NEWFOUNDLAND AND LABRADOR HYDRO

Emergency Response and Restoration

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newfoundland labrador hydro
a nalcor energy company

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Appendices:

EXECUTIVE SUMMARY

Newfoundland and Labrador Hydro (Hydro) has completed a comprehensive review of the events surrounding the supply disruptions on the Island Interconnected System during January 2-8, 2014. The review included an investigation of the rotating outages that occurred between January 2-8, 2014[1] and the transmission/terminal station equipment failures that occurred on January 4 and 5, 2014.

This report provides a detailed description of the events of January 2-8, 2014 from an emergency response and restoration perspective and is followed by key findings and recommendations.

Generally, this review shows that Hydro's personnel responded very well to the events of January 2014. While there are areas for improvement, Hydro was well prepared to address the situation and mobilized its staff effectively and efficiently to deal with the events as they unfolded.

Hydro's planning and preparation prior to the severe weather event was broad and comprehensive. When outages occurred on the morning of January 4, 2014 the local and corporate emergency response plans were utilized and crews responded immediately to the fire at Sunnyside Terminal Station (SSD TS). The safety of the employees and the public remained a top priority through response and restoration activities. The fire was evaluated from a safety and an environmental perspective and a plan was established to manage the situation. In addition to managing the fire, crews also focused on restoring customer power. This involved reconfiguring the station service and re-energizing SSD TS and completing manual switching at various other terminal stations to restore the transmission system. Pre-deployment of staff to plants resulted in fast manual intervention to bring units back in-service,

[1] Rotating outages occurred on January 2, 3, 5 and 8, 2014.

where necessary. A second major disturbance in the afternoon of January 4, 2014 was quickly resolved and the transmission system restored promptly.

Once the transmission system was restored, Units 2 and 3 at the Holyrood Thermal Generating Station were brought back in-service. Unit 1 was delayed due to temporary vibration issues which were investigated and resolved during the incident with the assistance of Alstom, the turbine service contractor.

There was a third major customer disturbance on the evening of January 5, 2014 when attempting to synchronize Holyrood Unit 1 to the system. There was a flash in the Holyrood Terminal Station (Holyrood TS) and all three Holyrood units tripped. Units 2 and 3 were restored early in the morning of January 6, 2014. Additional staff from the Bishop's Falls Office were deployed to relieve and assist local crews on the Avalon. Through a planned and carefully executed investigation the problem was isolated to a failed breaker in the Holyrood TS. This resulted in a safe and uneventful restoration of Holyrood Unit 1 in the afternoon of January 8, 2014 and all customers were restored shortly thereafter.

Based on the findings of this review, the following recommendations are made.

1 Emergency Preparedness

ERR1: Update Severe Weather Preparedness protocol and checklist to capture lessons learned from previous responses and best practices from other utilities.

2 Emergency Response

ERR2: Update emergency response plans with lessons learned from the January 4, 2014 transformer fire and emergency response, including specified methods for dealing with major transformer fires.

ERR3: PCB contents of all oil-filled transformers and equipment should be available in hard copy locally and an alternate location.

3 System Restoration

ERR4: Assess the need and options for additional station service supply for terminal stations in the event of loss of normal supply.

ERR5: Complete lighting improvement plan for the Holyrood plant in 2014.

1 INTRODUCTION

Hydro has completed an internal review of the supply disruptions on the Island Interconnected System for the period January 2 to 8, 2014. This particular report focuses on emergency response and restoration and covers the following areas:

1. Emergency Preparedness;
2. Emergency Response; and
3. System Restoration.

This report reviews how Hydro's emergency response plans were deployed and how decisions were made during the significant equipment outage events. It also looks at how safety and environmental concerns were handled and the effectiveness of Hydro's restoration efforts during challenging times.

2 REVIEW PROCESS

The internal review process was initiated by holding lessons-learned sessions with staff involved in the pre-event preparation, response, and restoration activities during the January 2-8, 2014 supply disruptions. The purpose of the exercise was to review the events to identify things that Hydro did well, in addition to areas to be considered for improvement.

The team also analyzed the sequence of events and emergency preparedness plans. Interviews were conducted with technical and operations personnel to gather additional insights and feedback.

The results of the reviews are mapped out in the Findings and Recommendations section of this report. Immediate concerns were addressed and, where appropriate, implementation status is being documented for longer-term items.

3 BACKGROUND

Hydro has a multifaceted approach to emergency response including corporate emergency response plans and local emergency response plans. Within Hydro, each local area as required, has an Emergency Response Plan (ERP) that describes the roles and responsibilities of personnel involved as they may relate to the various types of emergencies that may occur. A Corporate Emergency Response Plan (CERP) is also in place, which assigns specific responsibilities to individuals within Nalcor Energy's corporate management structure, as needed, during any emergency that may occur (safety, technical, logistic, finance/procurement, employee/family support, environmental, regulatory liaison, media relations, etc.). Within the CERP there are provisions to establish a Corporate Emergency Operations Center (CEOC) at Hydro Place to co-ordinate corporate emergency response activities and support the local response team.

Hydro operates under its documented emergency response plans. These plans include:

1. Local emergency and environmental emergency response plans;
2. Emergency Plans for Generation and Transmission and Rural Operations; and
3. Corporate Emergency Response Plan.

These plans are exercised and regularly reviewed as a function of the requirements of each particular plan.

In addition to a corporate emergency response, Hydro has local on-call[2] personnel, system on-call[3] personnel and an executive on-call[4] (EOC) at all times. These supervisors will co-ordinate response activities to any system or emergency event.

[2] Local On-Call System – Outside of normal operating hours, there is always one person on-call for each division within Hydro. Customer and systems events are channeled through this person from ECC, who then arranges for the dispatch of appropriate response.

[3] System On-Call System – Outside of normal operating hours, there is a manager responsible for coordinating response to broader system issues including generation and transmission system problems.

[4] Executive On-Call System – Outside of normal operating hours, there is an executive member responsible for providing corporate support and determining whether an issue warrants activation of the CERP.

One of the responsibilities of the system on-call person is to contact the EOC and provide information regarding the nature of the incident. The EOC has the authority to activate the CERP and mobilize the CEOC team in full, or in part.

4 SEQUENCE OF EVENTS: RELEVANT TIME FRAME

This section provides an overview of the emergency response and restoration efforts that occurred leading up to and during the outages to the Hydro electrical system during the period January 2 to 8, 2014. It documents a timeline of events and highlights the major incidents and response activities, including:

1. Emergency Preparedness;
2. Emergency Response; and
3. System Restoration.

A more detailed sequence of events is contained in Appendix 1 (Sequence of Events Following Sunnyside Transformer Fault on January 4, 2014).

4.1 Emergency Preparedness

At approximately 09:00 on Friday, January 3, 2014, Hydro's System Operations issued a severe weather warning notice to regional and plant managers for Saturday, January 4. Once the notification had been sent out, System Operations followed up with field operations staff to discuss the need for additional preparations for the pending weather. As part of standing practice, field staff made further coordination calls to secure the resources and vehicles to be on standby and/or report to specific sites.

As well, at 11:00 on January 3, 2014 there was a conference call between senior management, System Operations, Engineering, Transmission and Rural Operations (TRO), Hydro Generation, Corporate Communications and Holyrood Generation. The purpose of this call was to confirm that all groups were aware of the system status and to finalize co-ordinated efforts to respond to the pending severe winter weather. During this call, emphasis was placed on the need to

maintain the continuity of the existing generation infrastructure, and to ensure prompt response to any system issues in order to minimize customer impact.

Hydro deployed work crews in advance of the forecasted severe weather for January 4, 2014 as follows:

- Hydro Generation dispatched resources to various remote plants in preparation of the forecasted storm on January 4, 2014. This included stationing two operators at the Cat Arm plant and one operator and one protection and control technologist at the Granite Canal plant in advance of the storm to avoid potential travel issues during unfavorable weather conditions;
- Holyrood Generation arranged for two electricians and one extra operator to report to work to complement existing staff. As well, an early shift change was arranged in preparation for the pending storm. In addition, Newfoundland Power arranged for staff to operate the gas turbine on January 4, 2014;
- In TRO, it was decided that resources would report to terminal stations on the Avalon Peninsula the following morning. The deployment of resources had one individual covering Sunnyside and Come By Chance, one individual covering Western Avalon, one individual covering Holyrood, and another covering Hardwoods and Oxen Pond terminal stations. In addition, a transmission line crew and an administration officer reported to the Whitbourne office; and
- Hydro's gas turbine generation capacity was not fully available during this period. The Hardwoods and Stephenville gas turbines were either unavailable or de-rated during the January 2014 incident. Hydro secured operators and maintainers around the clock at the Stephenville gas turbine to ensure quick response in the event the gas turbine tripped and had to be restarted. Extra resources were arranged to ensure fuel deliveries for the Stephenville gas turbine, as it was expected to require additional fuel deliveries due to high operational requirements to meet high power system demands.

Hydro completed additional inspections as follows:

- Staff ensured there was full functionality and fuel tanks were full for necessary equipment and vehicles. Having full fuel tanks and fully operational vehicles and equipment ensures no delay in crew mobilization should the need arise; and
- At Holyrood, on-site emergency equipment was checked, operating procedures were reviewed for start-up and shutdown in the event of a power trip, and fuel was ordered to ensure adequate supply for the Newfoundland Power mobile gas turbine located near the plant. The black start plan was discussed with Hydro's Energy Control Centre (ECC).

Hydro arranged extra snow clearing as follows:

- Clearing of Upper Salmon Road to ensure access to Upper Salmon Generating Station;
- Clearing and extra sanding of Hinds Lake Road to ensure access to Hinds Lake Generating Station;
- Request to the City of St. John's to maintain access to Captain Whelan Drive as a priority, to ensure access to Hydro Place;
- Clearing of the main access road to Holyrood Thermal Generating Station and switchyard; and
- Clearing to access the Stephenville gas turbine.

4.2 Emergency Response

On January 4, 2014 at 09:05, Hydro experienced a fault on transformer T1 at the SSD TS, which resulted in a transformer fire. The ECC received several alarms related to breakers and equipment in the SSD TS. One of the breakers in the SSD TS failed to open properly, which created a chain of events resulting in the opening of many other system breakers and the automatic shutdown of generation units on the island power grid. This created an outage mainly in the Burin and Avalon peninsulas. Please refer to Appendix 1 for a more detailed breakdown of the exact sequence of events involving equipment operation.

The advanced deployment of a crew to the SSD TS meant that staff witnessed the catastrophic failure of the transformer (SSD T1) and could expedite response efforts. As per Hydro's local fire response plan, the crew immediately requested emergency support from the local fire department. The Come By Chance fire department responded and arrived at the terminal station shortly after they were notified. Prior to the supervisor arriving on site, the lead hand of the crew took charge and initiated discussions with the fire department. The local crew called ECC and Hydro started mobilizing additional internal resources to assist. Faced with extreme cold temperatures and high winds, the crew then secured the scene for public safety and minimal crew interface. The local on-call person and system on-call person were notified and updated of the situation. The system on-call person notified the EOC who immediately began the mobilization of key resources to the CEOC located in Hydro Place. At approximately 11:00, these resources were in the CEOC representing various corporate functional departments including, System Operations, Supply Chain, Safety, Engineering, Environment, and Corporate Relations. These individuals were available to provide support to the local operational areas and the responding crews if required.

In addition to the corporate support, there was mobilization of additional resources to the Bishop's Falls office to provide support to crews in the field; including senior management, TRO technical support, a safety and environment coordinator, and operations staff.

When the terminals supervisor arrived at SSD TS at approximately 10:30, the crew, terminals supervisor, and the local fire department further assessed the scene and began to formulate an approach forward. Also, the SSD TS was without power due to the both transformers T1 and T4 being out of service.[5]

Immediate areas of focus at that time included:

- The safety of the employees and public;
- Conducting a preliminary assessment of the environmental damage;

[5] The station service power supply is connected to T1 and T4 transformers tertiary windings via transfer switch.

- Conducting an assessment of other potential terminal station equipment damage;
- Achieving SSD T1 transformer isolation and SSD T4 capability to be placed in service to restore service to customers;
- Evaluating options to immediately restore station service. Note that station service is required to provide power to auxiliary equipment and facilities, such as air compressors, control circuitry, battery chargers, and control buildings;
- Evaluation of T1 fire and firefighting plans; and
- Environmental response, due to oil leaks and air emissions.

<u>The safety of the employees and public</u>

The supervisor met with local fire officials and discussed the transformer fire situation and the immediate concern for employee and public safety. The supervisor then consulted with operations support in the Bishop's Falls office, including the TRO safety and environment co-ordinator.

During this initial consultation, it was agreed that there were no immediate public safety concerns because of wind direction, and no immediate threat of the fire spreading to additional areas in the terminal station. Employees at the site followed appropriate safety precautions, such as keeping a safe distance and upwind from the burning transformer fire. The local fire department monitored the situation and performed crowd control.

The exact PCB concentration level in the transformer oil, and the six transformer bushings was unknown. It was agreed to treat the transformer fire as a PCB fire until otherwise confirmed. In order to start restoring power to SSD TS and to facilitate firefighting efforts, SD T1 had to be electrically isolated from the rest of the yard equipment. Utilizing Work Protection methods, SD T1 was safely isolated.

<u>Preliminary assessment of the environmental damage</u>

Once the site was secured, Hydro's environment officials were notified as well as the Canadian

Coast Guard (CCG). The CCG was contacted because of the oil spill as per Hydro`s Environmental Emergency Response Plans.

Initial assessment of the environmental impact showed that there was significant transformer oil sprayed on other terminal station equipment and on the snow covered ground as a result of the initial failure. In particular, there was visible oil on the 138 kV Bus 2 insulators and Bus 2 potential transformers. This would eventually require further testing and cleaning before Bus 2 could be re-energized, but did not impair restoration of service to customers. It was noted that the transformer body was intact and no further oil was being released into the environment. Remediation of the soil around the transformer was not possible due to the active fire on SSD T1. This was further discussed after the SSD T1 fire was extinguished on January 7, 2014. See the upcoming section on "Environmental Response" for details.

<u>Other potential terminal station equipment damage</u>

Station equipment of immediate concern and assessed for damage and contamination:

- 230 kV Disconnect Switch (B1T1): contaminated, deemed operable;
- 230 kV Bus Insulators (Bus 1): contaminated, deemed operable;
- 138kV Air Blast Breaker (B2T1): contaminated;
- 138 kV Bus Insulators (Bus 2): inoperable; and
- 138 kV Potential Transformers on Bus 2: inoperable.

Please refer to Appendix 2 for a single line diagram for SSD TS equipment arrangement.

<u>SSD T1 transformer isolation and SSD T4 restoration</u>

Even though B1T1 Disconnect Switch was contaminated, it was deemed safe to use as an isolation point for SSD T1 on the 230kV high voltage side. In addition, 138 kV Disconnect Switch B2T1-1 was also examined by the crew and was deemed safe to use as an isolation point on the 138kV low voltage side of SSD T1. With these two disconnects opened, SSD T1 was successfully

isolated electrically from Bus B2 and Bus B1 by the crew at approximately 12:00 on January 4, 2014.

The insulators on Bus B1 side, however, had to be monitored once power was restored because of the contamination. To facilitate this, it was decided that the station would be staffed 24-hours a day during the days following the event to monitor the fire and also be available to respond quickly in the event any issues occurred with the insulators and other equipment in the yard.

With SSD T1 isolated, the plan was to restore SSD Bus 1 and energize SSD T4 to restore power to the Burin Peninsula and local area. Through consultation with technical support staff, a review of TRO's emergency plans indicated that, "All transformers within the Stony Brook-Sunnyside Loop have the same rating and can withstand the loss of one unit". This meant that SSD T4 could meet load requirements without SSD T1 in service. This redundancy enabled Hydro to restore customers via SSD T4 and facilitate the supply of station service for the terminal station by manually switching the transfer switch.

<u>Evaluate options to immediately restore station service</u>

With the failure of SSD T1, the station service supply to the station controls was interrupted. The restoration of station service was very important to maintain air supply to air blast circuit breakers. Air blast circuit breakers use compressed air to actuate head mechanisms and extinguish arc in order to interrupt electrical circuits when required. Therefore, the crew established a priority to connect station service through an alternate feed.

It was decided to switch the station service to SSD T4 manually (no automatic transfer switch system) to gain station service supply when SSD T4 was energized. To maintain redundancy, it was decided that a second alternate supply would also be acquired through the means of a portable generator in the event that station service could not be achieved through SSD T4. A portable generator was rented and arranged to be shipped to SSD TS as soon as possible.

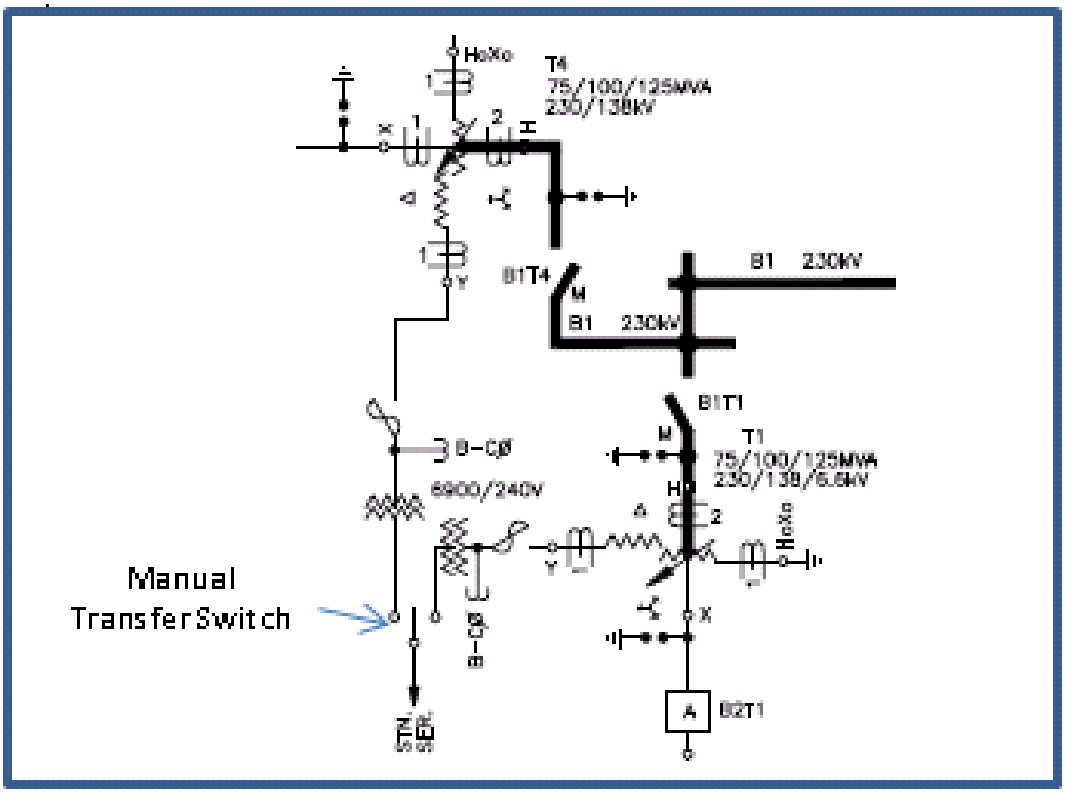


Figure 1: Sunnyside Station Service Supply Arrangement

Evaluation of SSD T1 fire and firefighting plans

Following the initial assessment on January 4, 2014 the Come By Chance volunteer fire department remained on site to assist and monitor. The TRO safety and environment co-ordinator consulted the Churchill Falls fire department mid-afternoon on January 4, 2014 because of their experience in dealing with terminal station transformer fires. They discussed strategies for extinguishing the fire and assessing the situation. It was decided to allow the fire to burn and concentrate efforts on restoring power.

On the morning of January 5, 2015 the TRO safety and environmental co-ordinator met with the Come By Chance and Sunnyside fire departments to tour the site and to discuss the options for extinguishing the fire. The local fire departments raised concerns about a lack of necessary equipment, training, and supplies to fight a transformer terminal station fire. Another concern

identified was the need to install grounds[6] to de-energize (i.e. isolate and ground) transformer SSD T1.

In the afternoon of January 5, 2014 the Emergency Response Team (ERT) co-ordinator in Holyrood was contacted to investigate if they could execute the extinguishing of the fire. They also expressed concern about their limited experience with this type of fire. At this time, it was decided to let the fire continue burning until grounds were in place to ensure the safety of firefighters.

Later in the afternoon, Hydro contacted the Gander fire department and arranged for the Gander fire department to assist and travel to SSD TS the following morning on January 6, 2014. The plan was to let the fire continue burning overnight on January 5, 2014 and in the morning, take a planned outage to Bus 1 to clean the insulators and extinguish the fire. The grounds were installed that night in preparation for firefighting on January 6, 2014. This was to be a joint effort between local fire departments from Sunnyside, Come By Chance and Gander.

However, the plan had to be suspended due to the trip in Holyrood TS during the evening of January 5, 2014. Based on the unfolding situation at Holyrood TS, and a decision to not take a planned outage on SSD Bus 1 due to system security concerns, a new firefighting strategy was implemented.

Arrangements were made to fly in a firefighting crew from Churchill Falls. In co-ordination with the Come By Chance Oil Refinery and the Holyrood Plant staff, the necessary firefighting equipment was obtained to support Churchill Falls and Come By Chance firefighters in extinguishing the fire.

[6] Grounds are electrical cables that connect equipment to the earth in order to protect personnel against the accidental energization of equipment.

The Churchill Falls firefighting crew arrived on site at approximately 18:30 on January 6, 2014. They toured the site and began preparations for extinguishing the fire. A tailboard discussion was held with Hydro personnel, the Churchill Falls, Sunnyside, and Come By Chance firefighters, and the plan was reviewed. The tailboard highlighted concerns of the limits of approach to overhead lines, other live equipment in the yard, as well as the angle of attack to the burning transformer to effectively extinguish the fire.

Firefighting commenced at approximately 23:30 on January 6, 2014 and continued until approximately 02:30 on January 7, 2014 when the fire was extinguished. Personnel remained on site throughout the night to monitor the transformer for possible re-ignition. The next morning, a status of all clear was given.

Throughout this process, the CCG, the provincial government, local fire departments, and Fire and Emergency Services NL received updates from Hydro. The provincial fire commissioner visited the site and provided advice. The Holyrood ERT co-ordinator was on site to witness the fire suppression activities.

Environmental response

When the supervisor arrived at Sunnyside on January 4, 2014 he assumed the responsibility of On-Scene Commander[7] and no environmental remediation measures were undertaken at the time due to the fire. TRO's Safety and Environmental Coordinator was consulted and appropriate agencies were notified. In consultation with Nalcor's Environmental Services Manager, an Environmental and Safety Specialist was scheduled to visit site the next day.

In the afternoon of January 4, 2014 it was confirmed that transformer SSD T1 was <2 mg/kg, which is considered non-PCB, but the PCB content of the transformer bushings remained unknown. However, given that the ratio of the volume of oil in the bushings versus the volume

[7] On-Scene Commander – in the event of an environmental emergency, the On-Scene Commander is a lead person which directs equipment and manpower for containment, cleanup, disposal, restoration and ensures human safety at all times.

of oil in the transformer was low, the PCB exposure risk to the employees and the public was also considered low.

On January 5, 2014 the TRO safety and environment co-ordinator arrived on site and assumed the role of On-Scene Commander. In addition, an Environment and Safety Specialist from Nalcor Energy's Environment department was also on site. Lab samples of the oil were taken from the surrounding area and preparations were initiated to start the remediation clean up when the area was deemed safe.

On January 6, 2014 limited remediation efforts began with Hydro personnel removing oil-contaminated snow. This was performed in an area considered safe from the fire. Also on January 6, 2014 a preliminary site visit was conducted by a remediation consultant, who recommended a soil remediation strategy to be implemented when the fire was extinguished. The soil remediation strategy commenced in full on January 10, 2014.

4.3 System Restoration

4.3.1 Transmission Restoration

This section provides an overview of the power system restoration efforts performed by Hydro following the transformer fire at the SSD TS. As previously noted, on January 4, 2014 at 09:05, the power system experienced an interruption initiated by the failure of SSD T1 at the SSD TS. This resulted in generation outages as well as multiple transmission line outages. This included generating units at Holyrood, Cat Arm, Hinds Lake, Star Lake, Granite Canal and Upper Salmon and transmission line outages localized to the east coast.

Restoration of the island power system was coordinated through ECC, who analyzed incoming alarms, and through discussions with field staff. Where necessary, field staff was dispatched to investigate the alarms prior to restoration of the affected area.

Restoration efforts from 09:05 to 12:58, January 4, 2014

Immediately following the failure of SSD T1, ECC operators performed an overall assessment of the situation to determine the initial cause and the extent of the outage. This included discussions with Hydro field personnel, the Holyrood plant and the Bay d'Espoir (BDE) plant. At 09:27, the ECC operator closed the breaker at Come by Chance to re-energize the line to Western Avalon (TL237) and effectively began the restoration of power to the Avalon Peninsula. The restoration efforts by ECC continued until power was restored to the Holyrood, Hardwoods, and Oxen Pond terminal stations

Restoration efforts were interrupted due to the loss of the Energy Management System (EMS) at ECC from 11:03 to 11:46. During this time ECC did not continue with restoration activities, as maintaining system stability was the first priority. For details of activities related to the EMS disruption, please see Technology and Communications Infrastructure Report.

At 12:22, ECC restored Western Avalon (WAV) Busses B1 and B3. Immediately following restoration, transformer WAV T5 tripped. Personnel were dispatched to investigate and discovered that WAV T5 was in lockout and therefore would have to be isolated until further investigation. WAV T5 was successfully isolated in the mid-afternoon and restoration of Bus 3 and Bus 4 were performed at 14:37. With WAV T5 isolated from the system, the 138 kV loop from Western Avalon to Holyrood was now supported by WAV T3 and T4 only. For more details of activities at the ECC, please see Transmission Availability Report.

In parallel to the transmission restoration, generating units at Cat Arm, Granite Canal and Upper Salmon were also brought back on line, with the last of these units being put on line at 12:56 on January 4, 2014. Restoration efforts in both the Cat Arm and Granite Canal generating plants were expedited by having crews dispatched earlier as per storm preparation plans of January 3, 2014. An operator and a supervisor were dispatched to Hinds Lake to support the restoration activities. During the unit start up they discovered a problem with the unit breaker, which was immediately addressed, and the unit was put in service at 15:14. The other

generating units at Star Lake and Upper Salmon were put back on line without incident. Holyrood generating sequence of restoration is explained in the section titled Holyrood Generation Restoration.

First attempt at Sunnyside restoration (12:58)

At 12:00, after SSD T1 at SSD TS had been electrically isolated by the on-site crew, and in consultation with the TRO technical group in Bishop's Falls and ECC, switching commenced to restore power to SSD T4. When Bus 1 was re-energized by ECC and verified by the on-site crews, and subsequently SSD T4 energized, the station service was restored to the SSD TS, thus providing power for the compressed air system. A few minutes later, ECC operators and on-site crews continued efforts of restoration by attempting to close B3T4 in order to re-energize the 138 kV Bus and TL219 to restore customers on the Burin Peninsula.

Bus 1 immediately tripped on the Bus differential protection lockout. This outage was localized to Sunnyside Bus 1 only. Crews proceeded to re-inspect Bus 1 and surrounding infrastructure to identify any obvious abnormalities. The visual inspection reaffirmed the initial inspection and no obvious defects were identified. Therefore, through consultation with the TRO technical group and System Operations, it was determined that the current transformers located inside of SSD T1 could possibly be damaged by the ongoing fire – triggering the Bus 1 differential protection.

On site crews, with direction from the TRO technical group, made emergency modifications to the wiring of the Bus 1 differential protection to eliminate the damaged current transformers from the protection circuit. The lockout protection was reset and a second restoration attempt was planned.

Second attempt at Sunnyside restoration (15:33)

With this emergency modification to the Bus differential protection circuitry (eliminating SSD T1 current transformers from the circuit), crews planned to reenergize Bus 1 through co-

ordination with ECC. Bus 1 was re-energized at approximately 14:36, thus energizing SSD T4, which feeds power to the station service for the SSD TS.

With SSD T4 energized, it was decided by the crews, and in consultation with the TRO technical staff, to delay further restoration until the compressed air system built up a reserve of air. This was required to ensure the Sunnyside air blast breakers would have enough reserve air to allow multiple operations if needed.

Once the on site crews verified the air system had adequate reserve, restoration continued. At 15:33 when the ECC performed a second attempt to energize the 138 kV bus, there was an immediate trip resulting in the line protection on TL202 and TL206 from Bay d'Espoir to Sunnyside, as well as TL 204 Bay d'Espoir-Stony Brook, and transmission lines to the Avalon Peninsula. This resulted in BDE (Unit 5 and Unit 6) and Cat Arm generating units tripping off line. Again, the supply to the Burin and Avalon peninsulas were cut off and the Sunnyside station service supply was once again disrupted.

A further investigation performed by the on-site crews in discussions with TRO technical staff, and systems operations, identified that the SSD T1 lockout relay was still activated thus triggering additional protection to operate, eventually causing the second major outage.

With an understanding of the cause of the protection operation, ECC commenced system restoration by contacting generating plants and field personnel. Both the generating units at BDE units (Unit 5 and Unit 6) and Cat Arm were restored to service within an hour. In addition, transmission lines were systematically restored to supply key terminal stations on the Avalon Peninsula.

<u>Third attempt at Sunnyside restoration</u>

The on-site crews at Sunnyside reset the SSD T1 lockout, reviewed the alarms now present from the outage, and began planning for a third restoration attempt. When the transformer SSD T1

lockout relay was reset at approximately 17:45, this:

- Enabled station service restoration at Sunnyside at approximately 18:42 through energization of SSD T4;
- Enabled restoration to TL219 and all the customers on the Burin Peninsula; and
- Enabled the restoration of the loop between Sunnyside and Stony Brook.

4.3.2 Holyrood Generation Restoration

This section covers the emergency response and restoration of Holyrood Units 1, 2, and 3 following the system disruptions on January 4 and 5, 2014.

Events of January 4, 2014

At 09:05, when the SSD T1 failed, all three Holyrood units were operating. With the sudden isolation of the Avalon Peninsula from the remainder of the island power system, the Holyrood units were unable to remain on line as the isolated Avalon Peninsula load was more than the plant could carry. All three generating units at Holyrood shutdown and the plant AC station service supply were interrupted. Upon loss of the AC station service supply, the following occurred:

- The DC lube oil pumps automatically started and supplied turbine bearing oil; and
- The two emergency diesel generating units were started to supply essential service power for basic lighting, AC lube oil pumps, battery chargers, turning gear, air heater drives, and power supply to Newfoundland Power's gas turbine for start up.

The manual shutdown of the three units was completed by plant personnel and the Newfoundland Power mobile gas turbine was started to support some of the station service load. This unit is not used to restart the Holyrood units, as it does not have sufficient capacity to start the boiler feed pump motors, essential for unit start up.

At 10:24, the Holyrood plant station service was restored from the grid. With the plant back to normal station service supply the unit start-up process was initiated. The priority was placed on

Unit 1 as it had no known issues and was capable of 170 MW. Unit 2 experienced a turbine rupture disc[8] failure during the sudden shutdown and Unit 3 was limited to 50 MW because of a forced draft fan failure. While restoring Unit 1 to service, repairs were being completed on Unit 2. Three attempts to run-up Unit 1 were unsuccessful due to excessively high vibration preventing the unit from reaching full speed for synchronization. In conjunction with performing repairs on Unit 2, staff attempted to start Unit 3 and it was identified that the auxiliary oil pump[9] was not working. Crews were dispatched to investigate further. The repairs to the turbine rupture disc on Unit 2 were completed at approximately 15:20 and Unit 2 was in start-up mode when the station service supply was lost again at 15:33.

Once again, the two emergency essential service diesels started up and the plant personnel resumed the same process as was completed at 09:05 during the first shutdown. When the normal station service supply was restored at 16:09 the plant staff began the start-up process once again with both Unit 1 and Unit 2 boilers being prepared and repairs to the auxiliary oil pump on Unit 3 continuing. Unit 1 boiler was already pressurized from previous attempts in the day, while Unit 2 was out of service since 09:05. Therefore, Unit 1 started up in a shorter time period and at approximately 19:00, Unit 1, while being brought up to speed, tripped due to high vibration. It was decided to suspend activities on Unit 1 and consult with Alstom[10] for further assistance. In parallel to the work on Unit 1, Unit 2's boiler was being pressurized and the turbine run up to synchronizing speed and at 21:34, Unit 2 was successfully synchronized to the system. In addition, work continued to identify a solution to the auxiliary oil pump system for Unit 3. The team implemented an alternate start-up method and Unit 3 was successfully synchronized to the system at 01:40 on January 5, 2014.

[8] A turbine rupture disc is a mechanical atmospheric protection device used to protect the turbine against backpressure.
[9] Unit 3's auxiliary oil pump supplies oil to the operating header and bearings when the turbine is operating below 3,600 RPM.
[10] Alstom are the service providers for the turbine generators.

Through the evening of January 4, 2014 investigation into the vibration issue on Unit 1 continued. The team speculated that a temporary bow [11] had developed in the turbine shaft that was causing the vibration. A conference call was held in the morning of January 5, 2014 between Holyrood staff, Project Execution and Technical Services (PETS) technical support engineers, and Alstom to discuss the start up approach for Unit 1. It was decided that Unit 1 would be started with a slower than normal process, to allow the bow to run-out. This means that the unit would be held at different speeds to allow the vibration to stabilize to normal operating levels before proceeding to higher speed.

In the afternoon of January 5, 2014 two attempts were made to bring Unit 1 up to synchronizing speed, but the unit tripped due to vibration both times. During the third attempt the unit was brought up to synchronizing speed over a longer period of time than the previous two attempts. For this third attempt, the unit was brought up to synchronizing speed over a period of four hours and the unit was allowed to stabilize at different speeds during the ramp up process. The unit reached synchronizing speed and was ready to be synchronized to the system at 21:27.

Initial response to January 5, 2014 event at 21:27

The Holyrood switchyard was in its normal configuration for bringing Unit 1 into service with both Unit 1 synchronizing breakers, B1L17 and B1B11 in the open position. One of the steps to bringing the unit on line is to close the unit's 230kV disconnect switch B1T1.

[11] A bow in a turbine shaft is caused by a temperature difference across the rotor diameter at zero speed.

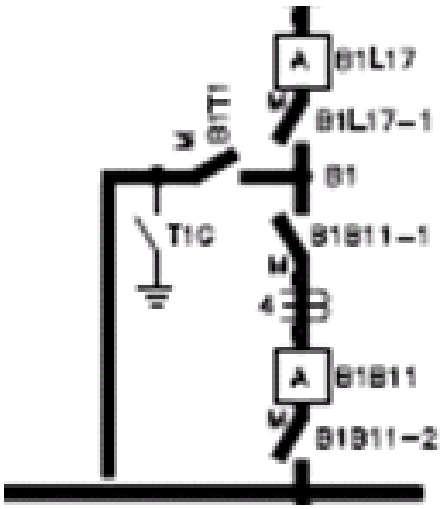


Figure 2 - Holyrood Unit 1 230 kV Connection Arrangement

While closing the Unit 1 disconnect switch B1T1, at 21:27, there was a protection operation resulting in multiple breaker operations in the Holyrood TS thus causing all units at Holyrood to trip offline. This resulted in a loss of service to many customers on the Avalon Peninsula. The process for restoration of essential plant services commenced with the normal start up of the two emergency diesel generators, supplemented by Newfoundland Power's mobile gas turbine.

A very bright flash of light from the Holyrood TS was reported by staff at the Holyrood plant at the time of the disconnect switch operation. It was immediately identified that the cause of the outage was located in the Holyrood TS and required terminal station maintenance staff to respond. TRO crews were dispatched to both the Holyrood and the Western Avalon terminal stations. In addition, TRO technical support and operations staff mobilized to the Bishop's Falls office to help manage and provide technical assistance for the restoration of the station. System operations engineers were also notified and requested to start analyzing data to determine the source of the problem.

In the meantime, the ECC took steps to restore TL-242 to the Holyrood TS to restore the station service to the plant. At approximately 22:20 the line was restored. Subsequently Holyrood

personnel reconfigured the plant for normal station service supply and initiated the restart of the units.

After careful review of the alarms and fault recording data, the source of the problem was identified to be Bus 1 in the Holyrood TS. Therefore, Unit 1 restoration had to be suspended and preparations were made to isolate Bus 1 for further investigation. Bus 1 was successfully isolated at 02:02. In parallel, crews at Western Avalon worked through alarms and the resetting of protective devices in order to facilitate the safe energizing of TL217 (Western Avalon to Holyrood). TL217 was successfully energized at 03:34 on January 6 and normal station service was restored to the Holyrood plant. At 05:29, Unit 2 was back on line and at 07:17, Unit 3 was back on line as well.

Refer to Appendix 3 for a single line diagram of Holyrood.

<u>Emergency response to enable Unit 1 to synchronize to the power grid</u>

In the morning of January 6, 2014 Unit 1 remained in hot stand-by mode and turbine vibration levels were monitored. Meanwhile, crews and technical support investigated the cause of the flash of light seen the previous night near disconnect switch B1T1.

Additional crews were dispatched from Bishop's Falls, while the majority of the Whitbourne based crews were on mandatory rest period. These additional crews helped to continue the fault-finding efforts in the Holyrood TS.

In order to minimize the risk of further interruptions a cautious and thorough examination of the problem was undertaken.

The initial approach to fault-finding and verification of equipment on Bus 1 focused on the following:

1. Visual inspection of B1T1 and Bus 1 from an aerial device;
2. Timing test of 230 kV breaker B1B11, and verification of the control circuits related to B1T1;
3. Determining the air leak location in breaker B1L17;
4. Isolating of breaker B1L17 for testing at a later date;
5. Visually inspecting of the unit step-up transformer T1 and its bushings;
6. Analyzing fault traces and alarms in order to determine a safe and reliable path to bring Unit 1 back online, through either breaker B1L17 or B1B11;
7. Reviewing the interface of the protection and control circuitry between the generating plant and the terminal station; and
8. Engineering analysis of the possible effects of energizing transformer T1 (and consequently Unit 1) from Bus 1 instead of the normal manner.

Regular update meetings were scheduled on January 6, 7, and 8, 2014 for the morning, late afternoon, and late evening to evaluate and discuss the ongoing work, and to decide next steps. Due to the complexity of this event, preserving restored generation and transmission, and not knowing exactly the root cause of the fault, it required a broader team to evaluate the evidence of this event. The meeting participants consisted of field staff, TRO technical support, technical services engineers, PETS, Systems Operations, Holyrood plant personnel, and executive leadership.

Through this iterative testing and consultation process, it was concluded that all equipment connected to Bus 1 including: disconnect switch B1T1, breaker B1B11, and transformer T1, were considered acceptable to energize and synchronize Unit 1 via B1B11. In addition, it was necessary to isolate breaker B1L17 for further investigation at a later date.

As a precaution to ensure there were no unidentified problems with the equipment in and around Bus 1 during the energizing process, a 25-step verification plan was developed to verify Bus 1's integrity before synchronizing to the system. After following this process, Holyrood

Unit 1 was successfully synchronized and put on line through B1B11 breaker at 15:38 on January 8, 2014.

5 KEY FINDINGS AND RECOMMENDATIONS

5.1 Emergency Preparedness

The deployment of crews, the extra snow clearing that was arranged and the emergency preparedness activities which were initiated on January 3, 2014, helped ensure that there was a timely and efficient response to the outages experienced on January 4, 2014. Some examples include:

- By having crews located at Granite Canal and Cat Arm, generation was reinstated at these plants as soon as the transmission system was restored;
- By having crews deployed to terminal stations on the Avalon Peninsula, there was a crew at Sunnyside when the fire started on SSD T1, meaning emergency response to this equipment failure was swift and immediate;
- Due to the extra snow clearing, operations staff were able to access the Holyrood Generating Station and Holyrood TS without issue; and
- Scheduling additional fuel deliveries and operations staff prior to the severe weather event helped ensure the availability of stand-by generation.

The lessons learned from this event, previous events, as well as best practices from other jurisdictions with respect to severe weather preparedness, should be incorporated into a formal protocol.

Recommendation		Status
ERR1	Update Severe Weather Preparedness protocol and checklist to capture lessons learned from previous responses and best practices from other utilities.	In Progress (May 15, 2014)

5.2 Emergency Response

The emergency response to the transformer fire at SSD TS required the co-ordination of many different groups including Hydro personnel, namely: North Atlantic Oil Refining Ltd, Churchill Falls staff, the Fire Commissioners Office, the Come By Chance local fire department, and others. Local fire departments did not have the tools, the training, or the obligation to deal with a transformer fire in a live switchyard. This was overcome by engaging support from other areas of Nalcor Energy and industry. In the end, the planning and execution of extinguishing the transformer fire was done professionally and safely. The learnings from this experience should be documented and emergency plans updated with specific information on methods for dealing with transformer fires.

When the PCB content of the burning transformer was uncertain, and consistent with Hydro's ERP, the first responders treated the fire as though there were PCB's present until they were guaranteed otherwise. This approach was taken to ensure the safety of employees and the public. The local crew were not able to confirm that there were no PCB's in the transformer because the information was not available inside the terminal station building, but only on the side of the burning transformer. In the future, all information about oil contents should be available in hard copy at the site and an alternate location.

Safety is Hydro's number one priority and this was demonstrated through the safe execution of the emergency response and restoration activities. There were no safety incidents during the period of January 2 to January 8 and crews maintained their focus on safety when faced with the challenging circumstances of a transformer fire in a live switchyard, poor weather conditions, cold temperatures, and knowledge of widespread customer power outages. Employees were relentless in their commitment to protecting themselves, their co- workers and the public throughout their restoration and response efforts.

Hydro's local and corporate emergency plans were utilized during the incidents. The local emergency response was co-ordinated from SSD TS under the care and direction of an on scene

commander. This local response was supported by resources in both the Bishop's Falls office and a partial mobilization of the CEOC in St. John's. The local emergency response and fire response were well coordinated and executed. There was no formal activation of the CERP but key functional departmental personnel were contacted individually and were available in the CEOC to provide support to the response and local operational areas. Given the magnitude of the events on January 4, 2014 it would have been appropriate to have had a formal activation of the CERP.

The outage on January 4, 2014 occurred outside normal business hours. Due to the pending weather, some staff were already scheduled to be at work, while additional staff were mobilized through requests made by supervisors on-call.

Recommendation		Status
ERR2	Update emergency response plans with lessons learned from the January 4, 2014 transformer fire and emergency response, including specified methods for dealing with transformer fires.	September 2014
ERR3	PCB contents of all oil-filled transformers and equipment should be available in hard copy locally and an alternate location.	May 2014

5.3 System Restoration

The field response for system restoration activities following the events of the SSD T1 fire on January 4, 2014 were handled well. ECC, system operations, generating plant control rooms, TRO support staff, and on-site crews all worked closely together to bring customers back on line.

ECC operators were faced with a large amount of data and alarms during the initial event, but with a systematic approach, and with the assistance of deployed resources already at key sites,

restoration efforts in both the generating plants, and the terminal stations were improved. Throughout the days of January 4 and 5, 2014 ECC coordinated all the restoration efforts in order to bring customers back online.

Onsite crews played an important role in the restoration efforts in the generating plants and terminal stations. They performed visual inspections of equipment, reset lockouts/alarms, isolated damaged equipment, and verified equipment operations during the restoration efforts. Restoration efforts in SSD TS began once the SSD T1 fire was evaluated and SSD T1 was isolated. In addition, the station service power supply requirements at SSD TS were important to maintain in order to continue the restoration. In general, outages to station service at terminal stations, can affect the ability of crews to restore the power system to normal configuration.

In addition, familiarity with control and protection circuits could improve response time. This was evident in the SSD TS restoration on January 4, 2014. It is important for Hydro to continue the efforts in standardizing control philosophies, and continue to provide avenues for less experienced workers to understand and develop skills.

At the hydroelectric generating plants, there were minimal issues relating to the restoration. In two plants there were operations personnel onsite because of known operational issues. This did result in quicker restoration with coordinated efforts between the ECC and Hydro Generation staff.

Restoration efforts at the Holyrood generating plant were also handled well. During a significant system event which results in a full power outage inside the Holyrood plant, there are a number of different steps to follow to ensure the plant and the units are secure. Plant lighting is limited in certain areas and when planned improvements are completed in 2014, this will aid in the efforts to safely secure the units as well as with the response time of getting units back.

Hydro's restoration of the power system during these challenging times was accomplished through focus and teamwork and without any safety incidents.

Recommendations of the restoration efforts are listed below.

Recommendation		Status
ERR4	Assess the need and options for additional station service supply for terminal stations in the event of loss of normal supply.	In Planning (June 2014)
ERR5	Complete lighting improvement plan at the Holyrood plant in 2014.	In Progress (September 2014)

Appendices

NEWFOUNDLAND AND LABRADOR HYDRO

Sequence of Events
Following Sunnyside Transformer Fault on January 4, 2014

February 2014

newfoundland labrador hydro
a nalcor energy company

Events Following SSD Transformer Fault - January 4, 2014

Date	Time	Event
Jan. 4, 2014		Weather forecast for blizzard conditions and heavy snowfall; crews prepared for storm response.
	08:00	Crews dispatched to major terminal stations on the Avalon. Remote hydroelectric plants staffed by operators, and the road to the Upper Salmon plant was maintained open.
	09:05:34	Fault detected in transformer T1 at Sunnyside (SSD). The SSD transformer T1 lockout protection operated resulting in following breaker operations: SSD L109T4 open SSD B3T4 open SSD B1L02 open SSD B2T1 open Four of five breakers for T1 operate, breaker B1L03 failed to open, keeping the 230 kV Bus B1 and transformer T1 energized from TL203. Fault evolved and protection circuits at multiple locations sensed the fault.
	09:05:35	SSD disconnect switch B1T1 in-transit alarm, indicated the disconnect switch had started to open.
	09:05:36	The Paradise River generating unit tripped, with a loss of 8 MW. As a result of the failure of SSD B1L03 to open and clear the T1 fault, the primary one, primary two and backup protection operated on transmission line TL203 at the Western Avalon Terminal Station (WAV). The backup protection also operated for transmission line TL203 at SSD. The following breakers opened for this event: SSD L03L06 open WAV L01L03 open WAV L03L17 open

Date	Time	Event
		TL203 was open at the WAV end and SSD Bus B1 and transformer T1 were de-energized. Backup protection also operated on transmission line TL237 at Come by Chance (CBC) and WAV. The following breakers opened for this event: CBC B1B2 open WAV L01L37 open Circuit breaker B1L37 at WAV appeared to have been delayed in opening by two seconds for the protection trip. **Transmission Lines TL203 (SSD – WAV) and TL237 (CBC – WAV) were out of service and the Avalon was isolated from the rest of the power system. Bus B1 and Transformer T1 at the Come By Chance TS were still energized. The Holyrood Generating Plant remained on-line, momentarily.**
	09:05:37	Normal Newfoundland Power supply to Hydro Place was lost; Hydro's EMS switched to battery power.
	09:05:37	Units at Holyrood cannot supply the load. Holyrood Units 2 and 3 are tripped and isolated from the system by unit breakers. Unit 1 trip is initiated and unit breaker B1B11 opened three phases. Unit breaker B1L17 opened only on two phases during the trip. Backup protection operated on transmission line TL242 at Hardwoods Terminal Station (HWD). Breaker B1L42 opened at HWD. Backup protection operated on transmission line TL218 at Oxen Pond Terminal Station (OPD). Breaker B1L18 opened at OPD. Holyrood Unit 3 was isolated from the system. **Transmission Lines TL203 (SSD – WAV) and TL237 (CBC – WAV) were out of service and the Holyrood Generating Plant was shut down and isolated. The 138 kV and 66 kV transmission had also tripped via NP lines 64L, 86L, 39L from WAV to HRD.**

Date	Time	Event
	09:05:38	Breaker B1L37 at WAV opened, closed and then re-opened in a three second period, an indication that the breaker operated only on two phases.
	09:05:38	Star Lake generating plant tripped with the loss of 18 MW and Stephenville Gas Turbine tripped.
	09:05:41	Cat Arm and Hinds Lake generating plants tripped with a loss of 205 MW of generation.
	09:05:41	SSD disconnect switch B1T1 was fully open, providing full isolation of transformer T1.
	09:05:45	Diesel G1 at Hydro Place on-line, re-storing AC supply.
	09:05:45	Hydro's EMS switched to diesel supply.
	09:09:45	EMS indication for breaker B2L42 at Holyrood toggled between open and closed multiple times, likely making its actual state unclear to the ECC operators.
	09:13	Upper Salmon generating plant tripped with the loss of 88 MW.
	09:27	Breaker B1B2 at Come By Chance closed by the ECC, marking the start of restoration phase and energizing transmission line TL237 to Western Avalon.
	09:41	Attempts to energize Bus B1 at WAV from line TL237. Line breaker B1L37 closed, but tripped again 1.2 seconds later. It was later determined that only two phases of the breaker had closed and there was a phase disagreement trip, momentarily energizing Busses B1 and B3, the WAV transformers, and transmission line TL208 to Vale, all on two phases. A Gas/Oil/Temperature alarm was received for transformer T5. ECC opened WAV breaker B1L08 to isolate TL208 and attempted to close B1L37 again, with the same result. Another Gas/Oil/Temperature alarm is received for T5.
	09:51	WAV circuit breaker L01L37 was closed by ECC, energizing a 230 KV ring Bus section at WAV, transmission line TL201 and the HWD terminal station.

Date	Time	Event
	09:57	Stephenville Gas Turbine in service at 25 MW.
	10:08	Upper Salmon generating plant in service at 88 MW.
	10:14	Granite Canal generating plant in service at 40 MW.
		ECC attempted to close breaker B2L42 at HWD to energize TL242 into Holyrood and restore station service. This energized HRD Bus B12 and, since unit breaker B1L17 had failed during the earlier events and remained closed on one phase, this resulted in a single-phase energizing of Unit 1 transformer T1. Protection circuits for TL242 operated at both HWD and Holyrood. Additional breakers were opened by ECC to provide for further isolation of the HRD TS.
	10:24	Holyrood station service is restored via transmission line TL242 (HWD – HRD) and HRD transformer T10.
	10:26	Holyrood unit disconnect switches B1T1 and B2T2 were opened by the HRD operators.
	10:38	Hydro Place diesel unit G1 tripped offline due to high temperature. There is no power at Hydro Place and EMS switched to battery power.
	10:41	Breaker B1L36 is closed at HWD, restoring transmission line TL236 (HWD – OPD) and OPD TS.
	10:41	ECC closed breaker B3L47 at Deer Lake, energizing transmission line TL247 and starting the process of restoring Cat Arm generating units.
	10:57	Breaker B1L03 at SSD, the breaker that failed to open during the T1 fault, opens un-commanded.
	11:03	The beginning of a 43-minute outage to the ECC, EMS. The outage resulted from a short power interruption (13 seconds), upon the loss of primary supply (Newfoundland Power), the standby diesels and the UPS system. The system was recovered and re-established at 11:46.
	12:00	SSD transformer T1 isolated from the system via disconnect switches. Transformer reported to be still on fire.

Date	Time	Event
	12:13	Three additional, but unsuccessful, attempts to close breaker B1L37 at WAV to restore 230 Busses B1 and B3. Similar to previous attempts the breaker closed only momentarily and at least one T5 transformer Gas/Oil/Temperature alarm was received. At 12:15 the ECC closed WAV breaker B1L17.
	12:18	Cat Arm Unit 2 in service at 65 MW.
	12:22	ECC closed breakers L03L17 and L01L03 at WAV, energizing Busses B1 and B3 from TL237. Due to previous actions this also energized transmission lines TL203 to SSD and TL217 to HRD. WAV transformer T5 lockout protection operated after restoration of Busses B1 and B3, isolating the transformer from the system via WAV breaker B1B3 and transformer disconnects B3T5 and B4T5. It was later determined there was an internal failure of the transformer tap changer. WAV busses B1 (230 KV) and B2 (66 KV) were restored.
	12:23	ECC restores TL217 (WAV - HRD).
	12:30	ECC restores TL218 (HRD - OPD).
	12:56	Cat Arm Unit 1 in service at 65 MW.
	12:57	Bus B1 and Transformer T4 are re-energized at SSD, re-establishing station service and restoring the breaker compressed air system.
	12:58	Switching at SSD to restore the load side of transformer T4 (138 KV). Breaker B3T4 closed by ECC, resulting in the operation of the Bus B1 lockout switch at SSD, initiated by the transformer disconnect switch, B1T4, opening under load and resulted in an arcing fault. Breakers B3T4 and B1L02 tripped. Breaker B1L03 had been previously isolated. Attempt to restore T4 failed. Impact was confined to the Sunnyside Station. Investigation determined the Bus B1 differential protection operated upon closure of B3T4, likely caused by the current transformers and

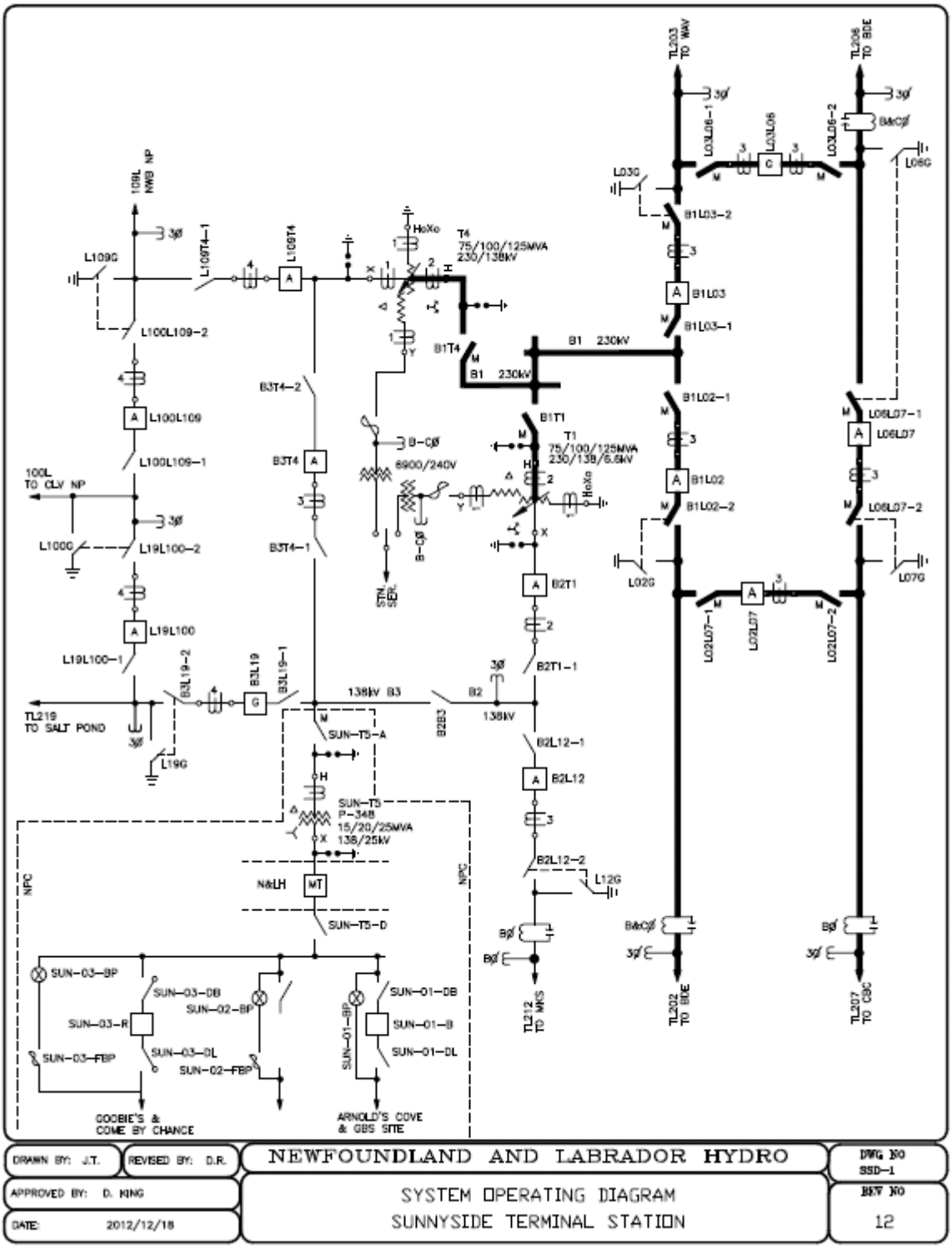
Date	Time	Event
		wiring on transformer T1 having been destroyed by the transformer fire.
	14:10	Stephenville Gas Turbine off line.
	14:28	Stephenville Gas Turbine in service at 25 MW.
	14:36	After a couple of unsuccessful attempts, the SSD transformer T4 disconnect B1T4 is closed.
	14:37	Circuit breaker B4L64 closed at WAV, restoring 64L and the 138 kV supply to Newfoundland Power on the Avalon.
	14:40	ECC closed breaker L03L06 at SSD, restoring both ends of TL203 (SSD – WAV).
	14:41	The SSD 230 KV Bus B1 was re-energized by ECC via breaker B1L02, which also energized transformer T4. SSD Station service is restored.
	15:12	Hinds Lake unit restarted and loaded to 75 MW. There were considerable issues with the unit breaker B1G1.
	15:25	Circuit breaker B8L39 was closed at HRD, restoring the 138 kV loop from WAV to HRD. **All transmission to the Avalon was restored.**
	15:33:26	A second attempt was made to restore the load side of SSD transformer T4 (138 KV). Breaker B3T4 closed by ECC and again resulted in the opening of the transformer disconnect switch B1T4 under load. The protection at Sunnyside did not operate as expected to clear the arcing fault, which resulted in the operation of the protection on the remote ends of transmission lines TL202 and TL206 at Bay d'Espoir (BDE).
	15:33:32	Breakers B11L06 and L06L34 opened at BDE to trip transmission line TL206 as expected.
	15:33:33	Protection at BDE did not operate to trip transmission line TL202 as expected. Breakers B3B4 and B4B5 would ordinarily trip TL202 at the

Date	Time	Event
		BDE end, but were slow in operating. Lockout protection operated and resulted in a trip of breakers B5B6, B3T5, B3T6, and B2B3. This resulted in a loss of TL204 (BDE – Stoney Brook), and BDE Units 5 and 6 (loss of 150 MW of generation). Breakers L02L07 and B1L02 tripped to isolate TL202 at SSD. **There was a loss of supply from BDE to Sunnyside and the Avalon Peninsula, including Come By Chance. The Auto Restoration Scheme (ARS) was in a disabled state following the return of the EMS at 11:46.**
	15:33:43	Cat Arm Units 1 and 2 tripped off-line with a loss of 130 MW of generation.
	15:37	ECC initiates a close of breaker B11L06 to close TL206 at the BDE end. The line was already closed at the SSD end. This action energized the terminal stations east of SSD.
	15:38	Primary one protection operated on the following transmission lines: TL201 – HWD and WAV TL203 – SSD and WAV TL207 – CBC and SSD TL217 – HRD and WAV TL218 – HRD and OPD TL236 – HWD and OPD TL242 – HRD and HWD Associated line breakers opened for these line protection trips.
	15:39	ECC initiated a breaker group open at WAV. Transmission Line TL206 was restored (BDE – SSD). Power was restored to SSD TS, TL207 and North Atlantic Refining at Come by Chance.
	15:40	Circuit breaker B3T4 was opened at SSD by ECC.
	15:53	Transmission Line TL203 (SSD – WAV) and WAV TS was restored.
	15:54	Transmission Line TL201 (WAV – HWD) and HWD TS was restored.

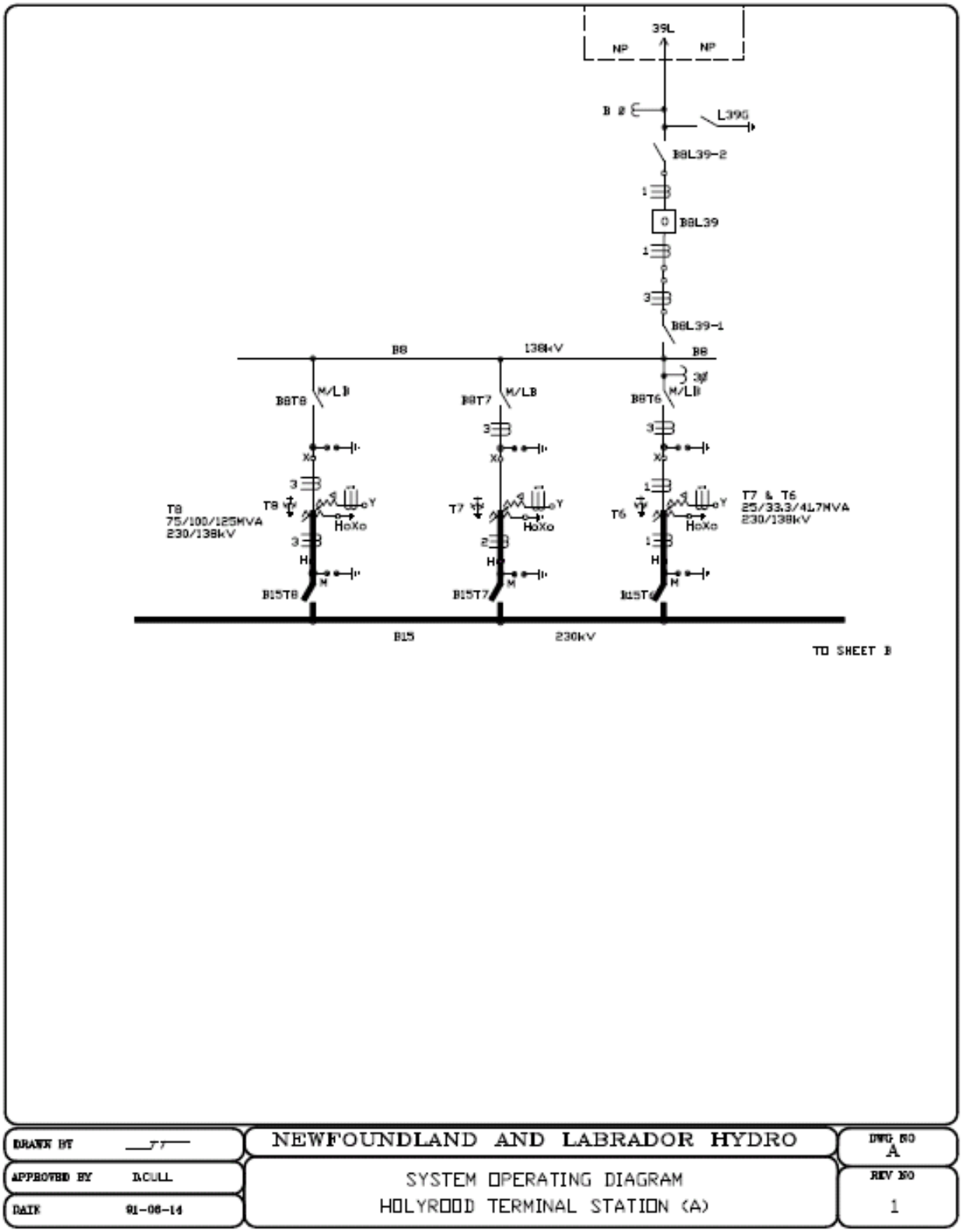
Date	Time	Event
	16:05	BDE Unit 6 restored at 75 MW. Transmission Line TL236 (HWD – OPD) and OPD TS were restored.
	16:06	BDE Unit 5 restored at 75 MW. Cat Arm Unit 1 restored at 65 MW.
	16:09	Transmission Line TL204 (BDE – Stony Brook) restored.
	16:09	Transmission Line TL242 (HWD – HRD) and HRD TS and station service restored.
	16:10	Transmission Line TL202 (BDE – SSD) restored.
	16:14	Transmission Line TL237 (CBC – WAV) in service.
	16:19	Transmission Line TL217 (WAV – HRD) restored.
	16:26	Cat Arm Unit 2 restored at 65 MW. Granite Canal unit restored to 32 MW.
	16:59	Star Lake generating unit restarted and loaded to 18 MW.
	18:00	Transmission Line TL218 (OPD – HRD) restored.
	18:31	SSD Transformer T4 re-energized, restoring station service.
	20:07	Transmission Line TL219 restored, bringing grid power to Burin Peninsula, which was lost during the initial trip at 09:05.
	21:34	Holyrood Unit 2 back on-line at 165 MW (minor de-rating of 5 MW).
	21:45	The 138 kV loop from Stony Brook to SSD restored.
Jan. 5, 2014	**01:40**	Holyrood Unit 3 on-line at 50 MW. (Holyrood Unit 1 remained down due to vibration issues)

Date	Time	Event
	08:10	ECC closes breaker B1L08 at WAV to energize TL208 to Vale.
	10:40	WAV transformer T3 overload protection trip. Transmission Line 64L tripped at WAV. Outages to Newfoundland Power customers in the Bay Roberts area. Newfoundland Power circuit breaker at Bay Roberts on 39L failed with no supply available from HRD.
	10:44	Transmission Line 64L restored at WAV. Newfoundland Power customers restored.
	11:08	WAV transformer T3 overload protection trip. Outages to Newfoundland Power customers in the Bay Roberts area. Newfoundland Power circuit breaker at Bay Roberts on 39L had failed with no supply available from HRD.
	11:18	Transmission Line 64L restored at WAV. Newfoundland Power customers restored.
	21:27:34	Disconnect switch B1T1 closed at HRD, the first step before the generator is synchronized to the system.
	21:27:41	Disconnect switch B1T1 opened at HRD after the operation of the unit lockout switch on HRD Unit 1. The unit lockout switch operated on HRD Unit 2. Primary protection one and backup protection operated on Transmission Line TL217 at WAV end only. Circuit breakers B1L17 and L03L17 opened. Backup protection operated on transmission line TL218 at OPD end only. Circuit breaker B1L18 opened at OPD.
	21:27:41	Primary protection one operated on transmission line TL242 at HWD end only. Breakers B2L42 at HWD and HRD opened. Protection relay 94TS/T1 operated on transformer T1 at HRD.

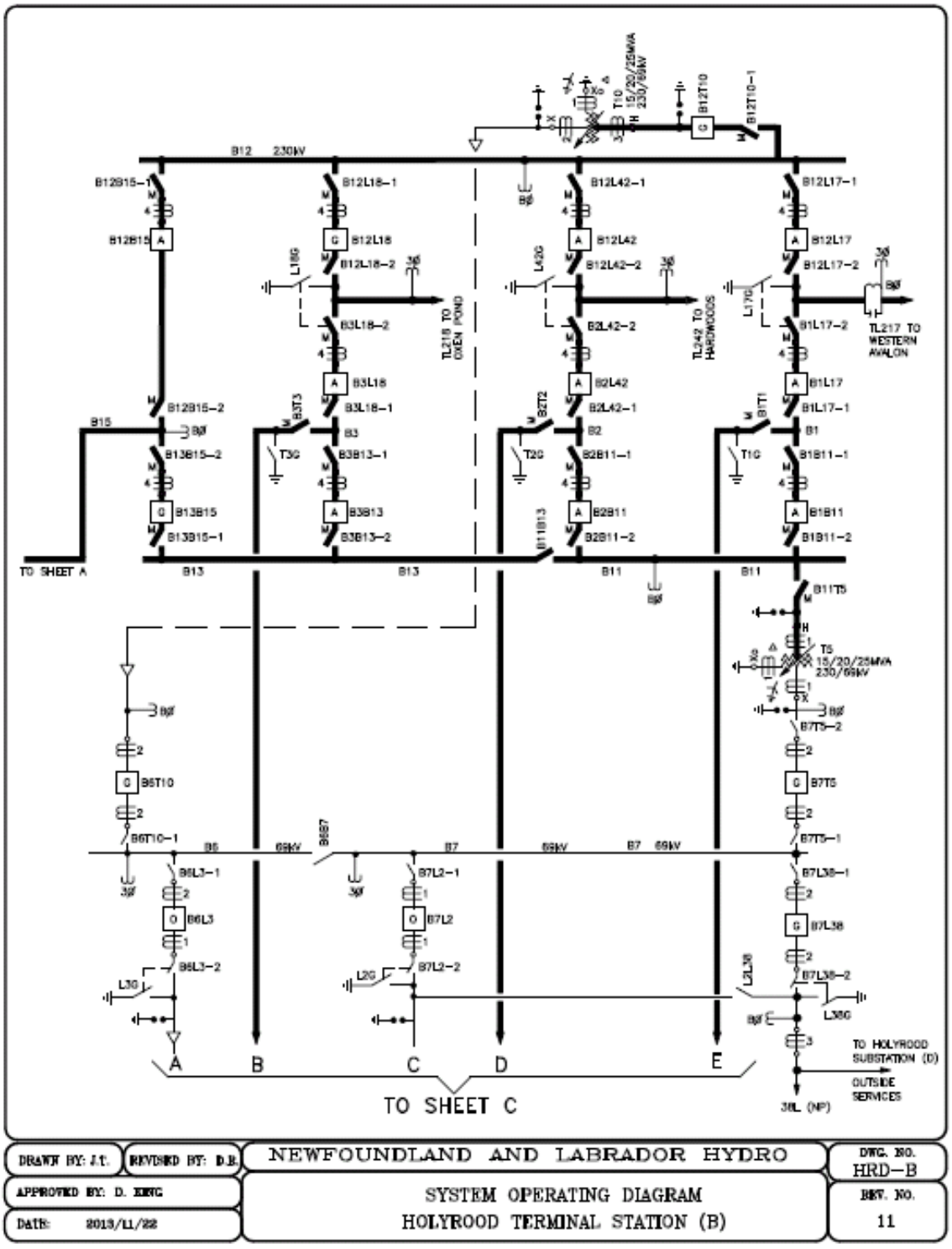
Date	Time	Event
		Breaker failure lockout protection operated on the following circuit breakers at HRD. HRD B3L18 HRD B3B130 HRD B1L17 Breaker failure lockout protection operated on circuit breaker B1L17 at WAV and Bus B1 at WAV. The unit lockout switch operated on HRD Unit 3. **The St. John's area was being supplied via TL201 from WAV. Holyrood Units 2 and 3 were off-line (Unit 1 had tripped during the previous day). The 138 kV loop from WAV to HRD was not available.**
	22:19	Transmission Line TL242 (HWD – HRD) restored.
Jan. 6, 2014	**02:02**	Circuit breaker B1L17 was isolated at HRD.
	03:34	Transmission Line TL217 was energized from WAV to HRD to test for line or Bus fault. No fault was found and TL217 was restored.
	05:29	Holyrood Unit 2 back on-line at 165 MW, with a minor de-rating of 5 MW.
	05:46	Transmission Line TL218 (OPD – HRD) restored.
	07:17	HRD Unit 3 on-line at 50 MW.
Jan. 8, 2014	**15:27**	Test performed to energize HRD Bus B1. Disconnect switches B1L17-1 and B1B11-2 were opened. HRD disconnect switch B1T1 was closed. No problems detected and disconnect switch B1B11-2 was closed. Approval given to HRD plant to synchronize Unit 1 to the system.
	15:38	Holyrood Unit 1 on-line at 165 MW, with a minor de-rating of 5 MW.



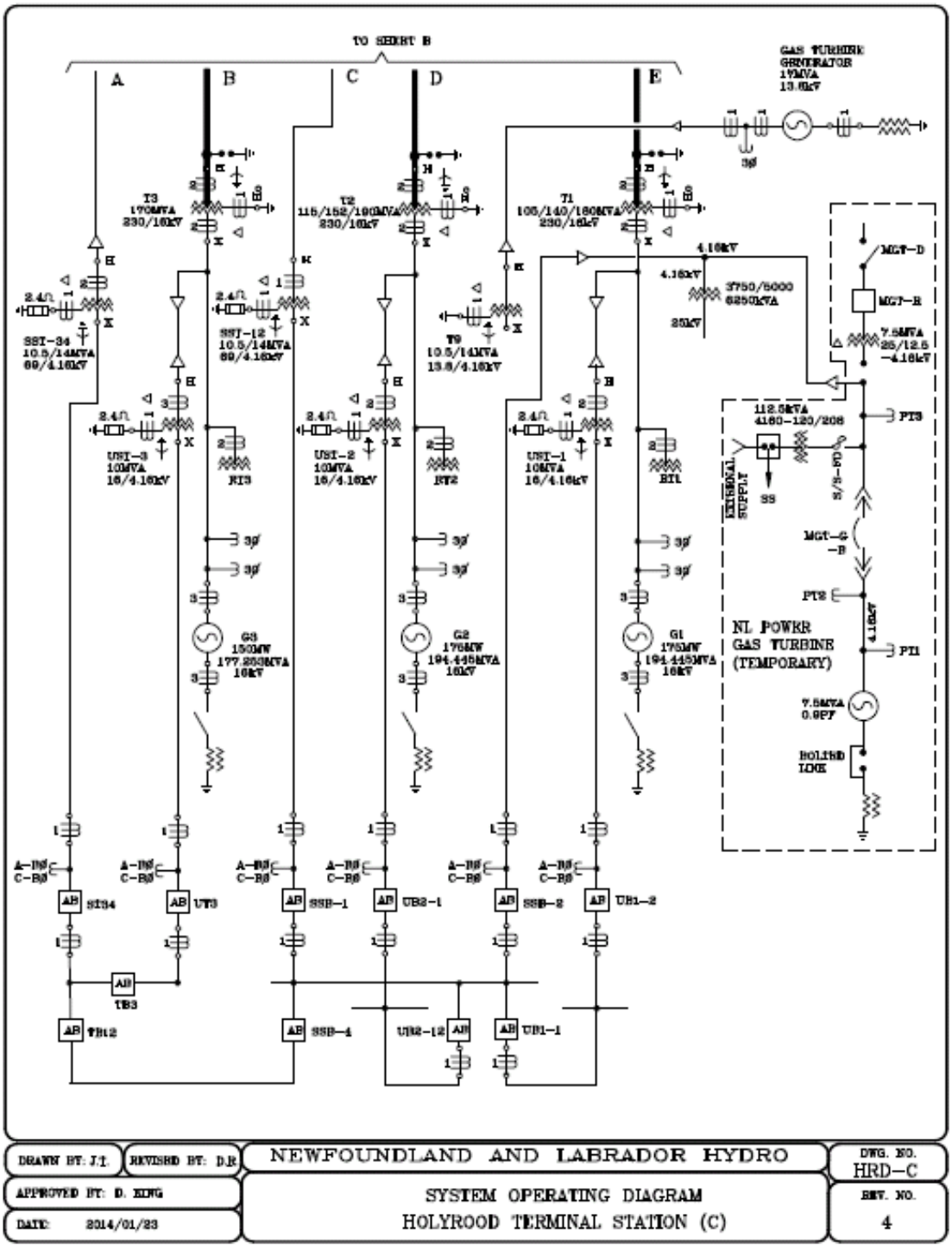
Sunnyside Terminal Station Single Line



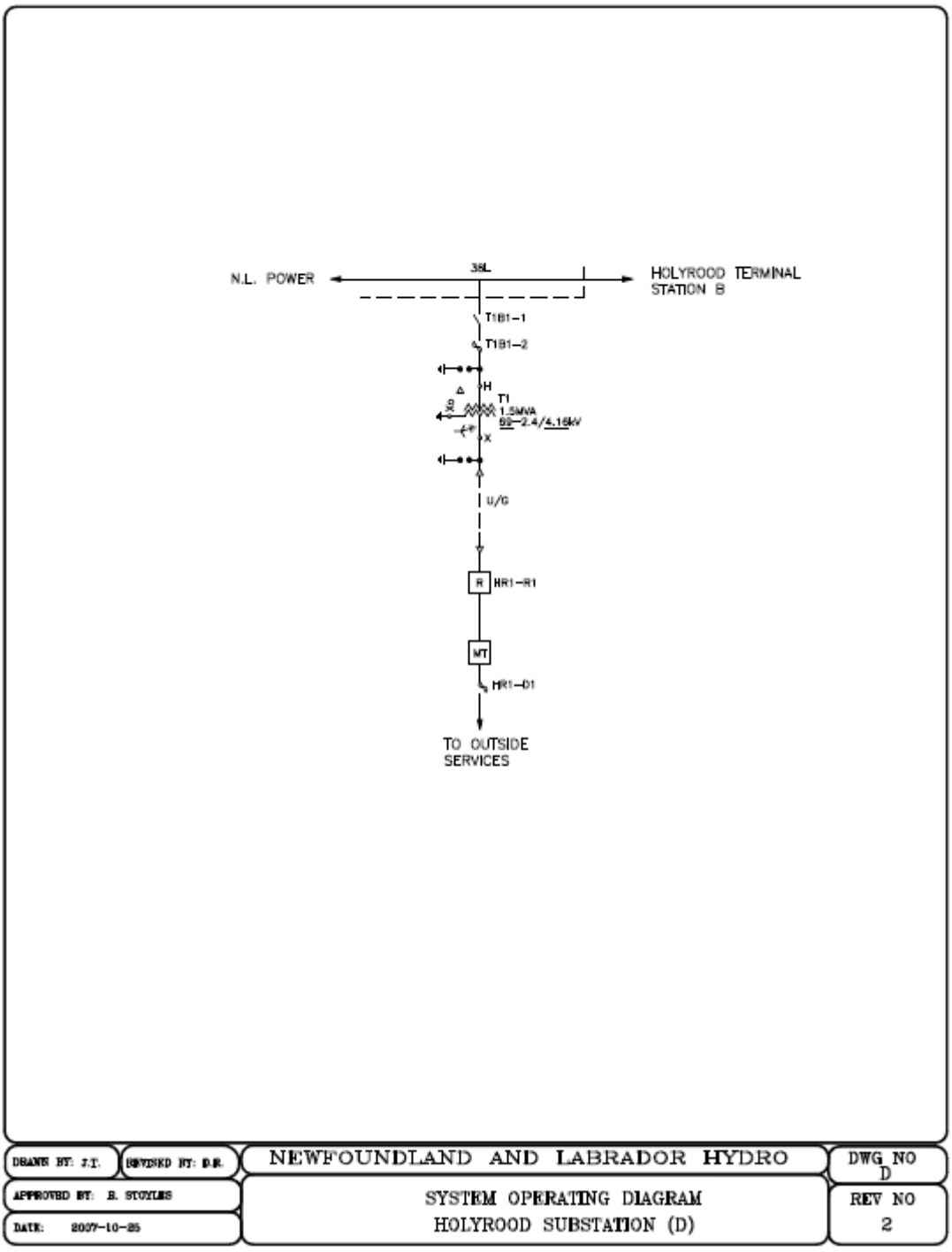
Holyrood Terminal Station Single Line



Holyrood Terminal Station Single Line



Holyrood Terminal Station Single Line



Holyrood Terminal Station Single Line