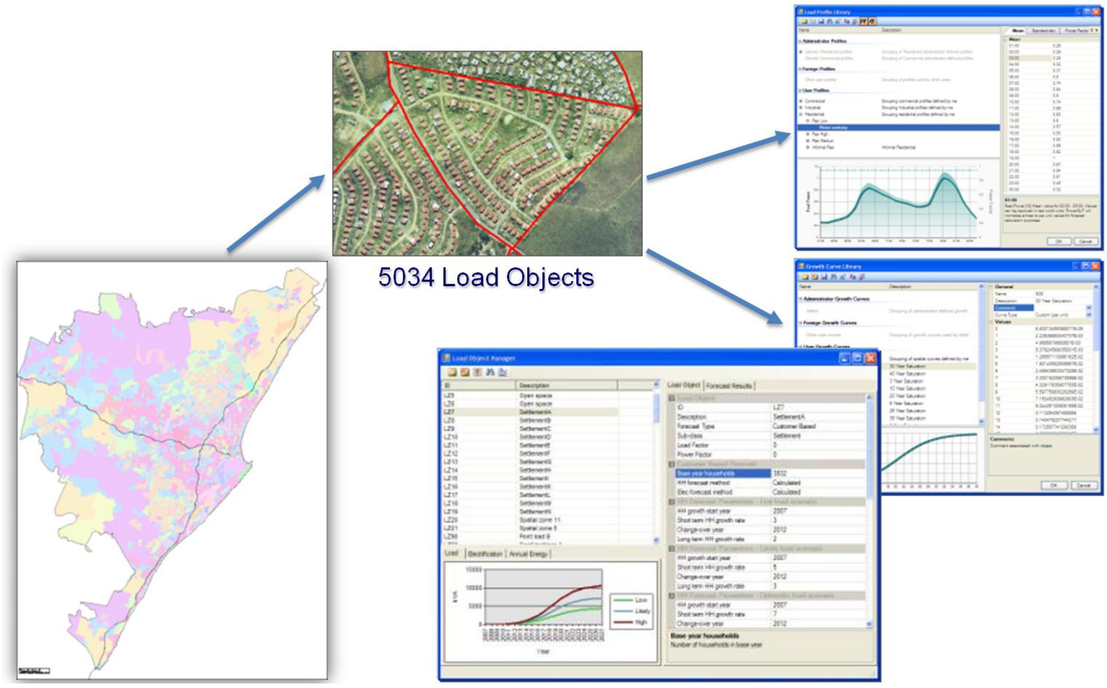


Figure 4-3: Typical Land Use within the GIS

4.2.4 Existing Load Information

Once the load forecast structure was created, base loads were assigned to the different forecast levels. These consisted of;

- Statistical meter readings,
- SCADA statistical information,
- Large Power User meter readings,
- eThekwini LPU Billing Information, and
- Transformer loading information.

4.2.4.1 SCADA Readings

SCADA readings for a period of three years were obtained for all 132kV substations within the study area. Apart from SCADA information, metered billing information for large customers, each record also provided a spatial identification or account name / number that could be used to uniquely identify the geographical position of the meter. The maximum demand for each year was derived and assigned to the associated feeder.

4.2.4.2 Large Power Users

Large Power User information were used in the same manner as the SCADA readings, with LPU's assigned geographically to each substation zone.

4.2.4.3 Transformer Schedules

Transformer schedules, obtained from the network planners, indicating transformer maximum demand values were used as the transformer load where statistical meter information was not available.

4.3 Development- and Socio Economic Study

4.3.1 Background

Kayamandi Development Services was appointed by NETGroup to utilise existing information and their knowledge on demographics and economics of the study area, to develop an economic and demographic model which forecasts the expected population and economic growth in the study area. Kayamandi Development Services was appointed to provide an indication of future size and spatial distribution of the population and economic activities. The objectives can be defined as follows:

- Determine present population and socio-economic characteristics,
- Provide estimates of possible future growth based on historic trends and future growth scenarios,
- Model population and economy to provide estimates of the future size and distribution of people and economic activities, and
- Provide take up rate of individual developments.

These results were then used by NETGroup to produce the expected electricity needs of the study area. The demographic and economic study period stretches from 2008 to 2030.

4.3.2 Structure of Demographic and Economic Study

The basic structure of the Demographic and Economic study is shown in Figure 4-4. The basic approach consisted of developing a baseline economic and demographic forecast and then identifying developments and initiatives that will influence this baseline in the future. A high-level discussion of each process is provided below.

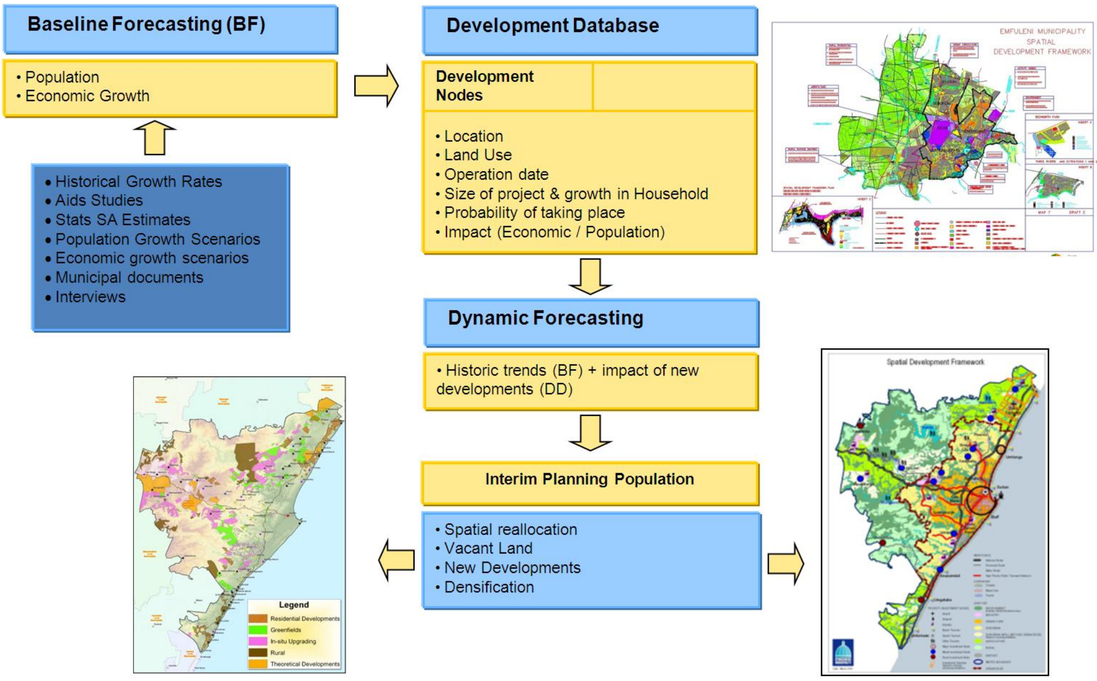


Figure 4-4: Development and Economic Study Approach

4.3.2.1 Baseline Forecast

The purpose of the baseline forecasting was to forecast population and economic growth on a sub place/main place level, to 2030, based on historic population and economic growth trends. Population growth was calculated by using 1996 - 2008 data and forecasting to 2030, based on this growth rate as well as demographic trends.

Gross Geographic Product (GGP) over the period 1995 to 2004 was used to calculate economic growth at a main place level. Economic growth was forecast to 2030, based on this growth rate.

4.3.2.2 Development Database

The purpose of the Development Database was to identify all planned developments in the study area and create a database, wherein the impact of each development on population and economic growth was determined. Information pertaining to identified planned developments includes the location of the development, a brief description, the land use, the approximate date of establishment and the size of the development.

4.3.2.3 Dynamic Forecast

The purpose of the dynamic forecasting was to forecast population and economic growth on a sub place/main place level, based on historic population and economic growth trends and also the impact of planned developments on population growth and economic growth in affected areas, to present a more realistic overview of forecasted population and economic growth trends.

The anticipated impact of each development was included in the dynamic forecasting. The impact of each development on population and economic growth, determined in the development database, were added to the baseline forecasting (based on historical trends), to create the dynamic forecasting. The model outline is provided in diagrammatic form in Figure 4-5.

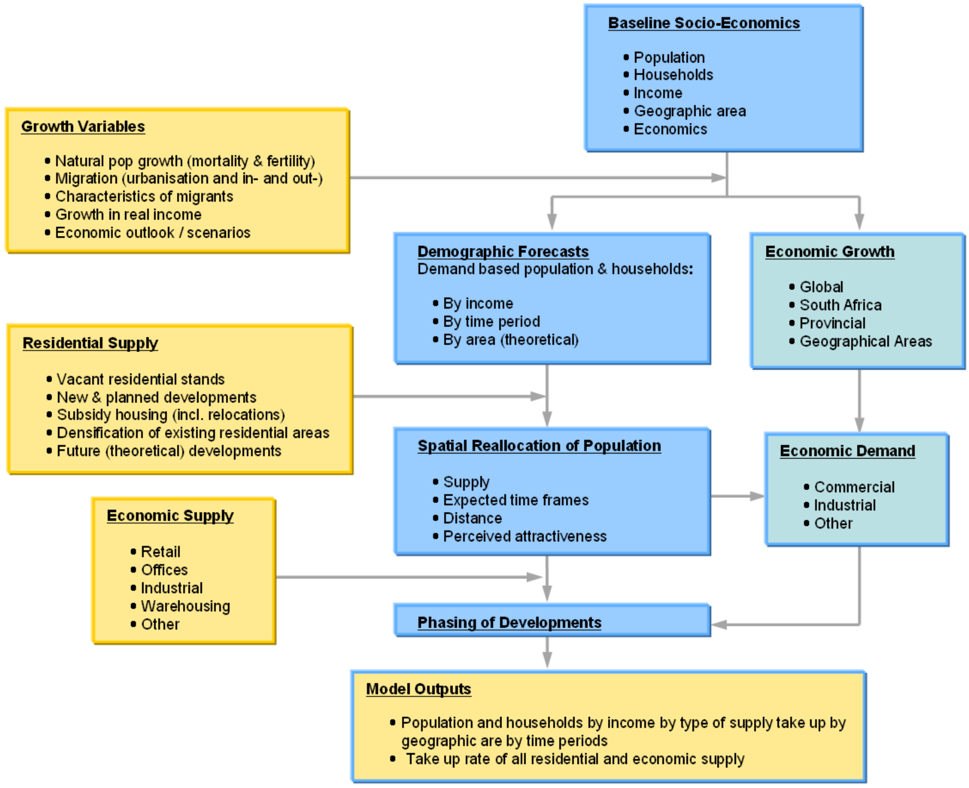


Figure 4-5: Development Potential Model Outline

4.3.3 Development Perspective

The Development Perspective seeks to provide an indication of the possible future scenario's or realities that may be created or come into existence as a result of developmental growth and expansion of a number of key sectors, be it commercial, industrial or social.

Several key factors have been identified that as a result of its future courses of development could change the form, function and future trends of the eThekwini Municipal Area (EMA). From closer examination the formal impacting sections explored is based on the Durban harbour developmental initiatives, industrial agglomeration within Cato Ridge, Hammarsdale and Shongweni and the impacts to be created by the King Shaka International Airport and related Dube Trade Port (DTP). Numerous discussions exist around the usage of the Durban International Airport (DIA) and Back of Port (BoP) and which could either be used for a dug-out port or land for business establishment. These sections have been selected as a result of the enormity of its end results that is largely an undeterminable hypothesis but which could eventually steer the entire future of what the EMA is defined as regionally, nationally and internationally.

These above mentioned elements are instrumental in the approach followed that is essentially based on a Low, Medium and High growth expectation. The developmental activities in relation to the various types of growth could result in numerous realisations in economic growth rates, employment opportunities, movement of people within the metropolitan area, the way the city functions and the processes and form of the major urban and infrastructural components.

4.3.3.1 Low Growth Expectations

The low growth expectation is based on predominantly status-quo realities being experienced but factors-in a constant and direct growth with minimal change to the existing developmental aspects of the area.

The scenario looks to explore a minimalistic industrial development approach and strategically focus on sectors such as tourism, conferencing and sporting events. Industrial activity as a main driver is used to slow down the major employment sections and incorporate a different economic composition that highlights the afore mentioned key areas of growth. Economic growth would be subject to the relative low growth rates and a slow down being experienced as the status-quo becomes cemented. Economic growth would be subject to a 4% constant with minimalistic expectations to decrease unemployment and rural/informal communities. Industrial activities would essentially seek to incorporate a larger component of diversification and facilitating smaller and medium type businesses which is strategically agglomerated to encourage some growth expectations.

The scenario depicts a slow growth rate and hampered activities in development as a result of numerous situations related to the minimal harbour development, and in relation lower development of industrial and commercial activity within Cato Ridge/Hammarsdale and DTP.

The harbour would have an existing management capability of import/export activity placing the predominant focus on the DTP. Smaller business locating to the BoP would essentially focus on the local markets and facilitate any development at the DTP. Regional significance would become dispersed between Durban and Richards Bay, placing a greater need on agglomeration and regional connectivity. The linkage along the N2 would become of great importance as it services the harbour, BoP, and the DTP and then runs towards Richards Bay.

The predominant focus of industrial activity would be on the northern region and would in effect extract the major activities and population from other regions of the area. Linkages to Cato Ridge would also need to be facilitated, in order to ensure that exporting of any manufactured products be swiftly transported.

The economy, estimated to grow at 4%, would be largely encouraged by the enhancement of tourist activity, conferencing and sporting activities. The DTP would play a significant role in this, as well as in the development of activities which would support the tourism perspective. Developmental activity would need to create tourism options that would attract international and higher income travellers, whilst the southern and central region would need to focus on domestic tourists. Tourism nodes will be located within Umhlanga, La Mercy and Sibaya in the Northern region. Along with tourism developmental aspects, another focus would be on high-tech industries to further encourage economic activity. High-tech technologies would be closely located to the DTP and would be in line with international economies.

Residential developments, along with commercial activity may predominantly then be continued along the DTP and N2 and possibly outwards to KwaDukuza Municipality. This may pose threats in the light of losing significant economic activities and then also formal residential components. This may cause a spending of capital in another municipality and facilitate the growth of the regional economic activity of adjacent municipalities.

The picture painted in this instance would be one that has significant development towards the northern region, whilst a predominant stagnant climate is created within the other regions of the area. Slower growth and development would be at the forefront and so lack of employment, possible significant growth in informal housing, and the poorer demographic.

4.3.3.2 Medium Growth Expectations

The medium growth scenario looks at a greater proportion of economic growth. The expectations of this scenario are centred on medium sized expansion of key industrial sites for the facilitation of developmental activity and larger focuses on international trade relations. Economic growth sought to be achieved would fall within the 5% to 6% bracket.

The scope of tourism objectives of scenario 1 now becomes a smaller facet that shapes the growth expectations described above. Industrial activity and associated trickle down effects now take centre stage which encourages a more equally distributed development of the metropolitan area. The central and northern regions would take a central predominance in developmental advantages, which in effect would encourage the creation of some presidented focus on the outer west region as a result of developmental spill-over.

Large scale changes would have impacts on infrastructure, composition and function of the area which would change the courses of strategic initiatives for future developmental typologies, and would require a greater level of planning.

Ultimately, the harbour expansion at Bayhead would create larger economic development aspects which could be accounted for by a trickle-down effect. The expansion would change the usage of the BoP area unlike that stated within scenario 1 and would see the establishment of more exporting and medium sized companies specifically related to harbour economies. The DIA land would be a mixture of uses that have manufacturing, petro-chemical and logistics components which would facilitate growth and development within the Cato Ridge area as a result of smaller logistics components in the DIA.

Cato Ridge would be mixture of logistics operations and heavy industries to create an inland port area that caters to the needs of the harbour manufacturers. This effectively would have an impact on the Cato Ridge town with an emphasis on development of a rural node that would service the surrounding rural and agricultural communities. The Hammarsdale area would continue textiles production and depending on need, expansion of the adjacent residential land may be required.

Linkages would be based on the N2 and N3 routes with a greater need for rail development. The N3 would link the Cato Ridge area to Pietermaritzburg and CBD of Durban and further out towards Gauteng and the Free State. The N2 is predominant in linking the harbour with the DTP and Richards Bay and Port Elizabeth. Nodal growth would be seen within the CBD, Umhlanga, Tongaat and ultimately Cato Ridge town.

The southern region would be a minimalistic centre for development. Effects would be felt by the DIA development but further outwards towards Amanzimtoti tourism would continue to be the major component. Umhlanga and surrounds may have the predominance of international tourists whilst the southern region would look at facilitating domestic sectors.

Industrial and residential development may be forced along the N2 and M4 towards Ballito and may have businesses and residential locating outside the area boundaries. This could have effects on the establishment of firms within the area boundaries. Larger residential development may occur around Cato Ridge.

The idea being characterised is compositional of a predominant urban structure within the central and northern regions, whilst the southern and outer west stay predominantly unchanged except for eventual developmental pressures. The Cato Ridge node would grow to be an urban/rural node with diverse economic and residential functions.

4.3.3.3 High Growth Expectations

The high growth scenario is based on a high economic growth rate of 7% as a result of major development of the harbour and Cato Ridge nodes. This scenario is based on a time-frame of 15 to 20 years.

This scenario would see major harbour expansion taking place which would increase its handling capacity and would cause specialisation of harbour functions. The Cato Ridge node would be directly affected by harbour expansions and would grow within significance in the metropolitan region. The DTP would initiate all support functions and facilitate the air freight and tourism objectives for high growth objectives.

All centres of the study area would be directly or indirectly affected in terms of form and function and the role played within the larger systems.

This scenario is based on high growth expectancy with specific reference to fast growth in economic and demographic terms. The end result of this scenario would predominate EMA as a international gateway for industrial, tourism and harbour activities.

The harbour would be a significant contributor to this reality as harbour functions are maximised and grown to incorporate various industrial activities related to the port and supporting services to ensure its efficient running. The BoP and DIA would be significant investment centres for exporting and importing firms and medium and large scale companies whom which would seek to establish in this area. The form and function of the area would be significantly changed as a second harbour would impact on the systems currently in-place.

The Cato Ridge area would facilitate the logistical components of the harbour along with extensive heavy industries. Cato ridge would become a large in-land port with linkages to Pietermaritzburg and the Durban CBD. The extensive growth in this area would cause significant changes to the Cato Ridge town and establish it as a regional node.

The DTP would continue to function in relation to elements stipulated within scenario 1 and 2. Its importance would be related to the air freight capabilities and tourism opportunities for international visitors. The intensity of its regional significance would facilitate large scale industrial activities and support functions to the harbour and Cato Ridge.

The N2 and N3 and regional distributors would become important linkage tools which would substantiate developmental activity alongside them. The major changes brought about would require some strategic approach to movement patterns in the city. Congestion and frequency of various modes of transport would be inhibited with the addition of more heavy vehicles which would require that the entry and exit points to and from the city be adjusted or reconfigured to allow for the movement of these vehicles.

Nodal development of these areas and surrounds would be instrumental in the residential and commercial components of the EMA. Residential, commercial and strategic industrial development would be an occurrence along the N2 towards Ballito, where numerous developments would be created outside the borders of the EMA. Also development would be occurring along the N3 towards Pietermaritzburg and the Durban CBD. The established nodes with sufficient commercial and residential components would be intensified and diversified to support the local communities, whilst possible smaller nodes or new nodes would have to be established to function as services nodes for the purposes of providing basic services and products. Major nodes to be identified would be Umhlanga, Durban CBD, DIA, Tongaat, Cato Ridge and Hammarsdale.

The initiative would be an economy of scale development with diversified services. The focus of the EMA would be evenly distributed within these regions causing developmental distribution and not single growth within certain urban regions.

4.4 Demand Forecast Integration

Once the base load was established, the load forecast was developed with the results obtained from the Development- and Socio Economic study providing the basis of the forecast.

4.4.1 Short- and Long-term Forecasting

For the Long-term forecast, the inputs from the development perspective were used to determine saturation loads. An S-curve was fitted between the Short-term forecast and the saturation load. The PowerGLF package automates a substantial portion of the above-mentioned process.

Special attention was given to the previously mentioned, envisaged development initiatives.

4.4.2 Base Load Verification

4.4.2.1 Check Load Densities

The calculation of existing land use load must be equal to the existing load measured. It must be ensured that when the load density is multiplied by the area of the load zone and then multiplied by the coincidence factor, with regard to the maximum time value for that supply zone, the different summated load should be equal to the measured value for that supply zone.

This calculation is done by using the load densities and load portion area and then multiplying that with the specific day profile for the maximum of the supply area. The different load zones are then summated to find a new daily profile, which is then normalized back to the measured theoretical profile. This determines the initial load zones load and also the initial density of each load zone.

4.4.2.2 Allocate Correct S-Curves

The S-Curves were chosen to simulate a specific land use “road” to saturation. The normalized annual peak load estimate per year is mathematically defined as follow:

$$f(n) = \frac{1}{(1+10C)} \times ((2+10C) \times (A + \frac{(1-A)}{(1+10Ce^{-B/n}}) - 1) \qquad (5.1)$$

Where:

- n indexes the year,
- A defines the starting point of the S curve (for an existing load the parameter A would be determined by calculating the existing load as a percentage of the saturation load),
- B defines the time till saturation, and
- C is a number between 1 and 10 that manipulates the initial growth pattern, where 1 is defined as strong initial growth an 10 results in slow initial growth,

The S-Curves that were used are shown in the following Figure 4-6:

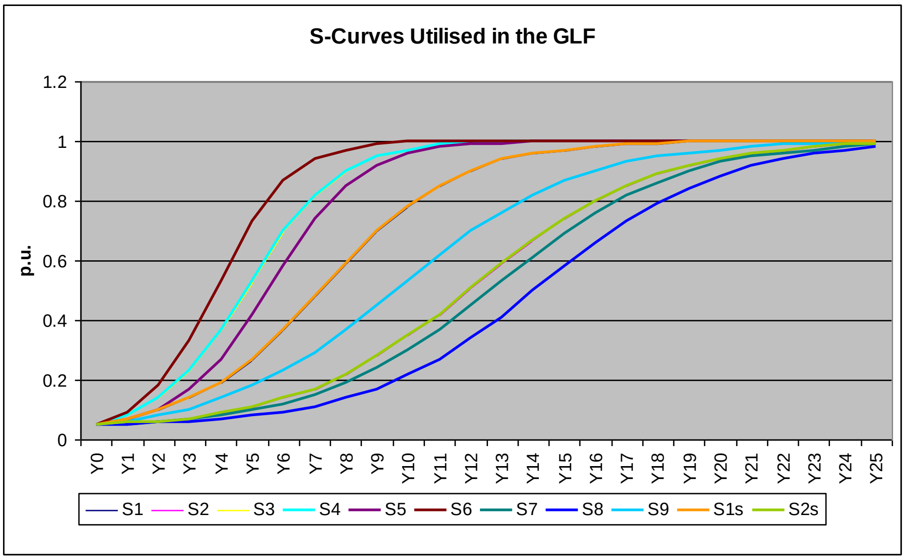


Figure 4-6: Load Category S-Curves

The different land-use types were appointed different S-curves. The allocation of S-Curves was based on experience in other utilities and should be sufficient to describe the growth pattern.

4.4.2.3 Confirm Growth

After the first calculation has been done the growth of each load zone is monitored to ensure that no irregular growth takes place. In the event of a load zone that has no land use change, the growth pattern is expected to be normal load growth of say an annual rate of 3%.

Land use changes that do occur will also be limited to similar land use density in that same supply area (although some exceptions can occur). These are all checked and densities modified until all growth rates are within expectations.

4.4.2.4 Verify Total Load

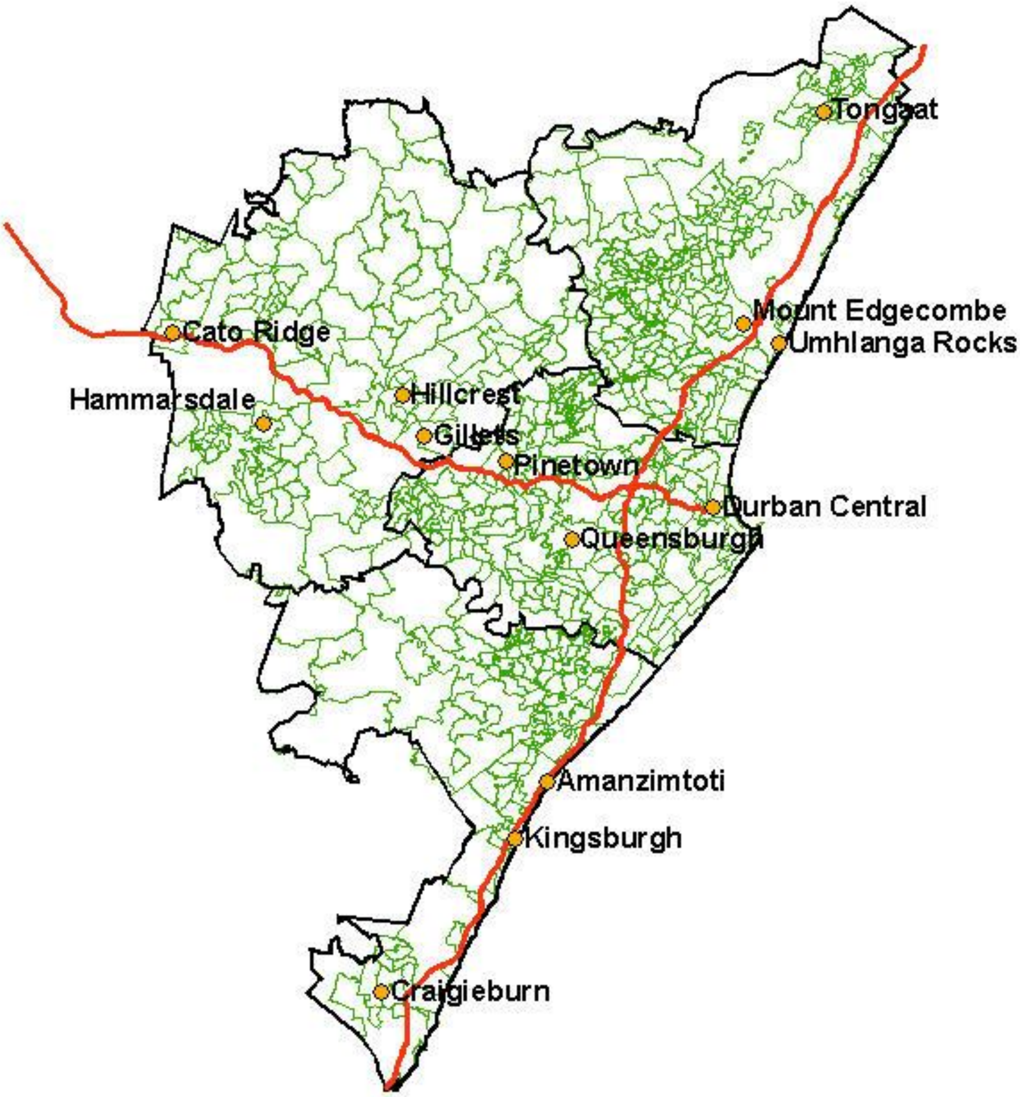
The diversified summated forecast to the top level, namely MTS supply areas must also be acceptable. Historically measured loads are always a good reference to determine whether the forecast is valid.

4.5 Demand Forecast Results

The results of the Geographical Load forecast and Socio Economic study are summarized in the table below.

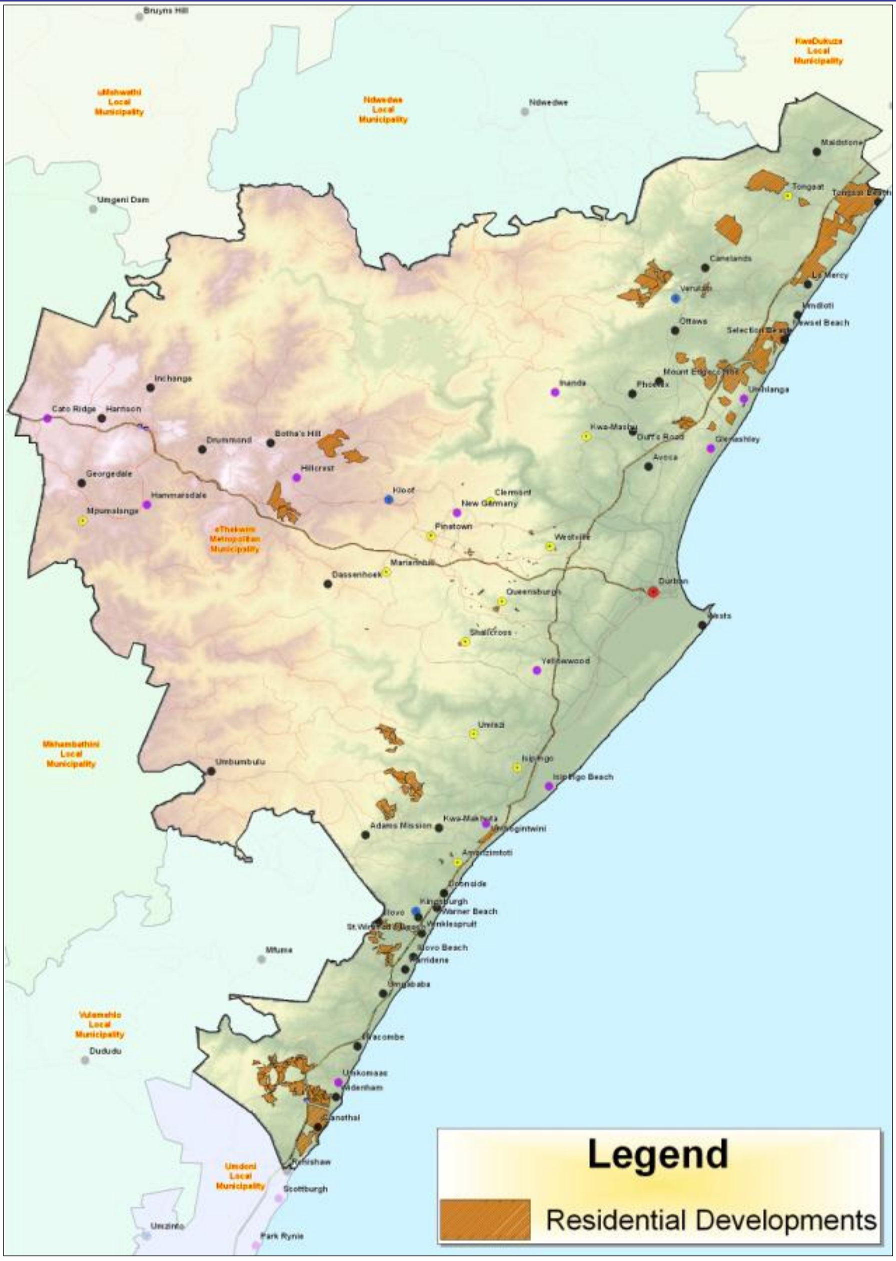
<u>Socio Economic Base data:</u>

- Sub place level
- Population
- Household Size
- Households
- Income level
- Dwelling

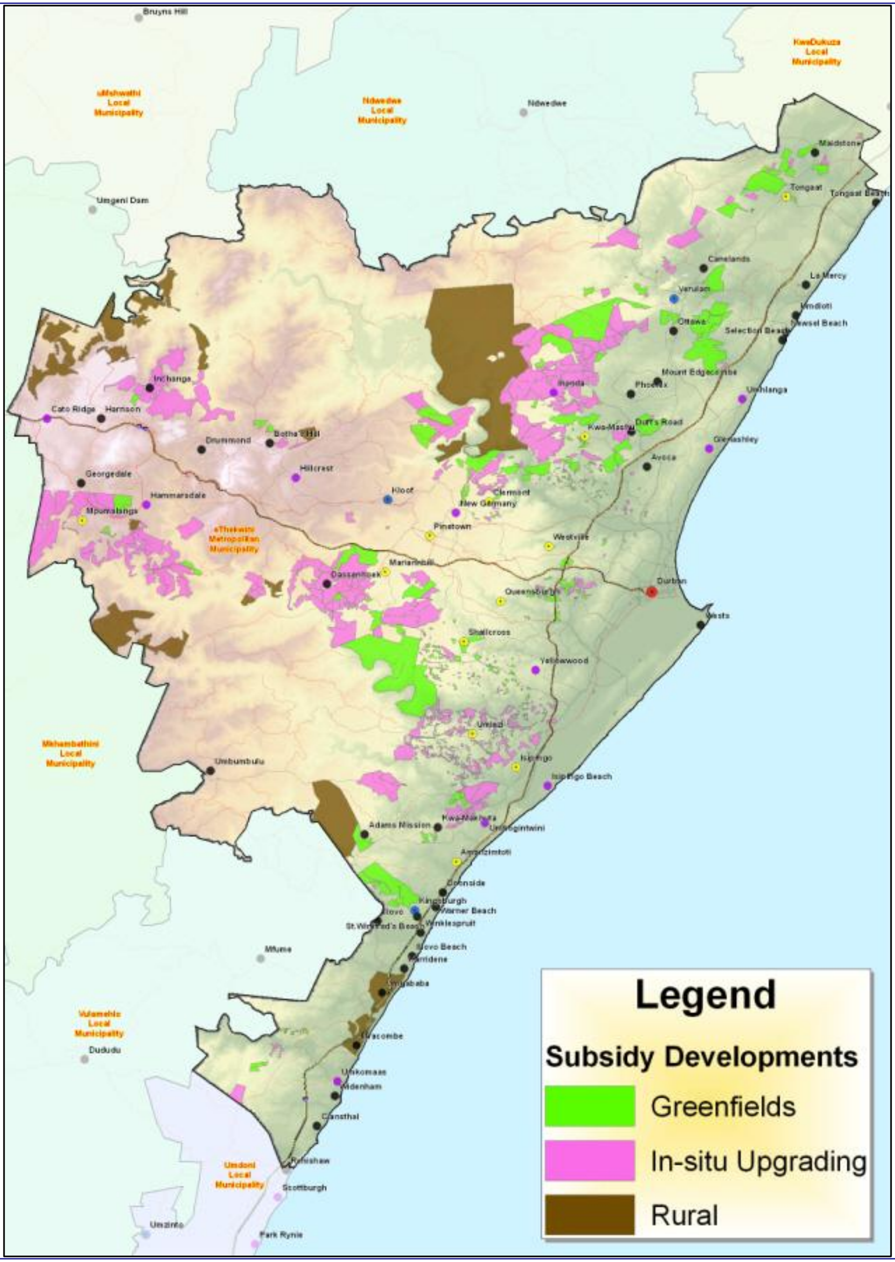


Residential Developments

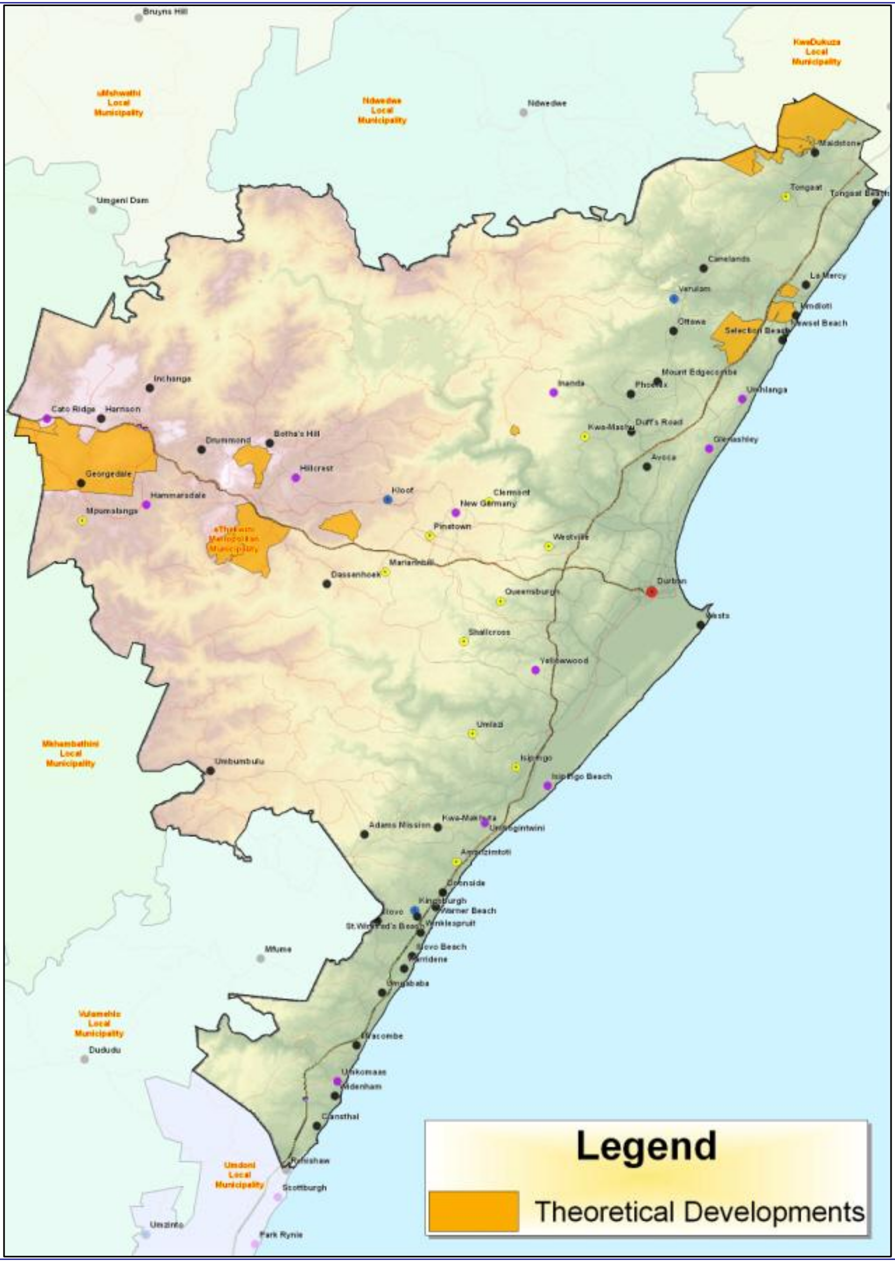
- Large growth to the Northern Region
- Infrastructure constraints in the Outer West Region
- Inner West and Central Regions built-up
- Topographical and agricultural constraints in the Southern Region
- Subsidy housing to try remove informal
- Subsidy housing predominantly located on urban periphery



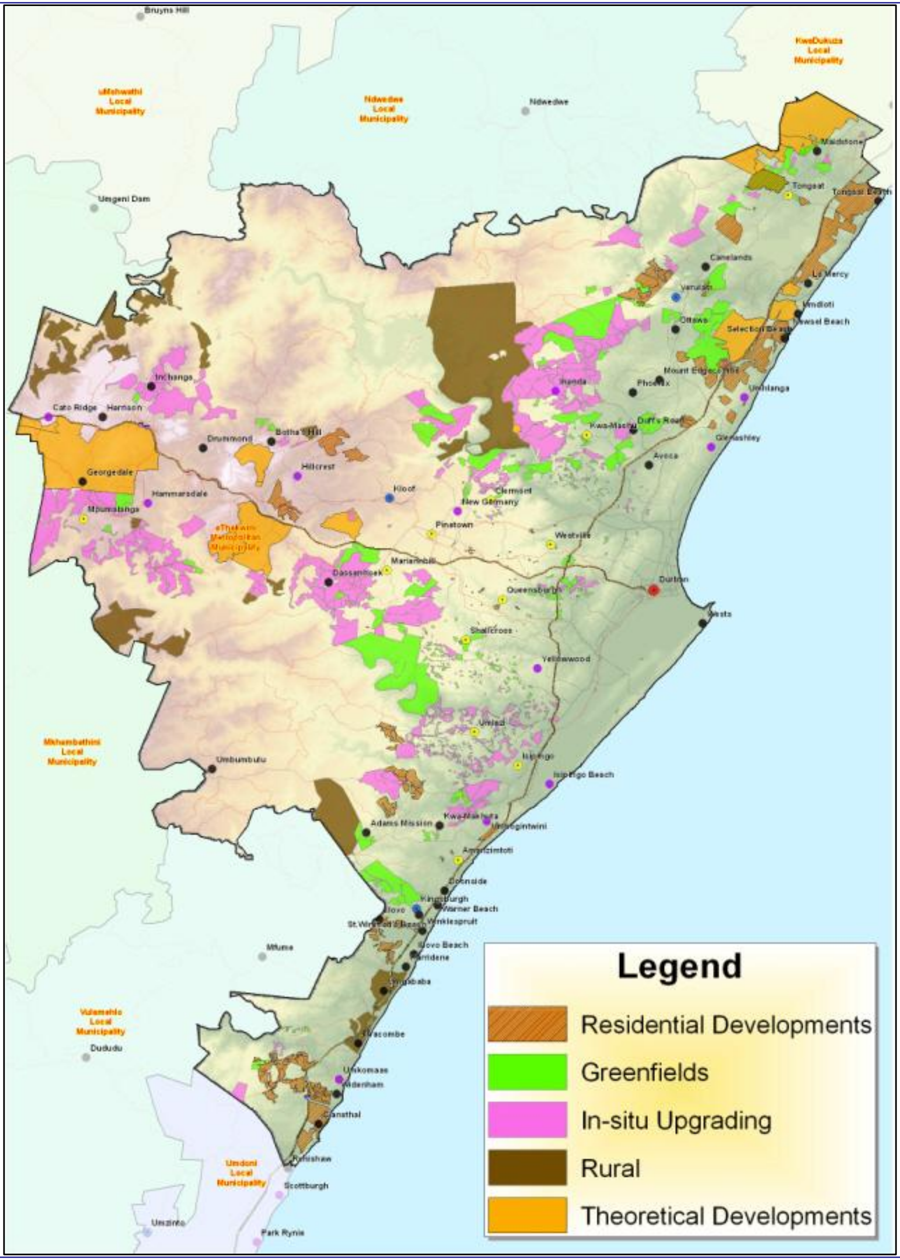
Subsidy Developments



Theoretical Developments

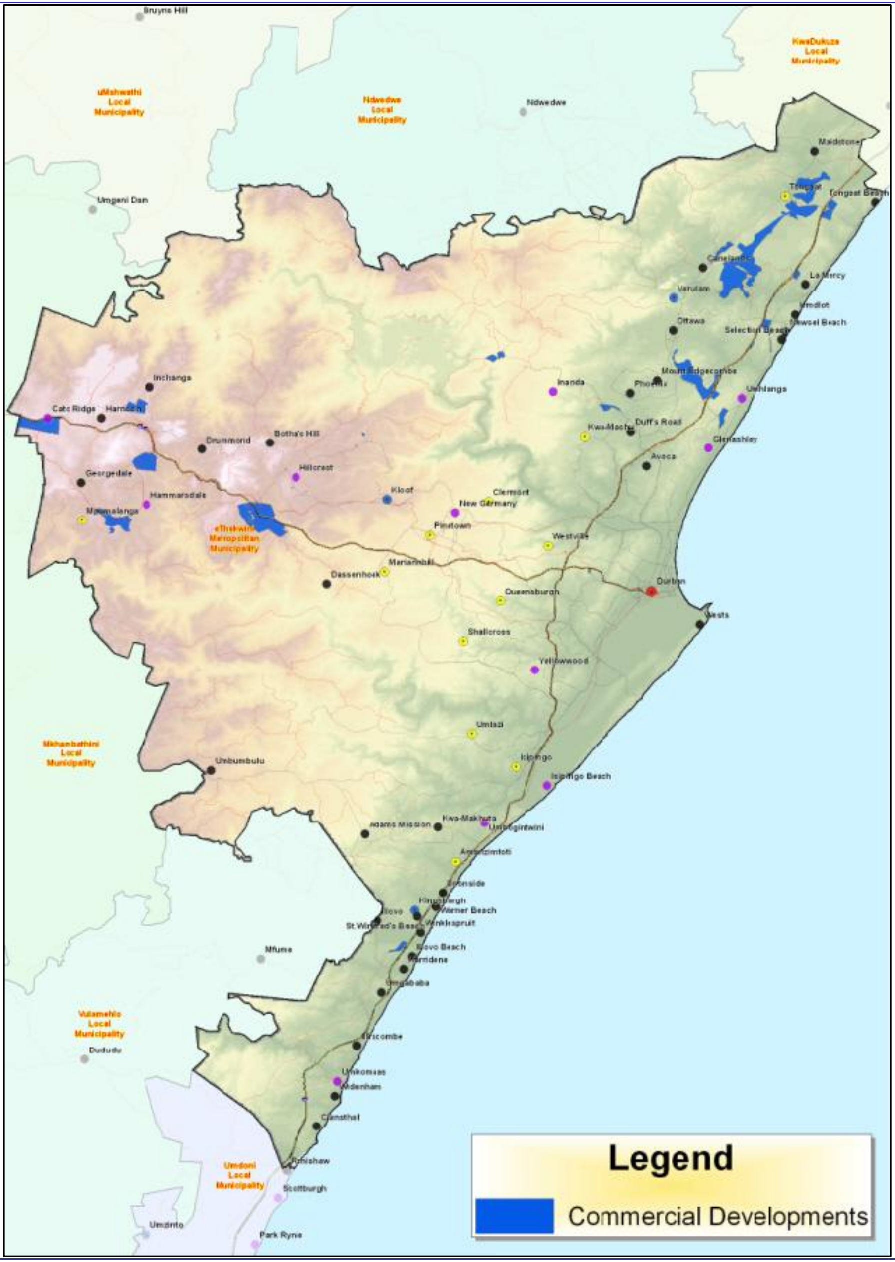


Residential Developments Summary



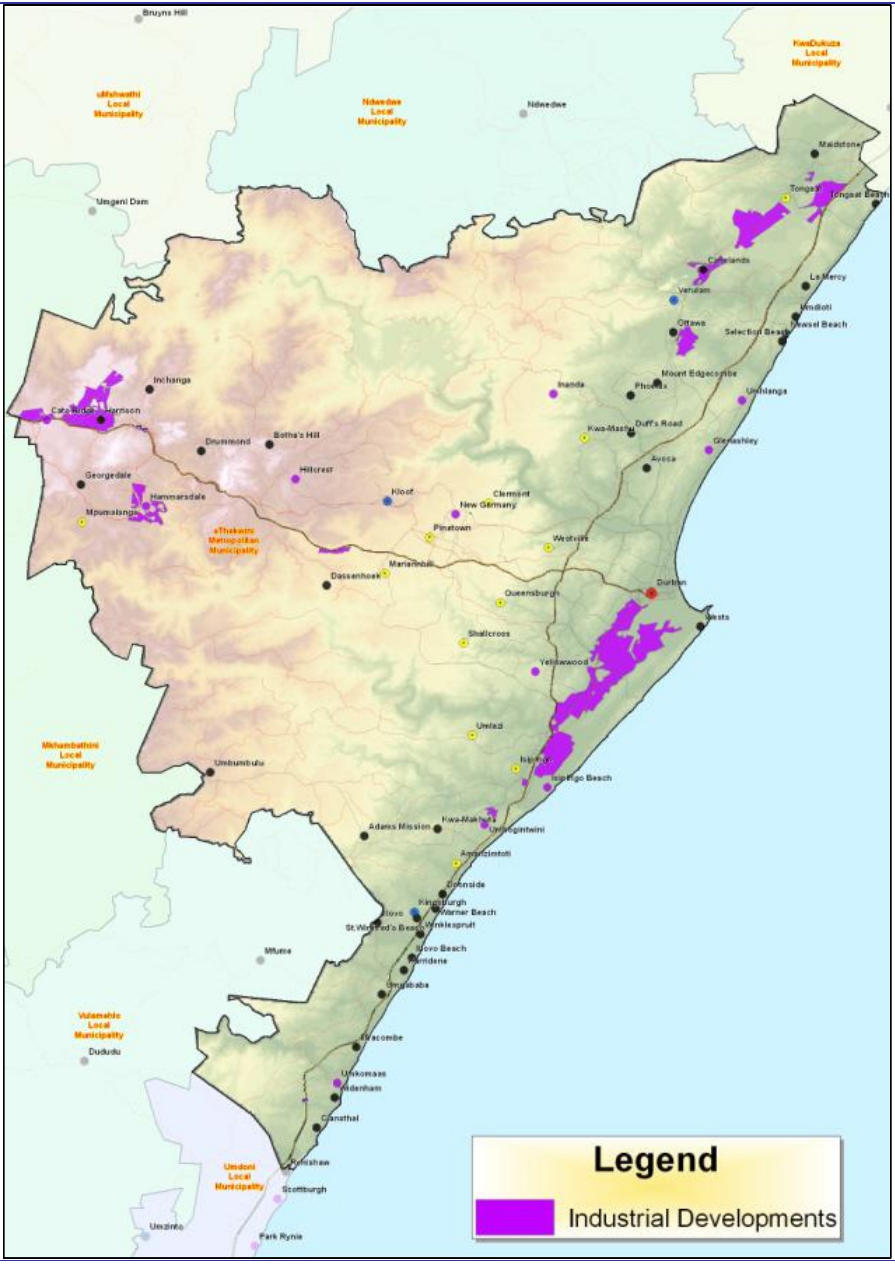
Comemercial Developments

- Economic opportunities with new airport
- Umhlanga ridge mixed use based on high income
- Economic potential at INK area (Bridge City)
- Limited land in the Inner West and Central Region
- Space for development in the extreme Outer West Region – Hammarsdale/Hillcrest

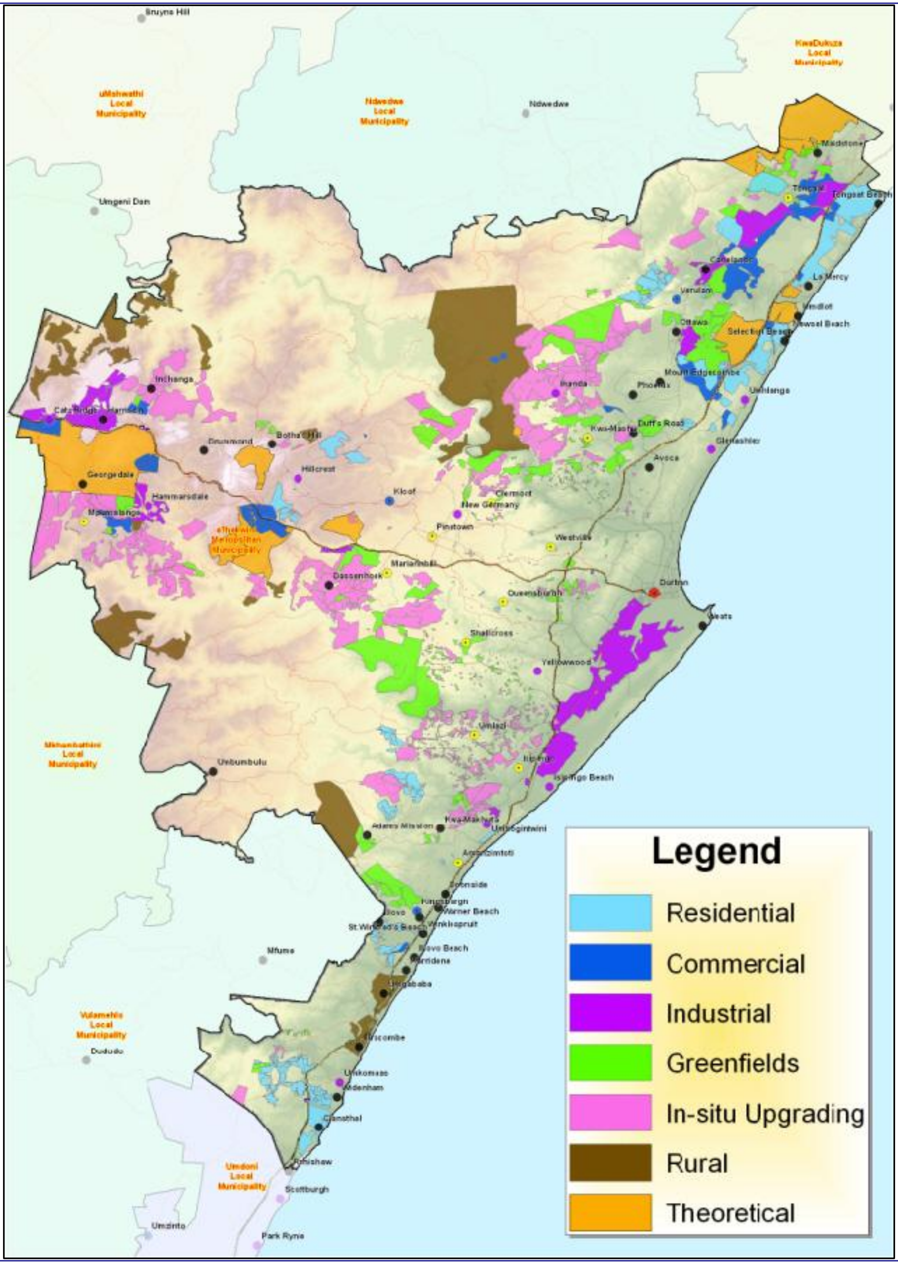


Industrial Developments

- Industrial development pressures
- Harbour port expansion
- Northern Region & Outer West opportunity for development
- DTP and surrounds
- Cornubia
- Cato Ridge
- Hammarsdale



All Developments



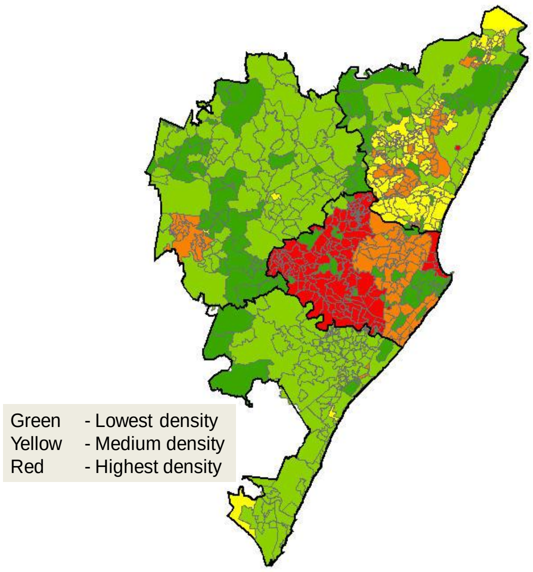
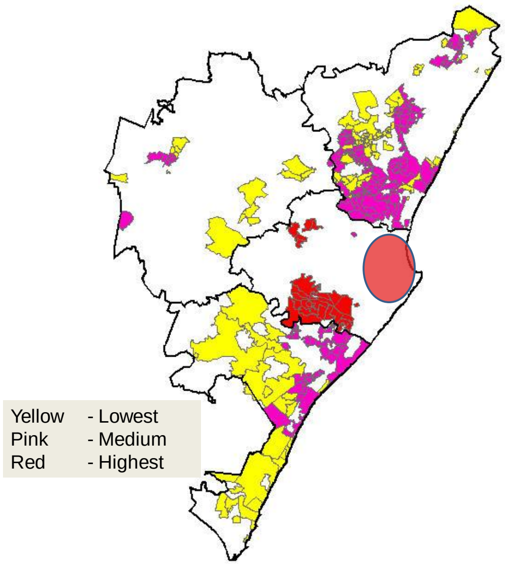
Existing Densification	Future Densification
	

Table 4-2: Socio-Economic Development Forecast Summary

Integrating the above Socio Economic Development forecast into the GLF, the total forecast was build. Data from the eThekwini SCADA and billing information was used to calculate the historical growth. The 2029 load values shown are the calculated forecast value due to the land use change forecast. Graphs showing the annual demand growth for the eThekwini area of supply and on Intake station level are shown below.

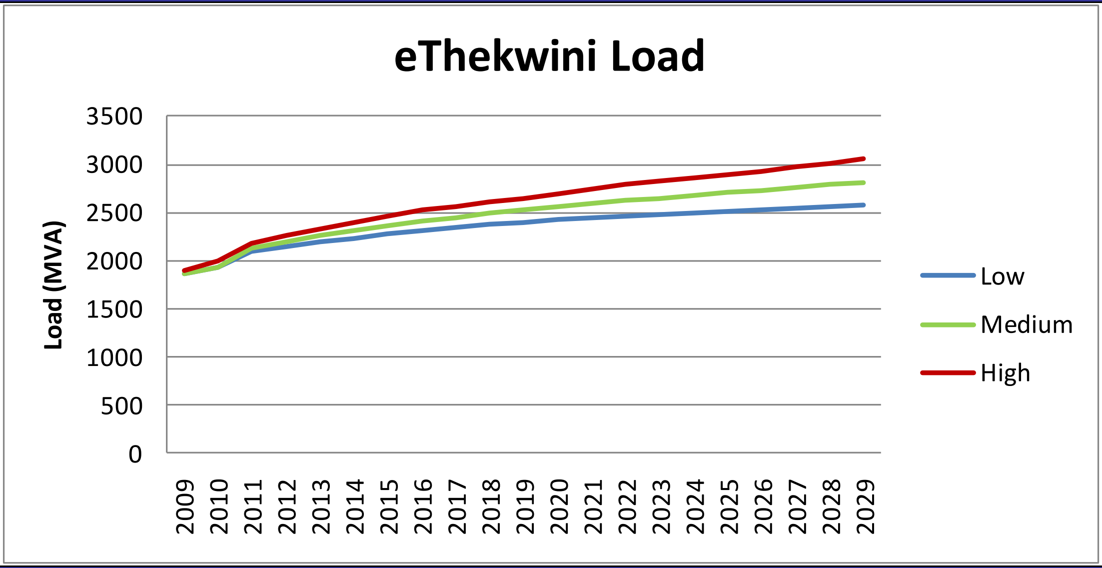
Existing Intake Station (2009)
Description and Load Forecast

eThekwini has 5x 275/132kV intake stations with:

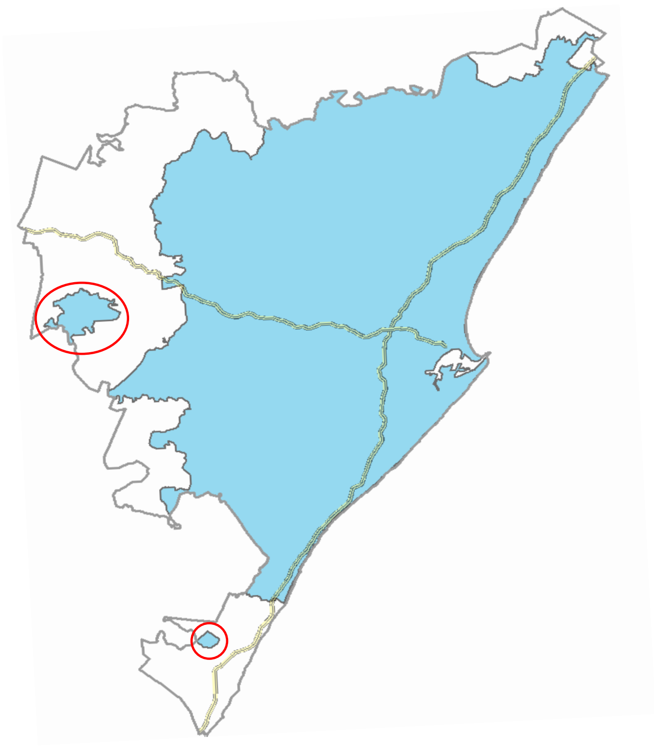
Installed capacity of 4150MVA and firm capacity of 2325MVA (if all operating at firm at the same time)

Base Case Load 2009: 1869MVA and Estimated Load 2029: 3000MVA

eThekwini Load Forecast



eThekwini Area of Supply



Existing Intake Station
Description and Load Forecast

Durban North 275/132kV Intake station

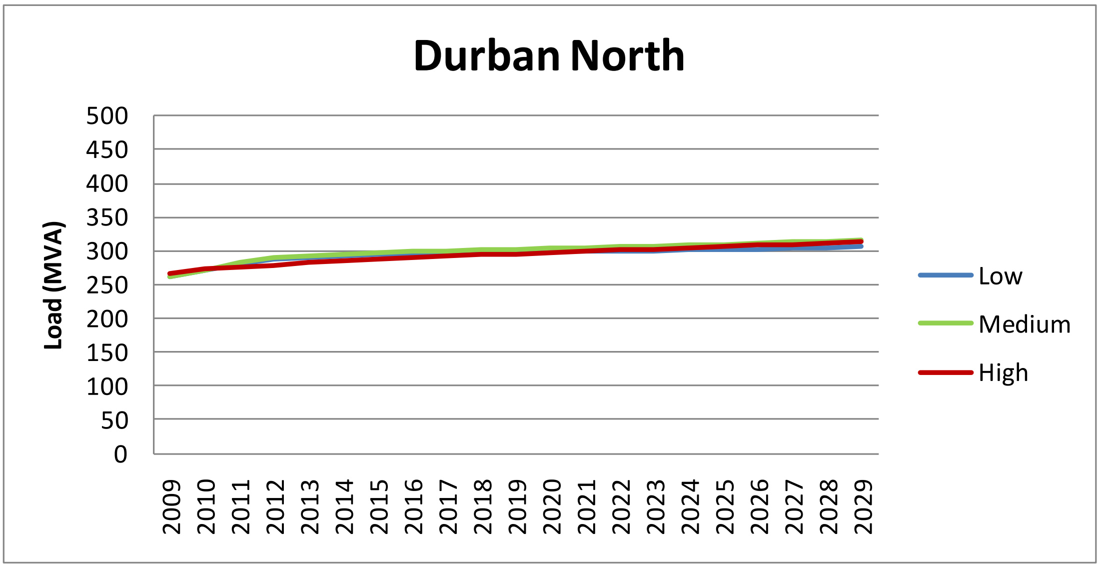
Installed Capacity: 630MVA

Firm Capacity: 315MVA

Load 2009: 260MVA

Load 2029: 310MVA

Intake Estimated Loading



Substation High Scenario	Installed	Firm	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
City Central	50	25	37	37	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38
Connaught	50	25	30	31	31	31	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
Durban North	630	315	262	273	286	292	296	299	302	304	305	307	308	309	312	314	315	317	319	321	323	324	326
Esplanade	50	25	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Jameson Park	25	0	13	14	15	15	15	15	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Livingstone Road	25	0	17	17	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Mzinyati	60	30	21	25	29	31	32	34	35	36	37	38	39	40	42	43	44	44	45	46	46	47	47
Newlands	60/120	30/60	38	40	42	43	44	44	45	45	45	45	45	45	46	46	46	46	46	46	46	47	47
Ntuzuma	120	60	44	48	53	54	56	57	58	59	60	60	61	61	62	63	64	65	67	68	69	70	72
Old Fort	180	90	96	96	97	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98
Old Fort	90	60	44	44	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
Parkhill	120	60	66	68	71	73	74	74	74	75	75	75	75	75	75	75	75	75	75	75	75	75	75
Point	50	25	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Spoornet Durban Station	40	20	27	27	27	27	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Spoornet Springfield Intake	8	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Spoornet Stanger Street	20	10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Springfield	180	90	42	43	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44

Existing Intake Station
Description and Load Forecast

Durban South 275/132kV Intake station

Installed Capacity: 1260MVA

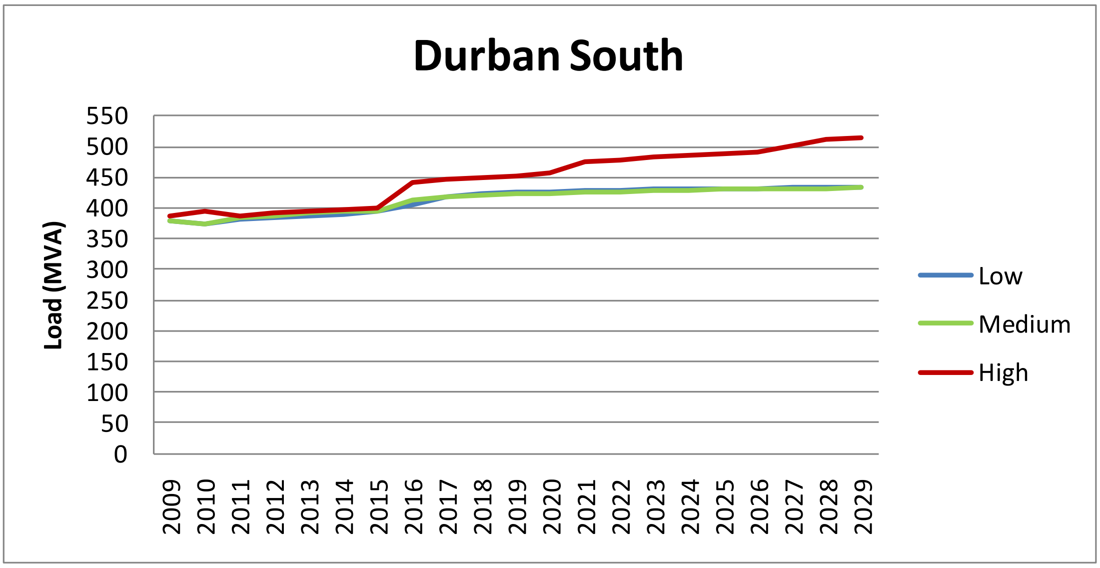
Firm Capacity: 630MVA

Load 2009: 390MVA

Load 2029: 520MVA

Comment: This substation seem to be operating below firm capacity under normal network operation. There is no need to improve the substation firm capacity unless if the topology and supply area changes.

Intake Estimated Loading



Substation High Scenario	Installed	Firm	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Durban South	1260	945	380	388	397	402	405	408	410	441	448	454	457	459	476	477	479	480	481	482	490	499	500
ENGEN Tara 2 (GENREF)	120	60	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
Havenside	60/120	30/60	34	36	38	38	39	40	40	40	40	41	41	41	41	41	41	41	41	41	41	41	41
Merewent	300	200	180	180	181	181	181	181	181	193	193	193	193	193	211	211	211	211	211	211	219	228	228
Mobeni South	60/120	30/60	38	39	41	42	42	42	43	44	45	46	46	46	46	46	46	46	46	46	46	46	46
Mondi Consumer S/S	210	190	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151
Shell			46	46	46	46	46	46	46	60	60	60	60	60	80	80	80	80	80	80	90	100	100
Umlazi	60/120	30/60	33	35	38	40	41	42	43	44	45	45	46	47	48	49	50	51	52	53	53	54	55

Existing Intake Station
Description and Load Forecast

Klaarwater 275/132kV Intake station

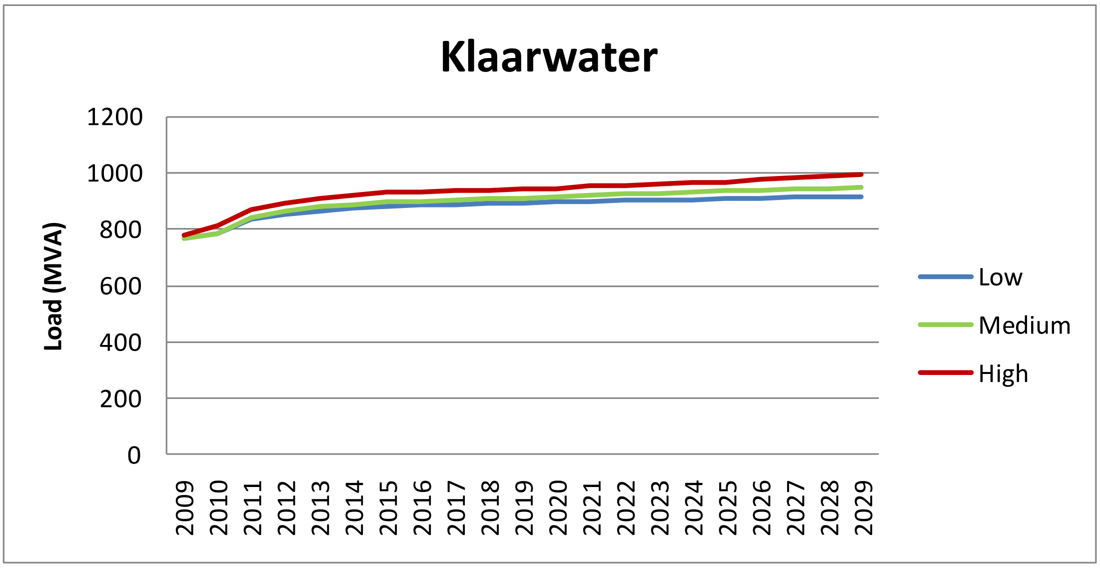
Installed Capacity: 1000MVA

Firm Capacity: 750MVA

Load 2009: 780MVA

Load 2029: 1000MVA

Intake Estimated Loading



Substation High Scenario	Installed	Firm	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Alice Street	60	30	44	44	44	44	44	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
Berea Park	60	30	42	42	42	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43
Blair Atholl	60/120	30/60	34	36	37	38	38	38	38	38	38	39	39	39	39	39	39	39	39	39	39	39	39
Bluff	30	15	22	23	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Cathedral Road	60	30	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
Chatsworth	90	60	49	52	56	58	59	60	61	62	62	63	63	64	64	65	65	66	66	66	67	67	67
Clermont	60/120	30/60	42	45	47	49	49	50	51	51	51	51	52	52	52	52	53	53	53	53	53	53	53
Congella	60	30	29	31	34	35	36	36	36	37	37	37	37	37	37	37	37	37	37	37	37	37	37
Dalton Road	60/120	30/60	32	32	33	33	33	33	33	32	32	32	32	32	32	32	32	32	32	38	39	40	40
EB Steam Lever Ponds	30	0	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Frametex 11kV Boiler	45	0	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Fynnlands (Old)	30	15	17	17	26	27	27	28	30	32	32	33	33	33	33	33	33	33	33	33	33	33	33
Hillcrest	120	60	56	62	76	81	85	88	91	93	94	95	96	97	98	99	100	102	103	103	103	104	104
Huntleys Hill	50	25	24	25	26	27	27	27	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Klaarwater	1000	750	768	792	850	871	886	897	907	910	916	922	927	931	939	943	948	952	956	965	972	979	986
Kloof	20	10	18	20	22	23	23	24	24	24	24	24	24	25	25	25	25	25	25	25	25	25	25
Mariannridge	60/120	30/60	44	49	56	59	61	62	63	65	66	67	68	70	74	75	77	79	80	85	91	97	103
Mayville	60	30	29	31	33	34	34	35	35	35	35	35	35	35	36	36	36	36	36	36	36	36	36
Mobeni Main	45	30	21	22	23	23	23	23	23	25	26	27	28	29	30	30	30	30	30	30	30	30	30
Phoenix Industrial Park	120	60	43	45	54	56	58	60	62	65	67	69	71	73	74	76	77	78	79	79	80	80	80
Pineside	60/120	30/60	44	45	46	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47
Pinetown	60/120	30/60	31	32	33	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
Roberts	60	30	32	33	34	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Spoornet Bayhead Intake	20	10	3	3	3	3	3	3	3	35	44	50	53	53	54	54	54	54	54	54	54	54	54
Sydenham	45	30	30	31	32	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
Umgeni	135	90	36	38	41	42	42	43	43	43	43	43	43	43	44	44	44	44	44	44	44	44	44
Underwood Road	25	0	25	26	26	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Waterfall	60/120	30/60	28	30	33	34	36	37	37	38	38	38	38	38	39	39	39	39	39	40	40	40	40
Westmead	120	60	58	59	59	59	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Woodlands	180	90	50	51	52	52	52	52	52	87	97	105	108	110	111	111	111	111	111	111	111	111	111

Existing Intake Station
Description and Load Forecast

Lotus Park 275/132kV Intake station

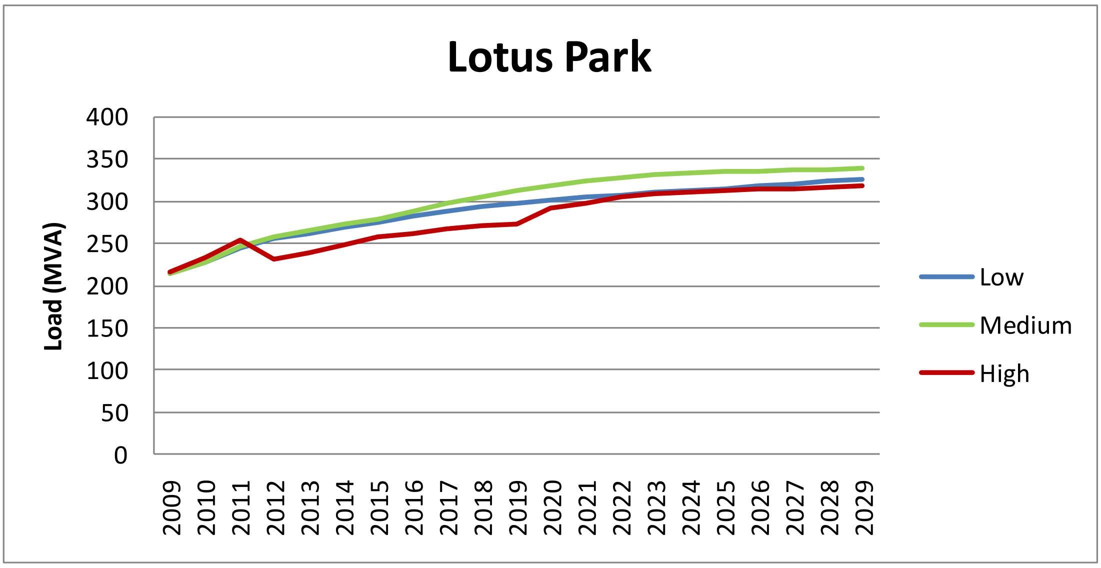
Installed Capacity: 630MVA

Firm Capacity: 315MVA

Load 2009: 220MVA

Load 2029: 320MVA

Intake Estimated Loading



Substation High Scenario	Installed	Firm	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
A.E.C.I	20	0	20	24	28	32	36	40	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
Doonside	30	15	17	18	19	19	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
EB Steam SAB	60	30	24	24	25	25	25	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Illovo Mill	2.5	0	5	5	5	5	5	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7
Isipingo	80	40	34	34	35	35	35	35	35	35	35	35	35	67	76	84	87	88	89	89	89	89	89
Isipingo	60	30	27	28	29	30	31	31	31	31	31	31	31	31	32	32	32	33	33	33	34	34	35
Lotus Park	630	315	214	229	250	262	272	282	291	297	302	307	311	332	340	346	350	352	355	356	357	359	360
Micro Steel	50	25	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Pearce Road	30	15	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
Plangweni	60/120	30/60	28	32	43	47	50	54	57	59	62	64	65	66	66	66	67	67	67	67	67	67	67
Prospecton Road	25	0	26	26	26	26	26	26	26	26	26	26	26	59	68	76	79	80	80	81	81	81	81
Romatex	15	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Smithfield	10	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sukuma	60/120	30/60	57	64	70	75	79	83	87	89	91	93	95	97	98	100	102	103	105	106	107	108	108
Toyota	120	60	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
Toyota Consumer S/S	90	45	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
Umbogintwini	180/90	90/45	50	53	59	62	65	68	72	73	74	76	77	79	79	79	80	80	80	80	80	80	80
Winklespruit	10	5	16	17	20	22	23	24	25	27	29	30	32	33	34	34	34	34	34	34	34	34	34

Existing Intake Station
Description and Load Forecast

Ottawa 275/132kV Intake station

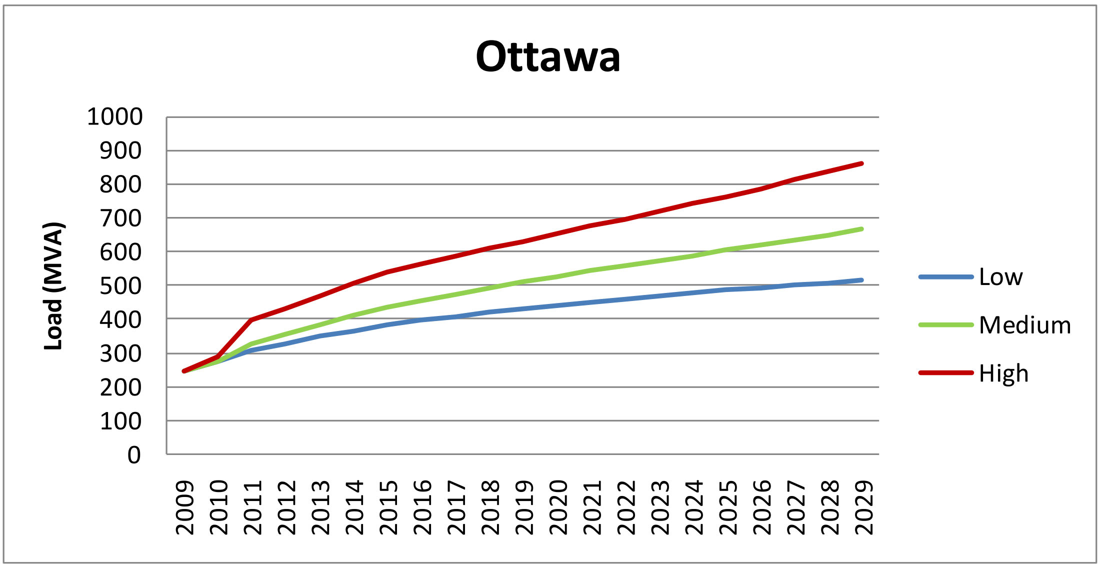
Installed Capacity: 630MVA

Firm Capacity: 315MVA

Load 2009: 240MVA

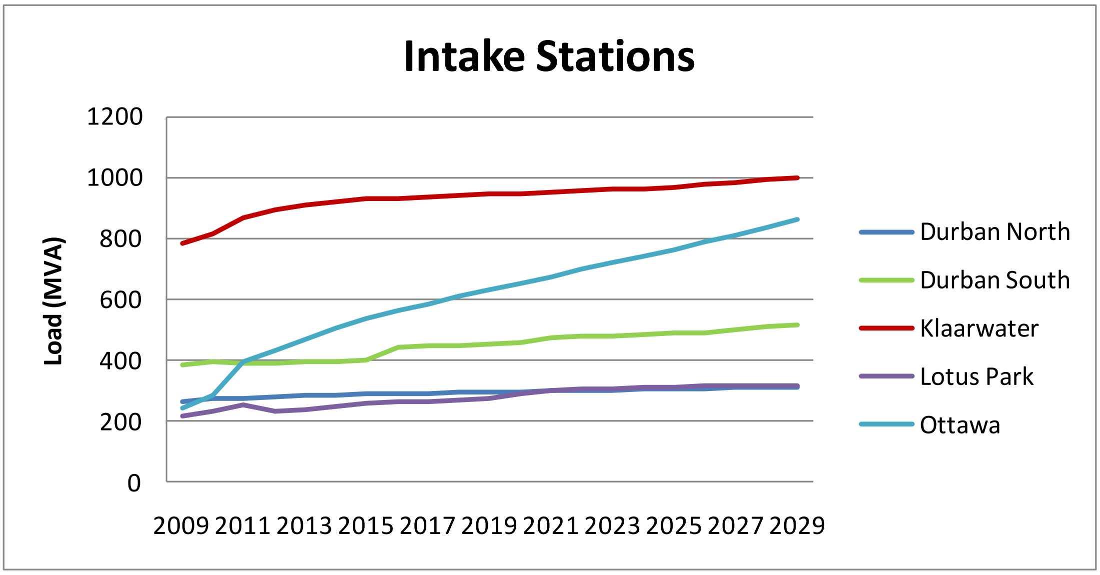
Load 2029: 860MVA

Intake Estimated Loading



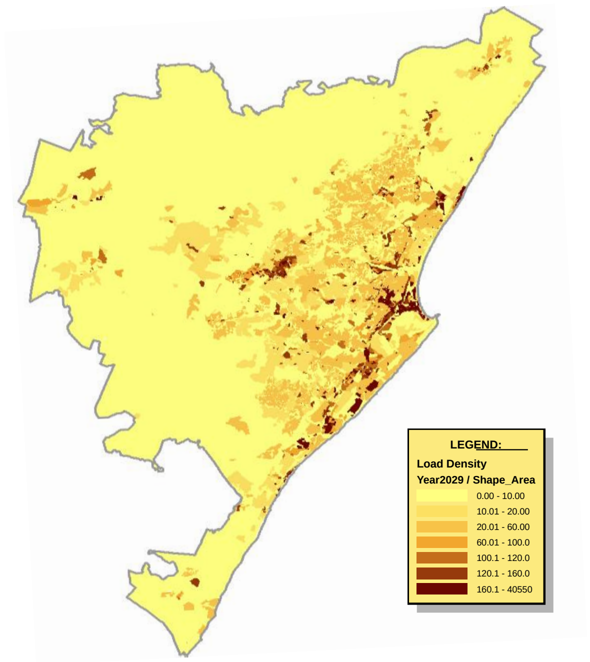
Substation High Scenario	Installed	Firm	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Clayfield	25	0	12	12	12	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
Coronation	30	15	9	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Driefontein	80	40	37	46	53	59	64	70	75	83	91	100	109	118	135	152	169	188	206	222	239	256	273
Eastbury	25	0	22	23	24	25	25	25	25	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Gateway	120	60	10	19	39	50	63	76	90	97	104	110	115	121	126	131	136	141	146	152	158	165	171
Glenashley	50	25	31	32	33	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
Greenbury	60/120	30/60	23	23	24	24	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Hazelmere	10	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Moreland	30	0	22	40	57	68	79	89	98	104	109	114	118	123	133	144	156	169	183	192	201	209	217
Moreland	90	45	23	24	26	28	29	31	32	34	37	39	42	45	46	46	47	47	47	47	47	47	47
Mount Edgecombe	180	90	100	106	112	115	116	118	119	120	120	120	120	120	120	120	120	120	120	124	127	131	135
Ottawa	630	315	246	279	330	360	391	421	450	469	487	504	520	536	554	569	585	600	616	634	650	668	685
Phoenix North	60/120	30/60	42	44	48	49	50	50	51	51	51	51	51	51	52	52	52	53	53	53	54	54	54
Redfern	25	0	13	14	16	17	17	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Sunningdale	120	60	65	68	74	80	87	95	102	106	110	114	118	122	124	125	126	127	128	129	129	129	129
Umdloti Beach	60/120	30/60	16	18	27	30	34	39	43	47	52	56	61	65	68	71	74	77	80	82	85	87	90
Umhlanga Rocks	50	25	19	21	22	23	24	25	26	26	26	27	27	27	27	27	27	27	27	30	34	38	42
Verulam	30	15	25	27	29	31	33	35	36	38	41	44	47	50	52	52	52	53	53	53	53	53	53

MTS Supply Area

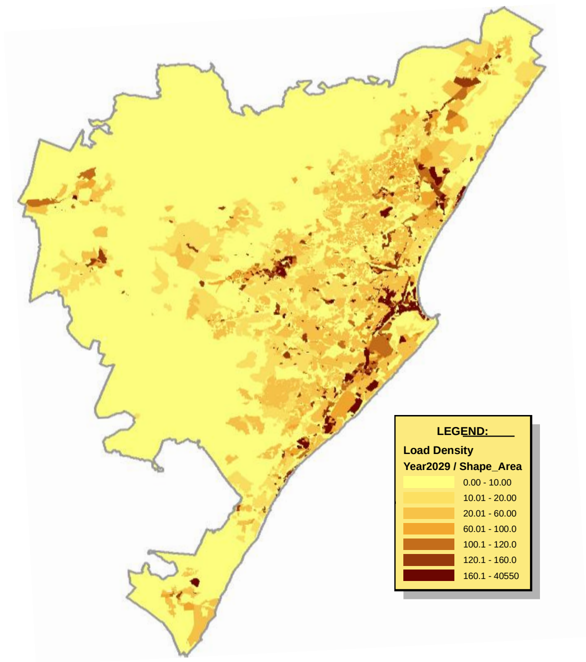


The Load densification (in kVA/ha) in the study area is shown in the diagram below for all three load forecast scenarios. The darker colours represent higher load per hector.

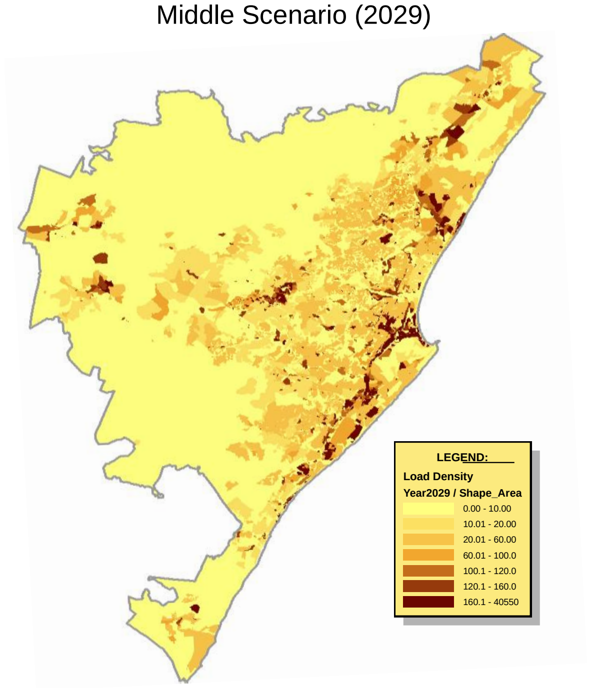
Base Case (2009)



Low Scenario (2029)



Middle Scenario (2029)



High Scenario (2029)

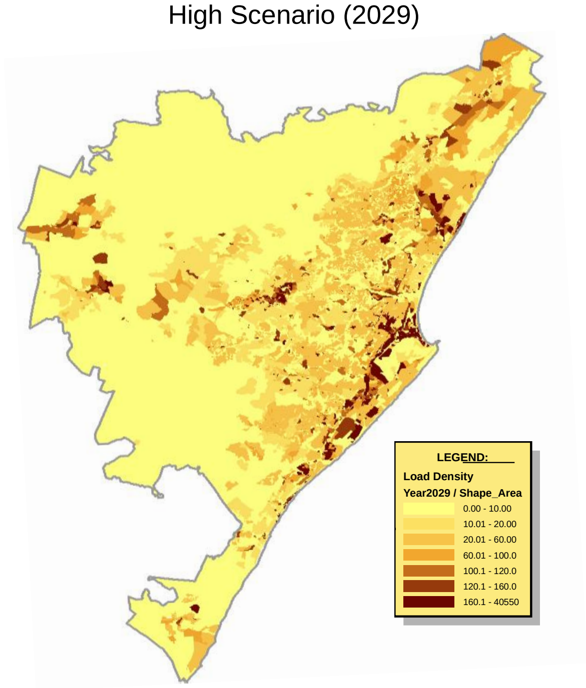


Table 4-3: Load Densification

5 EQUIPMENT REFURBISHMENT PLAN

5.1 Background and Introduction

Major portions of the eThekwini Transmission networks have been in service for many years and are approaching or have exceeded their design life. Such networks may begin to exhibit degradation in reliability performance, reduced safety margins, functional inadequacy, obsolescence or general deterioration. The electricity supply industry in general is starting to recognise these problems and eThekwini Electricity have started programs to extend the useful life of these networks.

To obtain maximum benefit from available networks, it is advantageous that a systematic, formal life extension (refurbishment) program be developed and carried out on a timely basis.

This refurbishment program commenced with various interactions in the form of workshops and study material provided and the set up of the program itself. As such this section forms part of a set of deliverables and need to be read in conjunction with the submitted documents Refurbishment Application, Refurbishment List, Presentation and Field inspection notes.

This document highlights the methodology, assumptions and finding of this systematic approach to identify equipment within the eThekwini Transmission Network that requires renewal.

5.2 Refurbishment Assessment Approach

The refurbishment plans followed a number of systematic steps. These are defined in the following sections as:

- The definition of the required output,
- Fundamental Approach,
- Data Collection and Field Inspection, and
- Development of the refurbishment plan.

5.2.1 Definition of Required Output

The fundamental outputs of the assessment were defined as:

- A refurbishment capital programs with project descriptions, integrated to the network master plan
- Equipment age profiles and summarised replacement values, and
- Full prioritisation of electrical networks in terms of refurbishment and renewal needs.

5.2.2 Fundamental Approach

The refurbishment requirements were developed by following a systematic approach which included the following steps:

- Development of technical inspection criteria,
- Technical inspections are conducted at all facilities,
- Prioritisation of electrical networks, and
- Refurbishment / renewal project requirements e.g. description, size and phasing.

5.2.2.1 Inspection Criteria

Specific attributes for each HV asset category was identified that would support the assessment of asset condition and remaining life. These attributes included aspects such as:

- Local experience with equipment (e.g. operational difficulties, availability of spares etc.),
- Physical attributes (e.g. oil leaks, unusual vibrations), and
- Measured or monitored values (e.g. oil samples, operations counts).

As an example, Table 5-1 provides the evaluation criteria and associated attributes for a power transformer. Similar criteria and attributes were developed for all inspected equipment.

Criteria	Attribute 1	Attribute 2	Attribute 3
Normal Loading	> 1.2	< 1.2 - > 0.5	< 0.5
Unusual Sound	Yes		No
Vibration	Unusual Vibration		No Vibration
Plinth Condition	Damaged		Good
Oil Leak – Main Tank	Large Oil Leak	Little	No
Oil Level – Main Tank	Low		Normal
Oil Sample – Main Tank	> 10yr	< 10yr - > 5yr	< 5 yr
Bushing Condition	Damaged		Good
Cooling Device	Damaged		Good
Expansion Vent	Damaged		Good
Instrument Condition	Damaged		Good
Earthing	Damaged		Good
OLTC Oil Leak	Large Oil Leak	Little	No

Table 5-1: PowerTransformer Condition Attributes

The above criteria were further used to develop a Condition Index (CI), expressed in % and defined as the ratio between the maximum possible condition score (as function of criteria and associated attribute) to the actual score.

$$CI_i(\%) = \frac{ActualScore_i}{MaxScore_i} \qquad (1)$$

Where:

- CI: is the Condition Index in (%),
- i: is the equipment / facility under review,
- ActualScore: is the assessment score,
- MaxScore: is the maximum allowable score based on the evaluation criteria and associated weighting factors.

5.2.2.2 Technical Inspection

The technical field inspection was conducted to obtaining basic equipment information and evaluated equipment status and condition on site. A second phase allowed a design engineer to evaluate this basic information and photos to provide a technical perspective of the state and suitability of the equipment.

Three qualified inspection teams visited 104 substations between the 4th of May and the 15th of June 2009. A preparation exercise to exhaust readily available information prior to the site visit was also conducted to enhance the quality of the technical inspection (Substation Single Line diagrams and an existing Equipment dataset).

The field inspection allowed for:

- A systematic review of substations and related networks that may have reached or exceeded their original design life,
- Identify systems, structures and equipment approaching wear-out or becoming obsolete, and
- Support the development of an equipment life expectancy based on the physical inspections.

The substation inspections focused on primary equipment within all sub-transmission substations (275/132kV, 132/88kV, 132/33kV, 132/11kV, 88/33kV, 33/11kV, 33/11/6.6kV and 33/6.6kV substations) as well as the substation yard, land and buildings, batteries and battery chargers.

Substation equipment included:

- Power and Auxiliary Transformers,
- Neutral Earthing Transformers,
- Instrument Transformers,
- Surge Arrestors,
- Indoor and Outdoor Circuit Breakers,
- Isolators,
- Reactors and Capacitors,
- Standby Generators, and
- Mini Substations.

The inspections further reviewed selective aspects of the station yard and building including civil works. These included comments with regard to:

- Substation Drainage,
- General structure and substation earthing,
- Substation Access,
- The overall condition of the building,
- Substation and building lighting, and
- Internal and External Fencing.

5.2.2.3 Prioritization of Electrical Networks

Various assessment levels are defined within a condition evaluation system. For eThekwini these are:

- System level: (which provides an overview of the condition index contribution of individual substations to the entire sub-transmission system),
- Substation level: (This level provides an indication of the contribution of specific equipment categories within a substations), and
- Equipment level: (which provide an indication of equipment attribute contribution).

Following this hierarchical levels and utilising the condition index, the system planner can;

- Obtain an overall perspective of the average condition of the system. (e.g. A system with a low CI can be regarded as new or well maintained system, whereas a system with a high CI can be regarded as an aged or ill maintained system),
- Identify each facilities contribution towards the system condition (e.g. large facilities with large number of well maintained equipment vs. small facility with few ill-maintained or aged equipment), and
- Identify the actual equipment that required renewal or refurbishment.

As an example Figure 5-1: shows approximately 300 eThekwini power transformers as a function of initial1 remaining life and associated condition index.

As shown in Figure 5-1: equipment age in itself does not provide a clear indication of condition. In this Figure the highest scoring transformer (worst condition) has been in commission for approximately 25 years with a condition index assessed at 75% whereas a number of transformer in service for more than 50 years have condition index of less than 10%.

[1] Initial remaining life refers to the life expectancy before a correction according to condition has been made.

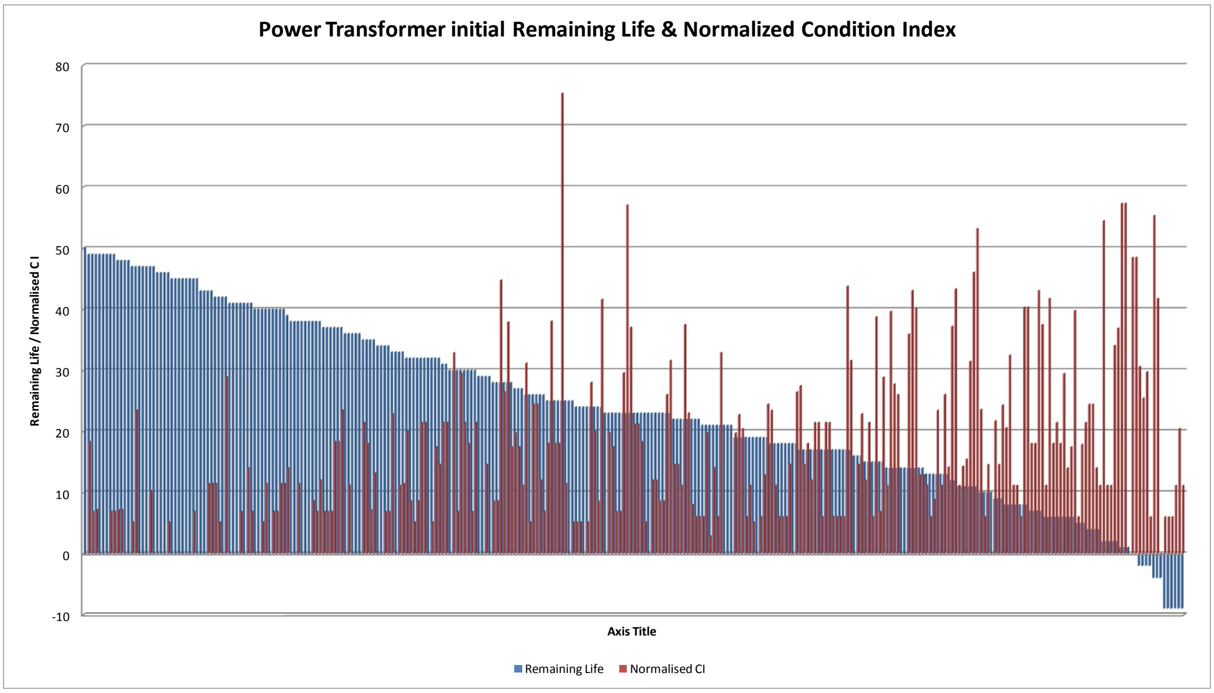


Figure 5-1: Transformer Initial Remaining Life and Normalized Condition Index

The condition index was further used to estimate the equipment remaining life. The remaining life is defined as the expected normal remaining service life based on a fixed life expectancy per asset category (50 years for transformers) as well as the assessed condition.

The equipment Remaining Life is calculated as follow:

$RL_i = iRL_i - (iRL_i * CI_i * CF_i)$ (Years) (2.1)

Where:

$iRL_i = LE_i - EA_i$ (Years) (2.2)

$EA_i = YoM - Evaluation\_Date$ (Years) (2.3)

$CF_i = \frac{LE_i - RL_i}{LE_i}$ (Dimensionless) (2.4)

Where:

- CI i = Condition Index (%),
- YoM = Year of Manufacture,
- EA i = Current Uncorrected Equipment Age
- LE i = Equipment Life Expectancy (years),
- RL i = Calculated Remaining life (years), and

- CF i = age correction factor2 (dimensionless),

Figure 5-2: provides the effect of varying the CI between 0-100% on the expected remaining life vs. the age of a large power asset.

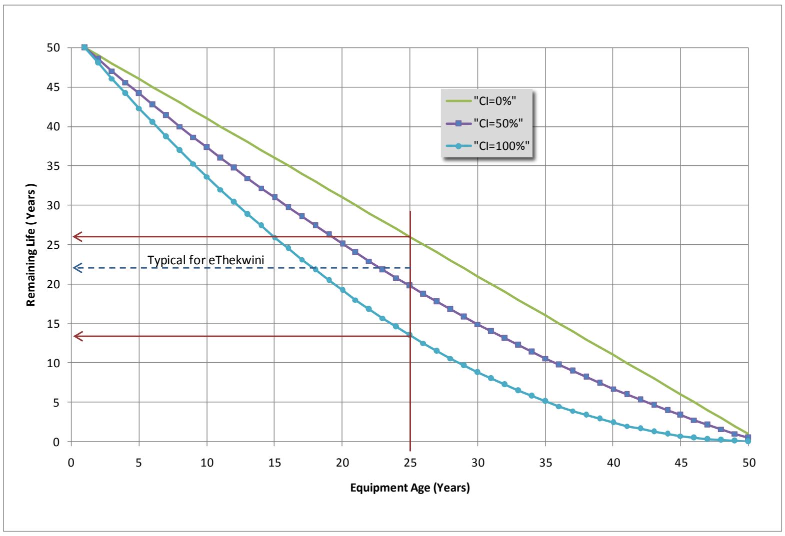


Figure 5-2: Impact of CI on Asset Remaining Life

Figure 5-3: provides the initial transformer remaining life against the corrected remaining life once adjusted with the condition index and age correction factor.

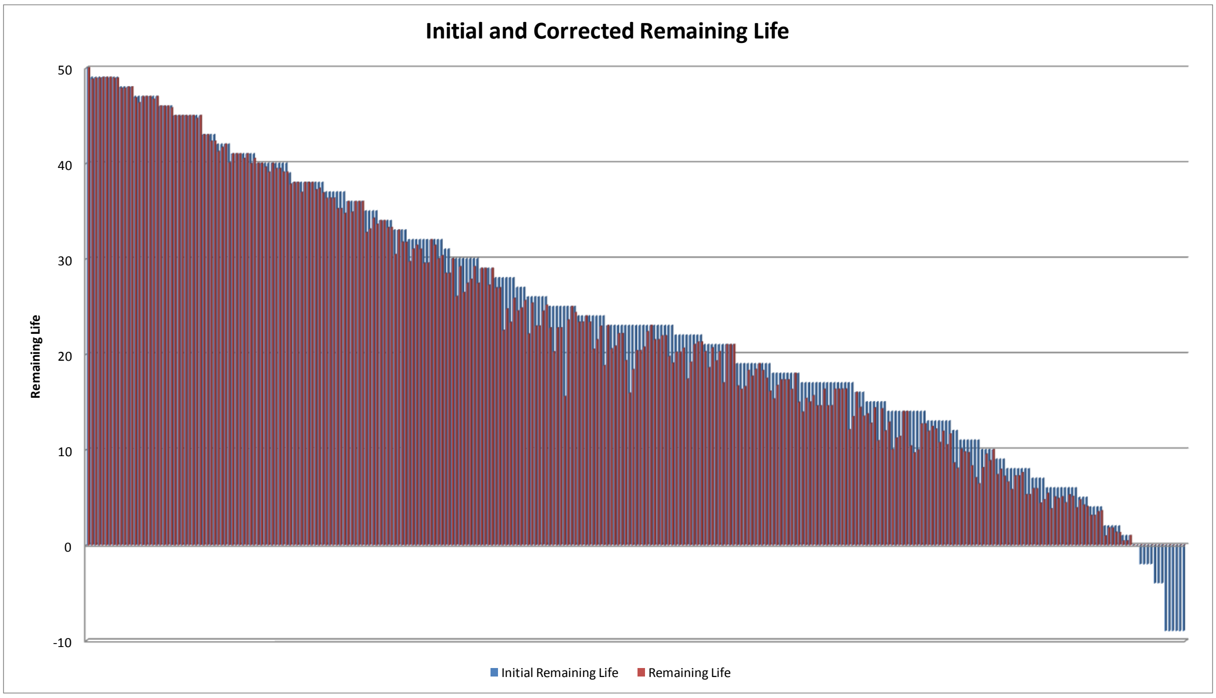


Figure 5-3: Transformer Initial Remaining Life and Normalized Condition Index

[2] The age correction factor is a dimensionless factor that is used to soften the impact of the condition index on new equipment.

The above principle was applied to all equipment to estimate the equipment remaining life for valuation purposes.

5.3 Refurbishment Plan

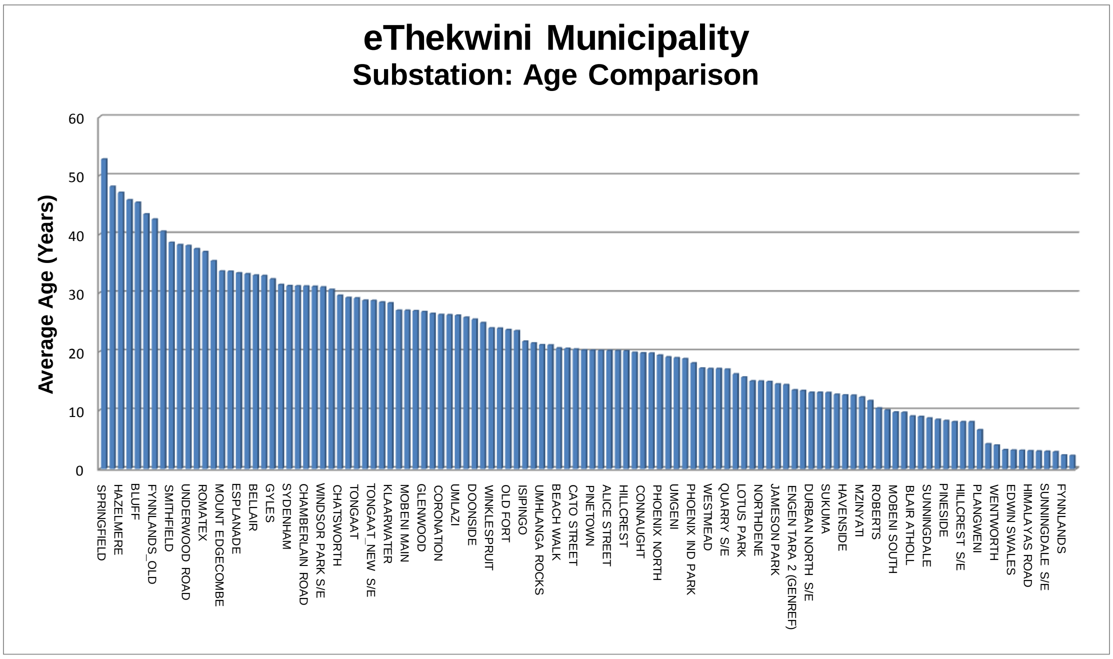
The inspection revealed an urgent need for first line maintenance on some items which could be considered as life threatening and / or could pose a problem during fault / switching conditions.



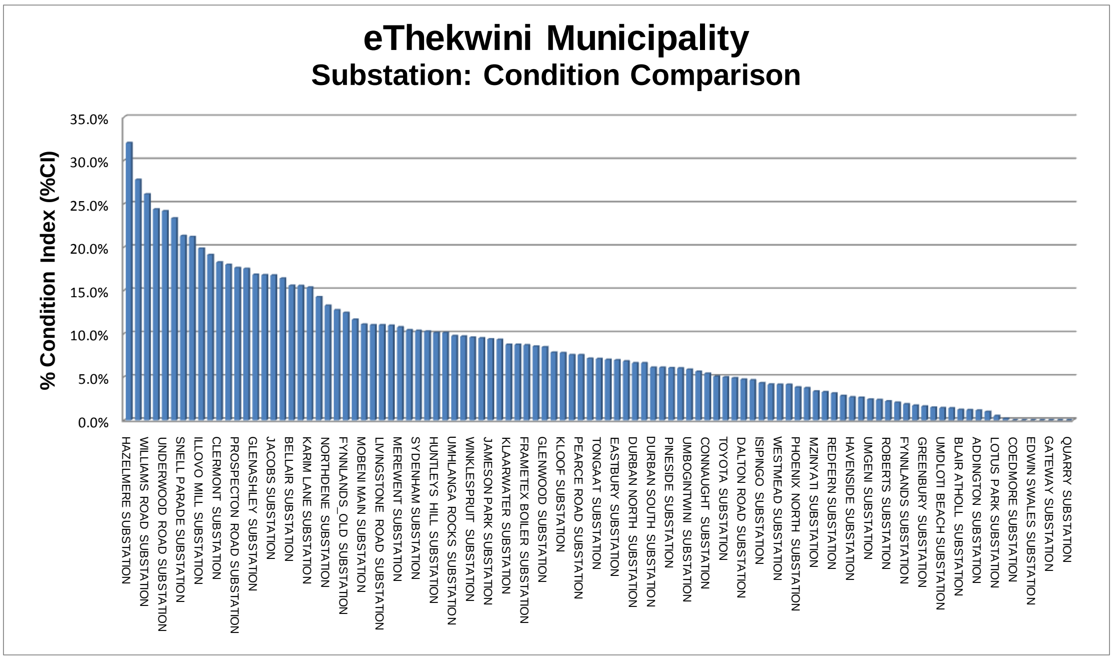

General findings and comments:

- The 275kV and 132kV substations are in a fairly good condition. 70% of these stations could be used as an example of a well maintained station,
- The 33kV substations are in a poor state. The network is aged, this is evident by the old equipment and protection schemes still in use,
- Most of the stations have good security measures (temporary guard houses in poor state), fences and access gates,
- Erosion is evident at a number of substations (main access road / yard) with the surface layer / stone cover not to standard / specification,
- At several substations, vegetation control was overdue for attention with rubbish lying around in the station yards,
- In a few HV yards and buildings, cable trench covers have been remove / damage and not replaced,
- There are a number of open excavation trenches (Inside / Outside substation perimeter) that are not marked with danger tape, dangerous,
- Control cables have been disconnected and lying loose in the yard / building floor,
- Steel structures in outdoor yards are rusted with primary / earth connections corroded,
- Half of all installed Primary Transformers have oil leaks (Little / Large) either on the main tank or cooling fins,
- A number of equipment is damage / bypass, need to be replaced,
- A number of control / switchgear rooms are in a poor state, no cleaning and / or maintenance have been done,
- A few control buildings have structural damage and / or water leaks. Most of the wooden doors show water damage,
- The ablution facilities are in a poor state,
- Lighting within the building basements is poor,
- Old unused and redundant equipment is stored or lying around in certain stations,
- The battery charger and batteries are in a good condition.



eThekwini Municipality
Substation: Age Comparison
Average Age (Years)
0
10
20
30
40
50
60
SPRINGFIELD
HAZELMERE
BLUFF
FYNNLANDS_OLD
SMITHFIELD
UNDERWOOD ROAD
ROMATEX
MOUNT EDGECOMBE
ESPLANADE
BELLAIR
GYLES
SYDENHAM
CHAMBERLAIN ROAD
WINDSOR PARK S/E
CHATSWORTH
TONGAAT
TONGAAT_NEW S/E
KLAARWATER
MOBENI MAIN
GLENWOOD
CORONATION
UMLAZI
DOONSIDE
WINKLESPRUIT
OLD FORT
ISIPINGO
UMHLANGA ROCKS
BEACH WALK
CATO STREET
PINETOWN
ALICE STREET
HILLCREST
CONNAUGHT
PHOENIX NORTH
UMGENI
PHOENIX IND PARK
WESTMEAD
QUARRY S/E
LOTUS PARK
NORTHDENE
JAMESON PARK
ENGEN TARA 2 (GENREF)
DURBAN NORTH S/E
SUKUMA
HAVENSIDE
MZINYATI
ROBERTS
MOBENI SOUTH
BLAIR ATHOLL
SUNNINGDALE
PINESIDE
HILLCREST S/E
PLANGWENI
WENTWORTH
EDWIN SWALES
HIMALAYAS ROAD
SUNNINGDALE S/E
FYNNLANDS



eThekwini Municipality
Substation: Condition Comparison
% Condition Index (%CI)
0.0%
5.0%
10.0%
15.0%
20.0%
25.0%
30.0%
35.0%
HAZELMERE SUBSTATION
WILLIAMS ROAD SUBSTATION
UNDERWOOD ROAD SUBSTATION
SNELL PARADE SUBSTATION
ILLOVO MILL SUBSTATION
CLERMONT SUBSTATION
PROSPECTON ROAD SUBSTATION
GLENASHLEY SUBSTATION
JACOBS SUBSTATION
BELLAIR SUBSTATION
KARIM LANE SUBSTATION
NORTHDENE SUBSTATION
FYNNLANDS_OLD SUBSTATION
MOBENI MAIN SUBSTATION
LIVINGSTONE ROAD SUBSTATION
MEREWENT SUBSTATION
SYDENHAM SUBSTATION
HUNTLEYS HILL SUBSTATION
UMHLANGA ROCKS SUBSTATION
WINKLESPRUIT SUBSTATION
JAMESON PARK SUBSTATION
KLAARWATER SUBSTATION
FRAMETEX BOILER SUBSTATION
GLENWOOD SUBSTATION
KLOOF SUBSTATION
PEARCE ROAD SUBSTATION
TONGAAT SUBSTATION
EASTBURY SUBSTATION
DURBAN NORTH SUBSTATION
DURBAN SOUTH SUBSTATION
PINESIDE SUBSTATION
UMBOGINTWINI SUBSTATION
CONNAUGHT SUBSTATION
TOYOTA SUBSTATION
DALTON ROAD SUBSTATION
ISIPINGO SUBSTATION
WESTMEAD SUBSTATION
PHOENIX NORTH SUBSTATION
MZINYATI SUBSTATION
REDFERN SUBSTATION
HAVENSIDE SUBSTATION
UMGENI SUBSTATION
ROBERTS SUBSTATION
FYNNLANDS SUBSTATION
GREENBURY SUBSTATION
UMDLOTI BEACH SUBSTATION
BLAIR ATHOLL SUBSTATION
ADDINGTON SUBSTATION
LOTUS PARK SUBSTATION
COEDMORE SUBSTATION
EDWIN SWALES SUBSTATION
GATEWAY SUBSTATION
QUARRY SUBSTATION

Sheet Name	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Grand Total
Batteries	54	9	4	11	7	29	9	17	10	7	7										164
Chargers	38	1	5	4	6	10	6	6	11	9	25	10	15	9	18	8					181
Current Transformers	323		1		1	8		3			7	4	3	1			3	12	13	91	470
Earth Switches	128			8	18	5	16	4	22	20	46	66		21	9	35	14	4	22	52	490
HV Breakers	230		5	3	5		13	2	13	21	13	17	10	7	2	40	5	4	1	43	434
Isolators	269			9	11	9	12	4	9	42	48	45		12	4	85	5	2	22	37	625
Linetraps																		4			4
MV Breakers	356	3						12	15	18	24	11	34	14		24		43	1	107	662
NECs	19	3	1		4	3									3				1		34
NERs	13		2			5		1	2		3				6	6	4	2		6	50
Reactors			1										2	1	3		1			6	14
Surge Arresters	197		6	6	29			14	39	34		6		14	31	48		82	36	52	594
Transformers	209	2			2	5	2	1	6	4	2			2	3	1	1	1		1	242
Voltage Transformers	122							7						1				4	7	37	178
Grand Total	**1958**	**18**	**25**	**41**	**83**	**74**	**58**	**71**	**127**	**155**	**175**	**159**	**64**	**82**	**79**	**247**	**33**	**158**	**103**	**432**	**4142**

Year	Batteries	Chargers	Current Transformers	Earth Switches	HV Breakers	Isolators	Linetraps	MV Breakers	NECs	NERs	Reactors	Surge Arresters	Transformers	Voltage Transformers	Grand Total
2009	R 7,605,398	R 3,963,969	R 22,009,884	R 3,927,632	R 89,843,757	R 25,584,273		R 63,727,097	R 4,465,000	R 1,512,225		R 3,776,277	R 1,418,390,506	R 7,179,570	R 1,651,985,588
2010	R 1,267,566	R 104,315						R 554,400	R 705,000				R 10,221,750		R 12,853,031
2011	R 563,363	R 521,575	R 41,125		R 2,079,000				R 235,000	R 232,650	R 231,000	R 97,944			R 4,001,657
2012	R 1,434,674	R 417,260		R 188,000	R 916,884	R 486,450						R 70,500			R 3,513,768
2013	R 928,598	R 625,890	R 35,250	R 676,014	R 1,528,140	R 1,418,756			R 940,000			R 553,446	R 2,425,500		R 9,131,595
2014	R 4,027,093	R 1,043,150	R 620,988	R 176,250		R 936,945			R 705,000	R 581,625			R 24,165,583		R 32,256,634
2015	R 1,267,566	R 625,890		R 564,000	R 29,569,547	R 1,249,260							R 13,923,525		R 47,199,788
2016	R 2,394,292	R 625,890	R 206,800	R 141,000	R 490,435	R 416,420		R 2,217,600		R 116,325		R 164,500	R 6,964,650	R 411,250	R 14,149,162
2017	R 1,408,407	R 1,147,465		R 846,519	R 29,288,793	R 886,890		R 2,772,000		R 232,650		R 839,902	R 9,644,250		R 47,066,875
2018	R 985,885	R 938,835		R 740,510	R 6,286,719	R 4,484,183		R 3,326,400				R 825,177	R 9,020,550		R 26,608,258
2019	R 985,885	R 2,607,875	R 532,275	R 1,621,500	R 65,165,628	R 4,997,040		R 4,435,200		R 348,975			R 7,056,183		R 87,750,561
2020		R 1,043,150	R 236,175	R 2,326,500	R 81,686,256	R 4,634,670		R 2,032,800				R 109,952			R 92,069,503
2021		R 1,564,725	R 200,925		R 3,937,656			R 6,283,200			R 462,000				R 12,448,506
2022		R 938,835	R 35,250	R 740,250	R 2,139,397	R 1,249,260		R 2,587,200			R 231,000	R 256,554	R 6,206,200	R 58,750	R 14,442,696
2023		R 1,877,670		R 305,500	R 611,256	R 416,420			R 705,000	R 697,950	R 693,000	R 568,084	R 22,938,300		R 28,813,180
2024		R 834,520		R 1,222,000	R 12,295,495	R 9,053,523		R 4,435,200		R 697,950		R 879,614	R 6,964,650		R 36,382,952
2025			R 248,513	R 493,500	R 1,528,140	R 520,525				R 465,300	R 231,000		R 6,964,650		R 10,451,628
2026			R 523,463	R 141,000	R 1,222,512	R 208,210	R 720,000	R 7,946,400		R 232,650		R 1,430,631	R 6,964,650	R 236,006	R 19,625,521
2027			R 594,550	R 775,500	R 305,628	R 2,613,966		R 184,800	R 235,000			R 659,711		R 411,250	R 5,780,405
2028			R 7,256,050	R 1,850,755	R 84,291,572	R 3,851,885		R 19,773,600		R 697,950	R 1,386,000	R 1,203,346	R 35,805,000	R 2,199,901	R 158,316,058
Grand Total	**R 22,868,726**	**R 18,881,011**	**R 32,541,247**	**R 16,736,430**	**R 413,186,816**	**R 63,008,676**	**R 720,000**	**R 120,275,898**	**R 7,990,000**	**R 5,816,250**	**R 3,234,000**	**R 11,435,638**	**R 1,587,655,947**	**R 10,496,726**	**R 2,314,847,366**

6 NETWORK ASSESSMENT

The objective of this task was to review the adequacy of the eThekwini Sub-transmission network through load flow and contingency analysis. However, the contingency analysis was not thoroughly done and documented, but it will be in the final report. The need for possible new transmission supply stations or intake stations was also evaluated.

The following sections present aspects of the technical evaluation which include network analysis as well as operational considerations and results for networks within the study area.

6.1 Network Analysis

Network simulations were conducted on the existing and future networks within PSS/E. Network simulations included:

- Steady-state analysis. Analyses were conducted on various network load levels and configurations to effectively identify thermal and voltage violations occurring due to existing and future load growth. Alternatives were identified and tested to ensure technical viable solutions to these violations,
- A contingency analysis was not thoroughly done for this draft report: Selective contingency analysis will be further carried out where a specific network element will be taken out of service and the result thereof tested through a load flow. In order to relief voltage and flow violations identified during the contingency analysis, the addition or upgrade of network facilities will be identified and tested technically.

Network analyses were grouped into three distinct time frames:

- Base year (2009),
- Short-term (2010 - 2015), and
- Longer-term (2016 - 2029).

The following sections provide high-level discussion and results obtained through the analysis of the existing and future network during these time frames. Detail discussion of specific network problems and the evaluation of related alternatives are provided in Addendum B to this report. The schematic and geographic presentation of the preferred solutions are provided in Volume B to this document with the associated capital program required to implement these solutions provided in Section 6 of this report.

The 132kV network is currently operated as a meshed or interconnected network. The base case has been tested for N-1 contingency and it is compliant. However, as stated above the results for the N-1 contingency analyses are documented properly. After several discussions with eThekwini representatives over a period of more than a year, it was vivid that the technical team is fond of the sub-transmission interconnected network. Thus the decision was made not to change the planning philosophy from this interconnected network, unless if it is technically viable. Nonetheless, N-2 contingency analysis will be conducted on 400kV and 275kV network to test the solidity of this configuration.

However, after a short discussion with Eskom Transmission representative, they are not really fond of this interconnection as it poses more uncertainty on their network under abnormal operations. A workshop is yet to be arranged with Eskom Transmission and the results thereof will be in the final report.

The network analysis was done based on the load forecast results. The load forecast had low, middle and high scenarios, and the latter scenario was used as basis for network analyses within PSSE.

For the short-term planning (2011 -2015), eThekwini existing capex (Rev 1) was utilized and complied to as per the discussion with eThekwini representative. However, few projects where incorporated to this time frame due to their delicacy based on the load forecast timing. The master plan timing is discussed in the next section.

6.2 Fundamental Approach

The following approach was followed to evaluate and identify network problems and to systematically identify and evaluate possible solutions to these problems.

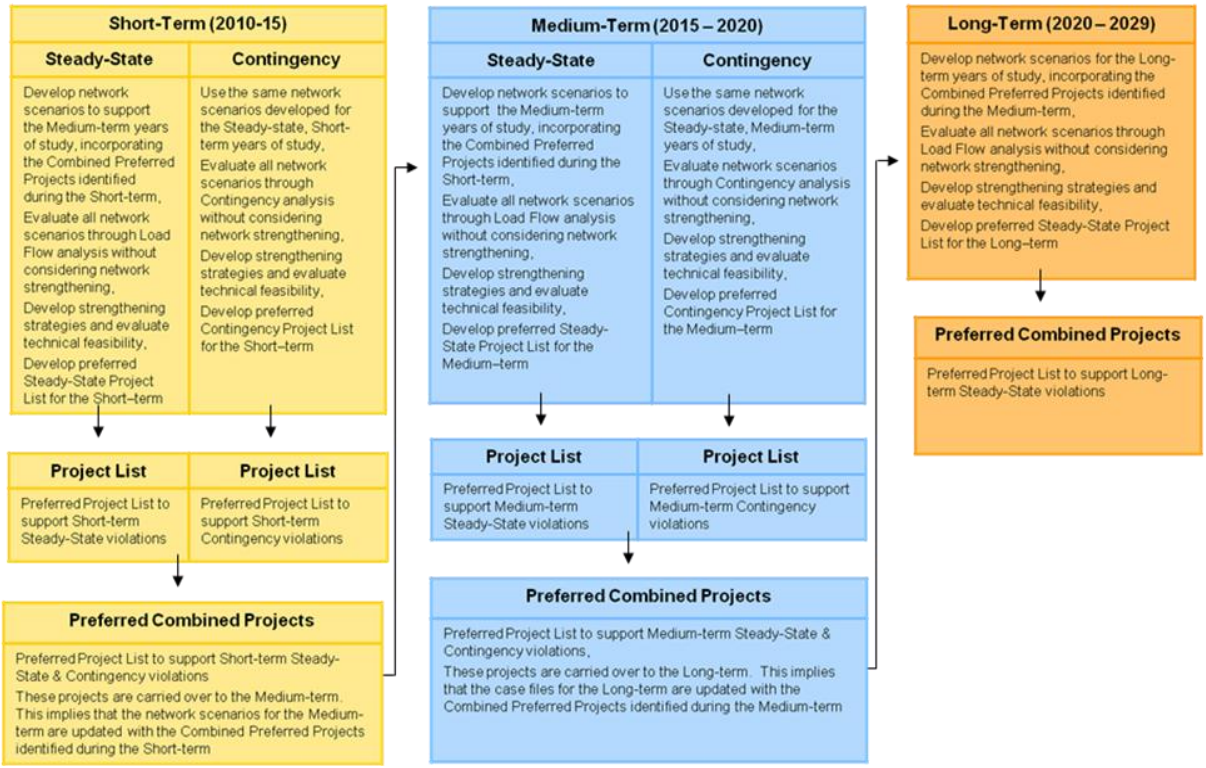


Table 6-1: Network Evaluation Approach

The master planning Exercise can fairly accurately predict network overloading, although the time line may differ due to economic and other factors contributing to the rate of growth. Projects are identified in the Master Plan after which these projects have to be investigated in more detail as the time approaches by means of a NDP. The time-line/uncertainty effect is explained in the figure below.

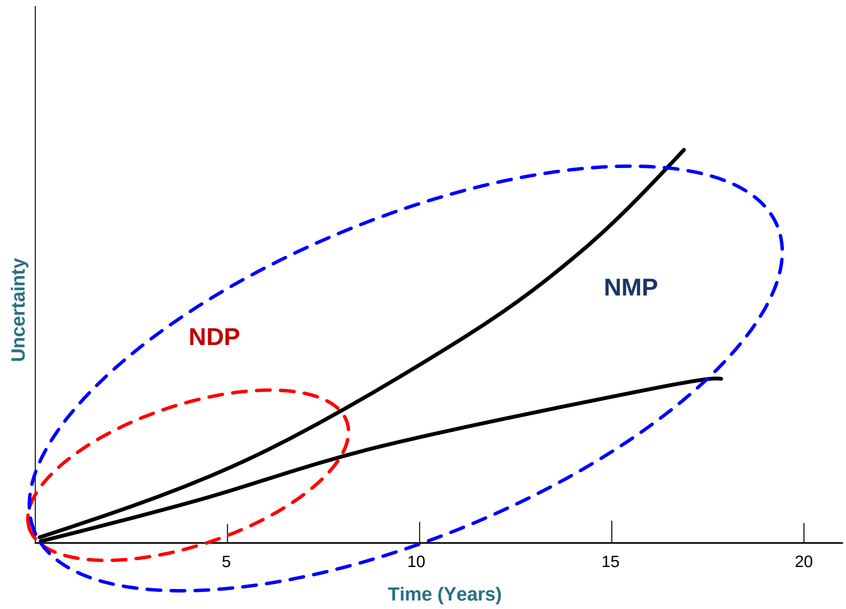


Figure 6-1: NMP Uncertainty

6.3 Proposed Network Development

The following section provides a systematic development perspective of the preferred network expansion options. Details of the evaluated alternatives are provided in Addendum B to this report.

The legend below is adopted from Addendum B and is used throughout this section:

400kV Substation

275kV Substation

132kV Substation

132/33kV Substation

132/33/11kV Substation

33kV Substation

132kV Traction

275kV Line

132kV Line

132kV Cable

33kV Line

33kV Cable

Decommissioned Substation

Switching Station

New 275kV / 400kV Intake

132kV New Substation (Existing Projects)

132kV Substation (Transformer Upgrades)

132kV New Substation (Additional Projects)

400kV Line (Proposed)

275kV Line (Proposed)

132kV Line (Proposed)

132kV Cable (Proposed)

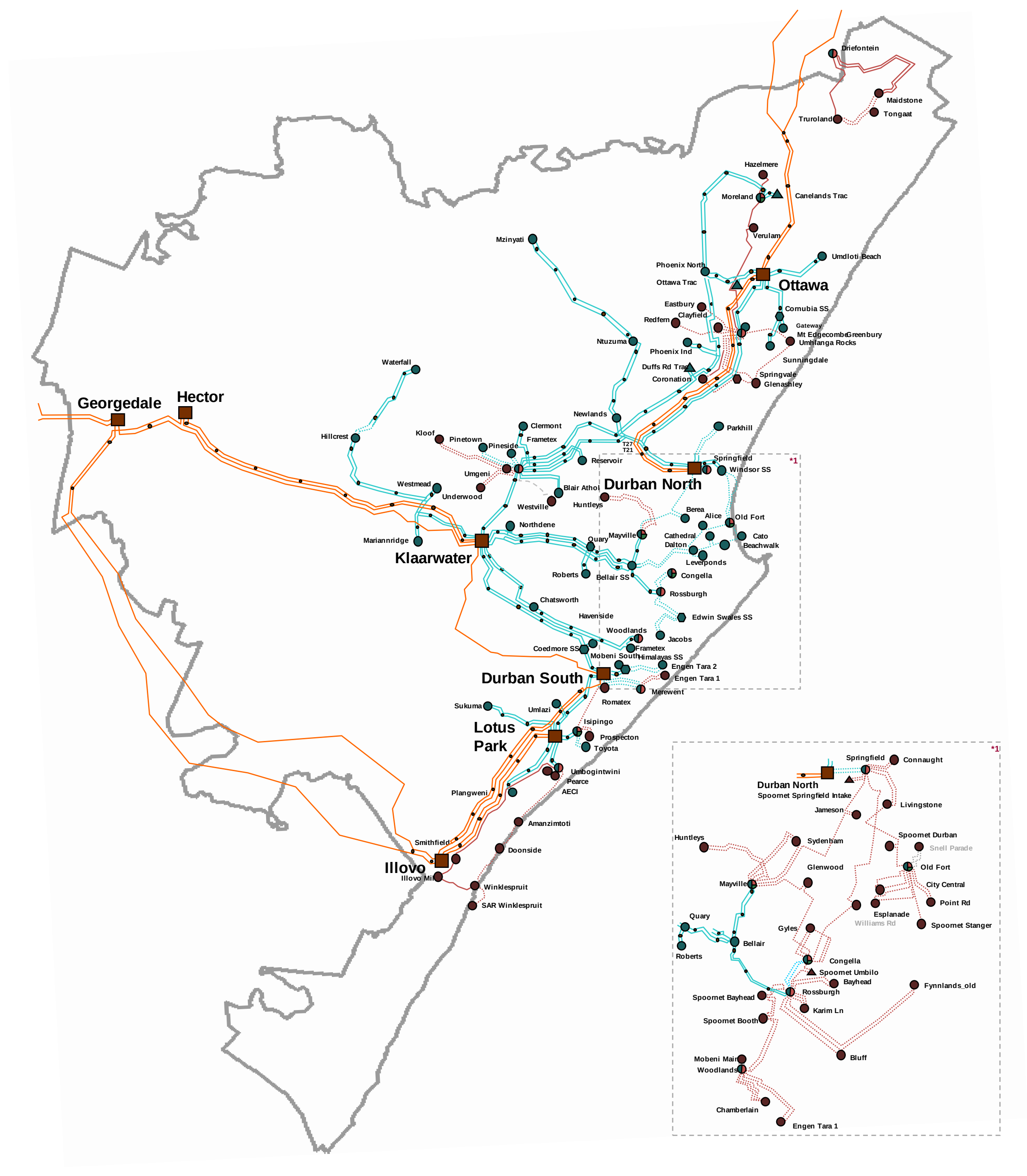
Line / Cable Upgrade

Reconfiguration

eThekwini MP – Base Case Network (2009)

2009 Network was used as the base case network.

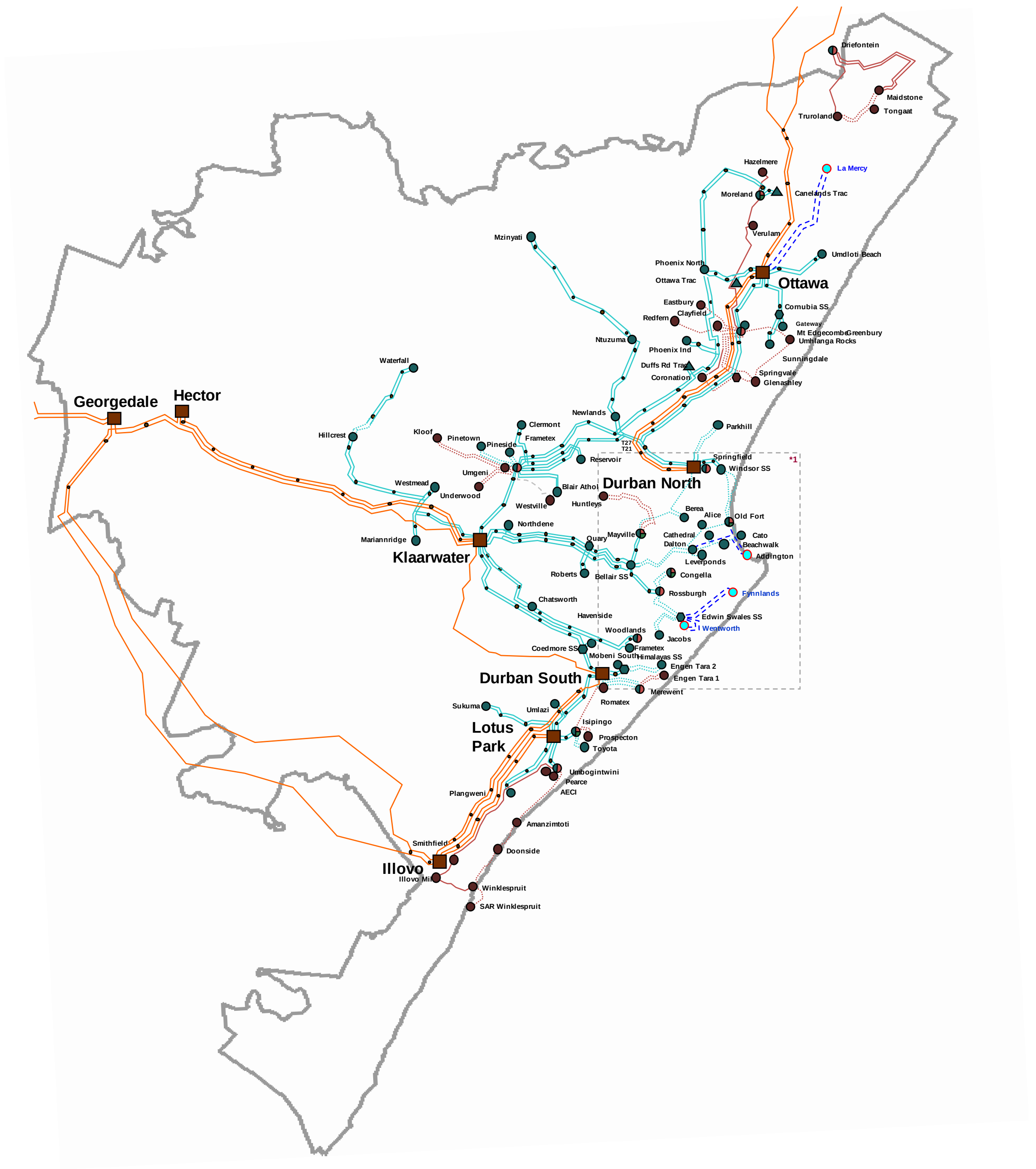
eThekwini MP – Base Case Network (2009)



Network Strengthening Projects (2010)

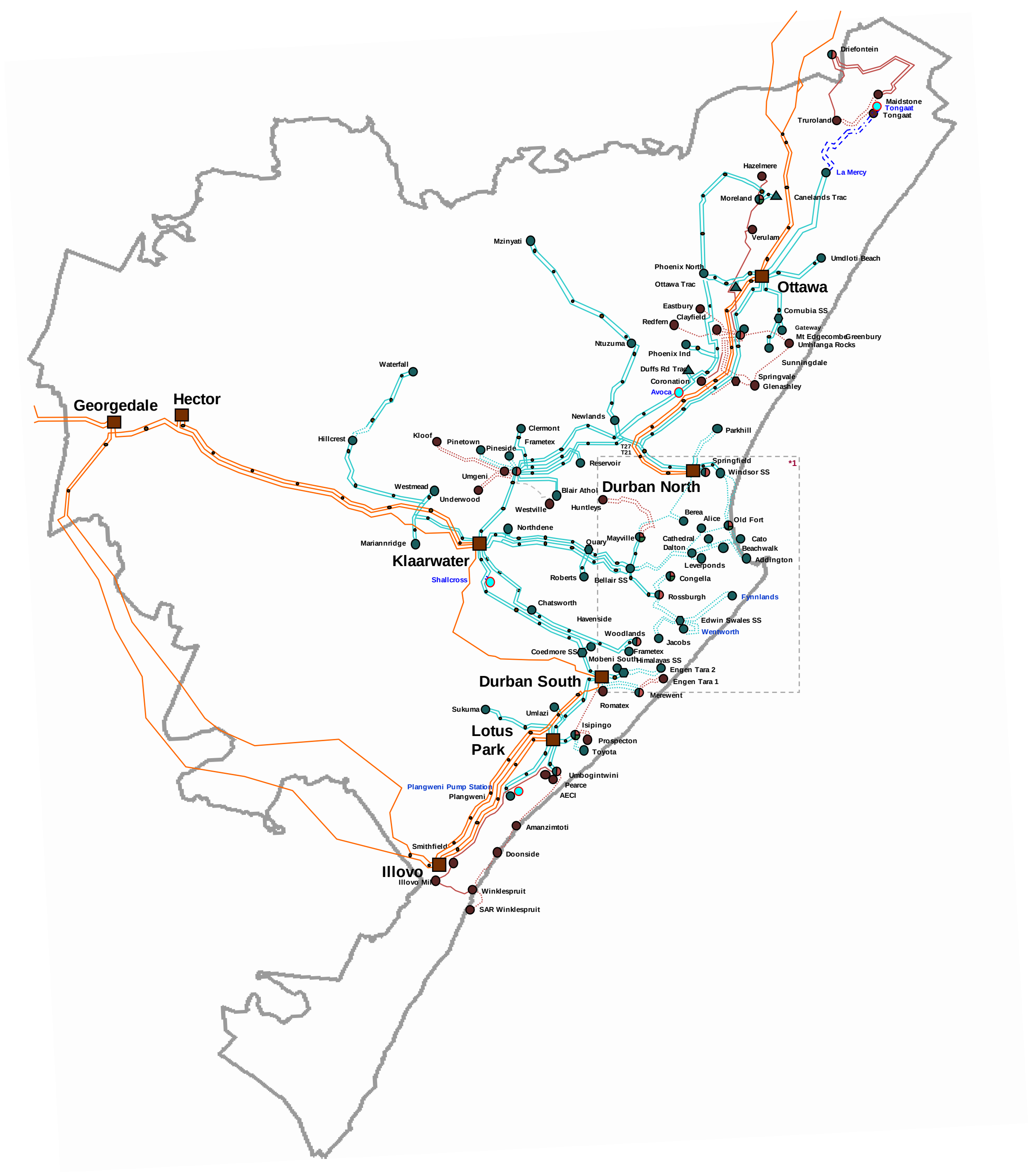
Newly built substations 2009 - 2010:	Substations with transformer upgrades:
Coedmore	Sukuma
Gateway	Northdene
Pineside	
Wentworth	
Fynnlands	
La Mercy	

eThekwini MP – Proposed Network (2010)



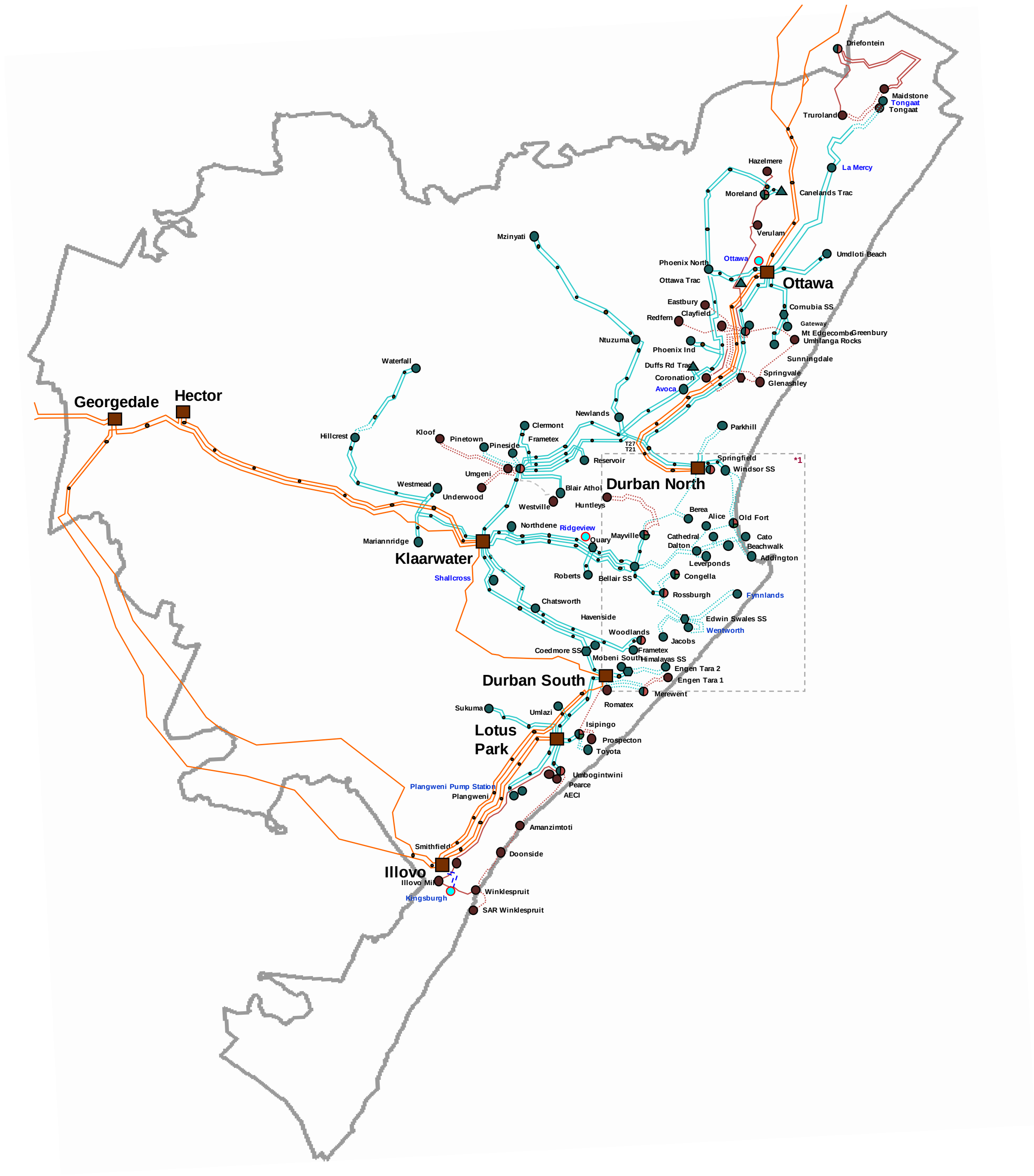
Network Strengthening Projects (2011)	
Proposed Substation	Proposed Transformer Upgrades:
Avoca	Klaarwater
Shallcross	Mobeni South
Tongaat	Newlands
Ridgeview	Clermont
Plangweni Pump Station	Dalton Road
	Havenside

eThekwini MP – Proposed Network (2011)



Network Strengthening Projects – Proposed Network (2012)	
Proposed Substation: Kingsburgh Ottawa Parlock Mondi	Proposed Transformer Upgrades: Umdloti Beach Klaarwater

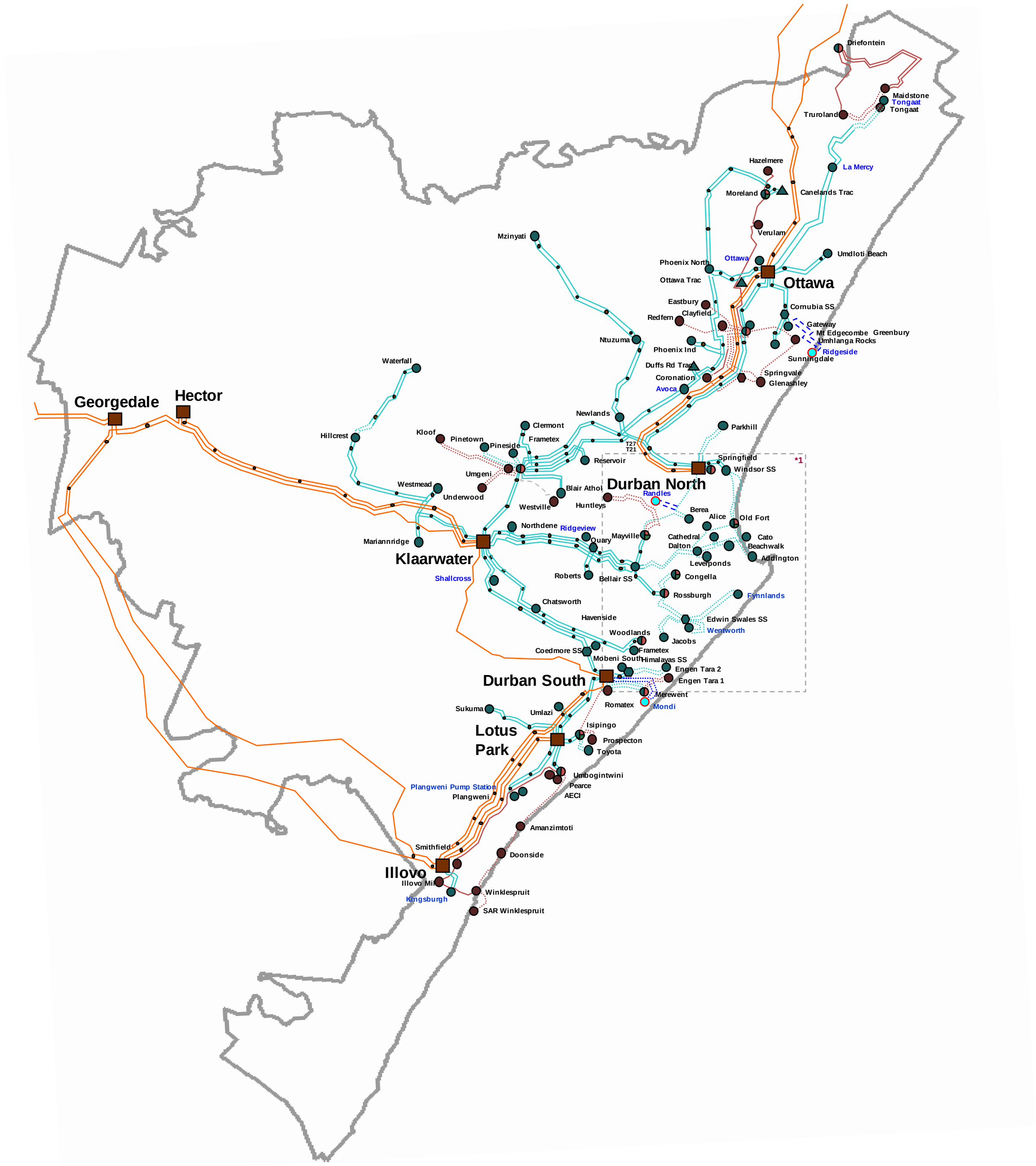
eThekwini MP – Proposed Network (2012)



Network Strengthening Projects – Proposed Network (2013)

Proposed Substation:	Proposed Transformer Upgrades:
Mondi	Klaarwater
Randles	Plangweni
Ridgeside	Blair Athol
	Phoenix North
	Pinetown
	Umlazi

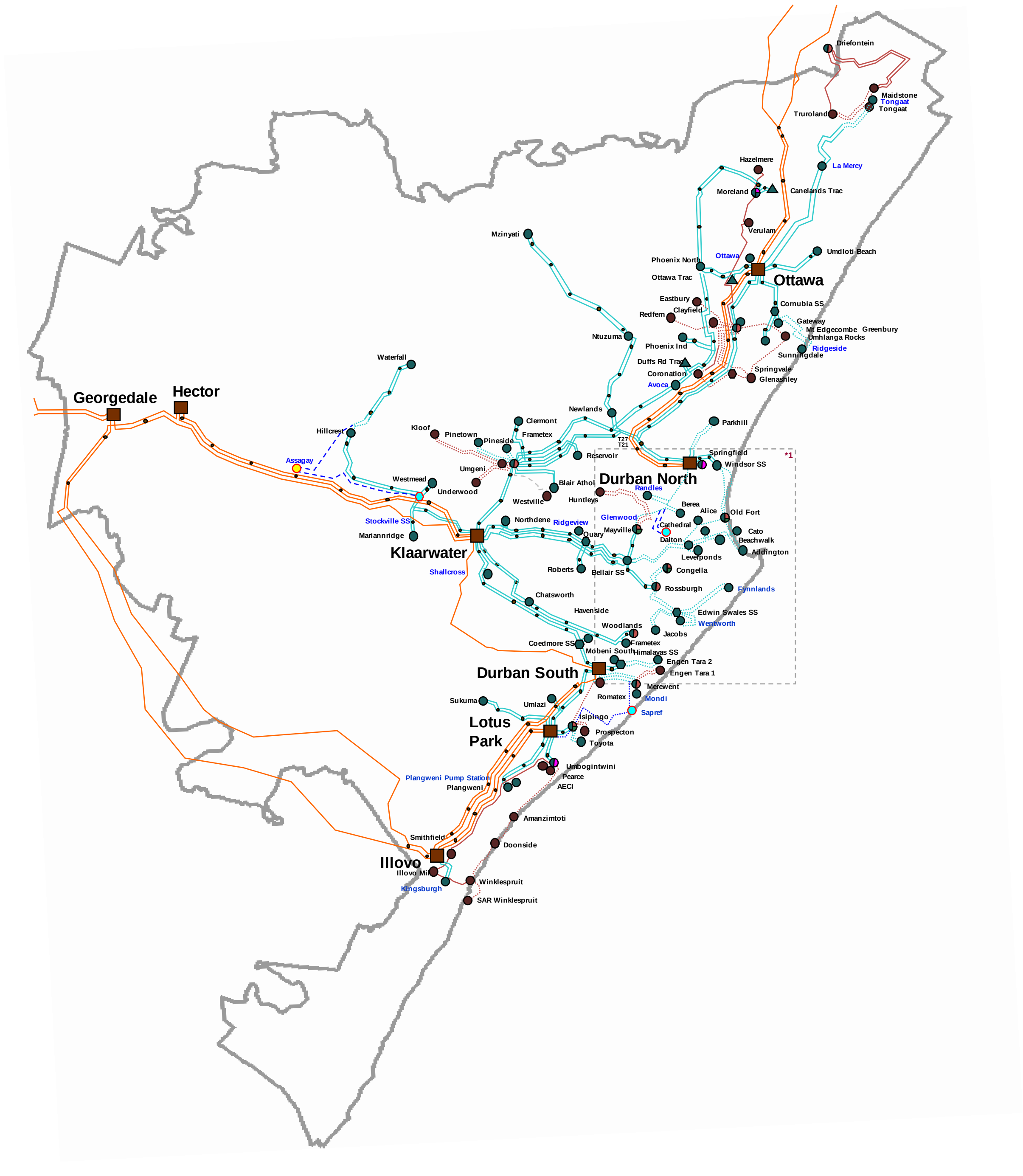
eThekwini MP – Proposed Network (2013)



Network Strengthening Projects (2014)

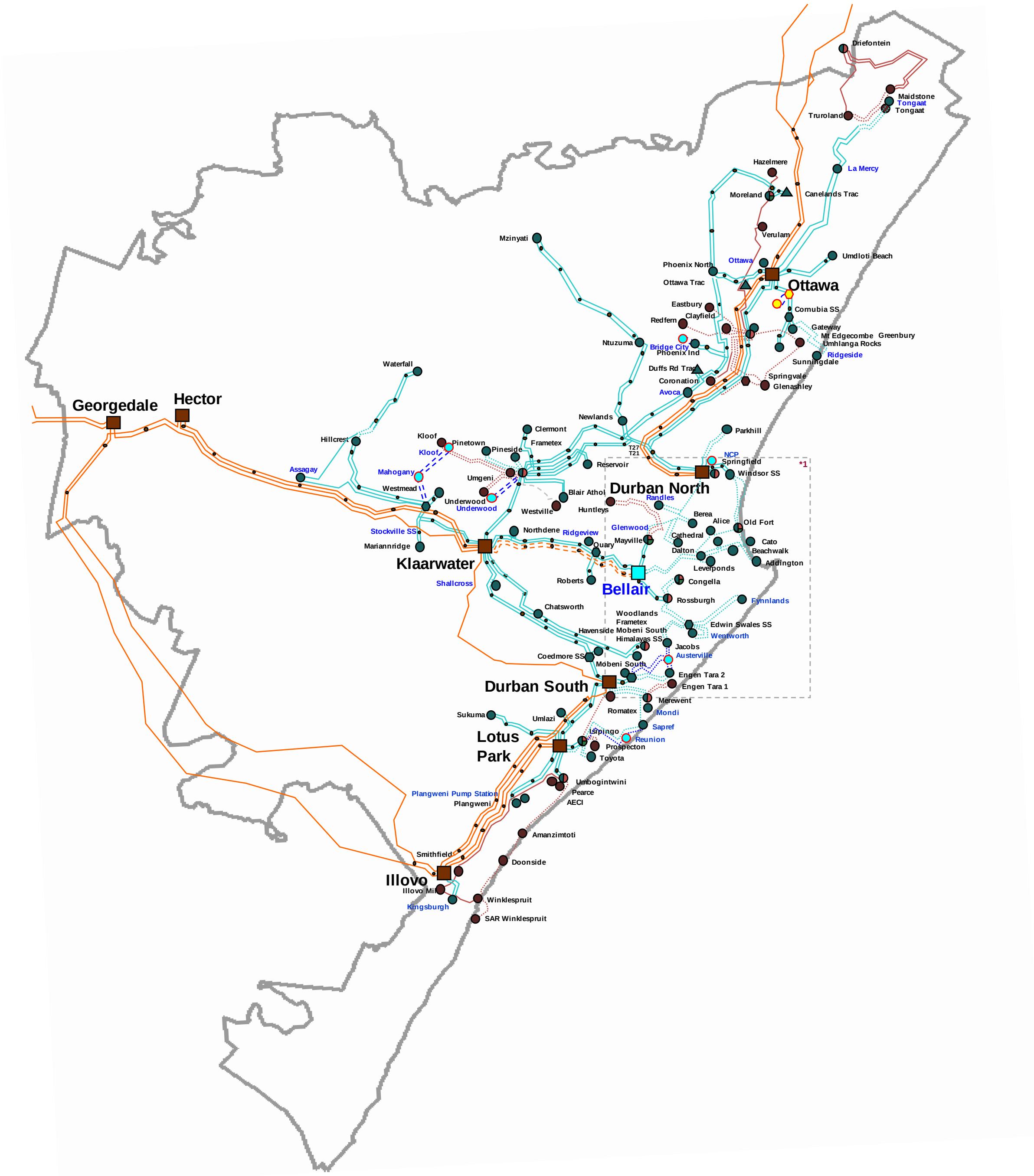
Proposed Substation:	Proposed Transformer Upgrades:
Sapref	Klaarwater
Glenwood	Springfield (Introduce 11kV)
Assagay	Umbogintwini (Introduce 11kV)
Stockville	Moreland

eThekwini MP – Proposed Network (2014)



Network Strengthening Projects (2015)	
Proposed Substation:	NCP
Reunion	Underwood
Austerville	
Bellair	Proposed Transformer Upgrades:
Bridge City	Klaarwater
Kloof	Lotus Park
Mahogany Ridge	

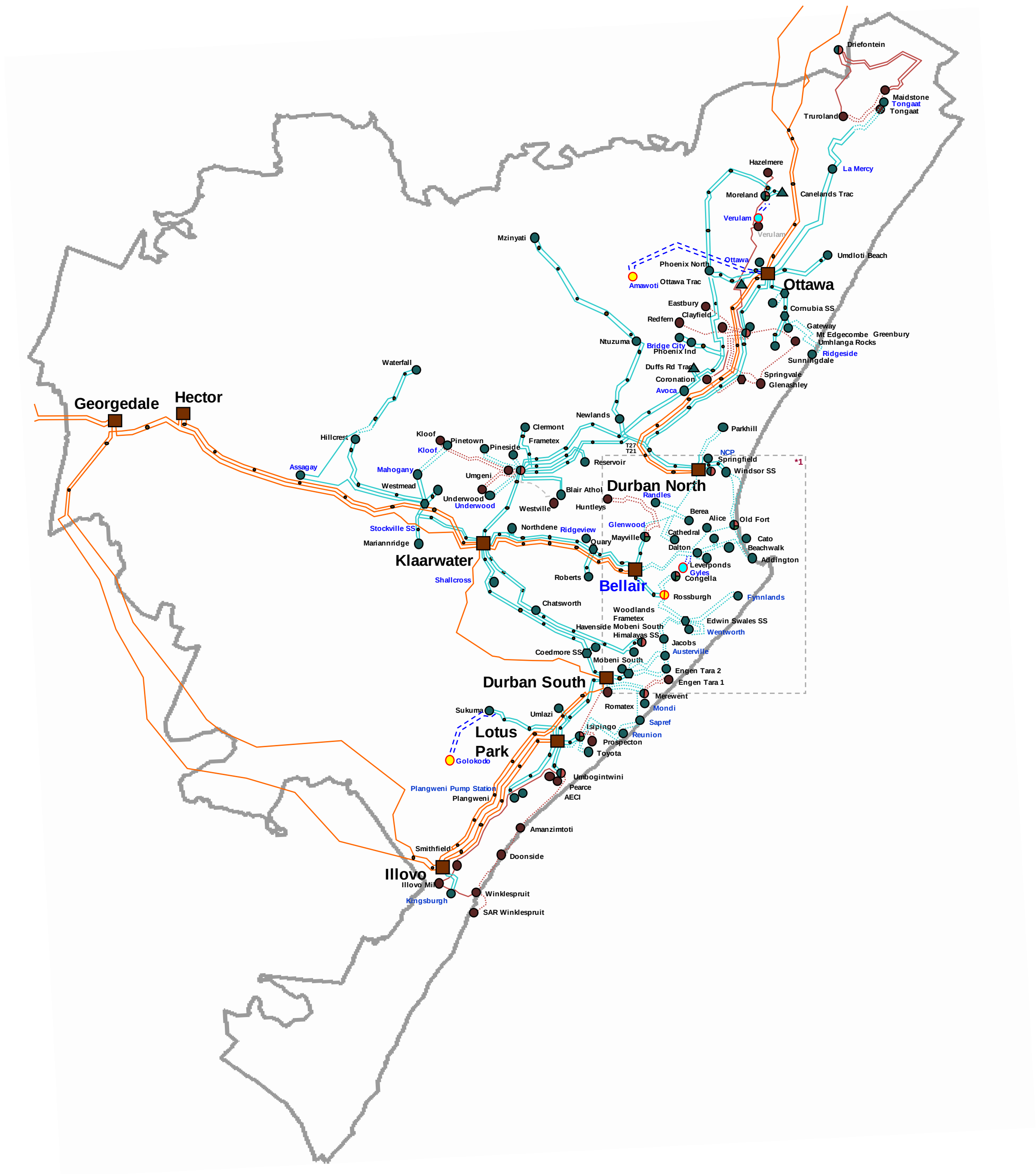
eThekwini MP – Proposed Network (2015)



Network Strengthening Projects (2016)

Proposed Substation: Amawoti Cornubia 1 Goloko Gyles 132kV	Vasu SS Verulam Proposed Transformer Upgrades: Rossburgh (introduce 11kV)

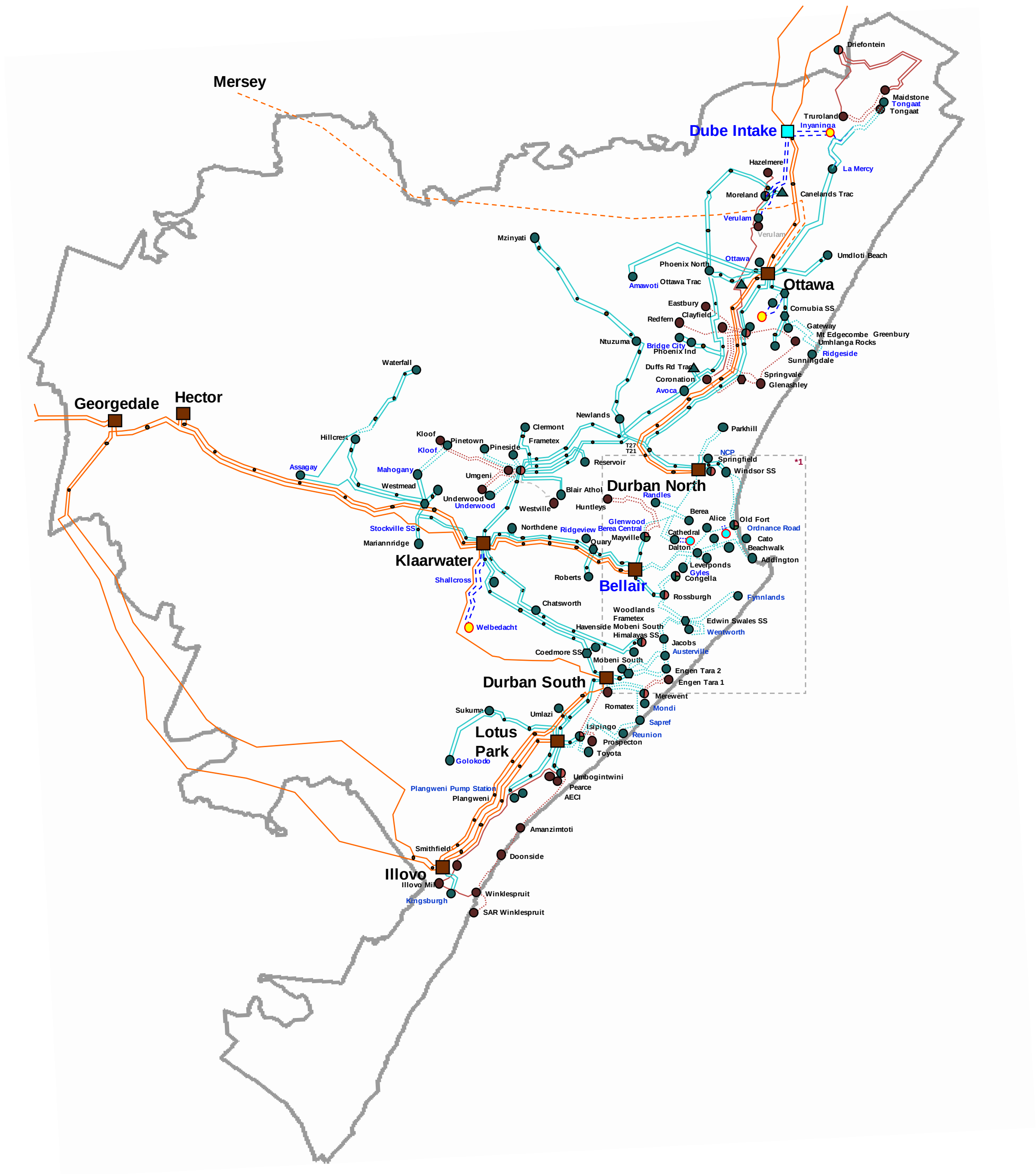
eThekwini MP – Proposed Network (2016)



Network Strengthening Projects (2017 - 2019)

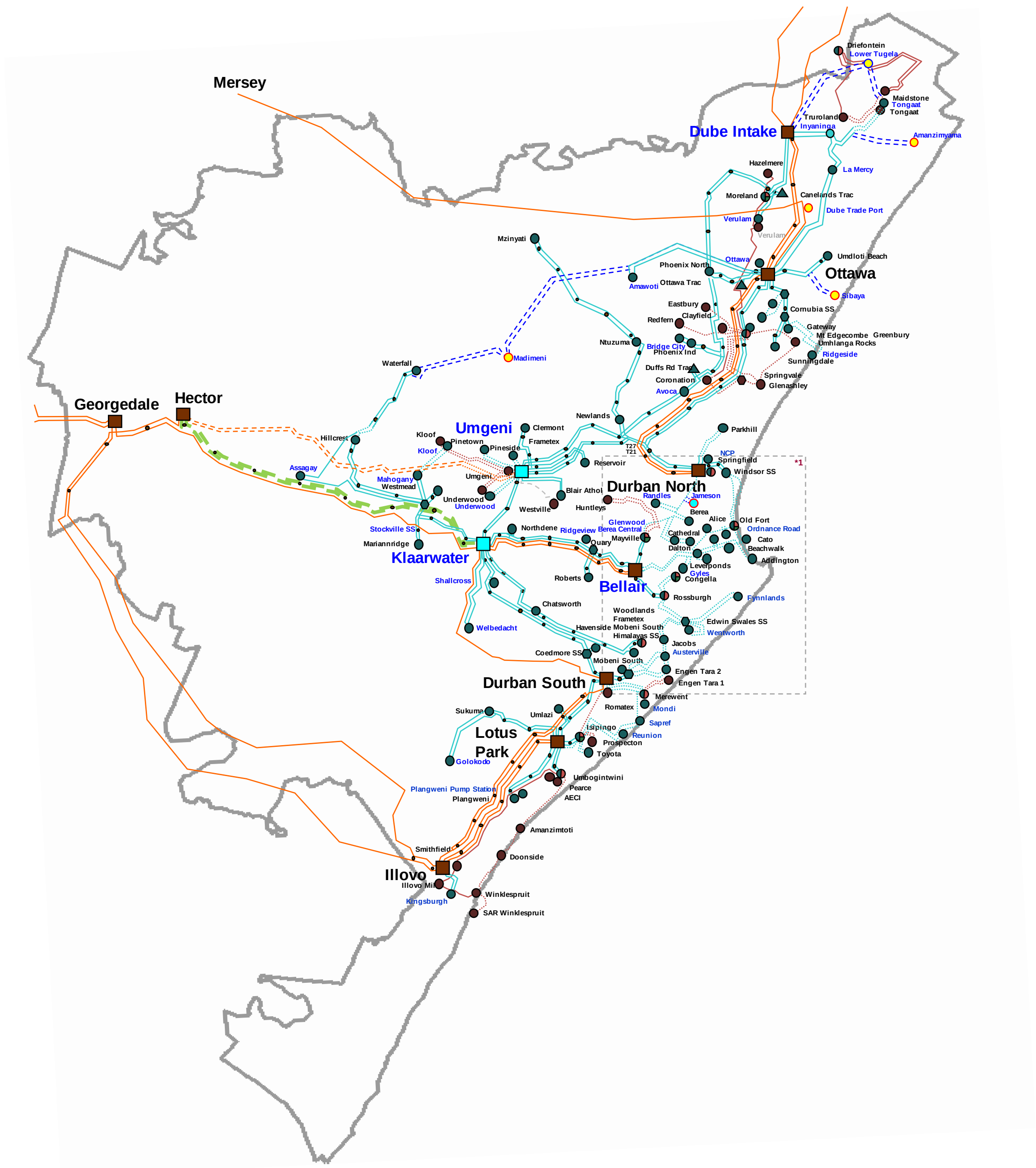
Proposed Substation:	Proposed Transformer Upgrades:
Berea Central Ordnance Road Dube Intake Inyaninga Welbedacht	Greenbury

eThekwini MP – Proposed Network (2017 - 2019)



Network Strengthening Projects (2020 - 2029)	
Proposed Substation: Cornubia 2 Dube Trade Port Umgeni Jameson Park Madimeni	Proposed Substation: Lower Tugela Amanzimyama New Klaarwater Sibaya

eThekwini MP – Proposed Network (2020 - 2029)



Project Description – Proposed Network Central (2029)

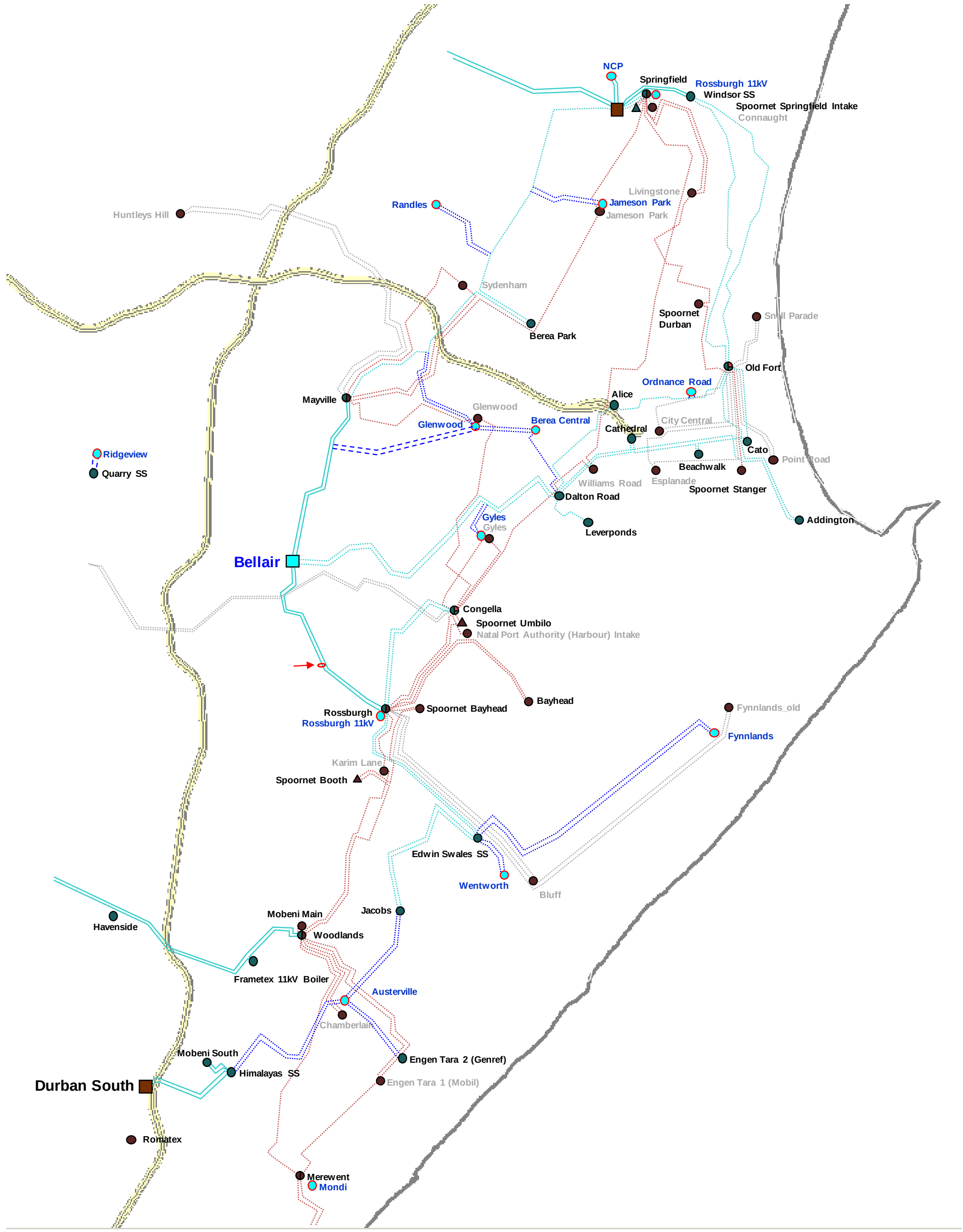
It is proposed that the most central area of eThekwini be supplied from 3 intake stations, namely:

Bellair (dedicated intake to central)

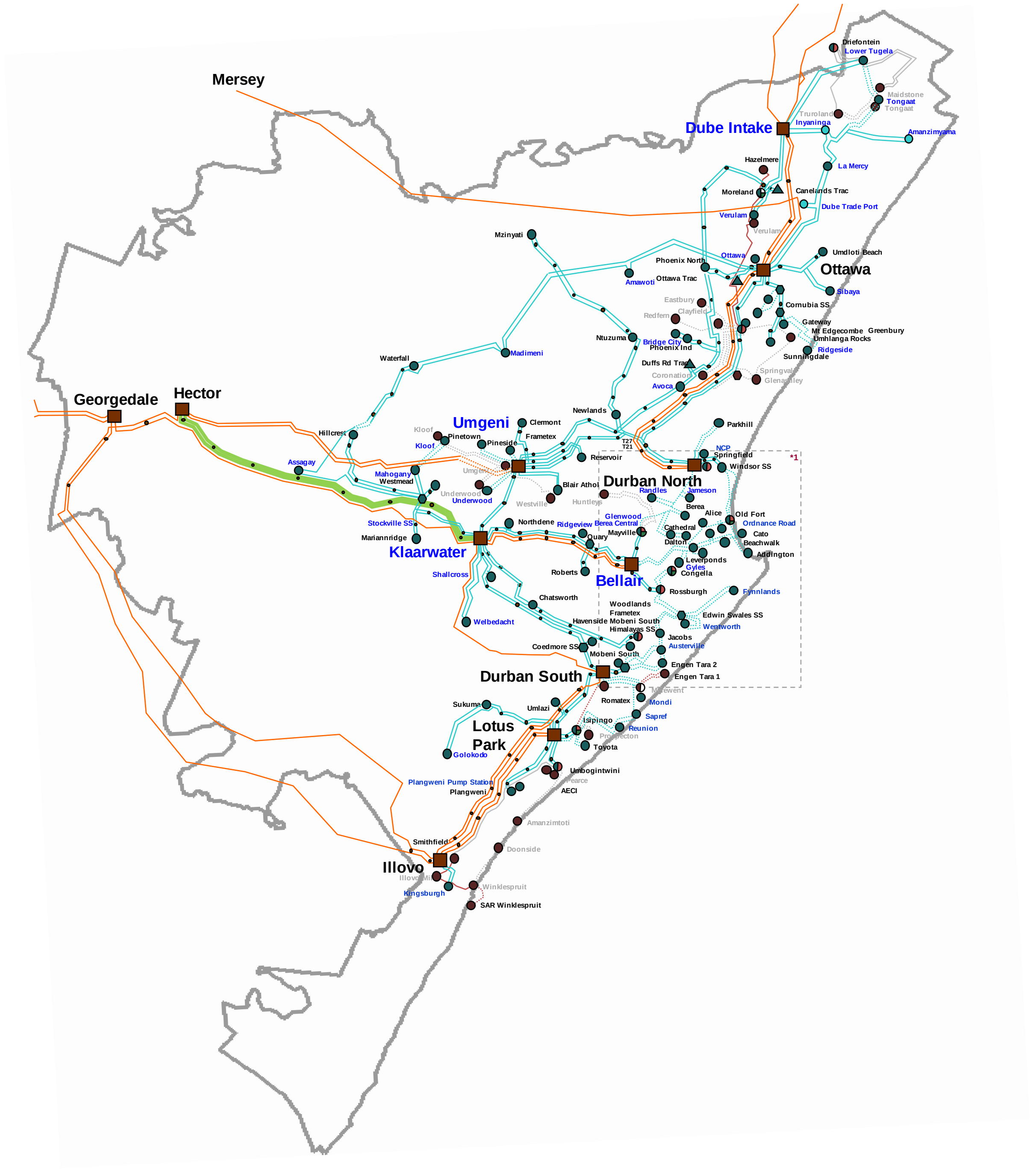
Durban North

Durban South

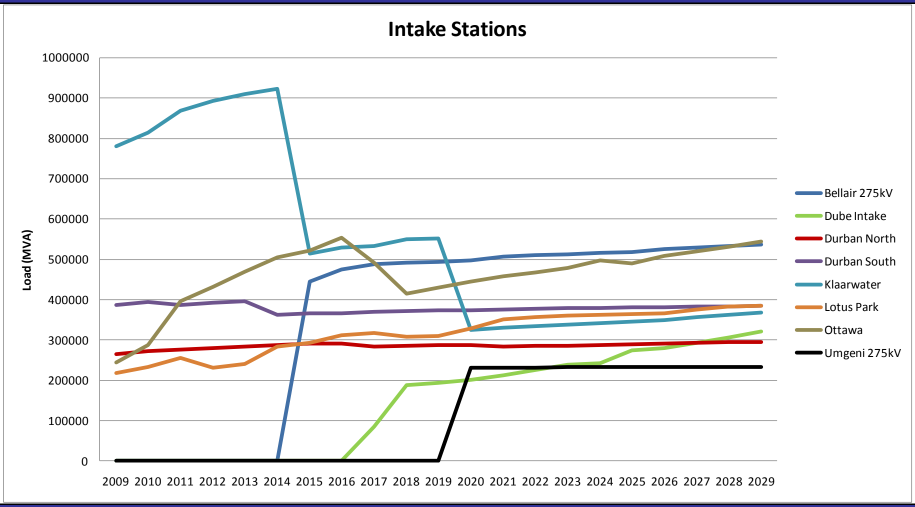
eThekwini MP – Proposed Network Central (2029)



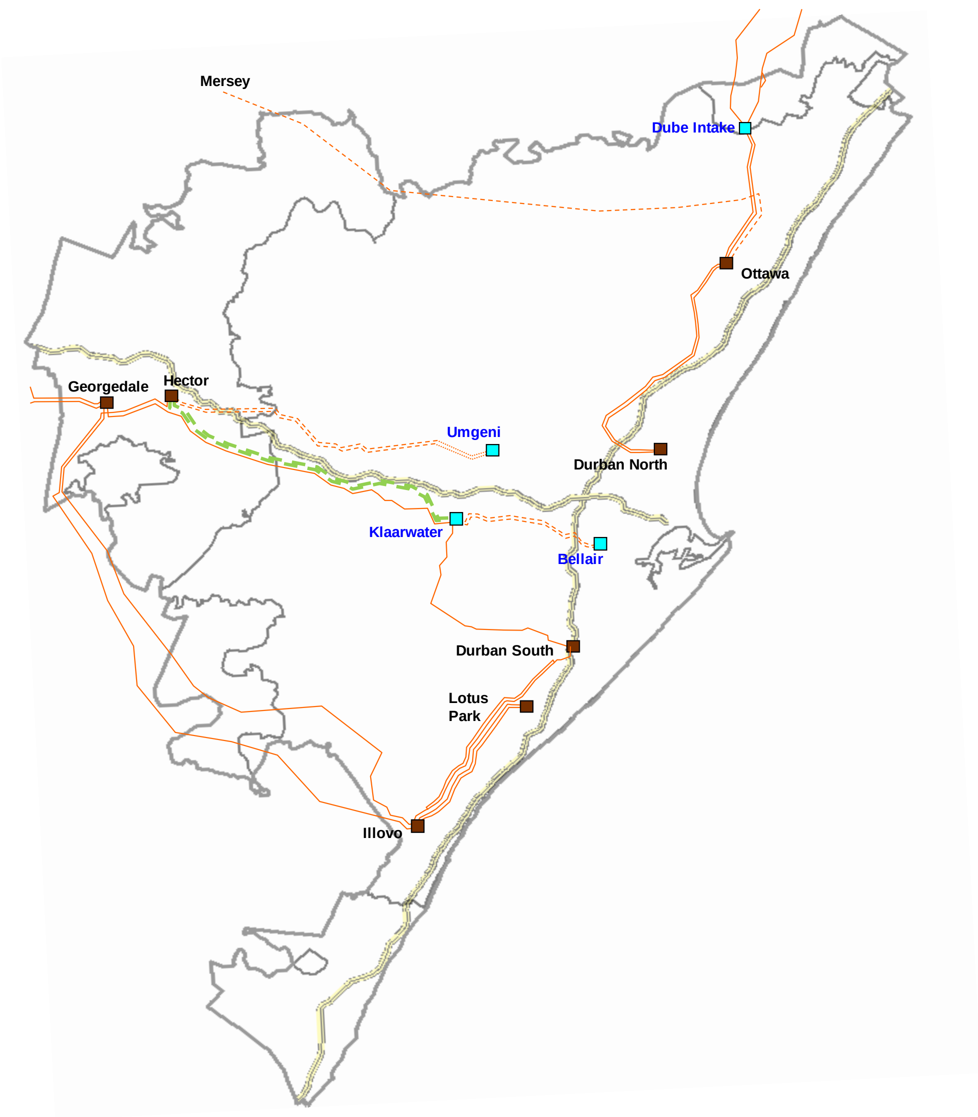
eThekwini MP – Proposed Network (2029)



Estimated Intake Substations Loading (Proposed Network Topology)



Estimated Intake Substations Loading



The benefits of the above projects are depicted on the table below as compared to the loading levels in section 4.5

Substation High Scenario	Installed	Firm	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
A.E.C.I	20	0	20	24	28	32	36	40	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
Addington	120	60	0	9	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Alice Street	60	30	44	44	44	44	44	45	45	45	27	27	27	27	27	27	27	27	27	27	27	27	27
Amanzimtoti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Amanzimyama	120	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37.97	40.93	44.75	48.9	53.11
Amawhoti	60	30	0	0	0	0	0	0	0	23.13	23.6	24.01	24.42	24.82	26.52	26.9	27.32	27.76	28.19	28.58	28.95	29.29	29.63
Assagay	120	60	0	0	0	0	0	26.74	29.41	30.48	31.51	32.35	33.05	33.72	34.73	35.76	36.82	37.9	39	45.92	49.93	54.27	58.63
Austerville	120	60	0	0	0	0	0	0	45	48	50	51	52	53	53	54	54	54	54	54	54	54	54
Avoca	120	60	0	0	31	32	33	35	36	38	40	42	44	46	47	49	50	51	52	52	52	53	53
Bayhead	30	15	8	8	9	9	9	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beach Walk	60	30	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Bellair Intake	630	315	0	0	0	0	0	0	445	474	487	491	494	497	508	511	513	516	519	525	529	532	536
Berea Central	60	30	0	0	0	0	0	0	0	0	27	27	27	27	27	27	27	27	27	27	27	27	27
Berea Park	60	30	42	42	42	43	43	35	35	35	28	28	28	28	28	28	28	28	28	28	28	28	28
Blair Atholl	60/120	30/60	34	36	37	29	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Bluff	30	15	22	15	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bridge City	120	60	0	0	0	0	0	0	31	31	31	31	31	31	32	32	32	32	32	32	32	32	32
Canelands Traction	4.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cathedral Road	60	30	31	31	31	31	31	31	31	31	24	24	24	24	24	24	24	24	24	24	24	24	24
Cato Street	60	30	25	25	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Chamberlain Road	45	30	23	23	23	23	23	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chatsworth	90	60	49	52	48	49	51	51	52	52	53	53	53	53	54	54	54	55	55	55	55	56	56
City Central	50	25	26	26	26	26	26	26	26	26	19	19	19	19	19	19	19	19	19	19	19	19	19
Clayfield	25	0	12	12	12	13	13	13	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clermont	60/120	30/60	42	45	47	49	49	50	51	51	51	51	52	52	52	52	53	53	53	53	53	53	53
Coedmore																							
Congella	60	30	29	31	34	35	36	36	36	28	28	29	29	29	29	29	29	29	29	29	29	29	29
Congella	160	80	31	32	34	34	35	28	28	43	43	43	44	44	31	31	31	31	31	31	31	31	31
Connaught	50	25	30	31	31	31	32	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cornubia Sub2	120	90	0	0	0	0	0	0	0	0	0	0	0	43	45	45	45	45	45	45	45	45	45
Cornubia Sub3	120	90	0	0	0	0	0	0	0	51	55	58	61	63	64	65	66	67	68	69	70	71	72
Coronation	30	15	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dalton Road	60/120	30/60	32	32	33	33	33	33	33	32	32	32	32	32	32	32	32	32	32	38	39	40	40
Doonside	30	15	17	18	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Driefontein	80	40	36	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dube Trade Port	120	60	0	0	0	0	0	0	0	0	0	0	0	23.88	26.17	28.02	29.68	43.29	46.35	56.94	57.97	58.59	59.13
Duffs Road Traction	6.94	3.47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Durban North	630	315	266	272	276	279	283	288	291	291	284	285	287	288	284	285	287	288	290	291	293	294	296
Durban South	1260	945	387	395	388	392	396	363	366	367	369	371	373	374	376	378	379	380	381	382	383	384	385
Eastbury	25	0	22	23	24	25	25	25	15	15	0	0	0	0	0	0	0	0	0	0	0	0	0
EB Steam Lever Ponds	30	0	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
EB Steam SAB	60	30	24	24	25	25	25	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
ENGEN Tara 1 (MOBIL)	60	45	8	8	9	9	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ENGEN Tara 2 (GENREF)	120	60	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
Esplanade	50	25	31	31	32	32	32	32	32	32	22	22	22	22	22	22	22	22	22	22	22	22	22
Frametex	60	30	17	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frametex 11kV Boiler	45	0	28	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fynnlands	60/120	30/60	0	17	26	27	27	28	30	32	32	33	33	33	33	33	33	33	33	33	33	33	33
Fynnlands (Old)	30	15	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gateway	120	60/90	3	31	51	46	50	54	58	61	63	66	69	72	76	80	72	77	81	73	75	78	80
Glen Hills	60	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glenashley	50	25	31	32	33	34	21	21	21	12	12	12	12	12	12	12	12	12	12	12	12	13	13
Glenwood	30	15	10	10	11	11	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glenwood	60	30	0	0	0	0	0	33	33	33	25	25	25	25	25	25	25	25	25	25	25	25	25
Golokodo	120	60	0	0	0	0	0	0	0	26.18	27.74	29.29	30.83	32.36	32.82	33.21	33.49	33.66	33.8	33.83	33.86	33.88	33.9
Greenbury	60/120	30/60	23	23	24	24	25	25	25	25	38	38	38	38	38	38	38	38	38	38	38	38	38
Gyles	30	15	11	11	12	12	12	12	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gyles 132kV	60	30	0	0	0	0	0	0	0	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Havenside	60/120	30/60	34	36	51	52	53	54	54	54	54	55	55	55	55	55	55	55	55	55	55	55	55
Hazelmere	10	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hillcrest	120	60	56	62	76	81	85	62	53	53	53	53	53	53	53	53	53	53	53	54	54	54	54
Huntleys Hill	50	25	24	25	26	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Illovo Mill	2.5	0	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inyaninga	120	60	0	0	0	0	0	0	0	0	0	18.82	21.38	23.94	53.29	58.02	57.33	60.22	63.11	64.11	64.48	64.56	64.57
Isipingo	80	40	34	34	35	35	35	35	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Isipingo	60	30	27	28	29	30	31	31	31	31	31	31	31	31	32	32	32	33	33	33	34	34	35
Jacobs	120	60	50	51	52	52	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53
Jameson Park	25	0	13	14	15	15	15	15	16	16	16	16	16	16	0	0	0	0	0	0	0	0	0
Jameson Park	60	30	0	0	0	0	0	0	0	0	0	0	0	0	25.66	25.72	25.77	25.83	25.88	25.89	25.9	25.91	25.91
Karim Lane	45	30	25	26	27	27	27	27	27	28	28	29	29	29	30	30	30	30	30	30	30	30	30
Kingsburgh	120	60	0	0	0	39	41	42	43	44	46	47	49	50	51	51	51	51	51	51	51	51	51
Klaarwater	1000	750	781	814	868	894	910	922	513	529	533	549	552	324	330	335	338	341	345	350	356	363	369
Kloof	20	10	18	20	22	23	23	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kloof	60	30	0	0	0	0	0	0	30	31	31	31	31	31	31	24	24	24	24	24	24	24	24
La Mercy	120	60	0	17	22	25	28	31	34	45	48	51	53	56	37	46	56	54	57	52	54	57	59
Livingstone Road	25	0	17	17	18	18	18	18	18	18	18	18	18	18	0	0	0	0	0	0	0	0	0
Lotus Park	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lotus Park	630	315	217	233	255	231	240	284	293	312	317	308	310	329	351	357	361	363	365	366	375	384	385
Lower Tugela	120	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20.81	21.26	21.71	21.98	22.15	22.28	22.4
Madimeni	60	30	0	0	0	0	0	0	0	0	0	0	0	0	0	15.04	15.16	15.29	15.41	15.44	15.47	15.49	15.51
Mahogany Ridge	60	30	0	0	0	0	0	0	28	29	29	29	30	30	30	30	31	31	31	31	31	31	31
Maidstone	30	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mariannridge	60/120	30/60	44	49	51	53	55	57	56	57	58	46	47	48	52	54	55	56	58	55	56	57	58
Mayville	60	30	28	29	31	19	20	20	20	20	21	21	21	21	21	21	21	21	21	21	21	21	21

Substation High Scenario	Installed	Firm	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Mayville	135	90	64	66	69	65	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Merewent	300	200	180	180	181	181	47	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micro Steel	50	25	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Mobeni Main	45	30	21	22	16	16	16	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mobeni South	60/120	30/60	38	39	41	42	42	42	43	44	45	46	46	46	46	46	46	46	46	46	46	46	46
Mondi	284	142	0	0	0	0	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151
Mondi Consumer S/S	210	190	151	151	151	151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Moreland	30	0	26	28	38	46	54	61	69	38	40	42	44	47	49	51	53	55	57	58	59	60	62
Moreland	90	45	20	21	23	25	26	28	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mount Edgecombe	180	90	100	106	103	105	72	72	55	25	12	12	12	12	12	12	12	12	12	12	12	12	12
Mzinyati	60	30	21	25	29	31	32	34	35	23	24	24	25	25	26	26	26	27	27	27	28	28	28
NCP	60	30	0	0	0	0	0	0	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Newlands	60/120	30/60	38	40	42	43	44	45	45	45	45	46	59	59	60	60	60	60	60	61	61	61	61
Northdene	60/120	30/60	38	39	29	29	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Ntuzuma	120	60	44	48	53	54	56	57	58	59	60	60	48	49	49	50	51	52	53	54	56	57	58
Old Fort	180	90	91	83	77	72	72	72	72	72	56	56	56	56	56	56	56	56	56	56	56	56	56
Old Fort	90	60	49	49	50	50	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
Ordnance Road	60	30	0	0	0	0	0	0	0	0	30	30	30	30	30	30	30	30	30	30	30	30	30
Ottawa	630	315	244	287	396	433	469	505	521	553	493	415	430	445	458	467	479	498	489	509	520	532	544
Ottawa 132kV	120	60	0	0	0	25	40	55	70	38	45	51	58	25	27	27	28	28	29	29	29	29	29
Ottawa Traction	4.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parkhill	120	60	65	67	64	65	66	66	50	58	58	58	58	58	58	58	58	59	59	59	59	59	59
Parlock SS																							
Pearce Road	30	15	13	13	13	13	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix Industrial Park	120	60	43	45	42	44	45	46	35	45	45	45	45	45	45	45	45	45	45	45	45	45	45
Phoenix North	60/120	30/60	42	44	48	49	50	50	51	51	51	51	51	51	52	52	52	53	53	53	54	54	54
Pineside	15	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pineside	60/120	30/60	46	55	56	57	57	57	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58
Pinetown	60/120	30/60	31	32	33	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
Plangweni	60/120	30/60	28	32	36	59	62	57	60	37	38	38	39	40	40	40	40	41	41	41	41	41	41
Plangweni Pump Station			0	0	7	8	10	12	14	16	18	20	20	20	20	20	20	20	20	20	20	20	20
Point	50	25	21	13	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prospecton Road	25	0	26	26	26	26	26	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Randles	120	60	0	0	0	0	48	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49
Redfern	25	0	13	14	16	17	17	18	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reservoir Hills	60	30	22	23	25	25	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Reunion	120	60	0	0	0	0	0	0	26	26	26	26	26	59	68	76	79	80	80	81	81	81	81
Ridgeside	60/120	30/60	0	0	0	0	35	36	37	37	38	38	38	38	38	38	38	38	38	41	45	49	53
Ridgeview	60	30	0	0	0	27	27	27	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Roberts	60	30	32	33	30	30	30	30	30	31	31	31	31	31	31	31	31	31	31	31	31	31	31
Romatex	15	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Rossburgh	200	100	65	43	37	33	34	34	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rossburgh	120	90	0	0	0	0	0	0	0	48.05	50.85	54	57.15	60.3	63.45	66.6	69.75	72.9	76.05	79.2	82.35	85.5	90
SAPREF Consumer S/S	300	200	0	0	0	0	0	46	46	60	60	60	60	60	80	80	80	80	80	80	90	100	100
SAR Winklespruit			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shallcross	60	30	0	0	25	26	27	28	28	29	29	29	30	30	30	30	30	31	31	31	31	31	31
Shell			46	46	46	46	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sibaya	120	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14.03	16.84	19.74	22.72
Smithfield	10	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Snell Parade	50	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spoornet Bayhead Intake	20	10	3	3	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spoornet Booth Road	9.9	4.95	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Spoornet Durban Station	40	20	9	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Spoornet Durban Station	9.9	4.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spoornet Springfield Intake	8	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Spoornet Springfield Intake	4.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spoornet Stanger Street	20	10	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Spoornet Umbilo	9.9	4.95	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Springfield	180	90	42	43	44	44	44	28	19	19	19	19	19	19	4	4	4	4	4	4	4	4	4
Springfield 132/11kV			0	0	0	0	0	18	18	18	18	18	18	18	25	25	25	25	25	25	25	25	25
Sukuma	60/120	30/60	57	64	70	55	58	60	62	63	64	50	51	51	52	53	54	55	57	57	58	59	60
Sunningdale	120	60	65	55	60	57	58	59	59	59	59	59	59	59	59	59	59	59	59	59	60	60	60
Sydenham	45	30	30	31	32	33	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tongaat	20	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tongaat	120	60	0	0	41	44	48	51	54	57	60	52	53	55	56	58	42	43	31	37	45	54	62
Toyota	120	60	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
Toyota Consumer S/S	90	45	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
Truroland	20	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Umbogintwini	180/90	90/45	50	53	59	30	32	24	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Umbogintwini	60	30	0	0	0	0	0	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
Umdloti Beach	60/120	30/60	16	18	27	30	34	39	43	47	52	56	61	45	47	48	61	63	45	46	48	49	50
Umgeni	135	90	35	32	35	36	36	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Umhlanga Rocks	50	25	19	21	22	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Umlazi	60/120	30/60	33	35	38	40	41	42	43	44	45	45	46	47	48	49	50	51	52	53	53	54	55
Underwood Road	25	0	25	26	27	27	27	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Underwood Road	120	60	0	0	0	0	0	0	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Verulam	30	15	23	24	26	28	30	31	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Waterfall	60/120	30/60	28	31	33	35	36	37	32	32	32	32	33	33	33	26	26	26	26	26	26	27	27
Welbedacht	120	60	0	0	0	0	0	0	0	0	0	26.79	26.89	26.97	27.51	27.87	28.23	28.61	29.01	29.68	30.35	31.04	31.75
Wentworth	60	30	0	9	19	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Westmead	120	60	58	59	59	59	60	60	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
Williams Road	50	25	6	7	7	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Winklespruit	10	5	16	17	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Woodlands	180	90	50	51	45	46	46	46	7	4	4	4	4	4	4	4	4	4	4	4	4	4	4

7 CAPITAL COST ESTIMATE

7.1 Background

One of the main criteria in evaluating system alternatives is the extent of capital outlay. Not only must the solutions to network problems be technically viable, but they must also be financially sound. The capital cost estimates developed under tis project aims to set-up a Short- and Long-term capital program which will allow for the adequate expansion and renewal of the eThekwini transmission network.

7.2 Costing of Capital Projects

Capital projects were identified through analysis and assessment of the following aspects:

- Expansion requirements,
- Reliability requirements, and
- Network refurbishment requirements.

The costing of capital projects were done by using standard equipment cost, contained in an equipment library.

The capital program allows for:

- Transmission Network Development, and
- Refurbishment Requirements.

The following paragraphs provide a summary of the predicted capital cost estimates. The total estimated capital expenditure to ensure the adequate functioning of the transmission networks within the Study Area is provided in the Figure 7-1: The total cumulative capital amount to R 4,700 million rand over the 20 year period.

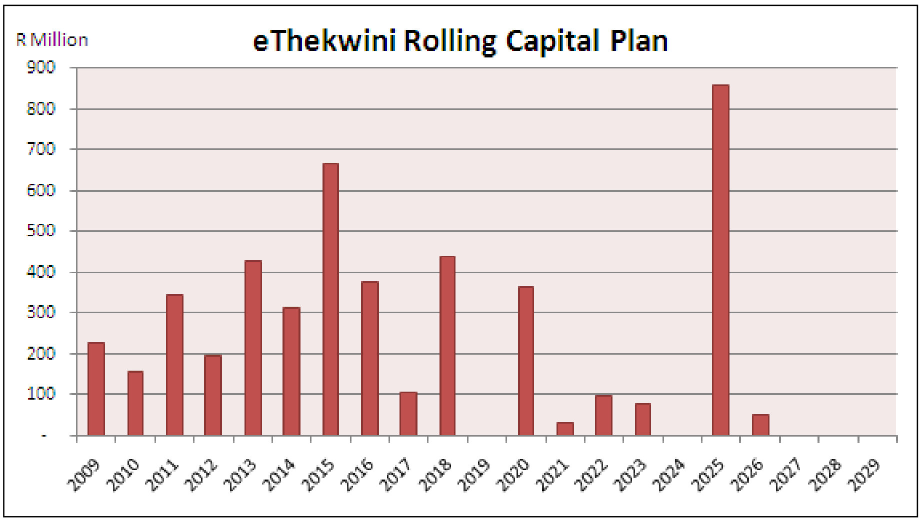


Figure 7-1: Estimated Total Capital Expenditure

The current eThekwini capital rolling plan, including estimates for 2009 and 2010, amount to R 2,000 million and allow for capital project between 2009 and 2015. The Additional R2,700 million were developed from project plans that were identified during the master plan exercise. The expected capital expenditure from this exercise is provided in Figure 7-12:

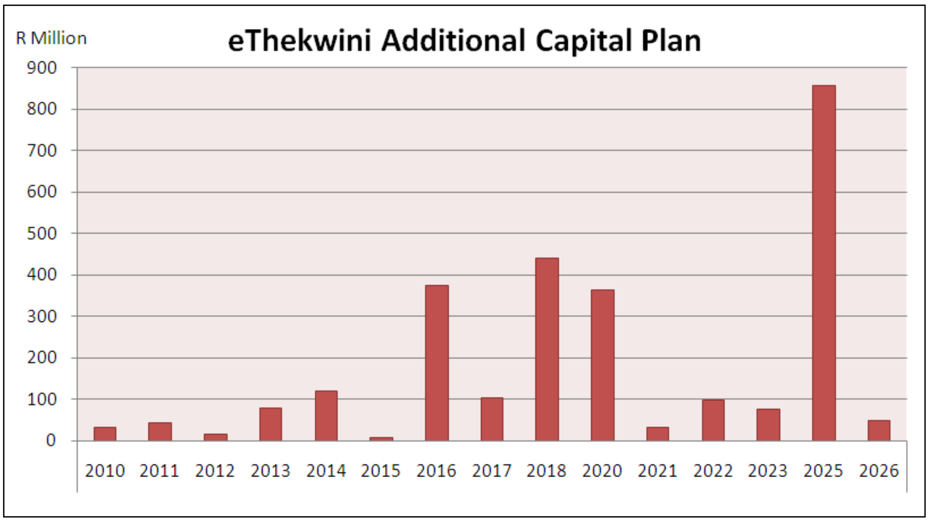


Figure 7-2: Estimated Total Capital Expenditure from NMP

A significant amount (R 850 million) is scheduled for 2025 of which R 800 million is allocated for the development of the new Klaarwater 400/275/132kV intake station.

The detailed Capital Program showing the preferred projects is shown in Table 7-1 below. An electronic version of the Capital Expenditure Program is provided as an addendum to this report.

Planned Year	REGION	Substation	Project Description	Category	Capital Plan Status	Tot Cost (xR1000)
2009	Central	Addington	Build 132/11kV 4x30MVA Substation.	Substation	Existing	**44,347**
2009	Central	Coedmore	Build Coedmore 132kV Switching Station, 8x 132kV feeder bays.	Substation	Existing	**25,543**
2009	Central	Pineside	Build 132/11kV 4x30MVA Substation.	Substation	Existing	**44,347**
2009	Central	Wentworth	Build 132/11kV 4x30MVA Substation.	Substation	Existing	**44,347**
2009	Northern	Gateway	Build 132/11kV 4x30MVA Substation.	Substation	Existing	**47,339**
2009	Southern	Sukuma	Add 132/11kV 2x30MVA transformers and 11kV Switchgear	Transformer	Existing	**19,404**
2010	Central	Fynnlands	Build 132/11kV 4x30MVA Substation (Trf 1 + 2 Bays completed)	Substation	Existing	**44,347**
2010	Central	Northdene	Add 132/11kV 2x30MVA transformers and 11kV Switchgear	Transformer	Existing	**19,404**
2010	Northern	La Mercy	Build 132/11kV 4x30MVA Substation	Substation	Existing	**33,271**
2010	Northern	La Mercy - Ottawa	Install 132kV Line Ottawa - La Mercy 10km Twin Elm.	Line	Existing	**24,366**
2011	Central	Klaarwater	Upgrade T21/5 with 275/132kV 315MVA, and decommission T21/1	Transformer	Existing	**38,593**
2011	Northern	Newlands	Add 132/11kV 2x30MVA transformers and 11kV Switchgear	Transformer	Existing	**19,404**
2011	Northern	Phoenix N-Phoenix Ind T	Commission line Phoenix North to Phoenix Industrial Park Tee (Twin Elm)	Line	Existing	**2,437**
2011	Southern	Mobeni South	Add 132/11kV 2x30MVA transformers and 11kV feeders	Transformer	Existing	**19,404**
2011	Central	Clermont	Add 132/11kV 2x30MVA transformers and 11kV Switchgear	Transformer	Existing	**19,404**
2011	Central	Dalton Road	Add 132/11kV 2x30MVA transformers and 11kV Switchgear.	Transformer	Existing	**19,404**
2011	Central	Klaarwater	Commission both Capacitor banks	Cap Bank	Existing	**3,290**
2011	Central	Klaarwater - Shallcross	Install 132kV Line from Klaarwater - Coedmore to Shallcross	Line	Existing	**1,218**
2011	Central	Shallcross	Build 132/11kV 2x30MVA substation.	Substation	Existing	**24,732**
2011	Northern	Avoca	Build 132/11kV 4x30MVA Substation.	Substation	Existing	**44,347**
2011	Northern	Avoca Tee	Build 2x132kV line Avoca to Umgeni-Canelands 0.5km Elm.	Line	Existing	**937**
2011	Northern	Durban North	Commission 132kV Cap Bank2	Cap Bank	Existing	**5,662**
2011	Northern	Tongaat	Build 132/11kV 4x30MVA Substation.	Substation	Existing	**44,347**
2011	Northern	Tongaat S/E -Tongaat	Install 2x132kV Cable from Tongaat S/E to Tongaat	Cable	Existing	**26,678**
2011	Northern	Tongaat-La Mercy	Build 132kV Line from La Mercy to Tongaat Sealing End side 5km Twin Elm.	Line	Existing	**12,183**
2011	Southern	Havenside	Add 2x132/11kV 30MVA transfomers and 11kV Switchgear.	Transformer	Existing	**19,404**
2012	Northern	Umdloti Beach	Add 132/11kV 2x30MVA transformers and 11kV Switchgear.	Transformer	Existing	**19,404**
2012	Southern	Ridgeview	Build 132/11kV 4x30MVA Substation.	Substation	Existing	**44,347**
2012	Southern	Ridgeview-Quarry	Build 2x132kV line Quarry to Ridgeview 0.5 Elm.	Line	Existing	**937**
2012	Central	Klaarwater	Upgrade T21/1 with 275/132 315MVA, and Decommission T21/3 250MVA	Transformer	Existing	**38,593**
2012	Northern	Ottawa	New 132/11kV 4x30MVA Substation.	Substation	Existing	**29,415**
2012	Northern	Parlock	New 132kV switching station with 12x 132kV feeder bays.	Substation	Existing	**14,524**
2012	Southern	Illovo - Kingsburgh	Install 2x132kV Line from Illovo to Kingsburgh	Line	Existing	**4,312**
2012	Southern	Kingsburgh	New 132/11kV 4x 30MVA Substation.	Substation	Existing	**29,415**
2013	Southern	Durban South	Install 275kV Bus Section	Bus section	Existing	**2,916**
2013	Central	Klaarwater-Umgeni	2x132kV 6.2km Twin Yew line.	Line	Existing	**25,182**
2013	Central	Klaarwater	Upgrade T21/3 with 275/132kV 315MVA, Decommission T21/4 250MVA.	Transformer	Existing	**38,593**
2013	Southern	Mondi	Build 132/33kV 2x142MVA Substation.	Substation	Existing	**43,291**
2013	Southern	Mondi - Durban South	Build 2x132kV cable from Durban South to Mondi 3.3km 200MVA cable.	Cable	Existing	**10,266**
2013	Southern	Plangweni	Add 2x30MVA transformers with 11kV switchgear.	Transformer	Existing	**19,404**
2013	Central	Blair Athol	Add 132/11kV 2x30MVA transformers GIS.	Transformer	Existing	**19,404**
2013	Central	Pinetown	Add 2x30MVA transformers and GIS.	Transformer	Existing	**19,404**
2013	Central	Randles	Build 132/11kV 4x30MVA Substation.	Substation	Existing	**44,347**

Planned Year	REGION	Substation	Project Description	Category	Capital Plan Status	Tot Cost (xR1000)
2013	Central	Randles - Loop in-out	Install 2x132kV cable Randles to Berea Park - Durban North 1.3km 200MVA (3x1c XLPE) Cable.	Cable	Existing	**19,818**
2013	Northern	Ridgeside	Build 132/11kV 4x30MVA Substation.	Substation	Existing	**44,347**
2013	Northern	Phoenix North	Add 132/11kV 2x30MVA transformers and 11kV Switchgear.	Transformer	Existing	**19,404**
2013	Northern	Ridgeside-Gateway	Install 2x132kV 2.8km 630mm Al Cable Gateway to Ridgeside Substation.	Cable	Existing	**22,067**
2013	Southern	Umlazi	Add 132/11kV 2x30MVA transformers and 11kV Switchgear.	Transformer	Existing	**19,404**
2014	Central	Klaarwater	Upgrade T21/4 with 275/132kV 315MVA, and Decommission T21/6 250MVA	Transformer	Existing	**38,593**
2014	Southern	Sapref	Build 132/33kV 3x100MVA substation.	Substation	Existing	**61,374**
2014	Southern	Sapref - Durban South (Merewent)	Build 2x132kV line from Durban South (Merewent) to Sapref 1.9km {*(1xc (500 Al/Cu S2 - Oil, CAS*}.	Cable	Existing	**6,416**
2014	Central	Glenwood	Build 132/11kV 2x30MVA Substation.	Substation	Existing	**24,732**
2014	Central	Glenwood - Loop in-out	Build 2x132kV cable Glenwood to Durban North/Mayville 2km 200MVA (3x1c XLPE) Cable.	Cable	Existing	**22,031**
2014	Northern	Springfield	Introduce 132/11kV 2x30MVA Transformation.	Transformer	Existing	**19,696**
2014	Southern	Umbogintwini	Reconfigure substation, replace 2x45MVA 132/33kV by 2x30MVA 132/11kV.	Transformer	Existing	**19,696**
2015	Southern	Reunion	Build 132/11kV 4x30MVA Substation.	Substation	Existing	**47,339**
2015	Central	Bellair	New 275/132kV 3x315MVA substation.	Substation	Existing	**142,234**
2015	Central	Klaarwater	Upgrade T21/6 with 275/132kV 315MVA, and Decommission T21/5 250MVA	Transformer	Existing	**38,593**
2015	Central	Kloof	Build Kloof 132/11kV 2x30MVA Substation.	Substation	Existing	**21,550**
2015	Central	Kloof - Mahogany Ridge	Build 132kV cable Kloof - Mahogany Ridge 4.5km 100MVA cable.	Cable	Existing	**25,664**
2015	Central	Mahogany Ridge	Build 132/11kV 2x30MVA Substation.	Substation	Existing	**24,732**
2015	Central	Mahogany Ridge-Stockville	Build 2x132kV line Stockville Switching Station to Magohany Ridge 2.5km Elm line.	Line	Existing	**4,686**
2015	Central	Underwood	Build 132/11kV 2x30MVA Substation.	Substation	Existing	**24,732**
2015	Central	Underwood-Umgeni	Install 2x132kV Cable from Umgeni to Underwood 3.2km <100MVA cable.	Cable	Existing	**25,275**
2015	Northern	Bridge City	Build 132/11kV 2x30MVA substation.	Substation	Existing	**24,732**
2015	Northern	Bridge City - Phoenix Ind	Build 2x132kV line Phoenix ind to Bridge City 1km Elm line.	Line	Existing	**1,875**
2015	Northern	NCP	Build 132/11kV 2x30MVA substation.	Substation	Existing	**24,732**
2015	Northern	NCP - loop in-out	Build 2x132kV Line NCP - Durban North/Parkhill (Sea Cow Lake) 0.1km Elm.	Line	Existing	**375**
2015	Southern	Austerville	Build 132/11kV 4x30MVA Substation.	Substation	Existing	**44,347**
2015	Southern	Austerville - Engen Tara 2	Install 2x132kV Cable from Austerville to Engen Tara 2	Cable	Existing	**19,712**
2015	Southern	Austerville-Jacobs	Install 2x132kV Cable Austerville - Jacobs 1.7km 200MVA.	Cable	Existing	**29,200**
2015	Southern	Isipingo - Sapref	Install 132kV Cable from Isipingo to Sapref	Cable	Existing	**32,467**
2015	Central	Klaarwater - Stockville	Install 132kV Line from Klaarwater to Stockville	Line	Existing	**7,618**
2015	Southern	Himalayas SS- Austerville	Build 2x132kV 200MVA Himalayas - Austerville cable interconnection	Cable	Existing	**20,872**
2015	Southern	Lotus Park	Add 275/132kV 2x315MVA transformers, and 275kV bus-section.	Transformer	Existing	**80,336**
2015	Southern	Reunion - Isipingo	Build 2x132kV cable from Reunion to Isipingo-Sapref cable, 0.5km 200MVA cable.	Cable	Existing	**14,494**
2010	Central	Edwin Swales SS - Fynnlands	Install 2x132kV Cable from Edwin Swales SS to Fynnlands	Cable	New	**27,881**
2010	Central	Edwin Swales SS - Wentworth	Install 2x132kV Cable from Edwin Swales SS to Wentworth	Cable	New	**5,297**
2011	Southern	Plangweni - Plangweni Pump Station	Install 2x132kV Line from Plangweni to Plangweni Pump Station	Line	New	**937**
2011	Southern	Plangweni Pump Station	Build 132/11kV 4x30MVA Substation	Substation	New	**42,656**
2012	Central	Congella - Dalton	Install 132kV Line from Congella to Dalton	Cable	New	**15,074**
2013	Northern	Ottawa	Add 275/132kV 2x315MVA transformers.	Transformer	New	**76,953**
2013	Southern	Merewent	Decommission Merewent.	Decommissio	New	**1,167**
2014	Central	Assagay	Build 132/11kV 4x30MVA Substation	Substation	New	**44,347**
2014	Central	Stockville	Build Stockville 132kV Switching Station with 8x feeder bays.	Substation	New	**25,543**

Planned Year	REGION	Substation	Project Description	Category	Capital Plan Status	Tot Cost (xR1000)
2014	Central	Stockville - Assagay	Install 132kV Line from Stockville to Assagay	Line	New	12,798
2014	Central	Waterfall - Assagay	Install 132kV Line from Waterfall to Assagay	Line	New	9,446
2014	Northern	Moreland	Add 132/11kV 2x30MVA transformers and 11kV Switchgear	Transformer	New	19,404
2014	Southern	Lotus Park - Isipingo	Install 132kV Cable from Lotus Park to Isipingo	Cable	New	9,856
2015	Central	Stockville - Mahogany	Install 132kV Line from Stockville to Mahogany	Line	New	7,797
2015	Central	Stockville - Mariannridge	Install 2x132kV Line from Stockville to Mariannridge	Line	New	1,462
2016	Central	Bellair - Gyles	Install 132kV Line from Gyles to Bellair - Dalton Road	Cable	New	2,899
2016	Central	Gyles 132kV	Build 132/11kV 2x30MVA Substation	Substation	New	38,800
2016	Northern	Amawoti	Build 132/11kV 4x30MVA Substation	Substation	New	44,347
2016	Northern	Cornubia 1	Build 132/11kV 4x30MVA Substation	Substation	New	44,347
2016	Northern	Ottawa - Amawoti	Install 132kV Line from Ottawa to Amawoti	Line	New	23,147
2016	Northern	Ottawa - Vasu SS	Upgrade existing 2x132kV Ottawa - Vasu SS line to TwinYew	Line	New	8,123
2016	Northern	Vasu SS	Build 132kV Switching Station	Substation	New	25,543
2016	Northern	Vasu SS - Cornubia	Upgrade 2x132kV Vasu - Cornubia to TwinYew	Line	New	8,936
2016	Northern	Vasu SS - Cornubia 1	Install 132kV Cable from Vasu SS to Cornubia 1	Line	New	1,218
2016	Northern	Verulam	Build 132/11kV 4x30MVA Substation.	Substation	New	44,347
2016	Northern	Verulam-Moreland	Install 132kV cable Verulam - Moreland 3km Elm	Cable	New	28,989
2016	Southern	Goloko	Build 132/11kV 4x30MVA Substation	Substation	New	44,347
2016	Central	Rossburgh	Introduce 132/11kV 4x30MVA Transformation and 11kV switchgear.	Transformer	New	48,608
2016	Southern	Sukuma - Goloko	Install 2x132kV Line from Sukuma to Goloko	Line	New	10,477
2017	Central	Berea Central	Build 132/11kV 2x30MVA Substation	Substation	New	38,800
2017	Central	Dalton Road - Berea Central	Install 132kV Line from Dalton Road to Berea Central	Cable	New	8,697
2017	Central	Glenwood - Berea Central	Install 132kV Cable from Glenwood to Berea Central	Cable	New	11,596
2017	Northern	Greenbury	Add 2x132/11kV 30MVA transformersf and 11kV Switchgear.	Transformer	New	19,404
2017	Northern	Ordnance - Alice	Install 132kV Cable from Ordnance to Old Fort - Alice	Cable	New	1,866
2017	Northern	Ordnance Road	Build 132/11kV 2x30MVA Substation.	Substation	New	24,732
2018	Central	Klaarwater - Welbedacht	Install 2x132kV Line from Klaarwater to Welbedacht	Line	New	17,056
2018	Central	Welbedacht	Build 132/11kV 2x30MVA Substation	Substation	New	38,800
2018	Northern	Dube Intake	Build 275/132kV 3x315MVA Substation	Substation	New	148,067
2018	Northern	Dube Intake - Inyaninga	Install 2x132kV Line from Dube Intake to Inyaninga	Line	New	6,091
2018	Northern	Inyaninga	Build 132/11kV 4x30MVA Substation	Substation	New	44,347
2018	Northern	Inyaninga - Tongaat S/E	Install 132kV Line from Inyaninga to Tongaat S/E - La Mercy	Line	New	1,218
2018	Northern	Ottawa - Mersey	Install 275kV Line from Ottawa to Mersey	Line	New	183,578
2020	Central	Umgeni	Build 275/132kV 2x315MVA Substation	Substation	New	107,899
2020	Central	Umgeni - Umgeni S/E	Install 2x275kV Cable from Umgeni to Umgeni S/E	Cable	New	43,632
2020	Central	Umgeni S/E - Hector	Install 2x275kV Line from Umgeni S/E to Hector	Line	New	97,479
2020	Northern	Cornubia 1 - Cornubia 2	Install 132kV Cable from Cornubia 1 to Cornubia 2	Line	New	2,437
2020	Northern	Cornubia 2	Build 132/11kV 4x30MVA Substation	Substation	New	44,347
2020	Northern	Dube Intake - Moreland	Install 132kV Line from Dube Intake to Moreland	Line	New	14,619
2020	Northern	Dube Intake - Verulam	Install 132kV Line from Dube Intake to Verulam	Line	New	3,047
2020	Northern	Dube Trade Port	Build 132/11kV 4x30MVA Substation	Substation	New	44,347
2020	Northern	Dube Trade Port - La Mercy	Install 132kV Line from Dube Trade Port to La Mercy - Ottawa	Line	New	1,218

Planned Year	REGION	Substation	Project Description	Category	Capital Plan Status	Tot Cost (xR1000)
2020	Northern	Vasu SS - Cornubia 2	Install 132kV Cable from Vasu SS to Cornubia 2	Line	New	**3,655**
2021	Northern	Jameson Park	Build 132/11kV 2x30MVA substation.	Substation	New	**24,732**
2021	Northern	Jameson Park - T	Build 2x132kV cable Jameson Park to Durban North/Mayville, 1.2km 200MVA cable.	Cable	New	**6,957**
2022	Northern	Amawoti - Madimeni	Install 132kV Line from Amawoti to Madimeni	Line	New	**43,858**
2022	Northern	Madimeni	Build 132/11kV 2x30MVA Substation	Substation	New	**38,800**
2022	Northern	Madimeni - Waterfall	Install 2x132kV Line from Madimeni to Waterfall	Line	New	**16,569**
2023	Northern	Dube Intake - Lower Tugela	Install 2x132kV line from Dube Intake to Lower Tugela	Line	New	**24,366**
2023	Northern	Lower Tugela	Build 132/11kV 2x30MVA Substation	Substation	New	**42,656**
2023	Northern	Lower Tugela - Tongaat	Install 2x132kV line from Lower Tugela to Tongaat	Line	New	**9,746**
2025	Central	New Klaarwater	Build 400/275/132kV 4x500MVA, 4x600MVA Intake station.	Substation	New	**800,000**
2025	Northern	Amanzimyama	Build 132/11kV 4x30MVA Substation	Substation	New	**44,347**
2025	Northern	Tongaat S/E -Amanzimyama	Install 132kV Line from Amanzimyama to Tongaat S/E - La Mercy	Line	New	**12,183**
2026	Northern	Ottawa - Sibaya	Install 132kV Line from Ottawa to Sibaya	Line	New	**10,234**
2026	Northern	Sibaya	Build 132/11kV 2x30MVA Substation	Substation	New	**38,800**

Table 7-1: eThekwini Transmission Planned Capital Projects

8 TRANSMISSION RISK ASSESSMENT

When assessing the risk of transmission networks special requirements should be incorporated that involves the simulations of operation measures which including load transfers, temporary network reconfigurations and equipment switching. Each of these measures normally causes an incremental change (positive or negative) in system risk. Load transfer, as an example, does not change the total load level in a system but can change the location of the load. This transfer could thus potentially move risk from one area to another or lower the overall risk.

Network reconfigurations and equipment switching actions in operation are associated with a temporary modification of network connections by opening or closing breakers and isolators. This will change power flow distributions and thus system risk. The main benefit of network reconfigurations and equipment switching is the possibility to move part of risk from one area to another with a resulting reduced total risk of the whole system.

Failure Mode Effect Analysis, which attempt to model the operational aspects of the network to allow for a more accurate estimation of system risk.

8.1 Failure Mode Effect Analysis

The objective of the Failure Mode Effect Analysis (FMEA) was to develop network reliability models for representative network configurations and to assess the loss of load expectation for each configuration in an attempt to assess the impact of these interruptions of connected customers.

This approach is a first attempt to use probabilistic analysis to assess the eThekwini Network risk. Figure 8-1 provides the business risk principles consisting of:

- Assessing the Probability of Failure (this is achieved through the FMEA of individual as well as representative substation configurations),
- Calculating the Consequence of Failure (calculation of the Expected Uncerved Energy [EUE] at substation load points), and
- Calculating the Business Risk (calculation of the impact on customers connected to each substation load point),

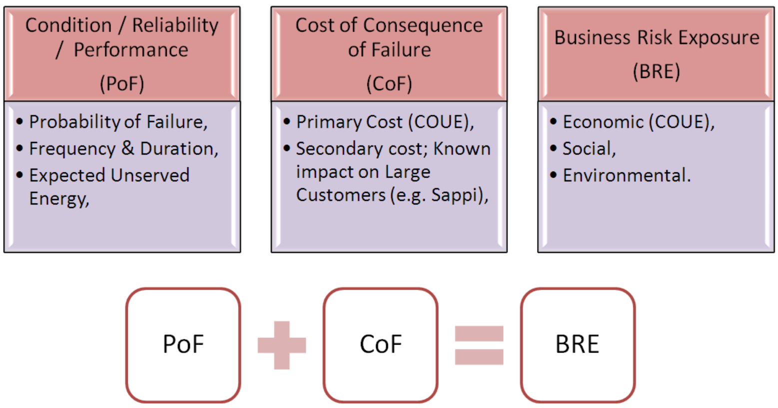


Figure 8-1: Business Risk Assessment

8.2 FMEA Process

The structures and equipment encountered in distribution substations are subject to a variety of uncontrolled conditions. Depending on the characteristics of the condition, customers connected to the network can perceive a number of voltage violations that could include harmonic violations, voltage dips and sustained interruptions. Although sustained interruptions are normally categorized as low probability events, they could impact severely on the system. Sustained interruptions are measured in terms of the frequency, average duration and severity of occurrence.

To quantify this margin of risk encountered within a substation the calculation of probabilistic risk measures are required. These indices are numerical parameters that provide quantitative measures of risk or upper bounds on unavailability. The most basic adequacy indices are provided through three fundamental attributes from which other measures can be derived.

These attributes are:

- Frequency of unacceptable events, (e.g. frequency of circuit overload = 0.5 / year)
- Duration of unacceptable events, (e.g. duration of circuit overload = 6.5 hours / year), and
- Severity of unacceptable events. (e.g. how does event impact on load curtailment)

In order to analyze the frequency and duration of substation related failures, a FMEA test for continuity between the substation source and at least one load outlet or sink. This is done while considering the combinations of possible system states in which the substation components and feeder lines could reside (energized, out of service, breaker stuck, breaker fail etc). All substation components can be in the normal, fault, repair, or maintenance states with the availability measured as the frequency and duration of encountering a specific state.

The systematic identification and evaluation of failure events is achieved through the process shown in Figure 8-2.

Load points are defined as the outgoing feeders of the substation and when interrupted, system failures are caused. The paths between the source and the load points are the continuous paths in the single line diagram of the system through which the load is supplied. All the system states are examined in an appropriate sequence in order to identify minimal cut system failure states.

Once all the minimal cut states up to the chosen highest contingency level have been determined, the system failure probability, frequency and mean duration is computed. The computations for the eThekwini systems were performed within the substation reliability module of the power system simulation tool, PSS/E Rev32.

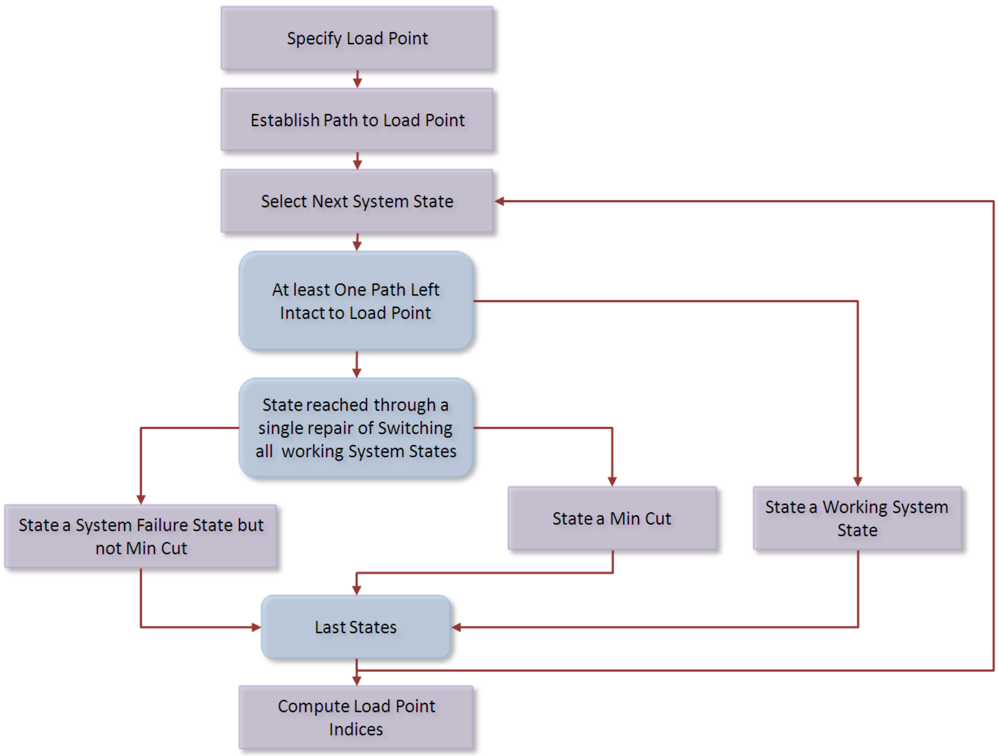


Figure 8-2: Failure Mode Effect Analysis

8.3 Representative Substation Configurations

All substations within the eThekwini network were classified into representative configurations types. The reliability for each of these representative types were modelled and analysed.

Figure 8-3 provides the representative substation configurations encountered within the eThekwini network.

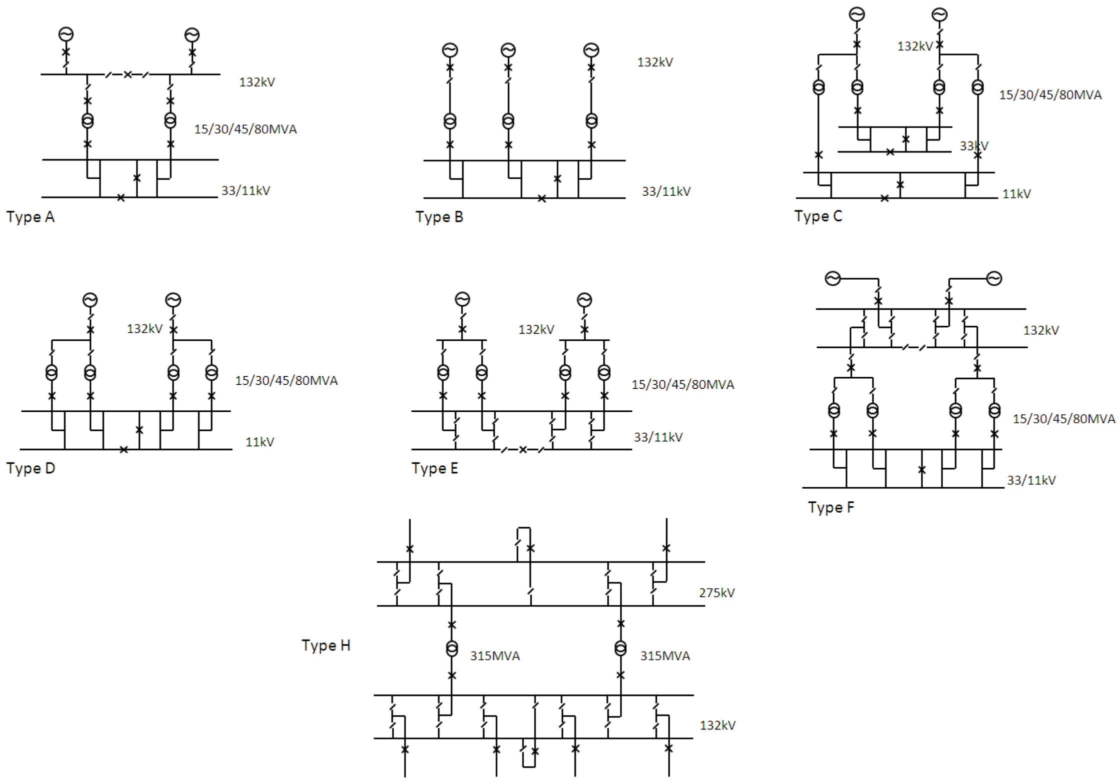


Figure 8-3: Representative eThekwini Substation Configurations

Apart from the representative substation configurations, all supply substations were modelled individually. The PSS/E model for Klaarwater substation is shown in Figure 8-4.

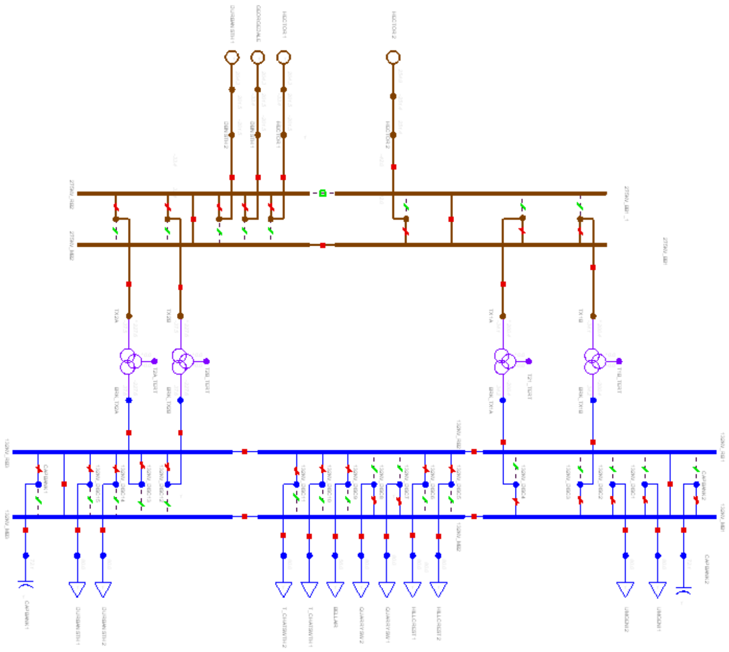


Figure 8-4: Klaarwater Substation Model

8.4 Substation Modeling Assumptions

The following aspects were considered within the substation models:

- Substation configuration or topology and connectivity was modelled,
- Protection philosophy of major equipment and possible switching actions to restore load when load are interrupted, and
- Substation bays or equipment groups which are affected by common mode failures, (e.g. a surge arrestor failure that causes a transformer bay to be tripped).

These aspects can best be shown through the example provided in Figure 8-5.

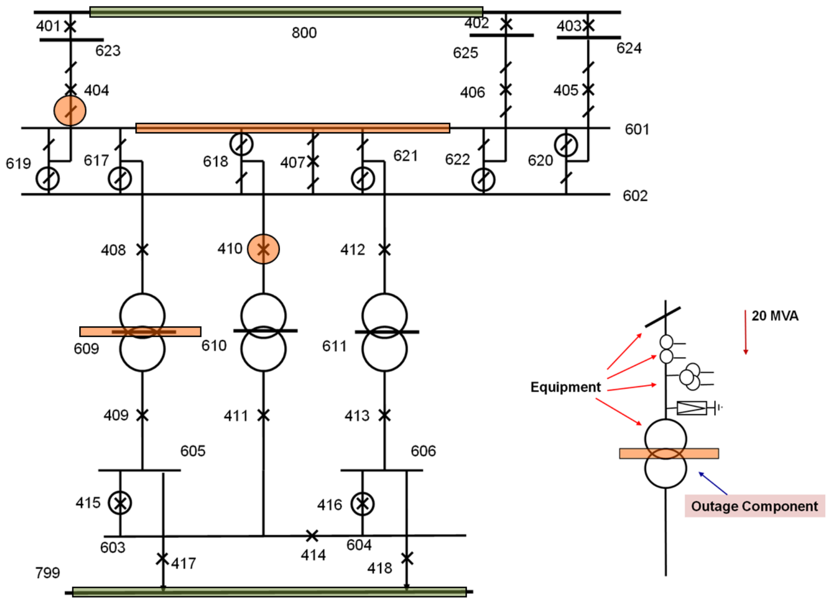


Figure 8-5: Substation Modelling Approach

The primary equipment groups and thus the primary contingencies that were evaluated during the FMEA included:

- The transformers,
- Individual Circuit Breakers (CB), and
- The bus-bars.

The transformer group consisted of the transformer as well as the terminal equipment connected to the transformer. The terminal equipment includes current and voltage transformers and surge arrestors.

The bus-bar group consists of the bus-bar, all the isolators connected to the bus-bar as well as any other terminal equipment which could be present (e.g. Current and Voltage transformers)

The circuit breaker group is modelled as a stand-alone entity with regard to outage statistics, with no terminal equipment forming part of this group.

This flexibility within the model is catered for by:

- Modelling the actual connectivity and normal operational statuses, and

- Incorporating the actual isolator switching time required to restore load after a fault has occurred.

8.5 Customer Presentation

Risk Assessment is primarily focused on the connected customers. The assumption was thus made that the effect of sustained interruptions are experienced differently by different customers.

The word that was done under the eThekwini Demand Forecast Study was used as basis for the definition of customer groups as well as Large Power Users connected to specific substations.

Figure 8-6 provides a spatial view of a typical substation supply area as well as land-use information classifying the customer group being supplied by this substation. The physical locations of large power users (LPU) are also available from this information.

Figure 8-6: Substation Supply Area / Customer Grouping

The simplified customer grouping and associated impact weighting is provided in Table 8-1:

Customer Group	Impact Weight
Agriculture	45
Airport	80
Commercial	80
Education	45
Health	70
Industrial	100
Residential	35
Retail	60
Recreational	35
Other	50

Table 8-1: PowerTransformer Condition Attributes

The impact weighting is a subjective attempt to assess the worth of energy to the various customer sectors.

The ability to assess the worth of service reliability is not well developed within South Africa and current sector information is limited. The determination of reliability worth is a difficult task and therefore direct evaluation is not possible. Customer interruption cost are considered to be a surrogate for the actual worth of service reliability and widely used in its assessment.

The most common index used to link a probabilistic approach with customer interruption cost is the expected energy not supplied (EENS/EUE). Customer interruption cost can be expressed in terms of the cost per unit of unserved energy designated as the interrupted energy assessment rate (IEAR) or the value of lost load (VOLL). The product of EENS and IEAR (VOLL) provides an explicit monetary value associated with the system condition under study and can be used in a wide range of utility decision-making processes.

A further study in support of the network risk assessment should thus include the development of sector reliability worth estimates.

8.6 Substation Risk Calculation

The systematic process to assess the risk per individual substation is provided in Figure 8-7.

Substation Type	• Define Reference Substation Type (Type A – Type H)
Customer Contribution	• Assess the Customer category contribution per substation supply area.
Substation Load	• Establish substation peak load. This value relates to the substation EUE per Substation Type
Reliability Analysis	• Conduct Substation Reliability Analysis
Customer Impact	• Assess Customer Impact based on the calculated EUE, Customer contribution as well as the Customer Weight
Significant LPU's	• Determine which other significant large Power users are supplied from Substation
Assess Impact	• Assess Combined Impact due to EUE as well as Frequency and Duration of sustained interruptions to LPU's
Rank Substations	• Rank Substations according to Impact

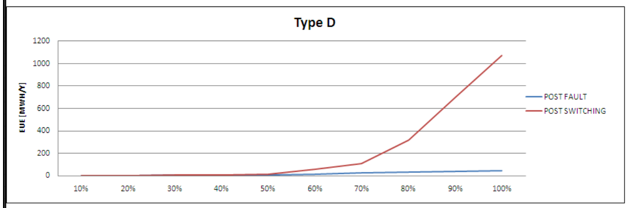
Figure 8-7: Substation Risk Assessment Process

Figure 8-8 below provides the relationship between Substation Load and the Expected Uncerved Energy. This relationship is used to calculate the EUE for each substation based on the representative substation Type as well as the substation peak load.

TypeD

LOADINGS		POST FAULT				POST SWITCHING			
		FREQ.	PROB.	I.P.	E.U.E.	FREQ.	PROB.	I.P.	E.U.E.
%	MVA	(OC/Y)	(H/Y)	(MW/Y)	(MWH/Y)	(OC/Y)	(H/Y)	(MW/Y)	(MWH/Y)
10%	12	0.184	0.18	2.02	2.02	0.068	0.44	0.41	2.62
20%	24	0.184	0.18	4.03	4.03	0.068	0.44	0.82	5.23
30%	36	0.184	0.18	6.05	6.05	0.068	0.44	1.22	7.85
40%	48	0.184	0.18	8.06	8.06	0.068	0.44	1.63	10.46
50%	60	0.184	0.18	10.08	10.08	0.068	0.44	2.04	13.08
60%	72	0.616	0.62	17.28	17.28	0.292	4.15	5.14	60.3
70%	84	0.616	0.62	24.48	24.48	0.292	4.15	8.23	107.52
80%	96	0.616	0.62	31.68	31.68	0.592	31.53	13.13	319.03
90%	108	0.616	0.62	38.88	38.88	0.592	31.53	19.82	694.84
100%	120	0.616	0.62	46.08	46.08	0.592	31.53	26.52	1070.64

Tx 4 x 30MVA : 4	30
Load 2 x 60MVA : 2	60



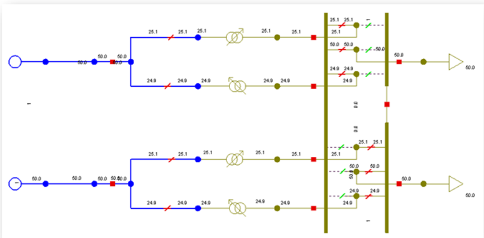


Figure 8-8: Substation EUE vs Substation Load

9 ADDENDUMS

Addendum A: Transmission Planning Code of Practice,

Addendum B: Network Assessment and Recommendations (Presentation Format),

Addendum C: Socio-Economic Development,

Addendum D: Environmental Assessment (EA) of the Study Area,

Addendum E: Substation Audits Summary (Presentation Format),

Addendum F: Supporting Electronic Information,

- ArcGIS Dataset,
- Demand Forecast within PowerGLF,
- Cost Estimates within MS Excel, and
- PSS/E case files,