TECHNICAL MEMORANDUM

DATE April 23, 2020 **Project No.** 18109589

TO Matthew Miller P. Eng.
Northwest Territories Power Corporation

CC Kevin Rattray P. Eng.

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JACKFISH LAKE WATER LICENSE RENEWAL – INSTRUMENTATION STUDY – REVISION 2

1.0 INTRODUCTION

Golder Associates Limited (Golder) has been requested by the Northwest Territories Power Corporation (NTPC) to prepare an instrumentation study to assess raw cooling water monitoring alternatives in order to meet the requirements set by the Mackenzie Valley Land and Water Board (Water Board) for the renewal of the Jackfish Lake power generating facility water license. The Jackfish Lake facility consists of three (3) existing diesel generator systems that require the circulation of raw lake water for cooling. The license requirements consist of raw cooling water flow and temperature monitoring of these three (3) systems. NTPC has previously retained Golder for the implementation of a short-term temperature monitoring system within Jackfish Lake.

2.0 OBJECTIVES

The key objectives of this instrument study are as follows:

- Identify the requirements of the new water license
- Identify the existing cooling and monitoring systems
- Propose measurement points required to satisfy new license requirements
- Provide a recommendation on the instrumentation and monitoring systems required

3.0 NEW LICENSE REQUIREMENTS

The Water Board requires continuous monitoring of raw cooling water flow and temperature as part of the new twenty-five (25) year water license (MV2019L1-0001). This data is to be reported to the Water Board on a monthly and annual basis. No measurement accuracy or sampling interval is stipulated by the Water Board, so an accuracy of +/- 5 % and a sampling interval of 15 minutes is assumed.

The current method used to determine the totalized raw cooling water flow comprises reading the runtime of each raw cooling water pump in hours and multiplying the number of hours by the rated pump capacity.

4.0 EXISITNG SYSTEMS

4.1 Cooling System

The Jackfish Lake generating facility consists of three (3) existing generator systems that require the circulation of raw lake water for cooling. Each cooling system has an open loop configuration, utilizing pumps to circulate raw lake water through a series of heat exchangers. These systems consist of the following:

K-Plant

- One (1) Mirrlees KV16 diesel generator (G1)
  - Unit has a dedicated raw water cooling loop with a gravity discharge to the lake
  - A second unit (G4) is no longer in use and will be decommissioned. It is not considered in the scope of this study
- Two (2) vertical 2-stage water pumps (W1-1, W1-2) located in a separate pumphouse
- One (1) 150 mm (6 inch) schedule 40 carbon steel pipe water header
- Summer pump operation
  - Normal: one (1) pump running
- Winter pump operation
  - Normal: two (2) pumps running

Table 1 : K-Plant Cooling Water Pump Specifications

PUMP No.	Horsepower [HP]	Pressure [psi]	Pressure [kPa]	Flow [USGPM]	Flow [m³/h]
W1-1	50	41	284	1500	341
W1-2	20	41	284	910	207

EMD Plant

- Four (4) EMD S20-645 diesel generators (G2, G3, G5, G8)
  - All units share the same raw water cooling loop
- Three (3) horizontal double suction water pumps (W2-1, W2-2, W2-3) located in the EMD powerhouse pump pit
- One (1) 200 mm (8 inch) schedule 40 carbon steel pipe water header
- Summer pump operation
  - Normal: one (1) pump running
  - Additional cooling: two (2) pumps running
- Winter pump operation
  - Normal: two (2) pumps running
- Maintenance: one (1) pump standby

Table 2 : EMD Plant Cooling Water Pump Specifications

PUMP No.	Horsepower [HP]	Pressure [psi]	Pressure [kPa]	Flow [USGPM]	Flow [m³/h]
W2-1	30	41.1	284	840	191
W2-2	30	41.1	284	840	191
W2-3	30	41.1	284	840	191

CAT Plant

- Two (2) CAT 3612 diesel generators (G14, G15)
  - All units share the same raw water cooling loop
- Three (3) vertical single stage water pumps (1, 2, 3) located in the CAT powerhouse
- One (1) 300 mm (12 inch) schedule 40 carbon steel pipe water header
- Summer pump operation
  - Normal: one (1) pump running
  - Additional cooling: two (2) pumps running
- Winter pump operation
  - Normal: one (1) pumps running
- Maintenance: one (1) pump standby

Table 3 : CAT Plant Cooling Water Pump Specifications

PUMP No.	Horsepower [HP]	Pressure [psi]	Pressure [kPa]	Flow [USGPM]	Flow [m³/h]
1	15	15	103	1060	241
2	7.5	15	103	530	120
3	7.5	15	103	530	120

4.2 Lake Water Temperature Monitoring System

The raw cooling water temperature leaving and returning to Jackfish Lake is monitored by an existing short-term system comprising of one (1) standalone battery operated datalogger and seven (7) thermistor temperature sensors. The temperature data is manually accessed via a SD memory card on a monthly basis. The temperature sensors are located underwater on the following lines:

- K-Plant pumphouse gravity feed lines (2)
- K-Plant pumphouse gravity return line
- EMD pump feed line
- EMD gravity return line
- CAT gravity feed line
- CAT gravity return line

4.3 Utilities

Spare 120 Vac circuits are available in lighting panels and spare copper Ethernet ports are available in corporate network switches located in each powerhouse.

5.0 MEASUREMENT POINTS

5.1 Flow Measurement

It is assumed that no raw cooling water loss will occur between the lake supply and return and that one (1) flow measurement point per cooling loop will be sufficient for reporting purposes. The following are the proposed flow measuring points:

- K-Plant unit G1 pumps common discharge
- EMD pumps common discharge
- CAT pumps common discharge

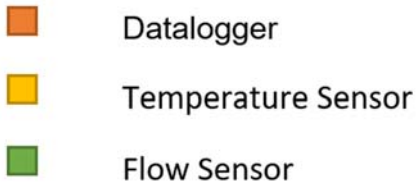
5.2 Temperature Measurement

To improve the reliability and extend the life of the raw cooling water temperature measurement system, additional temperature sensors can be installed in each of the powerhouses. These temperature sensors would be installed indoors in easy to access locations and would operate in parallel with the existing temperature monitoring system until a temperature offset can be determined. The offset would be used to compensate for any temperature differences between the senor locations of the two systems. Once all the data required from the existing system has been collected, it would be decommissioned. It is assumed that the Water Board will accept corrected temperature data for reporting purposes. The following are the proposed temperature measuring points:

- K-Plant unit G1 pumps common discharge
- K-Plant unit G1 return
- EMD pumps common discharge
- EMD common return
- CAT pumps common discharge
- CAT common return

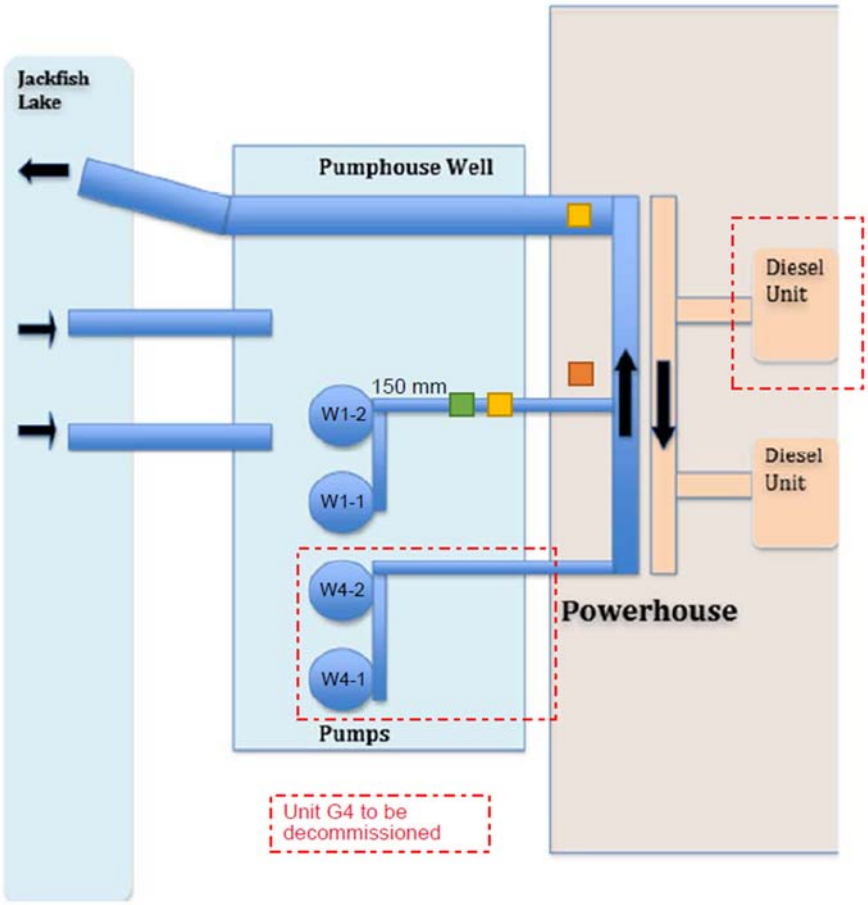
5.3 Powerhouse Schematics

5.3.1 Legend



5.3.2 K-Plant Measuring and Monitoring Points

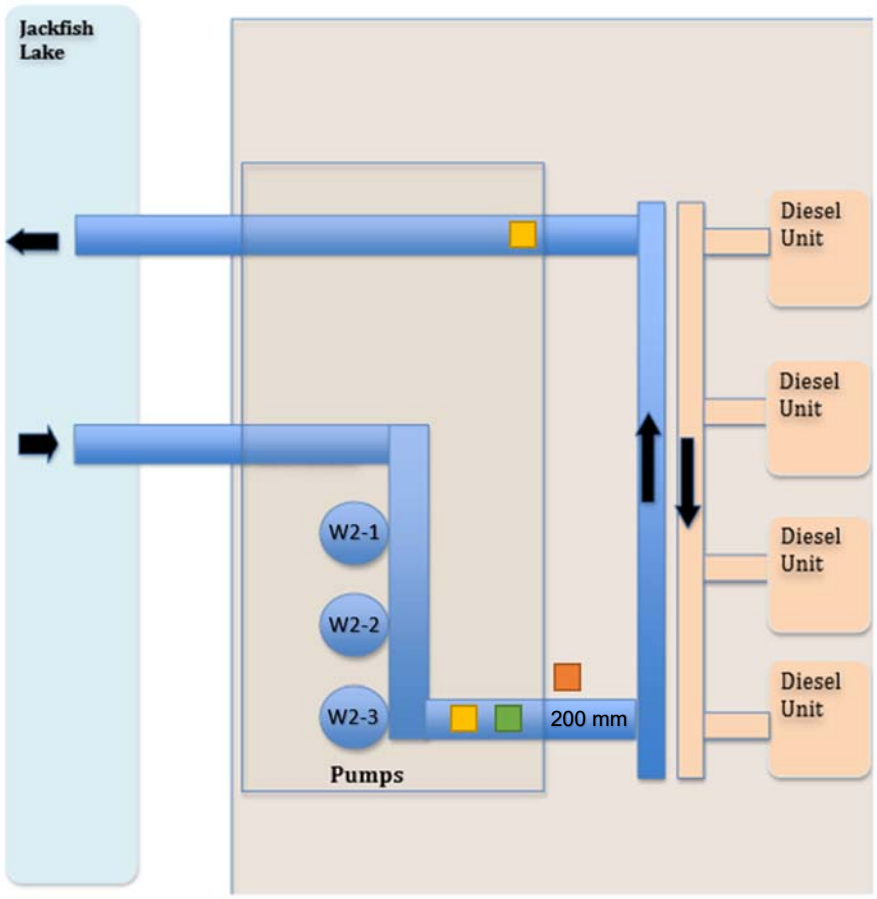
Figure 1: K-Plant Schematic



NTPC reference document: *Operations, Maintenance and Surveillance Manual, April 2019*

5.3.3 EMD Plant Measuring and Monitoring Points

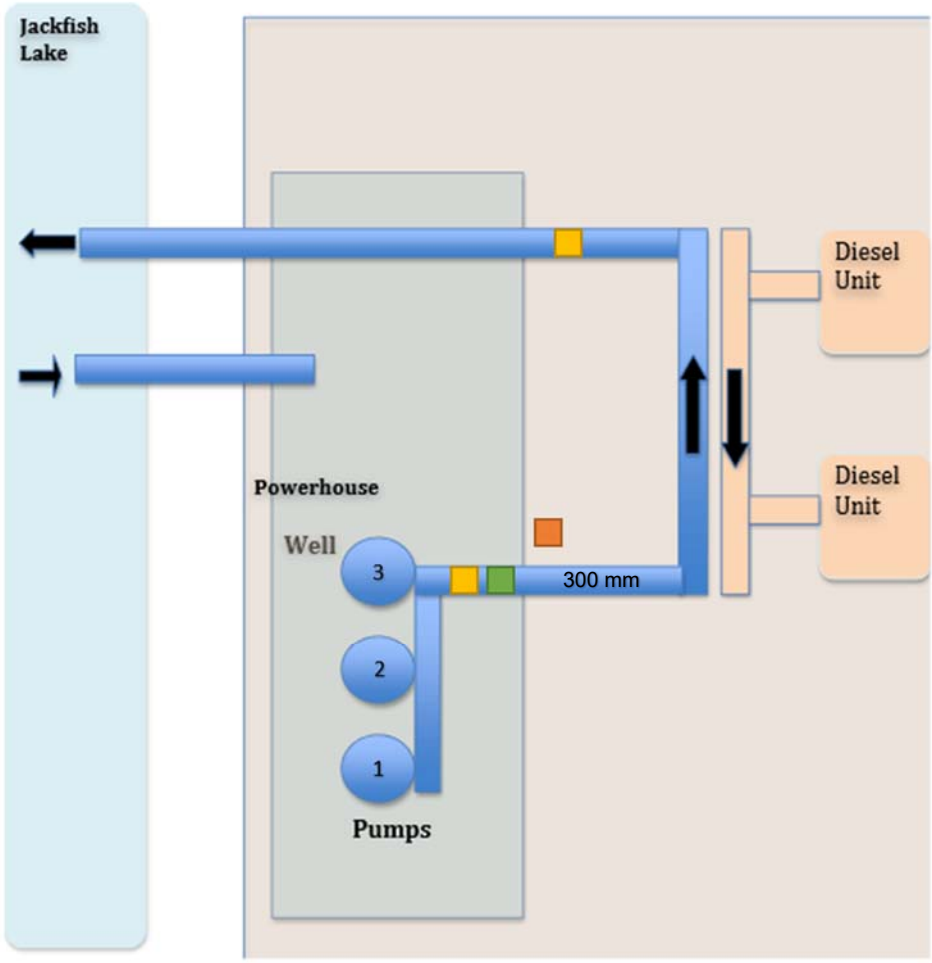
Figure 2: EMD Plant Schematic



NTPC reference document: *Operations, Maintenance and Surveillance Manual, April 2019*

5.3.4 CAT Plant Measuring and Monitoring Points

Figure 3: CAT Plant Schematic



NTPC reference document: *Operations, Maintenance and Surveillance Manual, April 2019*

6.0 OPERATIONAL CONSTRAINTS

The Jackfish Lake power generating facility is considered an essential service and complete powerhouse shutdowns should be avoided. If required, complete powerhouse shutdowns should be short and coincide with forecasted seasonal system loading.

7.0 RECOMMENDATION

It is recommended that the following be used to satisfy the monitoring requirements of the new license:

- Clamp-on ultrasonic flow meters
- Platinum Resistance Temperature Detector (RTD) sensors
- Ethernet capable dataloggers

7.1 Flow Measurement

Clamp-on ultrasonic flow meters provide the following advantages:

- Installed accuracy of +/- 2 %
- Clamp-on installation (no process shutdown required)
- Flow measurement is independent of process conditions
- Remote transmitter for easy access for configuration, maintenance, and troubleshooting
- Low installation cost
- Small installation envelope

Ultrasonic flow meters are highly prone to installation errors due to improper pipe preparation and transducer position and alignment. It is recommended that the instrument manufacturer install and commission the devices to ensure proper operation and best accuracy.

7.2 Temperature Measurement

Platinum Resistance Temperature Detector (RTD) sensors provide the following advantages:

- Long term stability
- Low maintenance

Two installation types of RTD sensors are available. An insertion type, that requires a penetration into the pipe and a surface type, that is mounted on the pipe outer surface. The insertion type provides the best accuracy and response time, however the surface type does not require a process shutdown for installation.

7.3 Data Monitoring Equipment

Ethernet capable dataloggers would be used to log the flow and temperature data at fifteen (15) minute intervals. This technology provides the following advantages:

- Can accept different input signals from the flow meter and RTD sensors
- Ethernet capable for integration into the corporate network
- Variable data sampling intervals
- Non-volatile memory

One (1) datalogger would be required for each of the three (3) powerhouses and be housed in an enclosure. Each enclosure would comprise of the following:

- Industrial enclosure
- Ethernet capable datalogger
- 24 Vdc power supply (required for the datalogger)
- 120 Vac power distribution circuits (required for the 24 Vdc power supply and ultrasonic flow meter(s))
- Field signal terminal strip (required for the RTD and ultrasonic flow meter signals)

7.4 Data Integration

It is recommended that flow and temperature data be interfaced with the corporate network and stored on a SQL server for use in the corporate dashboards and Water Board reports. Each datalogger panel will be require an Ethernet connection to a corporate network switch in each of the three (3) powerhouses.

7.5 Existing Lake Water Temperature Monitoring System Upgrade

To eliminate the need for manual data collection from the existing lake water temperature monitoring system, the existing datalogger could be replaced with an Ethernet capable datalogger and interfaced with the corporate network. This would improve system reliability and allow for automated reporting. This upgrade would require a 120 Vac power circuit and an Ethernet connection.

8.0 CAPITAL COST ESTIMATE

The following is a conceptual capital cost estimate (+/- 30%) for the recommended flow and temperature monitoring equipment:

Table 4: Conceptual Capital Cost Estimate (+/- 30%)

ITEM	QUANTITY	UNIT COST	INSTALLATION	MATERIAL	TOTAL (CAD)
Ultrasonic flow meter	3	$ 5,000.00	$ 1,330.00	$ 427.50	$ 20,272.50
RTD temperature sensor	6	$ 300.00	$ 760.00	$ 225.00	$ 7,710.00
Datalogger panel	3	$ 2,500.00	$ 2,470.00	$ 3,735.00	$ 26,115.00
					$ 54,097.50

Assumptions:

- *Combined labour rate: $ 95.00 per hour*
- *Cable length between instrument and datalogger: 15 m*
- *Cable length between datalogger and utilities: 90 m*

9.0 CLOSURE

We appreciate the opportunity to provide Golder's services for the Northwest Territories Power Corporation's Jackfish Lake power generating facility. If you have questions or comments, do not hesitate to contact the undersigned.

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NB/GD

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