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NEWFOUNDLAND POWER
A FORTIS COMPANY

March 3, 2023

Board of Commissioners
of Public Utilities
P.O. Box 21040
120 Torbay Road
St. John's, NL A1A 5B2

Attention: G. Cheryl Blundon
Director of Corporate Services
and Board Secretary

Dear Ms. Blundon:

Re: 2023 Supplemental Capital Expenditure Application – Memorial Substation Power Transformer Replacement

Please find enclosed an application by Newfoundland Power Inc. ("Newfoundland Power" or the "Company") proposing supplemental capital expenditures of $1,614,000 for the *Memorial Substation Power Transformer Replacement* project (the "Application").

Memorial Substation ("MUN Substation") is a 12.5 kV distribution substation located on Memorial University's St. John's campus (the "University"). MUN Substation has two power transformers, MUN-T1 and MUN-T2. Newfoundland Power was notified by the University in August 2022 that MUN-T2 was experiencing abnormal noise and temperature levels. A subsequent condition assessment determined that MUN-T2 is experiencing a rare form of core deterioration that results in a high probability of failure.

Newfoundland Power has determined that MUN-T2 cannot safely be returned to service. The full load of MUN Substation is currently being carried by MUN-T1, which has been in service for 57 years and has exceeded the typical useful life of a power transformer.

The loss of MUN-T2 reduces the redundancy and operational flexibility available to the University and exposes its operations to an increased risk of outages. A risk assessment confirmed the need to return MUN Substation to its normal configuration to mitigate the increased risk of outages. Newfoundland Power completed an assessment of three alternatives for returning MUN Substation to its normal configuration and determined that replacing MUN-T2 with a new unit is the recommended solution.

The proposed *Memorial Substation Power Transformer Replacement* project involves the procurement and installation of a new 15/20/25 MVA, 66-12.5 kV power transformer to replace MUN-T2 and return MUN Substation to its normal configuration. The estimated cost of this project is $1,614,000 over two years, with $48,000 in 2023 and $1,566,000 in 2024.

Newfoundland Power Inc.
55 Kenmount Road • P.O. Box 8910 • St. John's, NL A1B 3P6
PHONE (709) 737-5500 ext. 6200 • **FAX** (709) 737-2974 • **dfoley@newfoundlandpower.com**

The replacement of MUN-T2 was not included in Newfoundland Power's *2023 Capital Budget Application* as the results of inspections and oil sampling completed at that time appeared normal. Due to extended delivery times for power transformers, deferring this project to the Company's *2024 Capital Budget Application* would expose the University to an increased risk of outages until 2025, which is not recommended.

The Application includes a project description and detailed engineering report in compliance with requirements of the Board's *Capital Budget Application Guidelines (Provisional).* These materials show that the *Memorial Substation Power Transformer Replacement* project is justified as being required to provide safe and reliable service to the University and should be approved.

If you have any questions regarding the enclosed, please contact the undersigned.

Yours truly,

Dominic Foley
Legal Counsel

ec. Shirley Walsh
Newfoundland and Labrador Hydro

Dennis M. Browne, K.C.
Browne Fitzgerald Morgan Avis and Wadden

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IN THE MATTER OF the *Public Utilities Act* (the "Act"); and

IN THE MATTER OF an Application by Newfoundland Power Inc. for the approval of supplemental capital expenditures to proceed with the purchase and installation of a replacement power transformer for Memorial Substation pursuant to section 41(3) of the Act.

TO: The Board of Commissioners of Public Utilities (the "Board")

THE APPLICATION OF Newfoundland Power Inc. (the "Applicant") **SAYS THAT:**

1. The Applicant is a corporation duly organized and existing under the laws of the Province of Newfoundland and Labrador, is a public utility within the meaning of the Act, and is subject to the provisions of the *Electrical Power Control Act, 1994*.

2. The Applicant's Memorial Substation ("MUN Substation" or the "Substation") is a 12.5 kV distribution substation located on Memorial University's St. John's campus (the "University"). MUN Substation supplies power to University buildings through customer-owned switchgear and provides a source of redundant supply for buildings served by Long Pond Substation, including the Health Sciences Centre and Janeway Children's Hospital.

3. MUN Substation has two power transformers, MUN-T1 and MUN-T2. During normal operations, both transformers carry the load necessary to supply the University and provide a source of redundant supply for Long Pond Substation. MUN-T2 is also capable of carrying the full load of MUN Substation in the event of a failure of MUN-T1, thereby providing redundancy within the Substation.

4. MUN-T2 is a 47-year-old, 15/20 MVA, 66-12.5 kV power transformer. Newfoundland Power was notified by the University in August 2022 that MUN-T2 was producing an abnormal noise level during operation and was experiencing a higher than normal internal temperature. MUN-T2 was removed from service and an assessment was performed by an independent consultant. The assessment determined MUN-T2 is experiencing a rare form of core deterioration that exposes it to a high probability of in-service failure. Newfoundland Power has no previous experience with this failure mode.

5. MUN Substation is unique in that it is in close proximity to University buildings. Based on its condition and location, and uncertainties associated with the failure mode, the Applicant has determined that MUN-T2 cannot be returned to service without exposing the University and public to safety risks. The removal from service of MUN-T2 has reduced the redundancy and operational flexibility available to the University and exposes the University to a risk of prolonged outages.

6. Newfoundland Power completed an assessment of three alternatives for returning MUN Substation to its normal configuration and determined that replacing MUN-T2 with a new unit is the recommended solution.

7. The deteriorated condition of MUN-T2 was not known at the time of filing the Applicant's *2023 Capital Budget Application* as inspection and oil sampling results collected at that time appeared normal. Capital expenditures to replace MUN-T2 were therefore not included in that application.

8. The replacement of MUN-T2 with a new power transformer would not affect the execution of any capital projects previously approved by the Board.

9. The replacement of MUN-T2 cannot be deferred until the Applicant's next capital budget application. Delivery times for power transformers currently average 43 weeks, with additional time required for installation, testing and commissioning upon arrival. Deferring the replacement of MUN-T2 until the Applicant's *2024 Capital Budget Application* would defer the installation of a replacement power transformer to 2025. This would expose the University to an increased risk of prolonged outages for an extended period of time.

10. The Application proposes capital expenditures of $1,614,000 for the *Memorial Substation Power Transformer Replacement* project (the "Project"). The Project involves the procurement and installation of a new 15/20/25 MVA, 66-12.5 kV power transformer to replace MUN-T2. The Project would be executed over two years, with $48,000 in capital expenditures in 2023 and $1,566,000 in 2024.

11. Schedule "A" to this Application provides a description of the Project and Schedule "B" provides a detailed engineering report supporting the Project. The information provided in support of the Application is consistent with the requirements of the Board's *Capital Budget Application Guidelines (Provisional),* effective January 2022.

12. The Applicant submits that the proposed expenditures referred to in paragraph 10 hereof are necessary to provide service and facilities that are reasonably safe and adequate and just and reasonable, all as required pursuant to Section 37 of the Act.

13. Communications with respect to this Application should be sent to Dominic Foley, Legal Counsel for the Applicant.

14. **THE APPLICANT REQUESTS** that the Board approve, pursuant to Section 41(3) of the Act, supplemental capital expenditures of $1,614,000 for the purchase and construction of improvements and additions to the Applicant's property as set out in this Application.

DATED at St. John's, Newfoundland, this 3rd day of March, 2023.

NEWFOUNDLAND POWER INC.

Dominic J. Foley
Legal Counsel for the Applicant
Newfoundland Power Inc.
P.O. Box 8910
55 Kenmount Road
St. John's, Newfoundland A1B 3P6

Telephone: (709) 737-5500 ext. 6200
Telecopier: (709) 737-2974

IN THE MATTER OF the *Public Utilities Act* (the "Act"); and

IN THE MATTER OF an Application by Newfoundland Power Inc. for the approval of supplemental capital expenditures to proceed with the purchase and installation of a replacement power transformer for Memorial Substation pursuant to section 41(3) of the Act.

AFFIDAVIT

I, Byron Chubbs, of the Town of Paradise, in the Province of Newfoundland and Labrador, Professional Engineer, make oath and say as follows:

1. THAT I am Vice President, Engineering and Energy Supply of Newfoundland Power Inc.;

2. THAT I have read and understand the foregoing Application; and

3. THAT, to the best of my knowledge, information and belief, all matters, facts and things set out in this Application are true.

SWORN TO before me at the City of St. John's in the Province of Newfoundland and Labrador this 3rd day of March, 2023:

Lindsay S. Hollett
Barrister, NL

Byron Chubbs

PROJECT DESCRIPTION

Title:	**Memorial Substation Power Transformer Replacement**
Asset Class:	**Substations**
Category:	**Project**
Investment Classification:	**Renewal**
Budget (Multi-Year):	**$48,000 in 2023; $1,566,000 in 2024**

PROJECT DESCRIPTION

The *Memorial Substation Power Transformer Replacement* project involves the replacement of power transformer MUN-T2 located at Memorial Substation ("MUN Substation" or the "Substation") in the City of St. John's. Power transformer MUN-T2 is experiencing a rare form of deterioration that creates a high probability of in-service failure. Due to its condition, MUN-T2 has been removed from service to mitigate potential safety risks.

The 2023 and 2024 scope of work for the *Memorial Substation Power Transformer Replacement* project includes:

(i) Designing and procuring a new 15/20/25 MVA, 66-12.5 kV power transformer to replace MUN-T2;
(ii) Dismantling and removing the existing MUN-T2 power transformer;
(iii) Installing and assembling the new power transformer; and
(iv) Completing testing and commissioning of the new power transformer.

The design and procurement of the new power transformer will be completed in 2023. The dismantling of the exiting unit and the installation, testing and commissioning of the new unit will be completed in 2024.

Additional information on this project is provided in Schedule B to the Application, which is a detailed engineering report supporting the project.

PROJECT BUDGET

The budget for the *Memorial Substation Power Transformer Replacement* project is based on a detailed engineering estimate.

Table 1 provides a breakdown of expenditures proposed for 2023 and 2024 for the *Memorial Substation Power Transformer Replacement* project.

Table 1
Memorial Substation Power Transformer Replacement Project
2023/2024 Budget
($000s)

Cost Category	2023	2024
Material	-	1,478
Labour – Internal	-	11
Labour – Contract	-	-
Engineering	48	53
Other	-	24
Total	$48	$1,566

Proposed expenditures for the *Memorial Substation Power Transformer Replacement* project total $1,614,000, including $48,000 in 2023 and $1,566,000 in 2024.

ASSET BACKGROUND

MUN Substation is a 12.5 kV distribution substation located on Memorial University's St. John's campus (the "University"). MUN Substation has had equipment owned and operated by Newfoundland Power Inc. ("Newfoundland Power" or the "Company") since 1966. MUN Substation supplies power to the University through customer-owned switchgear that serves all St. John's campus buildings.

MUN Substation has two power transformers, MUN-T1 and MUN-T2. MUN-T1 is a 57-year-old, 11.125/14.83 MVA, 66-12.5 kV power transformer. MUN-T2 is a 47-year-old, 15/20 MVA, 66-12.5 kV power transformer. Both units have undergone regular maintenance and routine oil sampling to monitor their condition. Oil samples were taken from both transformers in 2022 and did not indicate any concerns at that time.

In August 2022, Newfoundland Power was notified by the University that MUN-T2 was producing a high noise level during operation and was experiencing a higher than normal internal temperature. The unit was removed from service to permit an internal inspection. An independent assessment of the inspection results determined that the abnormal noise and temperature levels were likely caused by deterioration of the core lamination to lamination insulation. This is a rare condition that exposes MUN-T2 to a high probability of failure. Newfoundland Power has not previously experienced this failure mode. There is no standard industry practice to monitor core deterioration.

MUN Substation is relatively unique in that it is located in close proximity to the University's Science Building and Facilities Management Building. As a result, a failure of MUN-T2 could result in damage to substation equipment, customer infrastructure and public property. Based on its condition and location, and uncertainties associated with the identified failure mode, Newfoundland Power has determined that MUN-T2 cannot be returned to service without exposing the University to an unacceptable safety risk.

With MUN-T2 removed from service, the University has lost its typical redundancy and operational flexibility. The University is currently dependent on MUN-T1 to supply the full load on MUN Substation, which represents about half the total load of the University. This exposes the University to the risk of an outage, particularly given that MUN-T1 has exceeded the typical useful life of a power transformer. An outage to the University could be significant, affecting several critical loads and requiring rotating outages to student residences and other buildings until service can be restored.

As detailed in the engineering report provided with the Application, Newfoundland Power has determined that returning MUN Substation to its normal configuration is necessary to mitigate the potential consequences of an outage to the University.

ASSESSMENT OF ALTERNATIVES

Newfoundland Power identified and assessed three alternatives to return MUN Substation to its normal configuration. These are: (i) refurbish MUN-T2; (ii) replace MUN-T2 with a spare unit; or (iii) replace MUN-T2 with a new unit.

The assessment determined that there is no spare power transformer currently available to replace MUN-T2. The remaining alternatives of refurbishing or replacing MUN-T2 with a new unit are both technically viable and comparable in costs. However, the alternative of replacing MUN-T2 with a new unit provides greater benefits, including a longer service life and less maintenance. These benefits were confirmed by an independent consultant with expertise in assessing power transformer failures.

Based on the identified costs and benefits, replacing MUN-T2 with a new unit is the recommended alternative.

It is recommended to commence the replacement of MUN-T2 in 2023. An analysis of market trends showed the average delivery time for power transformers has increased in recent years, reaching up to 43 weeks in 2022. Deferring the replacement of MUN-T2 until Newfoundland Power's *2024 Capital Budget Application* would mean a replacement unit could not be installed until 2025. This would expose the University to an increased risk of prolonged outages for an extended period of time, which would not be acceptable.

RISK ASSESSMENT

The *Memorial Substation Power Transformer Replacement* project is required to maintain safe and adequate facilities at MUN Substation and to mitigate risks to the delivery of reliable service to the University.

The University is Newfoundland Power's largest single customer and its campus provides essential services to the public, including critical healthcare services. MUN Substation provides service to various buildings on the campus, including educational facilities for over 15,000 students and residences housing nearly 1,700 students. A loss of supply to the University could lead to the closure of the majority of campus buildings. Normal operations would be suspended as customer-owned back-up generation is designed only for the operation of life safety systems. Certain buildings, such as residences, contain electric heat and would require rotating outages to maintain heat to those buildings. These conditions could persist for up to three days while Newfoundland Power installs and energizes a portable substation to restore service to the University. Over this period, critical loads supplied by Long Pond Substation, including the Health Sciences Centre and Janeway Children's Hospital, would be without their typical source of redundant supply and would be exposed to increased risk of outages.

MUN-T2 has been deenergized and cannot be returned to service without exposing the University to safety risks. The University is now without its typical redundancy in the event of a failure of MUN-T1. Given MUN-T1 has been in service for 57 years and has exceeded the typical useful service life of a power transformer, the failure of this unit and a subsequent outage to the university is considered possible.

Table 2 summarizes the risk assessment for the *Memorial Substation Power Transformer Replacement* project.

Table 2
Memorial Substation Power Transformer Replacement Project
Risk Assessment Summary

Consequence	Probability	Risk
Critical (5)	Possible (3)	Moderate (15)

Based on this assessment, not proceeding with the *Memorial Substation Power Transformer Replacement* project would pose a Moderate (15) risk to the delivery of safe and reliable service to customers.

JUSTIFICATION

The *Memorial Substation Power Transformer Replacement* project is required to maintain safe and adequate facilities at MUN Substation and to ensure the delivery of reliable service to the University. Completing this project in 2023 and 2024 will return MUN Substation to its normal configuration and mitigate risks to the Company's delivery of safe and reliable service to its largest single customer.

Memorial Substation Power Transformer Replacement

March 2023

Prepared by:

Nicholle Marsh, P. Eng.

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1.0 INTRODUCTION

Memorial Substation ("MUN Substation" or the "Substation") is a 12.5 kV distribution substation located on Memorial University's St. John's campus (the "University"). Newfoundland Power Inc. ("Newfoundland Power" or the "Company") has owned and operated equipment at MUN Substation since 1966. Both MUN Substation and Long Pond Substation ("LPD Substation") supply power to the University through customer-owned switchgear that serves all St. John's campus buildings and provides redundant supply to the buildings in the area of the Health Sciences Centre.[1]

MUN Substation has two power transformers, MUN-T1 and MUN-T2. Power transformer MUN-T2 is experiencing a rare form of deterioration. The transformer was removed from service in August 2022 to prevent potential damage to customer facilities and associated safety risks. An assessment of alternatives determined that MUN-T2 should be replaced.

Newfoundland Power is proposing to replace MUN-T2 over two years commencing in 2023 at an estimated cost of $1,614,000.

2.0 BACKGROUND

MUN Substation is supplied by the 12L/14L 66 kV looped transmission system between King's Bridge and Stamp's Lane substations, as shown in Figure 1.

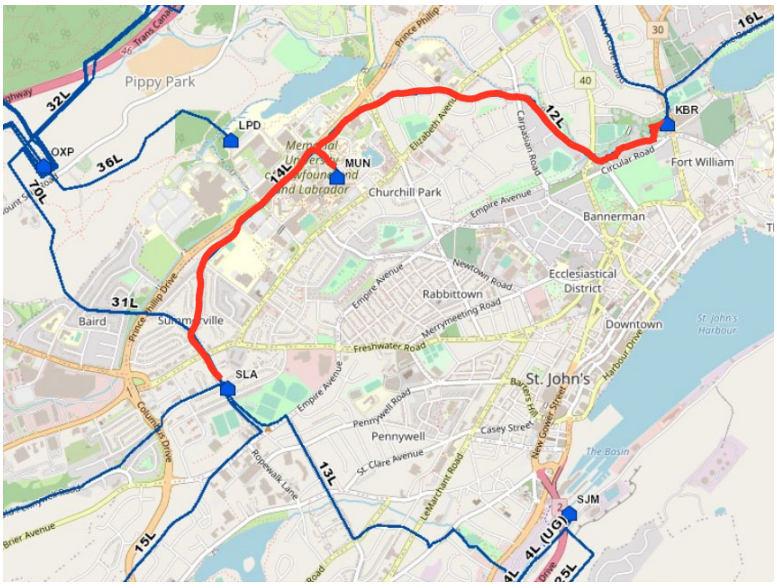

Figure 1: 12L/14L 66 kV Looped Transmission System Map

[1] LPD Substation was built in 2019. The loads normally carried by LPD Substation include the Core Science Facility and the Health Sciences Centre, Janeway Children's Hospital, Faculty of Medicine Extension, Animal Resource Centre, Utilities Annex and Molecular Imaging.

Appendices A and B provide a single-line diagram of MUN Substation and its equipment layout, respectively.

MUN Substation has been in operation for 57 years. MUN-T1 is a 57-year-old, 11.125/14.83 MVA, 66-12.5 kV power transformer manufactured by Ferranti-Packard Electric Limited. MUN-T2 is a 47-year-old, 15/20 MVA, 66-12.5 kV power transformer manufactured by Federal Pioneer.

Figure 2 shows MUN-T2.

Figure 2: MUN-T2 Power Transformer

Both power transformers have undergone regular maintenance. MUN-T1 last underwent full maintenance in June 2018 and MUN-T2 in July 2020.[2] Both power transformers have also undergone routine oil sampling to monitor their condition.[3] Oil samples were taken from both

[2] Full transformer maintenance includes an insulation resistance test, dissipation/power factor test, turns ratio test, winding resistance test, tap changer operation testing, and bushing condition inspection. Inspections also check for tank and cooler leaks, cooling fan and pump operation, operation of liquid and winding temperature equipment, oil level, tank pressure, breather operation and controls operation.

[3] Oil sampling includes standard oil tests and dissolved gas in oil analysis. Standard oil tests check for contaminants and moisture, which at unacceptable levels can lower the dielectric strength of oil and cause a fault. Dissolved gas analysis is used to monitor and diagnose internal transformer electrical problems, such as the presence of arcing or poor electrical connections. Certain gases naturally increase as a transformer ages, but can be a sign of excessive temperatures and overloading in newer transformers. Oil sampling and analysis is completed annually to gauge the internal health of transformers.

power transformers in 2022 in accordance with standard maintenance practices. The oil analysis did not indicate any concerns at that time.

In August 2022, Newfoundland Power was notified by the University that MUN-T2 was producing a high noise level during operation and was experiencing a higher than normal internal temperature. An oil sample was drawn and appeared dark in colour.[4]

MUN-T2 was subsequently removed from service and the load was transferred to MUN-T1 to permit a further condition assessment.[5] An additional oil sample was obtained and sent to a laboratory for analysis and diagnostics.[6] The results indicated all gases were within normal limits.

Following the oil analysis, an internal inspection of MUN-T2 was completed to further assess the cause of the abnormal noise and temperature levels. The inspection identified particles in the oil and slight gaps in the core, as shown in Figures 3 and 4.

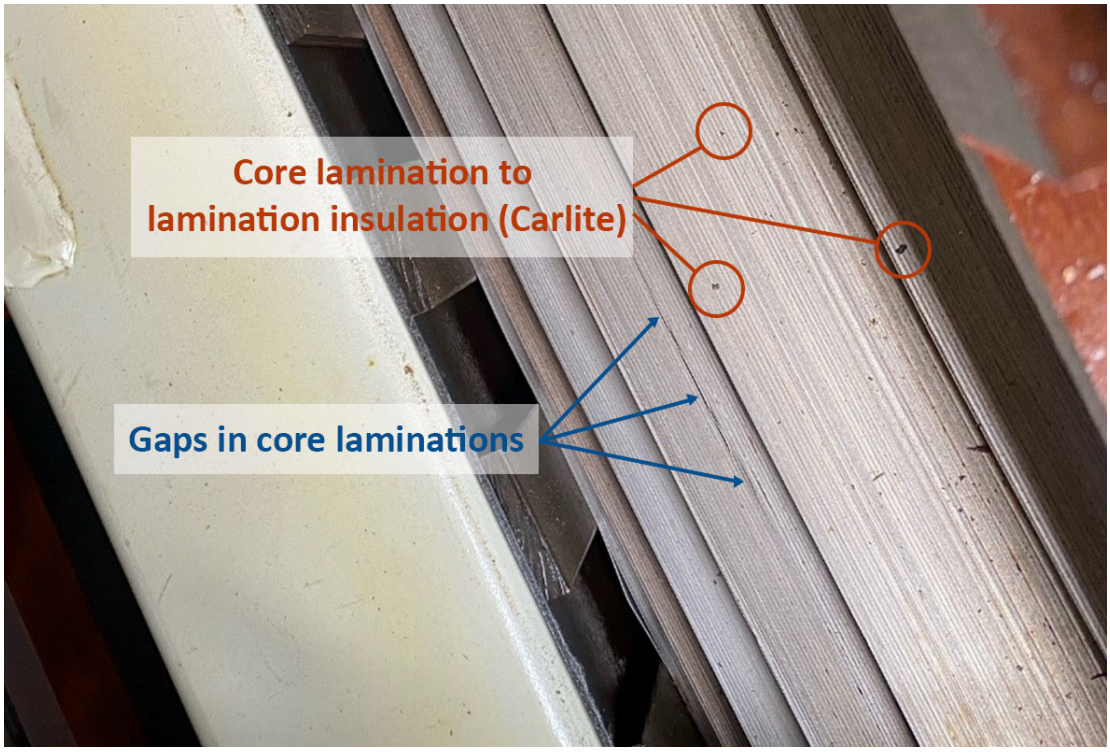

Figure 3: Debris and Gaps Observed in Core Lamination of MUN-T2

4 The colour of oil is monitored as part of the transformer condition assessment. A colour number of 2.5 or greater indicates aging oil and insulation. The colour number of MUN-T2 is 2.5 as of August 2022. Previous to this, the colour number was less than 2.5, indicating no concerns.

5 MUN-T1 was capable of supporting the entire load on MUN Substation as the remaining campus load was being supported by LPD Substation. Without the redundancy provided by LPD Substation, a portable substation would have been required to support the load when MUN-T2 was taken out of service.

6 The analytical laboratory in Calgary, Alberta is owned and operated by TJ/H2b Analytical Services Inc. This company specializes in diagnostic testing of oil, gas and other insulating materials used in transformers, power circuit breakers and load tap changers.

Figure 4: Debris Removed from MUN-T2

The particles were determined to be non-metallic, indicating the high noise level and temperature were likely caused by deterioration of the core lamination to lamination insulation. An independent assessment was performed by van Kooy Transformer Consulting Services Inc. (the "Consultant" or "van Kooy").[7] The Consultant confirmed the operational issues being experienced by MUN-T2 are due to deterioration of the core lamination to lamination insulation.

Appendix C provides the results of the Consultant's assessment.

3.0 RISK ASSESSMENT

Newfoundland Power has no prior record of experiencing a power transformer failure due to core deterioration, which is the case for MUN-T2.

van Kooy confirmed there is currently no standard industry practice used for monitoring core deterioration. A deteriorating core is a rare condition that cannot be monitored while the transformer is still in service. van Kooy has only observed one other instance of this failure mode in its 35-year experience. While there is no industry data to predict with precision the timing of the eventual failure of MUN-T2, industry experience suggests the insulation material between transformer core laminations will continue to break down without the ability to monitor the rate of deterioration.

A further decrease of insulation material will likely lead to additional core vibration. Increased vibrations can cause shifting in the transformer windings, resulting in an internal fault. The severity of this type of fault ranges from a fault between windings tripping the transformer protection to a severe failure that damages other components.

[7] van Kooy is an independent consultant located in Ontario, Canada with over 35 years of experience in conducting power transformer condition assessments.

MUN Substation is relatively unique in that it is located in close proximity to the University's Science Building and Facilities Management Building, as shown in Figure 5.

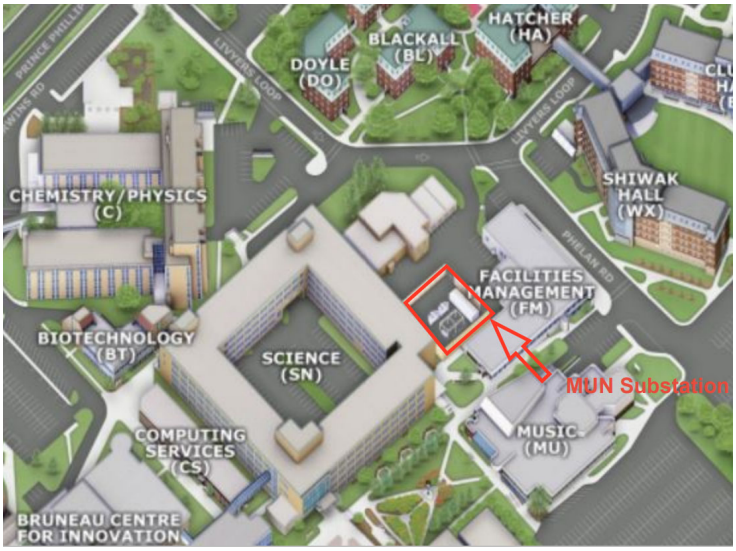

Figure 5: The University Campus Faculty Buildings

This area is frequented by students and staff of the University. A failure of MUN-T2 could result in damage to substation equipment, customer infrastructure and public property.

Based on its condition and location, and uncertainties associated with the identified failure mode, Newfoundland Power has determined that MUN-T2 cannot be returned to service without exposing the University to additional risks of damage and an unacceptable safety risk.

MUN Substation is currently dependent on MUN-T1 to supply its full load, which represents about half the total load of the University.[8] The University has lost its typical redundancy and operational flexibility, which exposes it to a higher risk of outages in the event of a failure of MUN-T1 or LPD Substation. The fact that MUN-T1 has exceeded the typical useful life of power transformers increases the probability of an outage.[9]

An outage to the University could be significant. The University is Newfoundland Power's largest customer and provides various public services. There are over 35 buildings on campus, some of which have critical loads such as the Health Sciences Centre and Janeway Children's Hospital. Over 15,000 students are currently enrolled at this campus and nearly 1,700 students are living in student residences on site.

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8 The current maximum coincident load on MUN Substation and LPD Substation is approximately 19 MVA. Approximately half of this load is able to be transferred from MUN Substation to LPD Substation. The University does not have the distribution infrastructure in place to allow for the transfer of all MUN Substation loads over to LPD Substation.

9 Industry experience suggests the typical useful service life of a power transformer is between 30 and 50 years under ideal conditions. See International Council on Large Electric Systems ("CIGRE"), *Asset Management Decision Making Using Different Risk Assessment Methodologies*, 2013, page 94.

Depending on the length of an outage, a loss of supply to the University could lead to the closure of the majority of campus buildings. Normal operations would be suspended as customer-owned back-up generation is designed only for the operation of life safety systems such as fire alarm, emergency lighting and select electric heat loads.[10] Certain buildings, such as residences, contain electric heat and would require rotating outages to maintain heat to those buildings.

The options available to Newfoundland Power to mitigate the impact of an outage in the event of a failure at MUN Substation are limited.

Typically, when failures occur at substations, the first step considered is to transfer load to an adjacent substation with available capacity and sufficient distribution tie points. In the case of MUN Substation, the load cannot be transferred to another substation due to the absence of sufficient customer-owned distribution tie points.[11]

When a load transfer is not possible, a portable substation is typically installed as a temporary emergency solution. Due to the unique location and configuration of MUN Substation, Newfoundland Power estimates it would require up to three days to install and energize a portable substation. During this time, University operations would likely be suspended.

An additional consideration in this risk assessment is LPD Substation.[12] Under normal operating conditions, the load on LPD Substation consists of the new Core Science Facility, as well as the Health Sciences Centre and surrounding buildings such as the Janeway Children's Hospital. The load of LPD Substation could normally be transferred to MUN Substation. However, with MUN-T2 out of service, the capacity of MUN Substation has been reduced and it is no longer possible to transfer the load from LPD Substation to MUN Substation in the event of a failure at LPD Substation. This leaves critical loads associated with the University without their typical source of redundant supply.

Based on this risk assessment, returning MUN Substation to its normal configuration is necessary to mitigate the potential consequences of an outage to the University.

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10 The University has back-up generation located in 12 buildings across campus. The back-up generation consists of 14 diesel generators ranging from 225 kW to 1,600 kW. Four 800 kW and two 2,180 kW emergency diesel generators are available to provide essential service power to the Health Sciences Centre, the Nuclear and Molecular Medicine Facility and the University Annex.

11 The switchgear located in MUN Substation and all distribution equipment feeding University is owned and operated by the customer. The University does not have the same level of flexibility as Newfoundland Power when transferring load due to limited distribution tie points.

12 LPD Substation was built in 2019 to increase the electrical reliability to the University and provide an increased level of redundancy to the Health Sciences Centre and the University. As all of the 12.5 kV distribution on the campus is customer-owned, the addition of LPD Substation offers the University some flexibility in transferring their distribution system loads between MUN Substation and LPD Substation. This is similar to the flexibility that Newfoundland Power would have on many parts of its distribution system.

4.0 ASSESSMENT OF ALTERNATIVES

4.1 General

Newfoundland Power assessed three alternatives to return MUN Substation to its normal configuration: (i) refurbish MUN-T2; (ii) replace MUN-T2 with a spare unit; or (iii) replace MUN-T2 with a new unit. These alternatives are discussed below.

4.2 Alternative 1 – Refurbish MUN-T2

Power transformer failures are typically caused by internal faults that damage the transformer windings and internal terminations. This is known as a dielectric failure, which is generally detected during routine maintenance. It is often possible to repair a power transformer experiencing a dielectric failure by rewinding the unit, replacing certain components and salvaging the core.

In the case of MUN-T2, the core cannot be salvaged due to the failure mode being experienced. A repair would involve replacing the core and transformer windings, with new windings being wound onto the new core. In order to extend the service life of the repaired unit, auxiliary components would require replacement as well, including external bushings, gauges and lightning arresters.[13]

A cost estimate for refurbishing MUN-T2 was obtained from a third-party repair facility. The cost estimate is $1,572,000.[14] However, as refurbishments of this magnitude are not common, there is potential for cost increases due to unforeseen deterioration that cannot be determined until the unit is factory assessed.

While undertaking the refurbishment would extend the service life of MUN-T2, its service life would still be less than that of a new power transformer. This is because the power transformer tank and radiators would be original to the unit and approaching 50 years in service.[15] The tank and radiators are susceptible to rust over time. Rust is addressed through routine maintenance by sandblasting and painting the tank. This leads to thinning of the metal over time, creating a risk of oil leaks and environmental damage.

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[13] As part of Newfoundland Power's power transformer specification, transformer monitoring devices are also included in these auxiliary components. These devices allow for remote monitoring and alarms of high internal gas and temperature levels. Without these devices, remote monitoring is not possible and internal gas and temperature levels are only able to be read from gauges mounted on the outside of the transformer tank. This monitoring allows the Company to detect early internal gassing and high temperatures. This can help prevent internal faults and extend the service life of a power transformer.

[14] This estimate includes: (i) dismantling and shipping costs; (ii) replacing the transformer core, windings, gauges and bushings; (iii) new monitoring devices and oil; (iv) sandblasting and painting the tank; and (v) onsite assembly and testing.

[15] Radiators are mounted to the outside of the transformer tank and are used to dissipate heat in the oil within the transformer. Radiators are typically designed to have thin metal to help cool the transformer oil. Radiators on older units were supplied without galvanizing and are known to rust and cause leaking.

4.3 Alternative 2 – Replace MUN-T2 with Spare Unit

Newfoundland Power assessed whether it could replace MUN-T2 with a spare unit from its inventory.[16] In order for MUN-T2 to continue to operate in parallel with MUN-T1, the voltage and winding configuration of a replacement transformer must match the existing MUN-T2 and have a sufficient capacity rating. An assessment of the Company's current inventory determined there are no spare power transformers with a 66-12.5kV voltage rating and a delta, wye-grounded winding configuration that also have a sufficient capacity to match the characteristics of MUN-T2.[17] This is therefore not a viable alternative.

4.4. Alternative 3 – Replace MUN-T2 with New Unit

This alternative involves procuring and installing of a new 15/20/25 MVA, 66-12.5 kV power transformer at MUN Substation. The total estimated cost of this alternative is $1,614,000.

As discussed in Alternative 1, replacing MUN-T2 with a new unit would provide a longer service life than refurbishing the unit. There are also operational benefits to replacing MUN-T2 with a new unit as it would require less maintenance. This is because all new power transformers are required to have galvanized radiators, which typically last the lifetime of the transformer, whereas an older refurbished unit would require regular maintenance to maintain the aged tank and radiators.

4.5 Discussion

Two technically viable alternatives have been identified to return MUN Substation to its normal configuration. These are: (i) repair MUN-T2 at an estimated cost of $1,572,000; and (ii) replace MUN-T2 with a new unit at an estimated cost of $1,614,000.

The costs of refurbishing or replacing MUN-T2 are comparable, with of a difference of $42,000 or approximately 3%. The alternative of replacing MUN-T2 with a new unit provides greater benefits than the refurbishment alternative. A new unit would have a longer service life and would require less maintenance.

Newfoundland Power obtained an expert opinion on the potential refurbishment or replacement of MUN-T2 from independent consultant, van Kooy. van Kooy noted that, in comparison to purchasing a new unit, refurbishing MUN-T2 would present a higher risk without any cost savings or other benefits. This is because the quality of work undertaken by a repair facility is generally less than that of an original equipment manufacturer and there would be no cost savings or reduction in delivery times.[18]

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16 As part of the *2023 Capital Budget Application*, procurement of a spare power transformer was approved by the Newfoundland and Labrador Board of Commissioners of Public Utilities. The spare power transformer is a wye-grounded, wye-grounded winding configuration, which gives the most flexibility amongst the Company's fleet. The existing MUN-T2 winding configuration is delta, wye-grounded, meaning the new spare unit is not compatible.

17 The Company currently has four spare power transformers with delta, wye-grounded winding configuration. Out of these four, one has insufficient capacity and three do not have the required voltage rating.

18 See Appendix C, pages 4 to 5.

Based on the identified costs and benefits, replacing MUN-T2 with a new unit is the recommended alternative.

As part of assessing alternatives, Newfoundland Power evaluated whether the procurement of a new power transformer could be deferred until its *2024 Capital Budget Application*. The Company uses a competitive tendering process to procure power transformers. An analysis of market trends shows the average delivery time for power transformers has increased in recent years, from an average of 34 weeks in 2019 to an average of 43 weeks in 2022.[19]

Given typical delivery times, commencing the replacement of MUN-T2 in 2023 would allow a new unit to be installed in 2024. Deferring the replacement of MUN-T2 until Newfoundland Power's *2024 Capital Budget Application* would mean a replacement unit could not be installed until 2025. This would expose the University to an increased risk of prolonged outages for an extended period of time.

Based on these factors, it is recommended to procure a replacement unit for MUN-T2 in 2023 with installation in 2024. Newfoundland Power would monitor the condition of MUN-T1 over this period. If the power transformer begins to show signs of deterioration, the Company would examine what options are available to mitigate the risk of an outage to the University until the Substation can be returned to its normal configuration.[20]

5.0 PROJECT SCOPE AND COST

This project involves purchasing a new 15/20/25 MVA, 66-12.5 kV power transformer to replace MUN-T2 while the existing unit remains out of service due to its deteriorated condition and associated safety risks. The project is proposed to be completed over two years. Year one would include design and procurement, followed by delivery, installation, testing and commissioning in year two.

[19] The analysis was based on delivery times proposed by vendors through Newfoundland Power's competitive tendering process for power transformers over the last 10 years.

[20] For example, Newfoundland Power would evaluate the extended deployment of a portable substation at the University in the event that MUN-T1 begins to exhibit deterioration. This, however, would have consequences for the Company's broader operations, which are exposed to a high risk of power transformer failure due to the age of its fleet. For more information, see the *2023 Capital Budget Application,* report *2.2 Substation Spare Power Transformer Inventory.*

Table 1 provides the cost of the *Memorial Substation Power Transformer Replacement* project.

Table 1
Memorial Substation Power Transformer Replacement Project
2023/2024 Budget
($000s)

Cost Category	2023	2024
Material	-	1,478
Labour - Internal	-	11
Labour - Contract	-	-
Engineering	48	53
Other	-	24
Total	$48	$1,566

The total project cost is estimated to be $1,614,000, including $48,000 in 2023 and $1,566,000 in 2024.

6.0 CONCLUSION

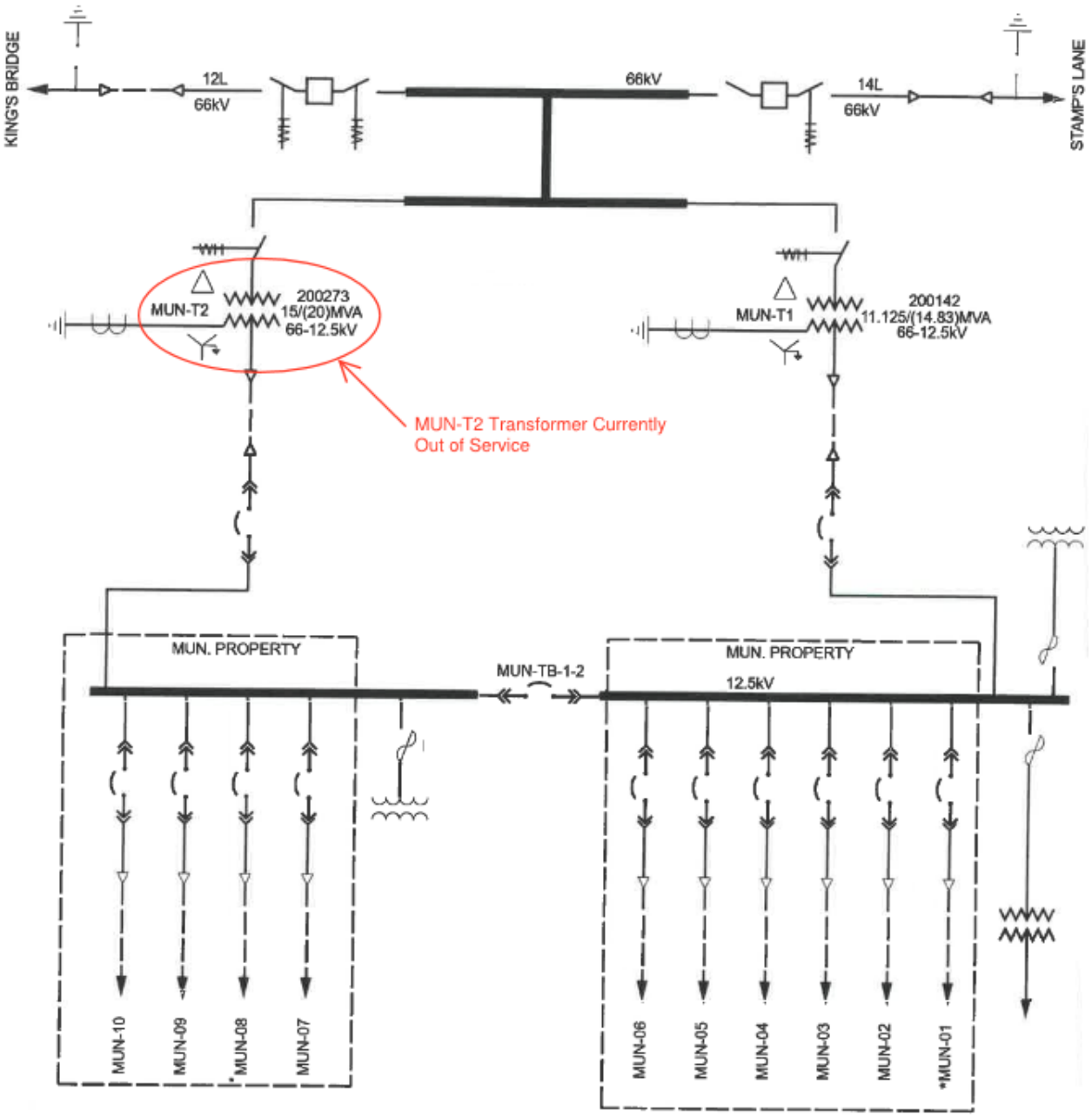
Power transformer MUN-T2 is essential to the safe and reliable operation of MUN Substation and the delivery of reliable service Newfoundland Power's largest single customer, the University. MUN-T2 is experiencing a rare form of core deterioration that will likely lead to failure of the unit. The potential consequences of the unit's failure are significant due to the Substation's close proximity to University buildings. Due to this risk, MUN-T2 cannot safely be returned to service and the University is exposed to a higher risk of outages.

Completing the replacement of MUN-T2 over two years commencing in 2023 is necessary to address the unit's deteriorated condition, return MUN Substation to its normal configuration, and ensure the continued delivery of safe and reliable service to the University. The Company will monitor the condition of MUN-T1 while the project is ongoing to mitigate any further risks to the delivery of safe and reliable service to the University.

APPENDIX A:

Memorial Substation Single-Line Diagram

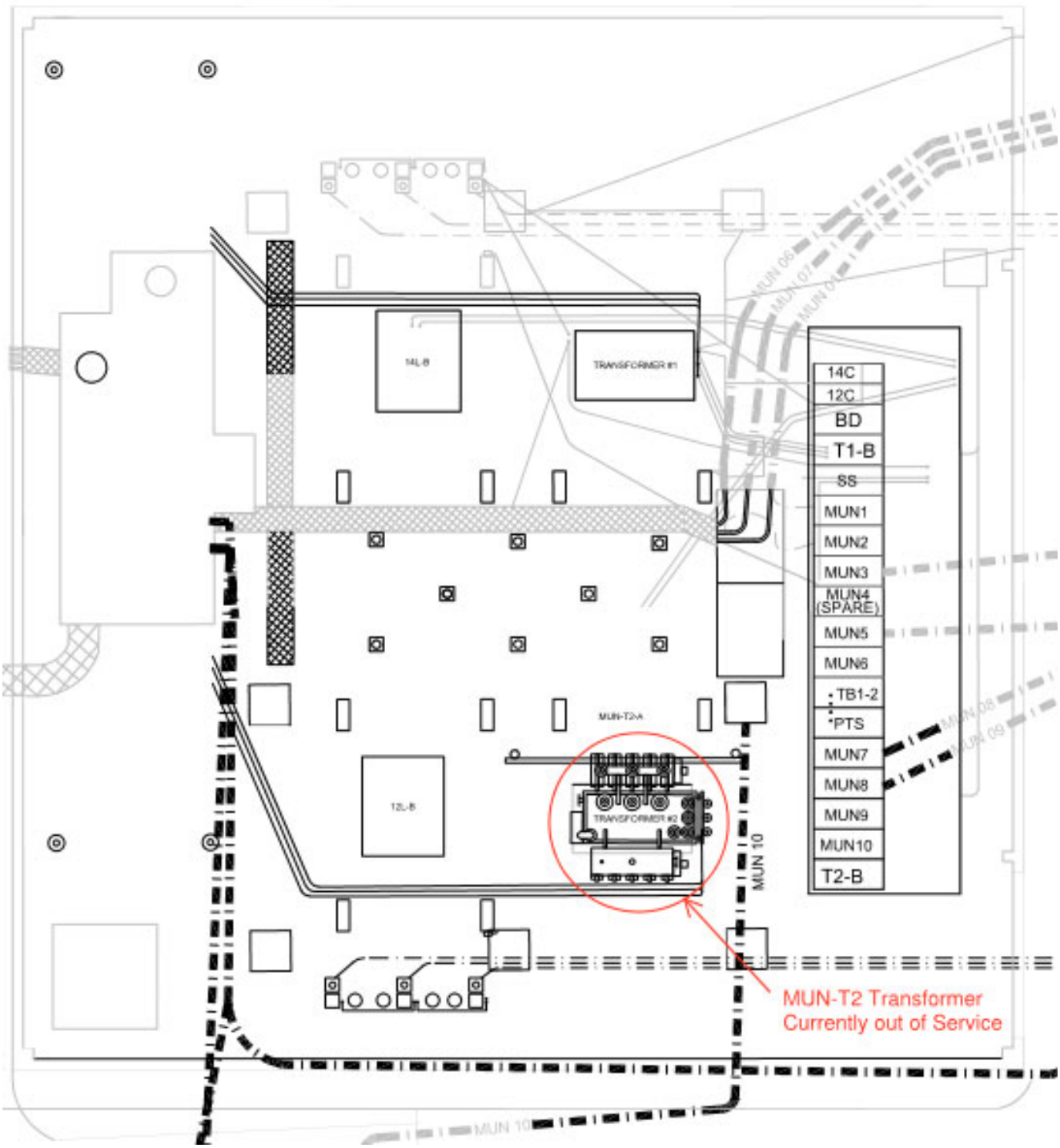
Memorial Substation Single-Line Diagram



APPENDIX B:

Memorial Substation Existing Equipment Layout

Memorial Substation Existing Equipment Layout



APPENDIX C:

van Kooy Transformer Consulting Services Inc. Condition Assessment

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September 8, 2022

To: Nicholle Marsh, Newfoundland Power

Subject: Transformer Condition Assessment
Memorial MUN-T2, CO# 20073
Federal Pioneer S# 64427, Manufactured in 1976
15/20 MVA, ONAN/ONAF Cooling, 65
66 kV Delta w DTC +1, -3 @ 2.5% to 12.47 kV Wye

Executive Summary

Recent events have raised the concern level on this now 46 year old transformer. New evidence of deterioration in combination with the critical need of consistent supply at this location and the difficulty of access, make this transformer a candidate for planned replacement.

Detailed Analysis

Oil Analysis provides key condition monitoring parameters

The Dissolved Gas in Oil Analysis (DGA) measures dissolved gasses in the oil that provide indication of overheating and insulation degradation. The recent DGA results for this transformer do not indicate any significant overheating and the aging, as indicated by the Carbon Monoxide and Carbon Dioxide levels, appears to be normal. We would expect to see higher levels of these carbon gases for this vintage equipment but the results are somewhat skewed because the load has been well below capacity. I expect that the transformer is more aged than the DGA indicates.

General Oil Quality (GOQ) monitors the oil electrical and chemical properties. The recent test results show acceptable electrical properties but the Color Number has hovered between 2.5 and 3. Any value 2.5 or above is an indicator of aging oil and other insulation. In this case the GOQ is more reflective of the 'age' of this equipment.

Recent Events

Starting in mid-August this year, the noise coming from this transformer has noticeably increased. Typically, the noise source in a transformer is the laminated steel core.
It was also noted that the top oil temperature was higher than expected for the loading at time, ~ 15% of maximum capability.

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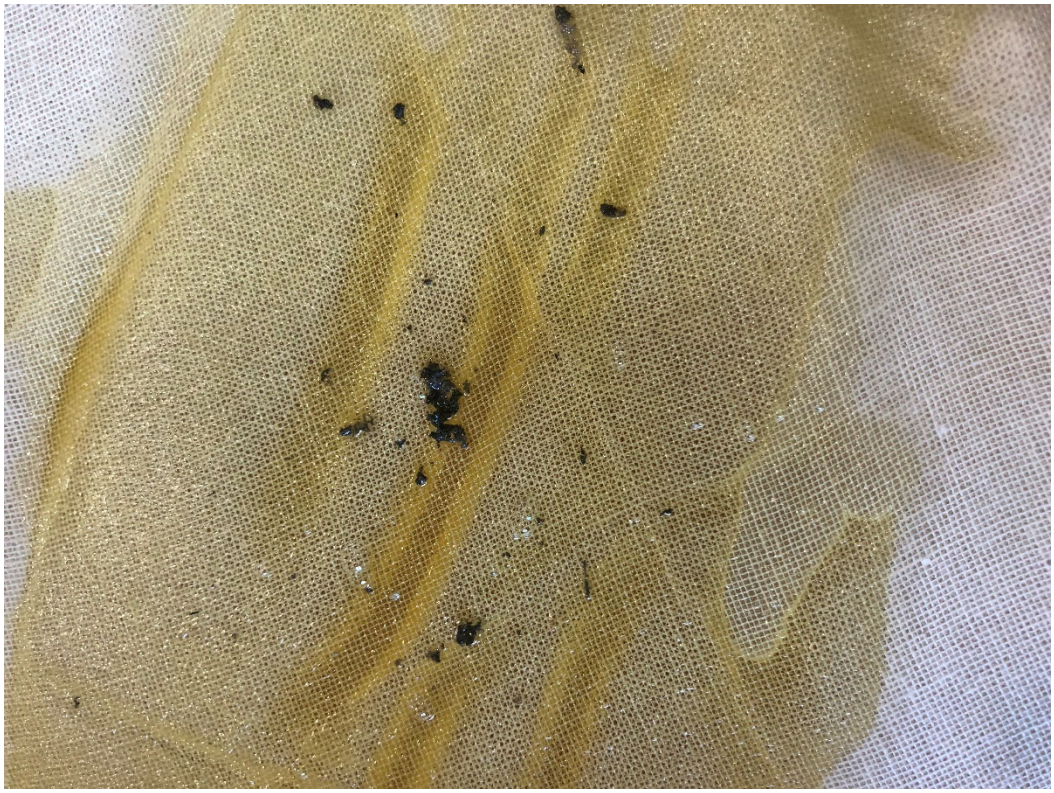
Oil samples taken at the time show various sized particles which is unusual. Some of these particles were filtered out, see picture below.



This led to a de-energization and investigation. Part of this investigation including draining part of the oil and performing an internal inspect from a manhole access on the top of the transformer cover.

During this inspection, more particles were noted on the top of the laminated steel core along with slight gaps in the core sections and indications of core heating.

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From this evidence I conclude that the core lamination to lamination insulation (Carlite) is deteriorating. This has led to the core producing more losses which in turn is creating more heat and more noise. The over heating core could affect the windings which are concentric around the core and lead to winding insulation damage.

In my experience this core deterioration is unusual and I have only seen it one other time. There is no way to track the core deterioration in service or to establish a point beyond which failure is imminent.

It is my understanding that this transformer is feeding critical load with associated equipment close by in an access challenged location.

It is my opinion that it would be prudent to replace this transformer.

This transformer will not be a candidate for repair/rewind because of the suspected core deterioration. Transformer rewind may a viable option but only if the core is reusable which is not the case with this transformer.

Regards,

van Kooy Transformer Consulting Services Inc.

per: Sjoerd (John) van Kooy

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February 16, 2023

To: Nicholle Marsh, Newfoundland Power

Subject: Buy New Versus Repair Evaluation
Memorial MUN-T2, CO# 20073
Federal Pioneer S# 64427, Manufactured in 1976
15/20 MVA, ONAN/ONAF Cooling, 65
66 kV Delta w DTC +1, -3 @ 2.5% to 12.47 kV Wye

Executive Summary

A Repaired/Rewound transformer will not have as long a lifespan as a New transformer. It can make economic/risk sense to repair a transformer if there is significant savings. For this specific transformer that requires the replacement of both major internal components, the Windings and Core, the economics + risk + no difference in delivery time make buying a New Transformer a better decision than Repair.

Detailed Analysis

Although repairing transformers is a common practice, it is understood that the general quality of a repaired/rewound transformer is not of the same quality as a new transformer. There are a number of key processes in the manufacture/major repair of a transformer that include:

- Coil Winding
- Core Stacking
- Core and Coil Assembly
- Transformer Dry-Out
- High Voltage Testing

In addition, other elements of manufacturing including Quality Control, Quality Assurance procedures and application, cleanliness and overall process control contribute to the integrity of the completed product and the longevity of operation.

In all of these factors, an original equipment manufacturer (OEM) will outperform a repair facility.

Why then would a transformer owner consider a major repair? Transformer owners will consider a repair if the cost saving is significant, the turn around time is faster than buying new and the risk of reduced quality is low.

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In the specific case of the MUN-T2 transformer, the transformer core has been compromised so a 'repair' would mean a complete replacement of the winding and core.
This transformer is 47 years old so it would be prudent to replace all external and internal components as well. In addition, the transformer should be retrofitted with the latest monitoring equipment that now comes standard on new transformers. The steel tank shell could be re-used but it will need to be sandblasted and repainted. In the end, I expect this 'repair', with two way transportation, will cost about as much as buying a new transformer.

In today's economy with the escalating price of copper and core steel along with extended deliveries, a repair facility cannot offer delivery faster than an OEM. The OEM will get better deliveries on materials and components because of their larger buying power.

The quality and resultant expected longevity will be less for a transformer refabricated at a repair facility than for a new transformer from an OEM. Warranty may be an issue as well as after sales service.

My recommendation is to replace this transformer rather than contemplate a repair.

Regards,

van Kooy Transformer Consulting Services Inc.

per: Sjoerd (John) van Kooy