01 November 2024

Ms. Melanie Geyer

George Municipality

71 York Street,

George

6530

**RE: Electricity Capacity Investigation Proposal for Gwaing WWTW**

Dear Ma'am,

This Grid Impact Study has been commissioned to evaluate the effects of the ultimate load of 4MVA on the existing network's performance and reliability.

The study will be conducted by GLS Consulting, who have been selected due to their existing familiarity with the network and their ongoing appointment with the Municipality for similar services.

This report will detail the methodology used to conduct the study, present the findings, and provide recommendations for any necessary upgrades or improvements to ensure a reliable and high-quality supply of electricity to the treatment plant.

T +27 21 880 0388
E info@gls.co.za
W gls.co.za

Stellenpark, Block D North
Cnr R44 and School Road
Stellenbosch, 7600

Walker Creek Office Park
90 Florence Ribeiro Ave,
Brooklyn
Pretoria

GLS Consulting (Pty) Ltd

# 1. Introduction

## 1.1 Purpose of Grid Impact Study

The primary objective of this study is to ascertain the effects of the 4MVA loads on the existing electrical network. By conducting a thorough analysis, the study aims to identify potential bottlenecks, shortcomings, and necessary upgrading measures to maintain a reliable and high-quality power supply to the treatment plant.

## 1.2 Study Area and Description of Wastewater Treatment Works

The study area encompasses the electrical network supplying the wastewater treatment works, which are located at the along the Gwaing river. See Figure 1-1 below.

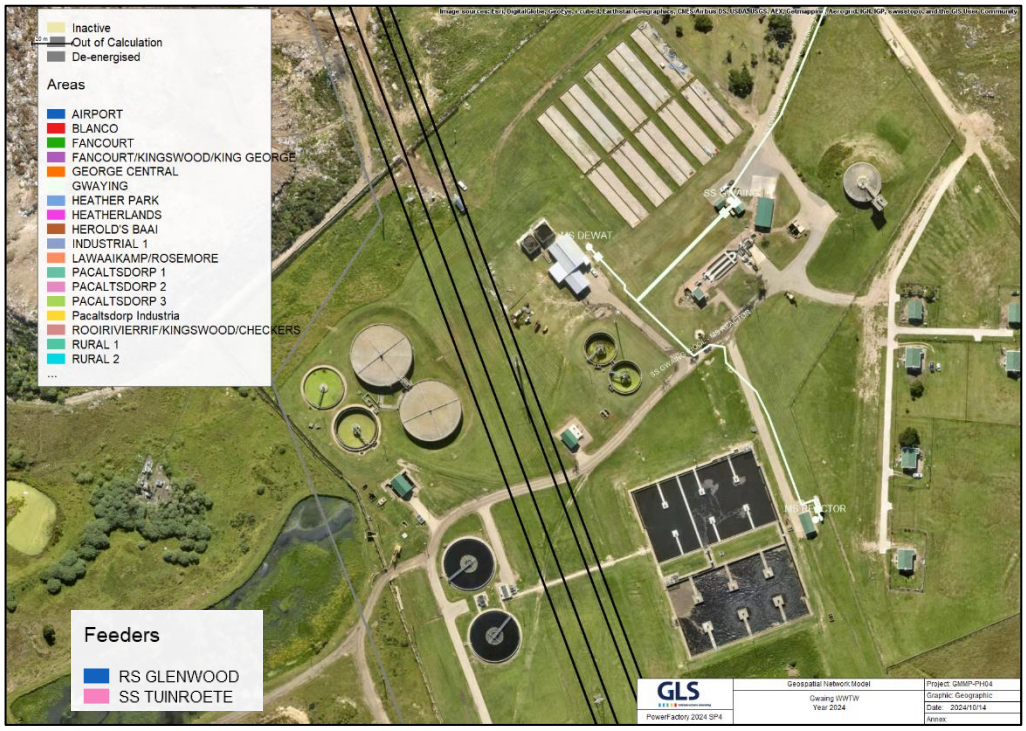



*Figure 1-1: Network Connection at the Wastewater Treatment Works*

As seen on the SLD (Appendix A), SS Gwaing Riool supplies Dewatering and Reactor mini substations as well as TF13 via 70mm2 Copper and 95mm2 Aluminium cables. and No.2 The table below details the existing and future loadings.

*Table 1-1: Existing Infrastructure and Loading*

| Supply | Average Maximum Demand [kVA] | Future Load [kVA] |
|---|---|---|
| **Rioolwerke** | 539 | 4 000 |
| **MS Dewatering** | | |
| **MS Reactor** | | |

## 1.3 Scope of study and Scenarios to be analysed

The ultimate capacity upgrades required for the wastewater treatment works is 4MVA, and this study will assess the viability of this, as well as the impact on the electrical network as below:

- Analyse the effect of the current load on the main and ring feed supplies from the SS-Gwaing Riool substation.
- Identify any bottlenecks, shortcomings.
- Determine any required upgrades to ensure a reliable and high-quality power supply.

By examining this, the study aims to provide a comprehensive understanding of the current and future requirements of the electrical network to support the wastewater treatment works effectively.

# 2. Methodology

The methodology for this Grid Impact Study is designed to thoroughly evaluate the effects of the current and future loads of the wastewater treatment works on the existing electrical network. The study involves data collection, simulation and modelling, and analysis of the electrical network

The following steps outline the detailed approach used in this study:

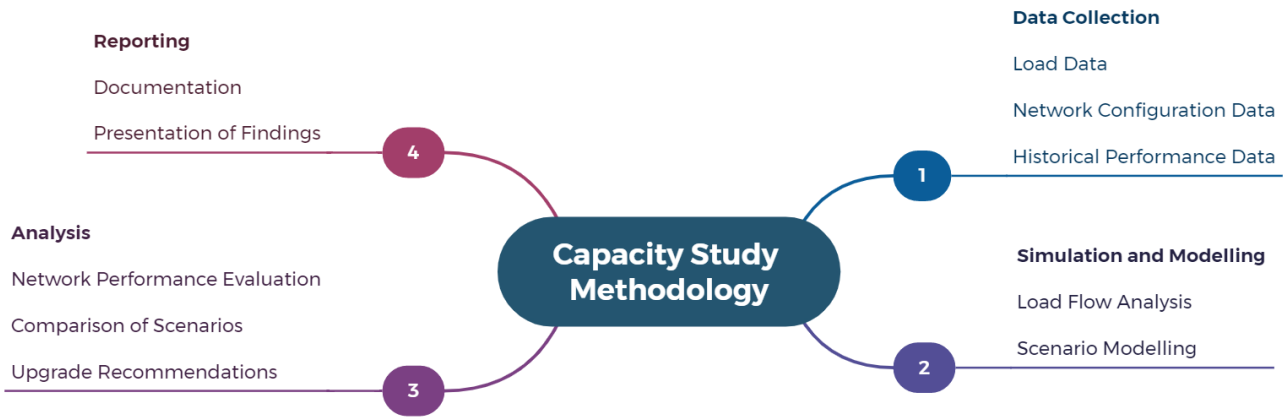



*Figure 2-1: : Capacity Investigation Methodology*

## 2.1 Data Collection

### 2.1.1 Wastewater treatment works Load Data

- Gather detailed specifications and operational data for the plant.
- Obtain current and historical load profiles to understand peak and average demand patterns.

### 2.1.2 Network Configuration Data

- Collect network diagrams, including the layout of the SS-Gwaing Riool, SS-Groeneweide & SS-Links substations, and the main and ring feed supply routes.
- Gather details on existing network components such as transformers, switchgear, and conductors.

### 2.1.3 Historical Performance Data

- Retrieve historical performance data of the electrical network, including voltage levels, power quality metrics, and incident reports.
- Analyse past instances of bottlenecks or reliability issues.

## 2.2 Simulation and Modelling

### 2.2.1 Load Flow Analysis

- Utilize advanced load flow analysis software to model the electrical network.

- Input the collected data, including load profiles and network configuration, into the simulation tool.

### 2.2.2 Scenario Modelling

**Scenario 1: Existing Installation:**

- Model the current load conditions using data received from the municipality with a maximum demand of approximately 0.53 MVA at SS-Gwaing
- Simulate the load impact on both the main and ring feed supplies.

**Scenario 2: Future Installation (4 MVA Load):**

- Model the future load conditions with a combined load of approximately 4 MVA after the planned upgrades to the wastewater treatment works.
- Simulate the future load impact on the electrical network.

**Scenario 3: Future Installation (4 MVA Load including interventions at Proefplaas):**

- Model the future load conditions with a combined load of approximately 4 MVA after the planned upgrades to the wastewater treatment works including interventions at Proefplaas, Protea and Glenwood.
- Simulate the future load impact on the electrical network.

## 2.3 Analysis

### 2.3.1 Network Performance Evaluation

- Assess the impact of the current and future loads on network performance metrics, including voltage levels, power losses, and reliability.
- Identify any existing or potential bottlenecks, shortcomings, and areas requiring immediate attention or upgrades.

The thermal ratings of network components shall not be exceeded under normal or emergency operating conditions when calculated on the following basis:

**Distribution Network Constraints**

The distribution network constraints can be divided into categories of three conditions:

- Constrained network,
- Network nearing limits, and
- Not constrained.

Table 2-1 illustrates these constraints under normal conditions with a colour coding system to distinguish easily were constrained networks need strengthening.

*Table 2-1: The distribution network constraints*

| Criteria | Red | Orange | Green |
|---|---|---|---|
| MV Voltage | ≤ 90% and > 105% | > 90% and < 95% | ≥ 95% and < 105% |
| Maximum thermal line loading | ≥ 100% | > 80% and < 100% | < 80% |

- Red indicates that the voltage and/or thermal limits have been violated and that no additional load can be connected on these networks.
- Orange indicates that a limited amount of load can be connected before limits are reached, however measures need to be put in place to avoid the limits being violated. Upon discussions with the municipality, the consultant was advised to provide upgrades for all lines loaded above 80%
- Green indicates that the network is capable of supplying load and that the limits have not been reached.

### 2.3.2 Comparison of Scenarios:

- Compare the results of the load flow analysis for the existing and future load scenarios.
- Evaluate the differences in network performance and identify the additional strain imposed by the increased load.

### 2.3.3 Upgrade Recommendations:

- Based on the analysis, determine the necessary upgrading measures for both the main and ring feed supplies.
- Prioritize the recommended upgrades and improvements to ensure a reliable and high-quality supply of electricity to the Wastewater Treatment Works

## 2.4 Reporting

### 2.4.1 Documentation:

- Compile the findings, analysis, and recommendations into a comprehensive report.
- Include detailed simulation results, network diagrams, and supporting data in the appendices.

### 2.4.2 Presentation of Findings:

- Present the results and recommendations to relevant stakeholders, including the Municipality and other concerned parties.
- Provide a clear and concise summary of the impact study and the proposed solutions to address any identified issues.

This methodology ensures a thorough and accurate assessment of the impact of wastewater treatment works loads on the electrical network, facilitating informed decision-making for future upgrades and improvements.

# 3. Existing Installation

## 3.1 System Description

The study involves the electrical network that supplies the wastewater treatment works facility, located along the Gwaing river. According to the Gwaing WWTW master plan, the vision for Gwaing WWTW is to change the focus from simply dealing with waste to recovering multiple resources and thereby transitioning it from being a WWTW to a WRRF (Water Resource Recovery Facility), and this makes it an integral part of the of the treatment works for the city of George. This is supplied from the SS Tamsui Feeder zone, which supplies SS-Groeneweide further downstream, then SS-Gwaing which supplies the treatment facility . An alternate network is supplied by SS Links through Feeder bay 1.

### 3.1.1 Electrical Network Configuration Summary

*SS-Groeneweide Substation:*

- Voltage Level: 11kV
- Role: Provides the primary feed to SS-Gwaing substation
- Feeder Bays: Feeder Bay 1 supplies SS Gwaing

*SS-Gwaing Substation:*

- Voltage Level: 11kV
- Role: Distributing power to the wastewater treatment works facility
- Supply Routes: The main supply to the substation is via a feed from the SS-Groeneweide substation, with an alternate feed supply to SS-Gwaing achieved with the SS-Links Feeder via Proefplaas hooflyn.

## 3.2 Load Characteristics

- Load: The worst-case scenario for the total load is approximately 4 MVA.
- Efficiency and Power Factor: The efficiency and power factor of the wastewater treatment works facility are considered to estimate the total load accurately.

### 3.2.1 Scenario 1

#### *3.2.1.1 Normal Operating Conditions*

Table 3-1 below shows that all of the line and cable loadings are within acceptable limits.

*Table 3-1: % Thermal Loading Results*

| Name | Type | Loading Scenario 1 (%) |
|---|---|---|
| **LUGHAWE LYNS_SS GROENE - LUGHAWE LYN** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 46,7 |
| **LUGHAWE LYN_SS GROENE - LUGHAWE LYN** | 11kV Mullberry Overhead Delta 3 11 | 29,8 |
| **LUGHAWE LYN - US20** | 11kV Mullberry Overhead Delta 3 11 | 29,2 |
| **LUGHAWE LYN - PROEFPLAAS LINE** | 11kV Mullberry Overhead Delta 3 11 | 19,8 |
| **LUGHAWE LYN - LB21 S1** | 11kV Mullberry Overhead Delta 3 11 | 19,8 |
| **LUGHAWE LYN - LB21 S2** | 11kV Mullberry Overhead Delta 3 11 | 19,8 |
| **SS GWAING RIOOL - LUGHAWE LYN S3** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underground | 14,8 |
| **SS GWAING RIOOL - LUGHAWE LYN S2** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underground | 14,8 |
| **SS GWAING RIOOL - LUGHAWE LYN S1** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underground | 14,8 |
| **GWAING RL LINE - TF 15/1 (WASTE TRAN) S1** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 14,1 |
| **GWAING RL LINE - TF 17/1 (WASTE PLNT) S1** | 11kV C1 1xPINE 50 11T 0xEW Overhead Delt | 11,9 |
| **GWAING RL LINE - UWLUT18 (KUYLER BOER) 1** | 11kV C1 1xPINE 50 11T 0xEW Overhead Delt | 11,2 |
| **SS LINKS - PROEFPLAAS LYN** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 3,4 |
| **HEATHERPARK - SS LINKS FD2** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 3,4 |
| **GWAING RL LINE - TF 15/1 (WASTE TRAN) S2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 2,3 |
| **PROEPLAAS LYN -US35** | 11kV Mullberry Overhead Delta 3 11 | 2,1 |
| **GWAING RL LINE - UWLUT18 (KUYLER BOER) 2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 1,5 |
| **PROEFPLAAS LYN_UT 19 - US35** | 11kV Mullberry Overhead Delta 3 11 | 1,4 |
| **PROEFPLAAS LYN_UT 19 - UT 9** | 11kV Mullberry Overhead Delta 3 11 | 0,7 |
| **PROEFPLAAS LYN_US35 - UT35/3** | 11kV Mullberry Overhead Delta 3 11 | 0,7 |
| **GWAING RL LINE - TF 17/1 (WASTE PLNT) S2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 0,7 |

Table 3-2 below presents the per unit bus voltage results of the analysis which are within acceptable limits for the existing installation.

*Table 3-2: Per Unit Bus Loading Results*

| Substation | Busbar | Scenario 1 Voltage [p.u.] |
|---|---|---|
| **SS GWAING RIOOL** | 11 BB1 | 0,986 |
| **SS GROENEWEIDE** | 11 BB2 | 1,005 |
| **SS GROENEWEIDE** | 11 BB1 | 0,995 |
| **SS LINKS** | 11 BB2 | 1,022 |
| **SS LINKS** | 11 BB1 | 1,022 |

#### *3.2.1.2 Contingency*

Should the municipality lose the Lughawe Lyn (via feeder 1 at SS Groeneweide), the WWTW would receive power through Proefplaas Lyn (via feeder 1 at SS Links).

*Table 3-3: Contingency Results*

| Name | Type | Loading Scenario 1 (%) |
|---|---|---|
| **SS LINKS - PROEFPLAAS LYN** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 49,3 |
| **HEATHERPARK - SS LINKS FD2** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 49,3 |
| **PROEPLAAS LYN -US35** | 11kV Mullberry Overhead Delta 3 11 | 31,4 |
| **PROEFPLAAS LYN_UT 19 - US35** | 11kV Mullberry Overhead Delta 3 11 | 30,7 |
| **PROEFPLAAS LYN_UT 19 - UT 9** | 11kV Mullberry Overhead Delta 3 11 | 29,9 |
| **UT 9 (PROEFPLAAS PS) - LUGHAWE LYN T-OF** | 11kV Mullberry Overhead Delta 3 11 | 29,2 |
| **SS GWAING RIOOL - LUGHAWE LYN S3** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underground | 14,9 |
| **SS GWAING RIOOL - LUGHAWE LYN S2** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underground | 14,9 |
| **SS GWAING RIOOL - LUGHAWE LYN S1** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underground | 14,9 |
| **GWAING RL LINE - TF 15/1 (WASTE TRAN) S1** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 14,1 |
| **GWAING RL LINE - TF 17/1 (WASTE PLNT) S1** | 11kV C1 1xPINE 50 11T 0xEW Overhead Delt | 11,9 |
| **GWAING RL LINE - UWLUT18 (KUYLER BOER) 1** | 11kV C1 1xPINE 50 11T 0xEW Overhead Delt | 11,3 |
| **LUGHAWE LYN - LB21 S2** | 11kV Mullberry Overhead Delta 3 11 | 10,1 |
| **LUGHAWE LYN - LB21 S1** | 11kV Mullberry Overhead Delta 3 11 | 10,1 |
| **LUGHAWE LYN - PROEFPLAAS LINE** | 11kV Mullberry Overhead Delta 3 11 | 10,1 |
| **GWAING RL LINE - TF 15/1 (WASTE TRAN) S2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 2,3 |
| **GWAING RL LINE - UWLUT18 (KUYLER BOER) 2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 1,5 |
| **PROEFPLAAS LYN_US35 - UT35/3** | 11kV Mullberry Overhead Delta 3 11 | 0,7 |
| **GWAING RL LINE - TF 17/1 (WASTE PLNT) S2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 0,7 |
| **LUGHAWE LYN - US20** | 11kV Mullberry Overhead Delta 3 11 | 0,5 |

below presents the per unit bus voltage results of the analysis. The per unit busbar loadings are within acceptable limits (0.95p.u – 1.05p.u) for the existing installation as shown above.

*Table 3-4: Per Unit Bus Loading Results*

| Substation | Busbar | Scenario 1 Voltage [p.u.] |
|---|---|---|
| **SS GWAING RIOOL** | 11 BB1 | 0,99 |
| **SS GROENEWEIDE** | 11 BB2 | 0,99 |
| **SS GROENEWEIDE** | 11 BB1 | 0,99 |
| **SS LINKS** | 11 BB2 | 1,01 |
| **SS LINKS** | 11 BB1 | 1,01 |

# 4. Future Installation

## 4.1 System Description

With the planned upgrade of the WWTW to 4MVA ultimately, this leads to a significant increase in demand on the electrical network.

## 4.2 Load Analysis

The increased future load of approximately 4 MVA necessitates a detailed analysis to evaluate its impact on the electrical network. This analysis includes the following components:

- Main Feed Supply: The primary supply route from SS Groeneweide to SS Gwaing Riool substation.
- Alternate Feed Supply: The alternate grid connection route providing a secondary supply to SS Gwaing Riool substation via SS-Links

The load analysis aims to determine if the existing infrastructure can handle the increased demand or if upgrades are required to ensure a reliable and high-quality power supply.

## 4.3 Simulation Results

### 4.3.1 Scenario 2

#### *4.3.1.1 Normal Operating Conditions*

*Table 4-1: % Thermal Loading Results - Scenario 2 – Normal Operating Conditions*

| Name | Type | Loading Scenario 2 (%) |
|---|---|---|
| **SS GROENEWEIDE - SS SAFFIER S1** | 11kV 3C PILC PVC SWA PVC Al 185 | 116,7 |
| **LUGHAWE LYNS_SS GROENE - LUGHAWE LYN** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 112,2 |
| **SS GWAING RIOOL - LUGHAWE LYN S3** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underground | 107,6 |
| **SS GWAING RIOOL - LUGHAWE LYN S2** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underground | 107,6 |
| **SS GWAING RIOOL - LUGHAWE LYN S1** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underground | 107,6 |
| **GWAING RL LINE - TF 15/1 (WASTE TRAN) S1** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 75,1 |
| **GWAING RL LINE - TF 17/1 (WASTE PLNT) S1** | 11kV C1 1xPINE 50 11T 0xEW Overhead Delt | 72,9 |
| **GWAING RL LINE - UWLUT18 (KUYLER BOER) 1** | 11kV C1 1xPINE 50 11T 0xEW Overhead Delt | 72,2 |
| **LUGHAWE LYN_SS GROENE - LUGHAWE LYN** | 11kV Mullberry Overhead Delta 3 11 | 71,4 |
| **LUGHAWE LYN - US20** | 11kV Mullberry Overhead Delta 3 11 | 70,9 |
| **LUGHAWE LYN - PROEFPLAAS LINE** | 11kV Mullberry Overhead Delta 3 11 | 20,4 |
| **LUGHAWE LYN - LB21 S1** | 11kV Mullberry Overhead Delta 3 11 | 20,4 |
| **LUGHAWE LYN - LB21 S2** | 11kV Mullberry Overhead Delta 3 11 | 20,4 |
| **SS LINKS - PROEFPLAAS LYN** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 3,4 |
| **HEATHERPARK - SS LINKS FD2** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 3,4 |
| **GWAING RL LINE - TF 15/1 (WASTE TRAN) S2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 2,3 |
| **PROEPLAAS LYN -US35** | 11kV Mullberry Overhead Delta 3 11 | 2,1 |
| **GWAING RL LINE - UWLUT18 (KUYLER BOER) 2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 1,6 |
| **PROEFPLAAS LYN_UT 19 - US35** | 11kV Mullberry Overhead Delta 3 11 | 1,4 |
| **PROEFPLAAS LYN_UT 19 - UT 9** | 11kV Mullberry Overhead Delta 3 11 | 0,7 |
| **PROEFPLAAS LYN_US35 - UT35/3** | 11kV Mullberry Overhead Delta 3 11 | 0,7 |
| **GWAING RL LINE - TF 17/1 (WASTE PLNT) S2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 0,7 |

Table 4-1 above shows that most lines are within acceptable limits, except for the underground cables along the Gwaing – Lughawe network and feeder 1 and 2 of SS-Groeneweide.

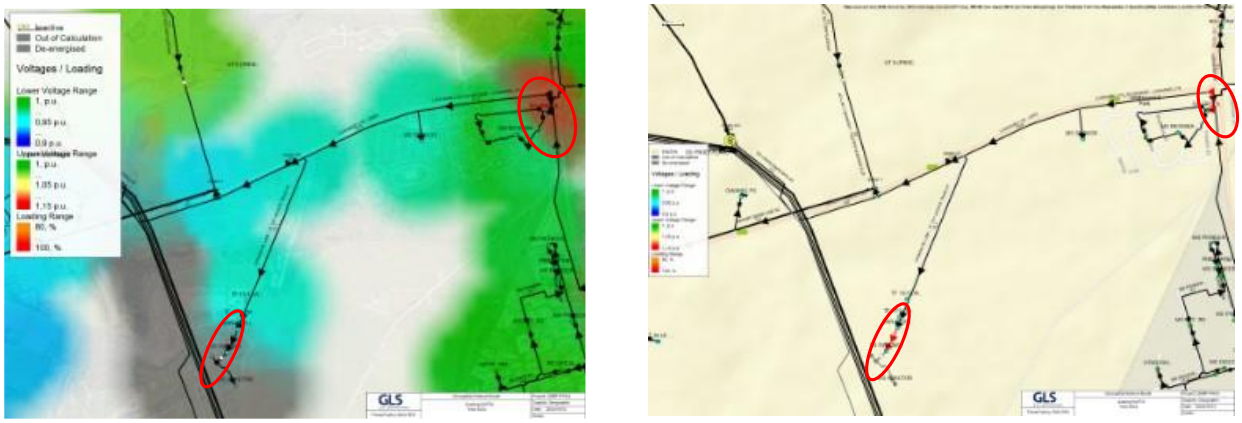


*Figure 4-1: Heatmap & Loading Results*

Table 4-2 below presents the per unit bus loading results of the analysis which are all within acceptable limits.

*Table 4-2: Per Unit Bus Loading Results – Scenario 2 – Normal Operating Conditions*

| Substation | Busbar | Scenario 2 Voltage [p.u.] |
|---|---|---|
| **SS GROENEWEIDE** | 11 BB1 | 1,02 |
| **SS GWAING RIOOL** | 11 BB1 | 1,02 |
| **SS LINKS** | 11 BB1 | 0,95 |
| **SS GROENEWEIDE** | 11 BB2 | 0,97 |
| **SS LINKS** | 11 BB2 | 1 |

#### *4.3.1.2 N-1 Contingency*

Should the municipality lose the Lughawe Lyn (via feeder 1 at SS Groeneweide), the WWTW would receive power via Proefplaas Lyn (via feeder 1 at SS Links). Taking into consideration the planned upgrades identified in the 2024 Master Plan, the below results were recorded.

*Table 4-3: Contingency Thermal Loading Results – Scenario 2 – N-1 Contingency*

| Name | Type | Loading Scenario 2 (%) |
|---|---|---|
| **SS LINKS - PROEFPLAAS LYN** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 114,8 |
| **HEATHERPARK - SS LINKS FD2** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 114,8 |
| **SS GWAING RIOOL - LUGHAWE LYN S3** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underground | 108,1 |
| **SS GWAING RIOOL - LUGHAWE LYN S2** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underg | 108,1 |
| **SS GWAING RIOOL - LUGHAWE LYN S1** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underg | 108,1 |
| **GWAING RL LINE - TF 15/1 (WASTE TRAN) S1** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 75,4 |
| **GWAING RL LINE - TF 17/1 (WASTE PLNT) S1** | 11kV C1 1xPINE 50 11T 0xEW Overhead Delt | 73,2 |
| **PROEPLAAS LYN -US35** | 11kV Mullberry Overhead Delta 3 11 | 73,1 |
| **GWAING RL LINE - UWLUT18 (KUYLER BOER) 1** | 11kV C1 1xPINE 50 11T 0xEW Overhead Delt | 72,5 |
| **PROEFPLAAS LYN_UT 19 - US35** | 11kV Mullberry Overhead Delta 3 11 | 72,4 |
| **PROEFPLAAS LYN_UT 19 - UT 9** | 11kV Mullberry Overhead Delta 3 11 | 71,7 |
| **UT 9 (PROEFPLAAS PS) - LUGHAWE LYN T-OF** | 11kV Mullberry Overhead Delta 3 11 | 70,9 |
| **AIRPORT LINE - PROEFPLAAS LINE S2** | 11kV Mullberry Overhead Delta 3 11 | 53,4 |
| **AIRPORT LINE - PROEFPLAAS LINE S3** | 11kV Mullberry Overhead Delta 3 11 | 53,4 |
| **LUGHAWE LYN - LB21 S2** | 11kV Mullberry Overhead Delta 3 11 | 51,7 |
| **LUGHAWE LYN - LB21 S1** | 11kV Mullberry Overhead Delta 3 11 | 51,7 |
| **LUGHAWE LYN - PROEFPLAAS LINE** | 11kV Mullberry Overhead Delta 3 11 | 51,7 |
| **AIRPORT BOND LINE S2** | 11 kV 95mm2 Al ABC 3Core (Eskom) Overhead | 26,3 |
| **AIRPORT BOND LINE S1** | 11 kV 95mm2 Al ABC 3Core (Eskom) Overhead | 26,3 |
| **SS GROENEWEIDE - SS SAFFIER S1** | 6.35/11kV 3C PILC PVC SWA PVC Al 185 | 2,4 |
| **GWAING RL LINE - TF 15/1 (WASTE TRAN) S2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 2,3 |
| **GWAING RL LINE - UWLUT18 (KUYLER BOER) 2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 1,7 |
| **PROEFPLAAS LYN_US35 - UT35/3** | 11kV Mullberry Overhead Delta 3 11 | 0,7 |
| **GWAING RL LINE - TF 17/1 (WASTE PLNT) S2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 0,7 |
| **LUGHAWE LYN - US20** | 11kV Mullberry Overhead Delta 3 11 | 0,5 |

*Table 4-4: Per Unit Bus Loading Results – Scenario 2 – N-1 Contingency*

| Substation | Busbar | Scenario 2 Voltage [p.u.] |
|---|---|---|
| **SS GWAING RIOOL** | 11 BB1 | 0,952 |
| **SS GROENEWEIDE** | 11 BB2 | 0,995 |
| **SS GROENEWEIDE** | 11 BB1 | 0,995 |

| Substation | Busbar | Scenario 2 Voltage [p.u.] |
|---|---|---|
| **SS LINKS** | 11 BB2 | 1,005 |
| **SS LINKS** | 11 BB1 | 1,014 |

Table 4-4 above shows per unit bus loading results of the analysis falling within acceptable results.

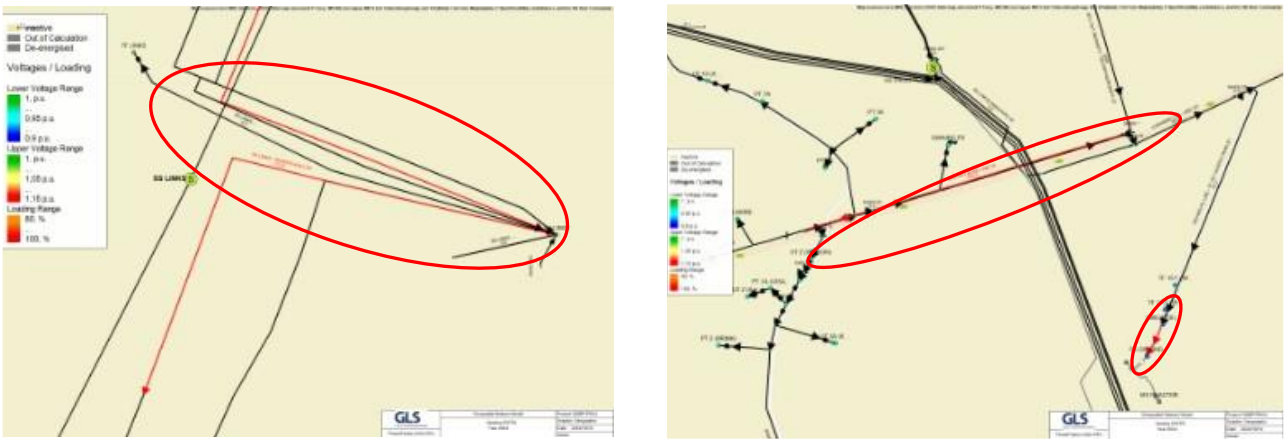


*Figure 4-2: Before Upgrades – Resultant Loadings*

Figure 4-2 above depicts the results of the study before the recommended upgrades. The image on the left shows the overloaded feeders at SS links while the image on the right shows the overloaded airport/Lughawe line supplying SS Gwaing (SS Gwaing Riool – Lughawe line).

### *4.3.1.3 Recommendations*

To resolve the thermal loading reported above, the below upgrades are recommended. Under N-1, the constraints identified under normal conditions are exacerbated ,resulting in additional constraints which require upgrades as below.

*Table 4-5: Scenario 2 Thermal Loading Upgrade Results*

| Name | Scenario 2 Type | | Loading (%) | | Cost Estimates |
|---|---|---|---|---|---|
| | Before | After | Before | After | |
| **SS LINKS - PROEFPLAAS LYN** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 11kV 3C PILC PVC SWA PVC Al 400 | 112,9 | 77,1 | R2 229 543,92 1,357 km |
| **HEATHERPARK - SS LINK S FD2** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 11kV 3C PILC PVC SWA PVC Al 400 | 112,9 | 77,1 | |
| **SS GROENEWEIDE - SS S AFFIER S1** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 11kV 3C PILC PVC SWA PVC Al 400 | 116,7 | 76,9 | |
| **LUGHAWE LYNS_SS GRO ENE - LUGHAWE LYN** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 11kV 3C PILC PVC SWA PVC Al 400 | 112,2 | 75,3 | |
| **SS GWAING RIOOL - LUG HAWE LYN** | 11 kV 95mm2 Al PILC 3Core ( Eskom) Underg | 11 kV 240mm2 Al PILC 3Core (GM) | 104,5 | 65,8 | R177 318,52 0,131km |

The total cost estimate of R2 406 862,44 includes engineering fees, material, contracts – labour, contracts -P's & Gs as well as commissioning.

*Table 4-6: Per Unit Bus Loading Results – Scenario 2 – N-1 Contingency Upgrades*

| Substation | Busbar | Scenario 2 Voltage [p.u.] |
|---|---|---|
| **SS LINKS** | 11 BB1 | 1,014 |
| **SS GROENEWEIDE** | 11 BB1 | 0,996 |
| **SS GWAING RIOOL** | 11 BB1 | 0,956 |
| **SS LINKS** | 11 BB2 | 1,008 |
| **SS GROENEWEIDE** | 11 BB2 | 0,995 |

As seen above, the results are within acceptable limits.

### 4.3.2 Scenario 3

The 2024 Master Plan identified a forecasted load growth in Proefplaas, a switching station planned for conversion into an HV/MV substation by relocating the 10MVA transformer situated at SS Protea which in turn will be replaced with the 20 MVA transformer at Glenwood, this was forecasted for June 2023. Should this conversion be completed before the WWTW upgrade is finalised, then the below results will apply. Taking into consideration the planned upgrades identified in the 2024 Master Plan, the below results were recorded.

#### *4.3.2.1 Normal Operating Conditions*

*Table 4-7: Thermal Loading Results – Scenario 3 - Normal Operating Conditions*

| Name | Type | Loading Scenario 3 (%) |
|---|---|---|
| **SS GWAING RIOOL - LUGHAWE LYN S3** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underg | 111,2 |
| **SS GWAING RIOOL - LUGHAWE LYN S2** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underg | 111,2 |
| **SS GWAING RIOOL - LUGHAWE LYN S1** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underg | 111,2 |
| **GWAING RL LINE - TF 15/1 (WASTE TRAN) S1** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 77,3 |
| **GWAING RL LINE - TF 17/1 (WASTE PLNT) S1** | 11kV C1 1xPINE 50 11T 0xEW Overhead Delt | 75,1 |
| **GWAING RL LINE - UWLUT18 (KUYLER BOER) 1** | 11kV C1 1xPINE 50 11T 0xEW Overhead Delt | 74,5 |
| **LUGHAWE LYN - PROEFPLAAS LINE** | 11kV Mullberry Overhead Delta 3 11 | 50,3 |
| **LUGHAWE LYN - LB21 S1** | 11kV Mullberry Overhead Delta 3 11 | 50,3 |
| **LUGHAWE LYN - LB21 S2** | 11kV Mullberry Overhead Delta 3 11 | 50,3 |
| **LUGHAWE LYNS_SS GROENE - LUGHAWE LYN** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 17,8 |
| **HEATHERPARK - SS LINKS FD2** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 15,1 |
| **SS LINKS - PROEFPLAAS LYN** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 15,1 |
| **LUGHAWE LYN_SS GROENE - LUGHAWE LYN** | 11kV Mullberry Overhead Delta 3 11 | 11,3 |
| **LUGHAWE LYN - US20** | 11kV Mullberry Overhead Delta 3 11 | 11 |
| **PROEPLAAS LYN -US35** | 11kV Mullberry Overhead Delta 3 11 | 9,6 |
| **PROEFPLAAS LYN_UT 19 - US35** | 11kV Mullberry Overhead Delta 3 11 | 9,4 |
| **PROEFPLAAS LYN_UT 19 - UT 9** | 11kV Mullberry Overhead Delta 3 11 | 9,2 |
| **GWAING RL LINE - TF 15/1 (WASTE TRAN) S2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 2,3 |
| **GWAING RL LINE - UWLUT18 (KUYLER BOER) 2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 1,6 |
| **PROEFPLAAS LYN_US35 - UT35/3** | 11kV Mullberry Overhead Delta 3 11 | 0,7 |
| **GWAING RL LINE - TF 17/1 (WASTE PLNT) S2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 0,7 |

*Table 4-8: Per Unit Bus Loading Results – Scenario 3 – Normal Operating Conditions*

| Substation | Busbar | Scenario 3 Voltage [p.u.] |
|---|---|---|
| **SS GWAING RIOOL** | 11 BB1 | 0,979 |
| **SS GROENEWEIDE** | 11 BB2 | 1 |
| **SS GROENEWEIDE** | 11 BB1 | 0,995 |
| **SS LINKS** | 11 BB2 | 1,018 |
| **SS LINKS** | 11 BB1 | 1,018 |

Table 4-8 above shows that the resultant bus loadings are within acceptable limits.


Figure 4-3: Resultant Heatmap

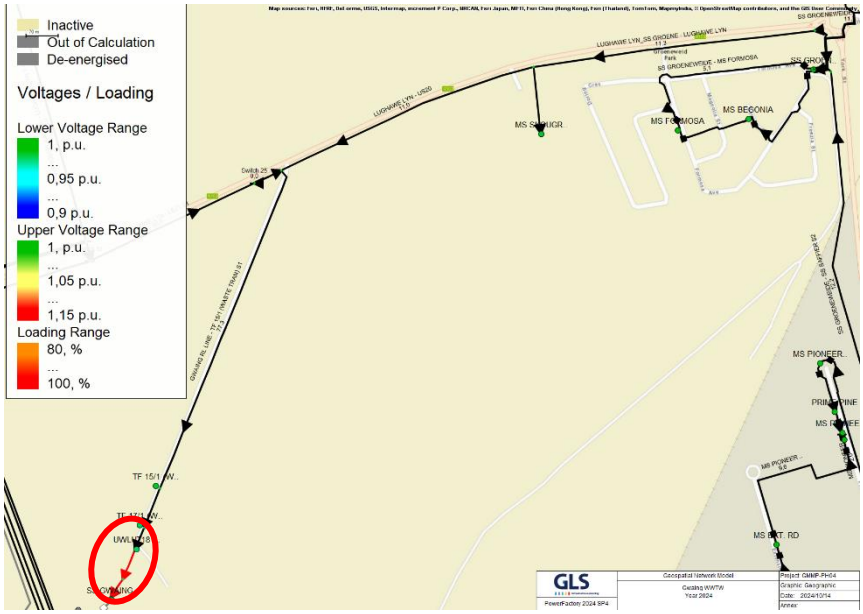



*Figure 4-4: Resultant Loadings*

The circled areas in Figure 4-3 and Figure 4-4 show the overloaded feeder supplying SS-Gwaing Riool from Lughawe Lyn.

### *4.3.2.2 N-1 Contingency*

Should the municipality lose the Lughawe Lyn (via feeder 1 at SS Groeneweide), the WWTW would receive power via Proefplaas Lyn (via feeder 1 at SS Links). Taking into consideration the planned upgrade at Proefplaas, identified in the 2024 Master Plan, the below results will apply

*Table 4-9: Thermal Loading Results – Scenario 3 – N-1 Contingency*

| Name | Type | Loading Scenario 3 (%) |
|---|---|---|
| **SS GWAING RIOOL - LUGHAWE LYN** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underg | 111,6 |
| **GWAING RL LINE - TF 15/1 (WASTE TRAN) S1** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 77,6 |

| Name | Type | Loading Scenario 3 (%) |
|---|---|---|
| **GWAING RL LINE - TF 17/1 (WASTE PLNT) S1** | 11kV C1 1xPINE 50 11T 0xEW Overhead Delt | 75,4 |
| **GWAING RL LINE - UWLUT18 (KUYLER BOER) 1** | 11kV C1 1xPINE 50 11T 0xEW Overhead Delt | 74,8 |
| **LUGHAWE LYN - LB21 S2** | 11kV Mullberry Overhead Delta 3 11 | 53,1 |
| **LUGHAWE LYN - LB21 S1** | 11kV Mullberry Overhead Delta 3 11 | 53,1 |
| **LUGHAWE LYN - PROEFPLAAS LINE** | 11kV Mullberry Overhead Delta 3 11 | 53,1 |
| **AIRPORT LINE - PROEFPLAAS LINE S3** | 11kV Mullberry Overhead Delta 3 11 | 35,2 |
| **AIRPORT LINE - PROEFPLAAS LINE S2** | 11kV Mullberry Overhead Delta 3 11 | 35,2 |
| **AIRPORT BOND LINE S2** | 11 kV 95mm2 Al ABC 3Core (Eskom) Overhead | 25 |
| **AIRPORT BOND LINE S1** | 11 kV 95mm2 Al ABC 3Core (Eskom) Overhead | 25 |
| **UT 9 (PROEFPLAAS PS) - LUGHAWE LYN T-OF** | 11kV Mullberry Overhead Delta 3 11 | 19 |
| **HEATHERPARK - SS LINKS FD2** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 18,5 |
| **SS LINKS - PROEFPLAAS LYN** | 11 kV 185mm2 Al PILC 3Core (Eskom) Under | 18,5 |
| **PROEPLAAS LYN -US35** | 11kV Mullberry Overhead Delta 3 11 | 11,8 |
| **PROEFPLAAS LYN_UT 19 - US35** | 11kV Mullberry Overhead Delta 3 11 | 11,7 |
| **PROEFPLAAS LYN_UT 19 - UT 9** | 11kV Mullberry Overhead Delta 3 11 | 11,6 |
| **SS GROENEWEIDE - SS SAFFIER S1** | 11kV 3C PILC PVC SWA PVC Al 185 | 2,4 |
| **GWAING RL LINE - TF 15/1 (WASTE TRAN) S2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 2,2 |
| **GWAING RL LINE - UWLUT18 (KUYLER BOER) 2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 1,6 |
| **PROEFPLAAS LYN_US35 - UT35/3** | 11kV Mullberry Overhead Delta 3 11 | 0,7 |
| **GWAING RL LINE - TF 17/1 (WASTE PLNT) S2** | 11kV C1 1xPINE 50 11V 0xEW Overhead Delt | 0,7 |

As can be seen in the above results, SS Gwaing Riool - Lughawe Lyn is the only cable overloading in this scenario while all others are within acceptable limits.

*Table 4-10: Per Unit Bus Loading Results – Scenario 3 – N-1 Contingency*

| Substation | Busbar | Scenario 3 Voltage [p.u.] |
|---|---|---|
| **SS LINKS** | 11 BB1 | 1,017 |
| **SS LINKS** | 11 BB2 | 1,018 |
| **SS GROENEWEIDE** | 11 BB1 | 0,995 |
| **SS GROENEWEIDE** | 11 BB2 | 0,995 |
| **SS GWAING RIOOL** | 11 BB1 | 0,983 |

Table 4-10 above shows that all voltages are within acceptable limits in the contingency scenario.

### *4.3.2.3 Recommendations*

To resolve the thermal loading violations seen in the SS Gwaing Riool - Lughawe line in this scenario , the below upgrades are recommended:

*Table 4-11:Scenario 3 Upgrades*

| Name | Scenario 3 Type | | Loading (%) | | Cost Estimates |
|---|---|---|---|---|---|
| | Before | After | Before | After | |
| **SS GWAING RIOOL - LUG HAWE LYN** | 11 kV 95mm2 Al PILC 3Core (Eskom) Underground | 11 kV 240mm2 Al PILC 3Cor e | 111,6 | 67,7 | R177 318,52 0,1319km |

The total cost estimate of R177 318,52 includes engineering fees, material, contracts - labour, contracts -P's & G's as well as commissioning.

*Table 4-12: Per Unit Bus Loading Results*

| Substation | Busbar | Scenario 3 Voltage [p.u.] |
|---|---|---|
| **SS LINKS** | 11 BB1 | 1,017 |
| **SS LINKS** | 11 BB2 | 1,018 |
| **SS GROENEWEIDE** | 11 BB1 | 0,995 |
| **SS GROENEWEIDE** | 11 BB2 | 0,995 |
| **SS GWAING RIOOL** | 11 BB1 | 0,984 |

Table 4-12 above shows the per unit bus loading results of the analysis fall within acceptable limits.

# 5. Conclusions

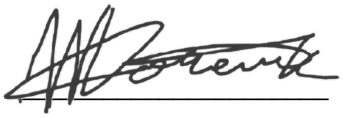
In conclusion, after evaluating the loading conditions and considering the future demand from the planned WWTW upgrades, the upgrades recommended in this report will ensure the reliability and stability of the power supply to the WWTW under normal and contingency operating conditions.

The municipality can confidently proceed with the WWTW improvements, knowing that the backbone feeder network is robust and capable of handling the increased load, thus ensuring continued high-quality service delivery.

We trust you find this of value.

Yours sincerely,

GLS CONSULTING (PTY) LTD REG. NO.: 2007/003039/07



Tsolane Mokoena, Pr Eng

Head of Energy, GLS Consulting

**Email:** Tsolane.Mokoena@gls.co.za

**Tel:** +27 21 880 0388

# 6. Appendices

## 6.1 Appendix A

See attached.