October 2013

ANNEX I - ATMOSPHERIC AND ACOUSTIC BASELINE REPORT

Tazi Twé Hydroelectric Project

Submitted to:
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Report Number: 10-1365-0004/DCN-072

REPORT

List of Abbreviations

Abbreviation	Term
a.m.	ante meridiem
AOD	aerosol optical depth
ARCTAS	Arctic Research of the Composition of the Troposphere from Aircraft and Satellites
AUC	Alberta Utilities Commission
EIS	Environmental Impact Statement
IDF	intensity duration frequency
MODIS	Moderate Resolution Imaging Spectroradiometer
MOE	Saskatchewan Ministry of Environment
NASA	National Aeronautics and Space Administration
NO	nitrogen oxide
NO_2	nitrogen dioxide
O_3	ozone
p.m.	post meridiem
Project	Tazi Twé Hydroelectric Project
SAAQS	Saskatchewan Ambient Air Quality Standards
SO_2	sulphur dioxide

List of Units

Abbreviation	Term
%	percent
°C	degrees Celsius
dB	decibels
dbA	A-weighted decibels
cm	centimetre
h	hour
$L_{eq,1hour}$	equivalent energy sound level on a one hour time scale
$L_{eq,1min}$	equivalent energy sound level on a one minute time scale
$L_{eq,day}$	equivalent energy sound level over the daytime period (7:00 a.m. – 10:00 p.m.)
$L_{eq.night}$	equivalent energy sound level over the nighttime period (10:00 p.m. – 7:00 a.m.)
km	kilometre
km/h	kilometre per hour
m	metre
m/s	metre per second
m^3/s	cubic metres per second
min	minute
mm	millimetre
Mm	megametres
ng/m^3	nanograms per cubic metre
nm	nanometres
µm	micrometres
ppbv	parts per billion volumetric

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1.0 INTRODUCTION

1.1 Project Proponent

In response to an increasing demand for energy in northern Saskatchewan, Black Lake First Nation (BLFN) together with Saskatchewan Power Corporation (SaskPower) are the Proponents of the Tazi Twé Hydroelectric Project (Project). Black Lake First Nation's interest in the Project is being held through the Elizabeth Falls Hydro Limited Partnership (EFHLP).

1.2 Project Location and Overview

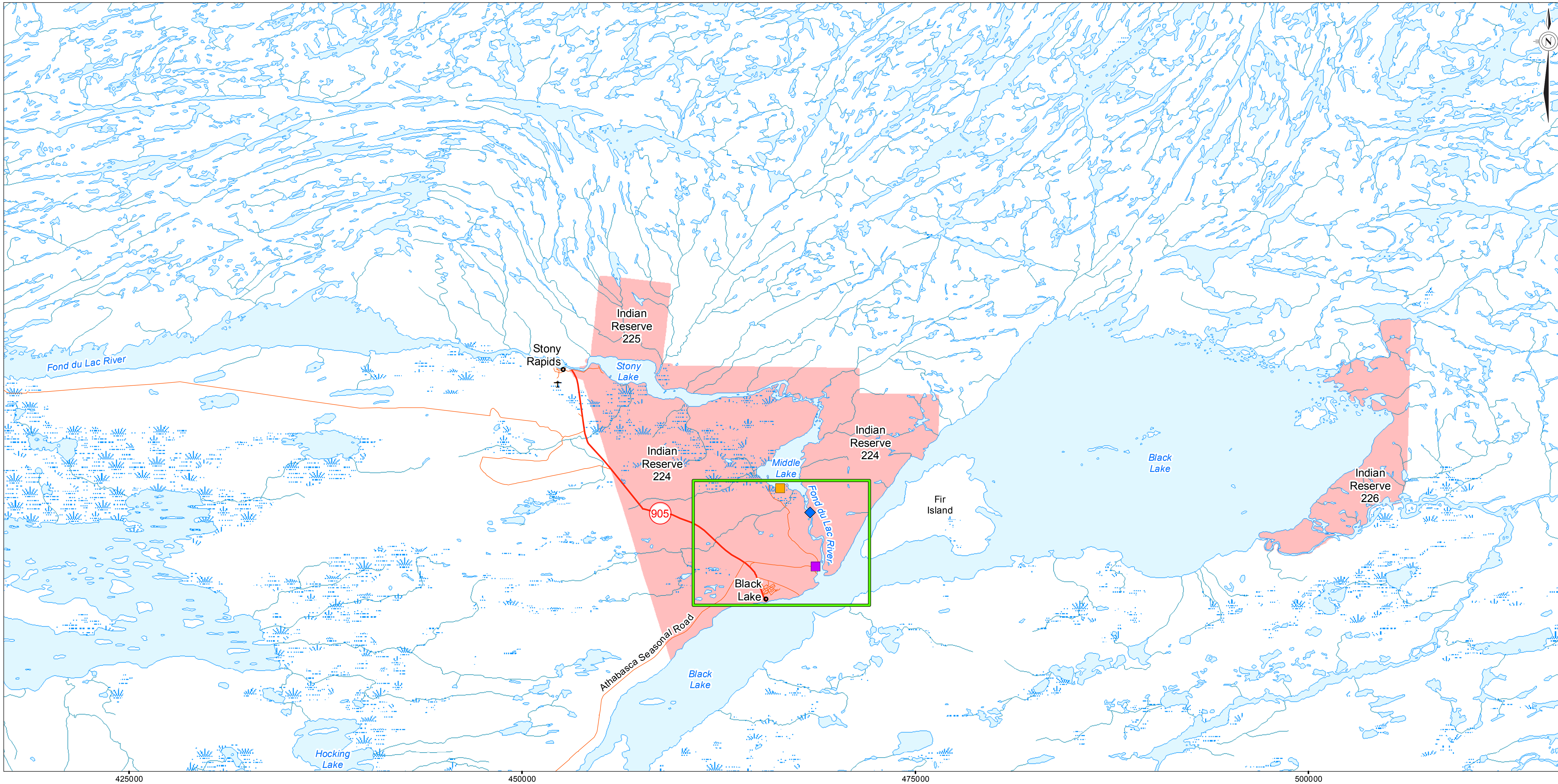
The proposed Project will be a 50 megawatt (MW) water diversion type electrical generating station. The Project is located on the Chicken Indian Reserve 224, approximately 7 kilometres (km) from the community of Black Lake adjacent to the Fond du Lac River between Black Lake and Middle Lake (Figure 1.2-1). Black Lake has an approximate area of 418 square kilometres (km^2) and discharges an average flow of 305 cubic metres per second (m^3/s) into the Fond du Lac River. The Fond du Lac River traverses Elizabeth Falls on its way to Middle Lake. Water from Black Lake will be diverted through an intake and power tunnel to the powerhouse before being released through a tailrace channel into the Fond du Lac River, which ultimately discharges into Middle Lake.

The principal components of the Project consist of the following:

- gravel, all-season access road to the Project site from the all-season road between the communities of Stony Rapids and Black Lake;
- bridge over the Fond du Lac River;
- powerhouse and associated infrastructure;
- water intake and power tunnel to convey flow from Black Lake to the powerhouse;
- tailrace channel from the powerhouse to the Fond du Lac River just upstream of Middle Lake;
- submerged weir located in the Fond du Lac River at the outlet of Black Lake at Grayling Island;
- transmission lines and switching stations to connect to the northern Saskatchewan electrical grid; and
- all related physical works and physical activities required to carry out these works, including the associated coffer dams, access roads, laydown areas, construction camp, borrow areas, waste rock piles, concrete batch plant, fuel storage facility and fueling areas, explosives storage, construction camp, and sewage treatment and potable water facilities.

1.3 Objective of the Baseline Report

The objective of the atmospheric and acoustical baseline report is to provide information on the current environmental conditions related to climate, air quality, and noise in the Project area. This information will be used to support assessment of the effects of the Project on biophysical and socio-economic environments in the area.



LEGEND

- VILLAGE
- RUNWAY
- HIGHWAY
- ROAD
- RIVER
- WETLAND
- WATERBODY
- INDIAN RESERVE
- ELIZABETH FALLS
- CAMP GRAYLING
- PERMANENT RESIDENT'S CABIN
- GENERAL PROJECT LOCATION

REFERENCE

DMTI HIGHWAYS AND ROADS
NTS MAPSHEET 74I, 74J, 74O, 74P
DATUM: NAD 83 PROJECTION: UTM ZONE 13

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

GENERAL PROJECT LOCATION

Golder Associates
Saskatoon, Saskatchewan

PROJECT		10-1365-0004	FILE No.
DESIGN			SCALE AS SHOWN REV. 1
GIS	SM	12/07/13	
CHECK	CM	26/07/13	**FIGURE: 1.2-1**
REVIEW	VS	26/07/13	

2.0 CLIMATE

2.1 Introduction

The Project planning considers the context of the prevailing climate of northern Saskatchewan, a region characterized by a subarctic continental climate, experiencing long, very cold winters and short, cool summers. Climate, which is the long-term record and pattern of weather in an area, influences many aspects of the Project. There are strong links between climate and other environmental disciplines. Climate greatly influences terrestrial and aquatic ecosystems through its continual influence on air, surface water, and terrestrial environments. For example, climate, in part, determines the plant and wildlife communities that are present in the area, and has a direct effect on the availability of water in terms of total volume and the timing of that availability.

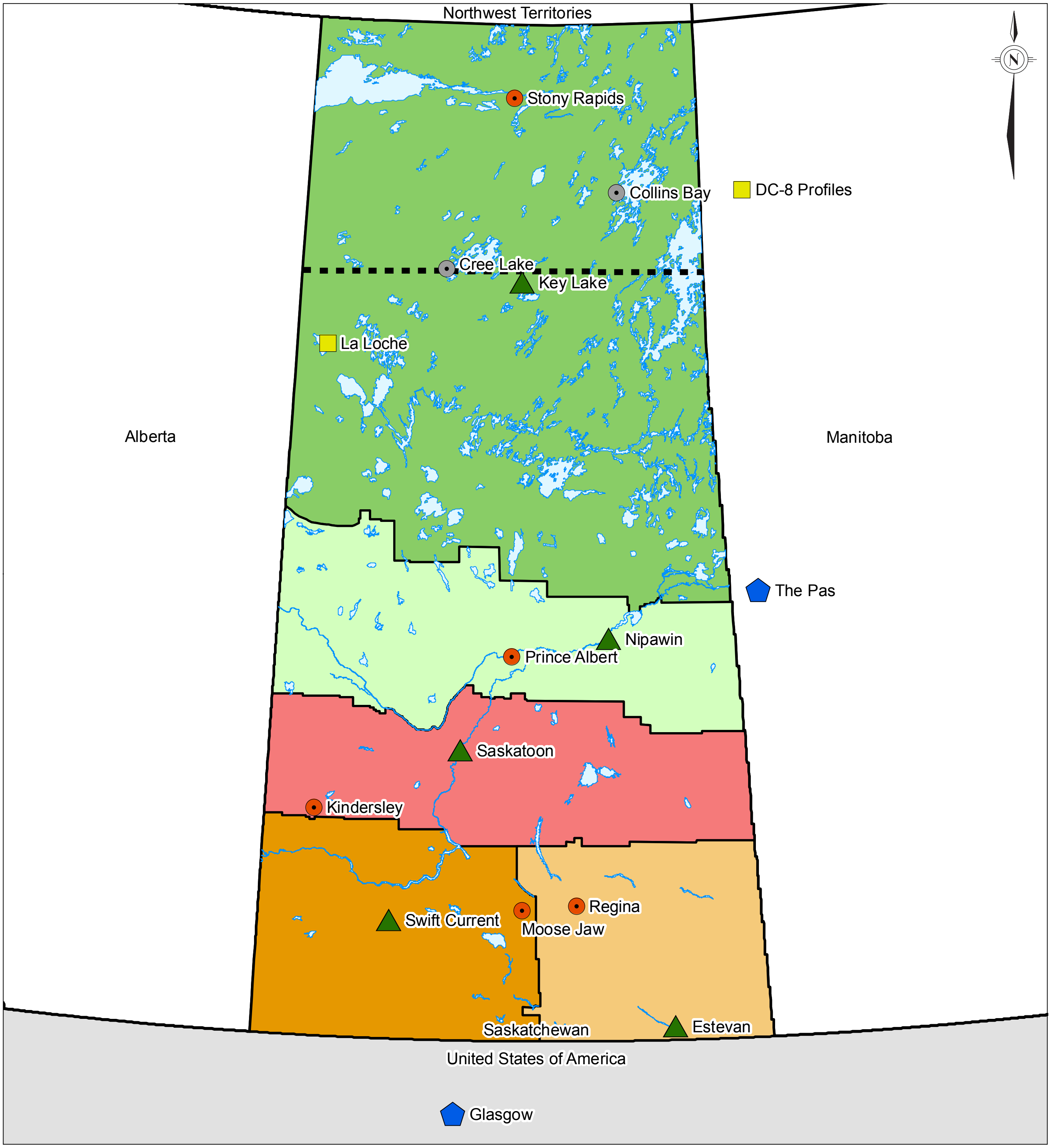
Seasonal and daily air temperatures can range by tens of degrees, while the underlying processes of energy exchange and transformation occur within and between air, soil, snow pack, and surface waters. Precipitation (including snowfall) and evaporation (including evapotranspiration and sublimation) govern the availability of moisture in the environment. Wind influences microclimate over the landscape, and enhances evaporation and blowing snow. Climate has a continual influence on most of the existing biophysical and socio-economic components of the environment.

2.2 Study Area

The regional study area for this baseline assessment of climate data is the Northern Air Dispersion Modelling Zone Figure 2.2-1, as defined in the Saskatchewan Air Quality Modelling Guideline (MOE 2012). The study area encompasses a large area because of a general lack of infrastructure and the coarse spatial resolution of global climate models.

2.3 Methods

Data from the climate stations are used to present climate statistics and provide information on the long-term weather patterns in the area. The Project is located in proximity to two historical weather stations managed by Environment Canada in Stony Rapids. Climate data recorded between 1960 and 1978 is available from the 'Stony Rapids' weather station while climate data recorded between 1982 and 2010 is available from the 'Stony Rapids A' station. The climate data for Stony Rapids are presented alongside data from the three other Environment Canada climate stations within ~225 km of the Project with long term climate records (1971-2000) to provide regional context (Table 2.3-1).



LEGEND

AIR DISPERSION MODELLING ZONE

- NORTHERN
- NORTH CENTRAL
- CENTRAL
- SOUTHWESTERN
- SOUTHEASTERN
- SUBZONE DIVIDING LINE

- ALTERNATIVE SURFACE STATION
- SURFACE STATION
- UPPER AIR STATION
- ADDITIONAL METEOROLOGY STATION
- AIR QUALITY MONITORING LOCATION

200 0 200

SCALE 1:7,000,000 KILOMETRES

REFERENCE

CANVEC © 2012, NATURAL RESOURCES CANADA
AIR DISPERSION MODELLING ZONE: SASKATCHEWAN MINISTRY OF ENVIRONMENT
DATUM: NAD 83 PROJECTION: UTM ZONE 13

PROJECT

TAZI TWÉ HYDROLELECTRIC PROJECT

TITLE

AIR DISPERSION MODELLING ZONES AND AIR QUALITY MEASUREMENTS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		10-1365-0004	FILE No.
DESIGN	CM	05/02/13	SCALE AS SHOWN REV. 0
GIS	SM	21/06/13	
CHECK	CM	25/07/13	**FIGURE: 2.2-1**
REVIEW	VS	25/07/13	

Table 2.3-1: Meteorology Stations with Long Term Climate Records for the Project's Regional Study Area

Station	Station ID	Latitude	Longitude	Elevation (m)	Period
Stony Rapids	4067PR5	59°15' N	105°50' W	245	1960-1978
Stony Rapids A	4067PR5	59°15' N	105°50' W	245	1982-2010
Collins Bay	4061630	58°11' N	103°42' W	492	1971-2000
Cree Lake	4061861	57°21' N	107°08' W	492	1971-2000
Key Lake	4063755	57°15' N	105°37' W	509	1971-2000

m = metre

Monthly averages are used to calculate statistics to describe temperature, precipitation, wind, and relative humidity as described below:

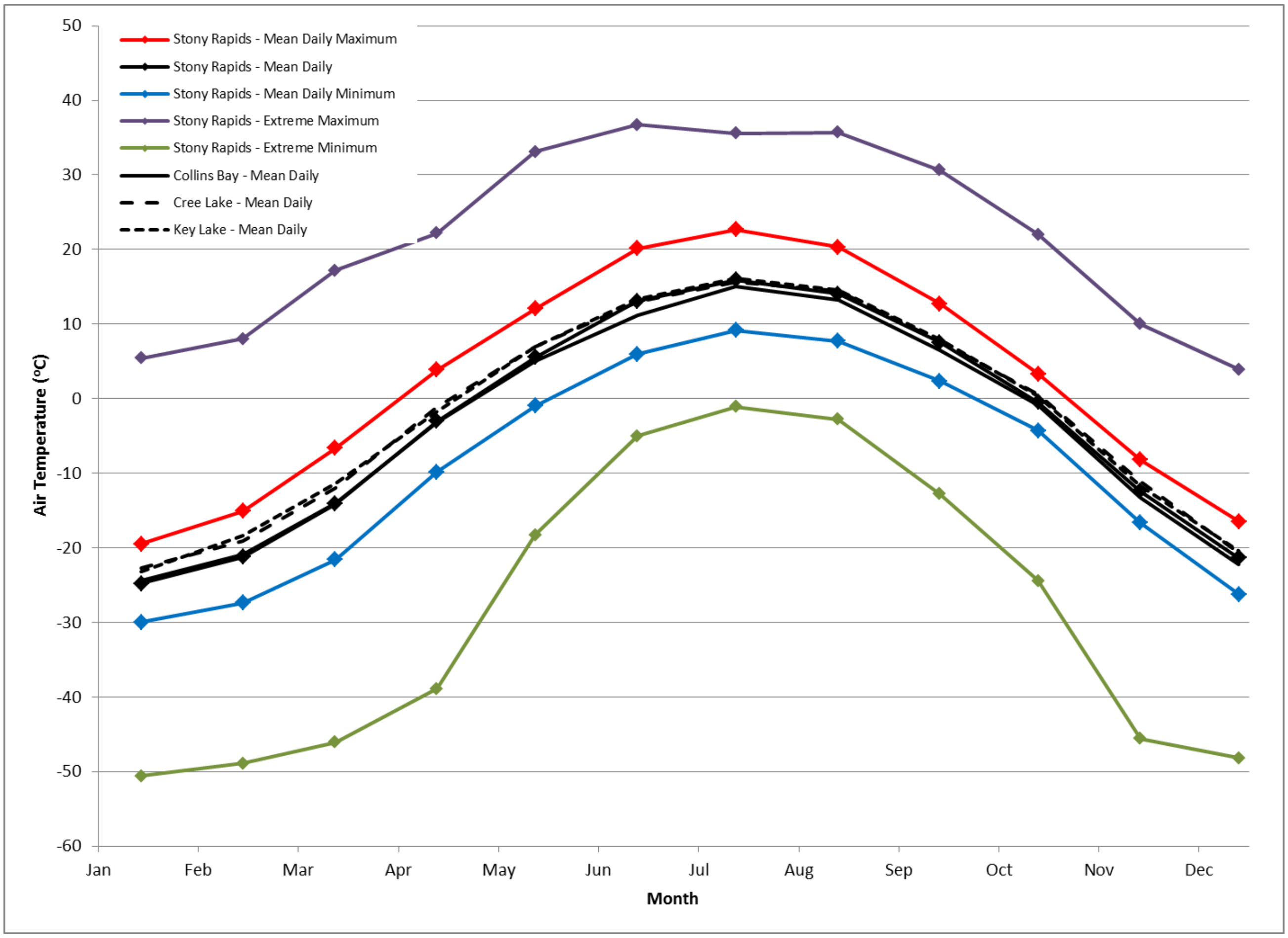
- Temperature:
  - mean daily maximum and minimum temperature;
  - mean daily temperature; and
  - extreme daily maximum and minimum temperature.
- Precipitation:
  - mean monthly snowfall, rainfall and total precipitation;
  - extreme daily rainfall and snowfall; and
  - intensity duration and frequency for rainfall.
- Wind: average hourly wind speed and direction; and
- Relative Humidity: mean monthly.

2.4 Results

2.4.1 Temperature

Stony Rapids experiences extreme seasonal temperature variations. In the summer, mean maximum daily air temperatures reach a July high of 22.7 degrees Celsius (°C), while in January mean minimum temperatures are as low as -30°C (Figure 1.4-1). Extreme temperature ranges between a low of -50.6°C which occurred in January, to a high of 36.7°C which occurred in June. These seasonal differences of more than 50 to 80°C between the warmest summer days and the coldest winter nights are characteristic of continental climate types. As shown in Figure 2.4-1, mean air temperature at Stony Rapids is comparable to that at Collins Bay, Cree Lake, and Key Lake.

Figure 2.4-1: Comparison of Annual Daily Average Air Temperature at Stony Rapids from 1986-2010 to Collins Bay, Cree Lake and Key Lake from 1971-2000.



2.4.2 Precipitation

Mean annual precipitation over the 1986-2010 time period at Stony Rapids is 424 millimetres (mm) with 66 percent (%) of the precipitation occurring as rainfall during the spring, summer and fall (Figure 2.4-2). Precipitation for the Project's location is similar to that of Cree Lake (446 mm) but 12 to 23% drier than the Key Lake (481 mm) or Collins Bay (552 mm) locations (Figure 2.4-2). Figure 2.4-2 also shows that peak precipitation at Stony Rapids occurs in July, August and September, which is ~1 month later than at all three of the other meteorological stations. Extreme rainfall and snowfall events for the period 1960-2007 at Stony Rapids are presented in Table 2.4-1. The highest daily rainfall event occurred in August at 69.9 mm while the highest daily snowfall event occurred in March with 31.0 centimetres (cm) of snow.

Figure 2.4-2: Annual Precipitation at Stony Rapids, Collins Bay, Cree Lake, and Key Lake

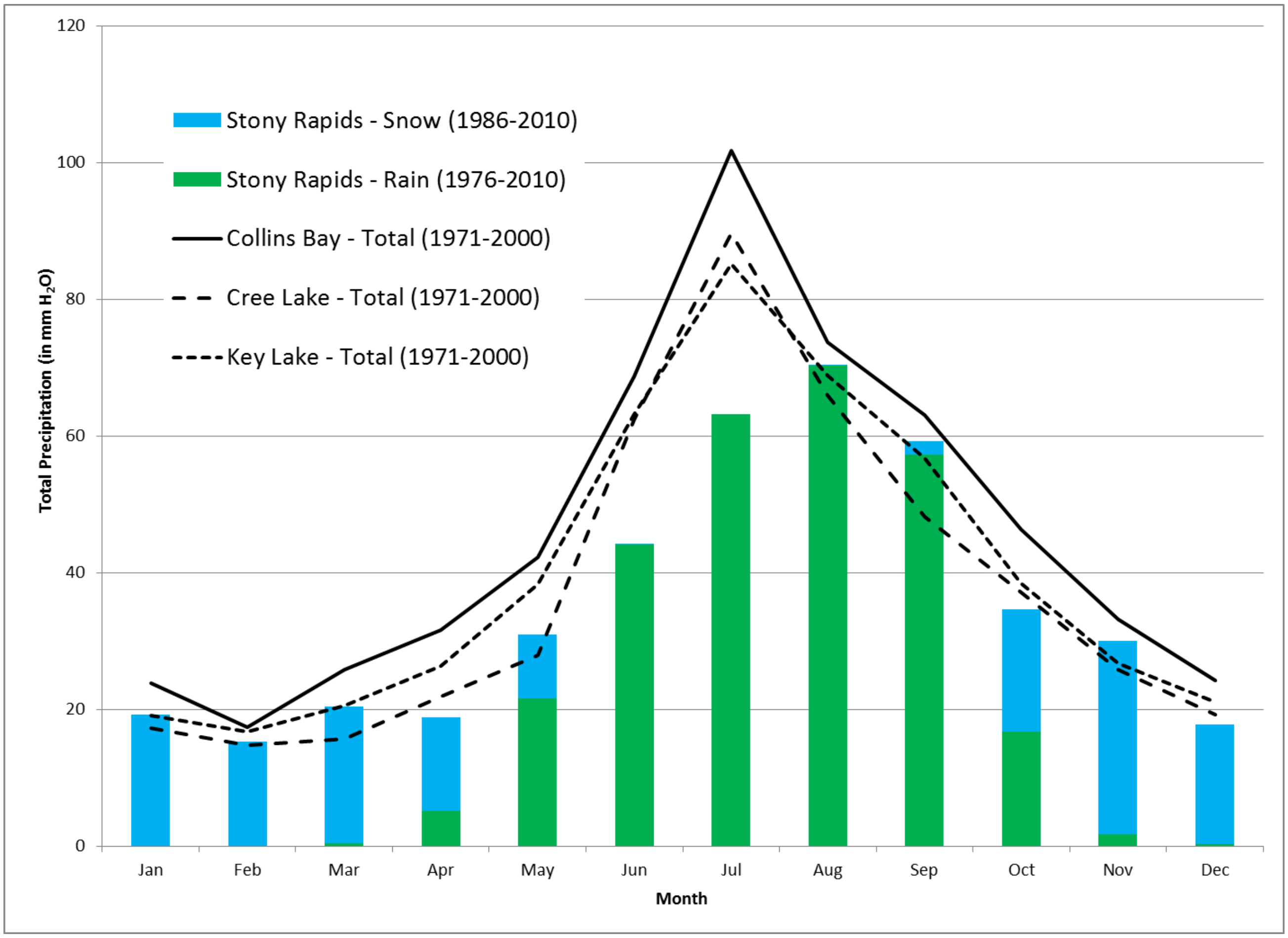


Table 2.4-1: Extreme Precipitation Records for Stony Rapids (1960-2007)

Month	Extreme Daily Rainfall (mm)	Extreme Daily Snowfall (cm)
January	0.6	12.7
February	0.2	12.7
March	1.8	31.0
April	17.8	20.4
May	26.8	23.0
June	37.6	2.2
July	59.4	0.0
August	69.9	0.4
September	55.6	13.6
October	22.9	15.2
November	8.4	25.4
December	3.0	25.2

mm = millimetres; cm = centimetres

Environment Canada provides rainfall intensity duration frequency (IDF) data at stations throughout Canada. These data are used to obtain short duration rainfall intensity statistics, which are useful for estimating rainfall patterns and probabilities of extreme precipitation events. The closest Environment Canada IDF data to the Project area is Stony Rapids A, Saskatchewan.

Short Duration Rainfall Intensity-Duration (IDF), Return Level, and Quantile curves for the Environment Canada Stony Rapids A Station are included in Appendix I.1, while return period rainfall amounts are also included in Table 2.4-2. The IDF values are based on 20 years of data over the period 1986 to 2006. As such, a 100 year return period corresponds to an 86.7 mm precipitation event over 24 hours (Table 2.4-2).

Table 2.4-2: Intensity Duration and Frequency Rainfall Statistics for Stony Rapids A (mm)

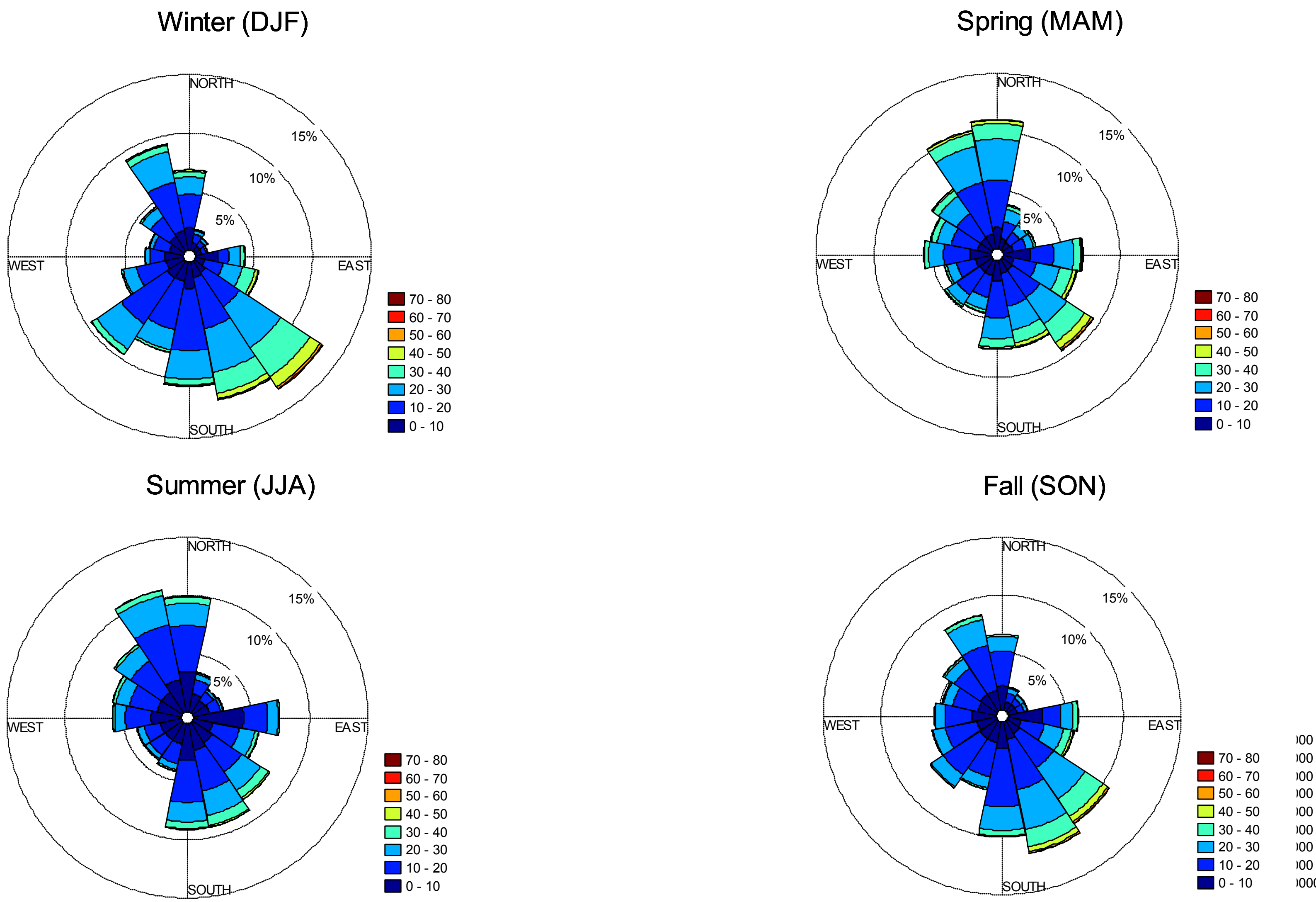
Duration	Return Period (years)					
	2	5	10	25	50	100
5 min	4.2	6.2	7.4	9.1	10.3	11.4
10 min	5.9	8	9.3	11.1	12.3	13.6
15 min	7.3	9.6	11.2	13.2	14.7	16.2
30 min	9.1	12.4	14.6	17.3	19.4	21.4
1 h	11.2	16.1	19.4	23.6	26.7	29.7
2 h	14.4	21.6	26.4	32.4	36.9	41.4
6 h	21.8	29.9	35.2	42	47	52
12 h	28.7	40.2	47.7	57.3	64.4	71.5
24 h	35.2	49	58.1	69.7	78.2	86.7

min = minute; h = hour; mm = millimetre

2.4.3 Wind

Hourly average wind speed in kilometers per hour (km/h) and direction, in 10 degree increments, are available for the Stony Rapids A weather station for the period of July 1986 to February 2010. Figure 2.4-3 presents the seasonal distribution of wind speed and direction. Both annually and seasonally, most winds come from either the southwest or northwest with some variability in their strength among the seasons. On a seasonal basis, winds have the highest average speeds in spring, 18.6 +/- 10.0 km/h, and lowest speeds in summer, 14.5 +/- 8.5 km/h.

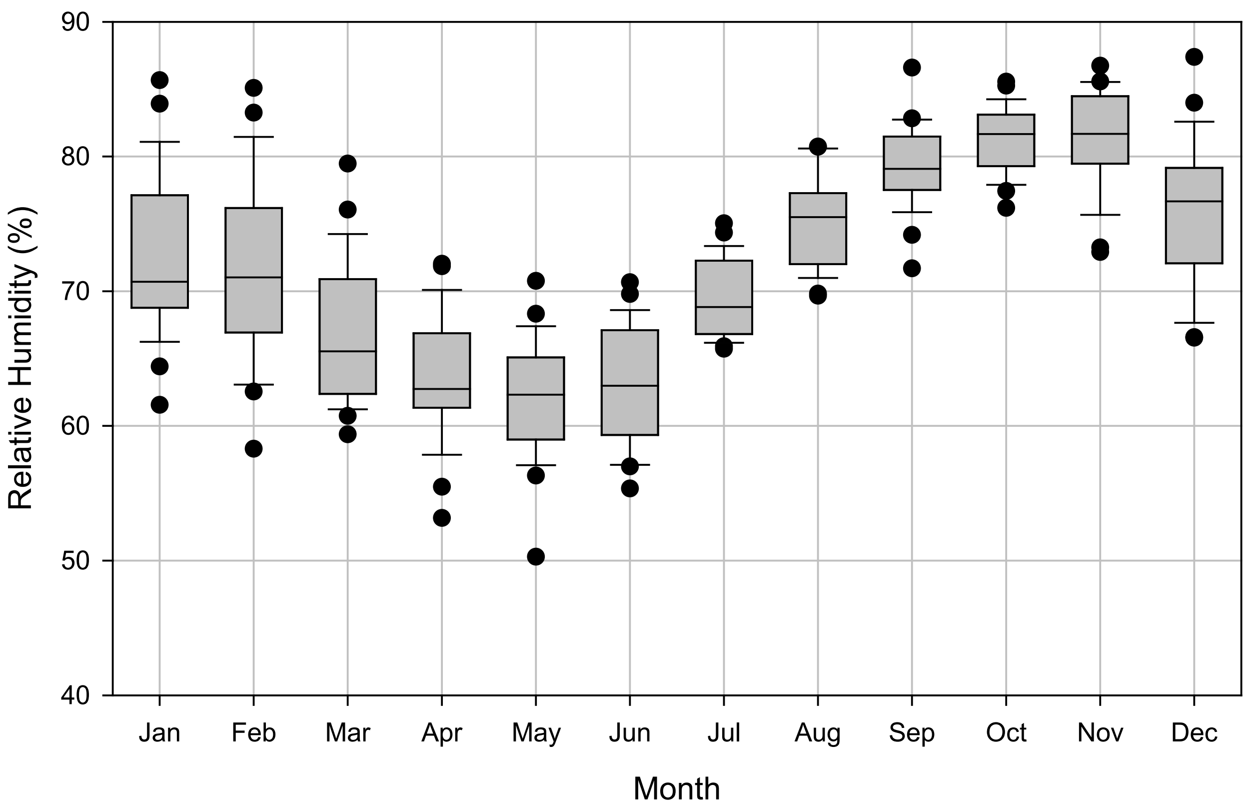
Figure 2.4-3: Hourly average wind speed and direction for the 'Stony Rapids A' Climate Station for the Period 1986 to 2010.



2.4.4 Relative Humidity

Humidity is the amount of water vapour present in the air, while relative humidity is the amount of water vapour present in the air relative to its carrying capacity, or saturation point. Both climatic parameters are related to evaporation and condensation (Viesmann and Lewis 1996). Relative humidity was measured hourly at the 'Stony Rapids A' climate station from July 1986 to February 2010 (EC 2012). These data were used to calculate mean monthly values, for which the 10th, 25th, 50th, 75th, 90th percentiles and outliers are presented in Figure 2.4-4. Monthly relative humidity is typically lowest during the spring, with a median value in May of 62%, and highest in the early winter, with a median value in November of 82%. Although mean monthly relative humidity can vary considerably, all mean monthly values are between 50% and 88%.

Figure 2.4-4: Relative Humidity Statistics at the 'Stony Rapids A' Climate Station for the Period July 1986 to February 2010 Indicating the 10th, 25th, 50th, 75th, 90th Percentiles and Outliers for Each Month.



2.4.5 Evaporation

Evaporation is defined as the process that transfers water from land and waterbodies to the atmosphere (Viessman and Lewis 1996) and is an important factor for consideration in water balance estimates. Evaporation is a function of climatic conditions, including temperature, precipitation, relative humidity, wind speed, net radiation, and available energy and water body characteristics. Pan evaporation represents the evaporation rate from small open water bodies that have negligible heat storage. Therefore, these evaporation rates are typically higher than the corresponding lake evaporation rate from large water bodies with high heat capacity.

While there are numerous methods available for calculating and estimating evaporation from climatic data, Natural Resources Canada provides approximate mean values for pan evaporation across Canada which indicate pan evaporation rates near the Project of 400 mm/year (NRC 1978). Environment Canada (EC 2012) provides an estimate for lake evaporation rates for four locations within 250 km of the Project (Table 2.3-1) over the period 1970 to 2007 (Figure 2.4-5). The estimates are derived from daily observed values of measured pan evaporative loss, mean water and air temperature, and wind. While annual lake evaporation for these sites range between 55 mm/year and 600 mm/year, the sites have an average lake evaporation rate of 377 mm/year. The evaporation is largely distributed during the open water season of May through September, with the highest evaporation rates in June or July (Figure 2.4-6).

Figure 2.4-5: Annual Evaporation Rates from Environment Canada (2012)

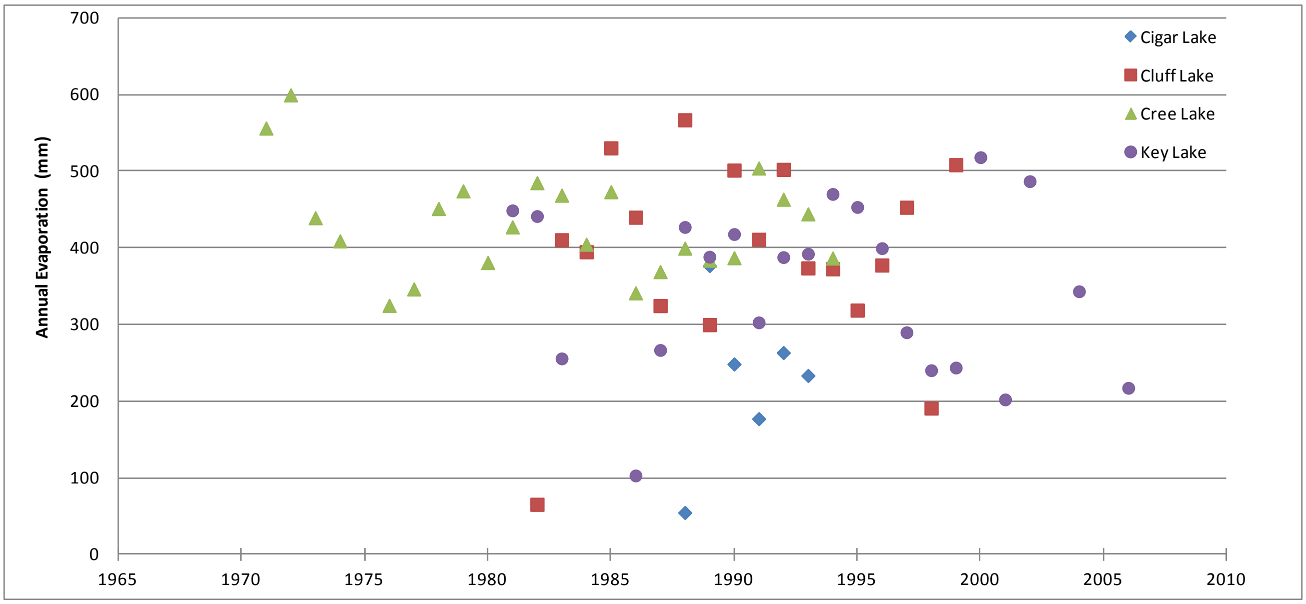
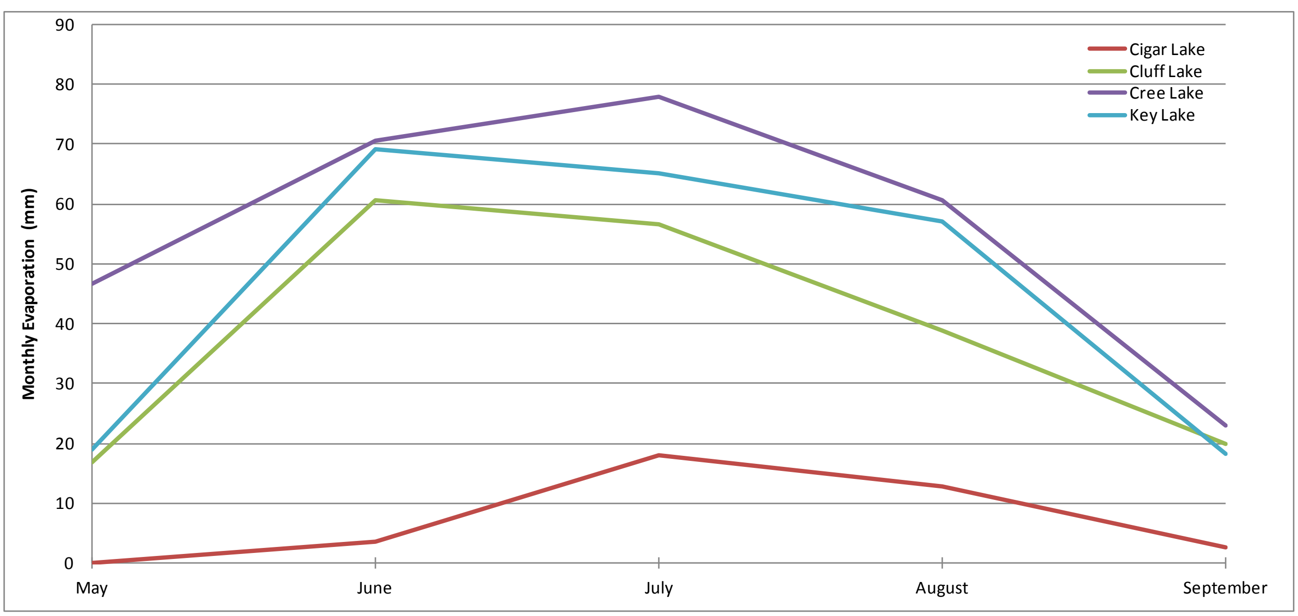


Figure 2.4-6: Monthly Evaporation Rates from Environment Canada (2012)



3.0 AIR QUALITY

3.1 Introduction

The Project is located in the remote boreal forest, more than 200 km northeast of the nearest large industrial sources of air pollution, uranium mining/milling in Saskatchewan's Athabasca Basin, and more than 400 km northeast of the oil sands mining and upgrading activities near Fort McKay and Fort McMurray, Alberta. Despite its remoteness the region is subject to seasonal variations in air quality.

Air quality predictions, including the ground level concentrations and deposition rates of trace gases and particulate matter (PM), are linked closely to other environmental assessment disciplines such as surface water quality, fish habitats, soils, vegetation, and wildlife habitat.

Baseline data collection provides the standard against which future predictions and modelling can be put into the correct context. Comparison to baseline data is the most objective way to determine the contributions of the Project emissions to the over-all emissions load in a particular air-shed.

The objectives of the atmospheric baseline study are the following:

- to provide representative baseline concentrations of PM and trace gases;
- to provide context for potential direct and indirect effects from the Project on air quality, and surface water and terrestrial environments.

3.2 Study Area

The regional study area for this baseline assessment air quality is the Northern Air Dispersion Modelling Zone (Figure 2.2-1), as defined in the Saskatchewan Air Quality Modelling Guideline (MOE 2012). Such a large area is required because of a lack of local air quality monitoring data.

3.3 Methods

From 2008 until 2011, the Saskatchewan Ministry of Environment (MOE) collected ambient air quality measurements at La Loche, Saskatchewan. The MOE measurements monitored concentrations of nitrogen oxide (NO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ozone (O_3) and PM smaller than 2.5 micrometers (μm) in aerodynamic diameter ($PM_{2.5}$). Although La Loche is located ~375 km southwest of the Project, it is the only MOE air quality monitoring station in Saskatchewan's "Northern Region" airshed. These data were downloaded from MOE, analyzed and presented as the air quality baseline for the Project.

During the 2007/2008 International Polar Year[1], the National Aeronautics and Space Administration (NASA) conducted the Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS[2]) mission (Jacob et al. 2010). The experiment had two phases, a spring 2008 phase based in Fairbanks, Alaska, and a summer 2008 phase based in Cold Lake, Alberta. The primary objective of the spring-phase of ARCTAS was to measure the Arctic Haze phenomenon (Shaw 1995), and the long-range transport of air pollution into the Arctic domain. The primary objective of the summer-phase of ARCTAS was to measure forest fires in the boreal forests of Canada and to track the evolution of these plumes during long-range transport. Together two aircraft, the NASA DC-8 and NASA P3-B, collected more than 14 hours of 1-minute data below 1 km altitude while

[1] http://www.ipy.org/

[2] http://www.espo.nasa.gov/arctas/

sampling over Western Canada (i.e., 49°N - 62.5°N, 95°W - 120°W). These data have also been analyzed as part of the air quality baseline for the Project.

3.4 Results

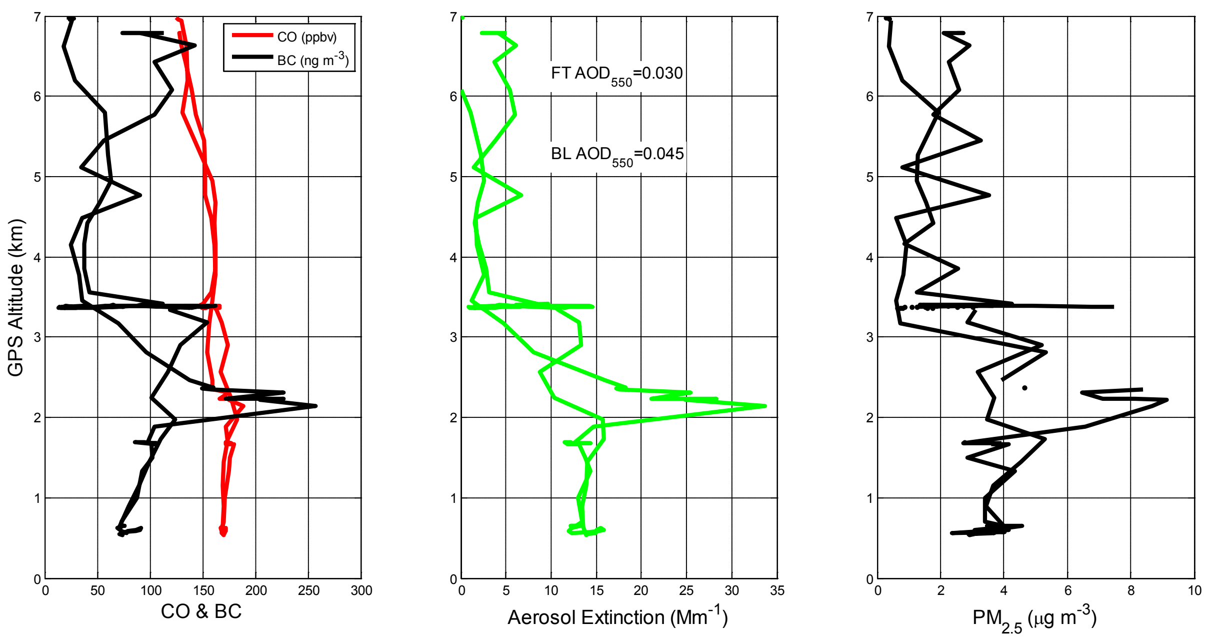
3.4.1 Trace Gases

3.4.1.1 Carbon Monoxide, CO

Saskatchewan Ministry of Environment measurements of background concentrations of CO are not available for La Loche SK. Though dispersion modelling is not planned for the Project, the Saskatchewan Air Quality Modelling Guidelines (MOE 2012) recommends using an 8-hour 90th percentile value of 500 parts per billion volumetric, (ppbv) (or 572 micrograms per standard cubic metre, $\mu g/m^3$) for air dispersion modelling purposes. This is the value that will be used as a baseline CO concentration in this assessment.

During the spring-phase of ARCTAS the NASA P-3B aircraft completed two vertical profiles over Northern Saskatchewan (left panel – Figure 3.4-1). On March 31, 2012 the concentrations of CO observed below 2 km by the NASA P-3B aircraft were 150 to 200 ppbv. During one of the two profiles a layer of intense air pollution of approximately 400 metre thickness was encountered at 2 km altitude. This layer contained $PM_{2.5}$ concentrations that reached 9 $\mu g/m^3$, black carbon concentrations of up to 250 nanograms per cubic metre (ng/m^3), and values of light extinction due to PM at 550 nanometre (nm) wavelength of up to 32 inverse megametres (Mm^{-1}). These trace gases and particulates, their characteristics, and their ambient concentrations are typical of Arctic Haze, air pollution transported long-range into the Arctic and sub-Arctic from mid-latitude urban/industrial sources in Asia, Europe and/or North America.

Figure 3.4-1: Two Aircraft Profiles over Northern Saskatchewan on March 31, 2008: (left) CO and mass of black carbon, (middle) aerosol extinction and its vertical integral, aerosol optical depth, and (right) $PM_{2.5}$ Mass. AOD at ambient RH (average <40%) is calculated separately at 550 nm wavelength in the 3 km boundary layer (BL), and the free troposphere (FT = 3-10 km).



Forest fire activity was intense in Northern Saskatchewan in the summer of 2008. The NASA P-3B aircraft sampled smoke from these wildfires directly during ARCTAS by penetrating their convective updrafts (Figure 3.4-2). The NASA DC-8 did not penetrate the smoke plumes near their sources, but intercepted them further downwind to study their transport, dilution, and chemical evolution over time. Average and standard deviations of the CO concentrations measured aboard the P-3B were 254 +/- 410 ppbv with a median of 121 ppbv. Average and standard deviations of the CO concentrations measured aboard the DC-8 were 277 +/- 248 ppbv with a median of 160 ppbv. The difference between the mean values is not significant; the high standard deviations are due to the differing sampling approaches employed by the science teams aboard the two aircraft. The median CO concentrations of 120 – 160 ppbv are more representative of "background conditions" for Northern Saskatchewan. As expected, these summertime background values are lower than the P-3B measurements in winter, i.e. 150 – 200 ppbv (Figure 3.4-1). Lower summertime concentrations are due to enhanced photochemical destruction of CO by sunlight in summer compared to winter. The observed concentrations are all well below Saskatchewan's 8-hour average SAAQS of 5,000 ppbv for CO.

Figure 3.4-2: Two Views of the West Lake Athabasca Forest Fire Complex Sampled Directly by the NASA P-3B aircraft in July of 2008 During ARCTAS.

3.4.1.2 Oxides of Nitrogen, NO_x

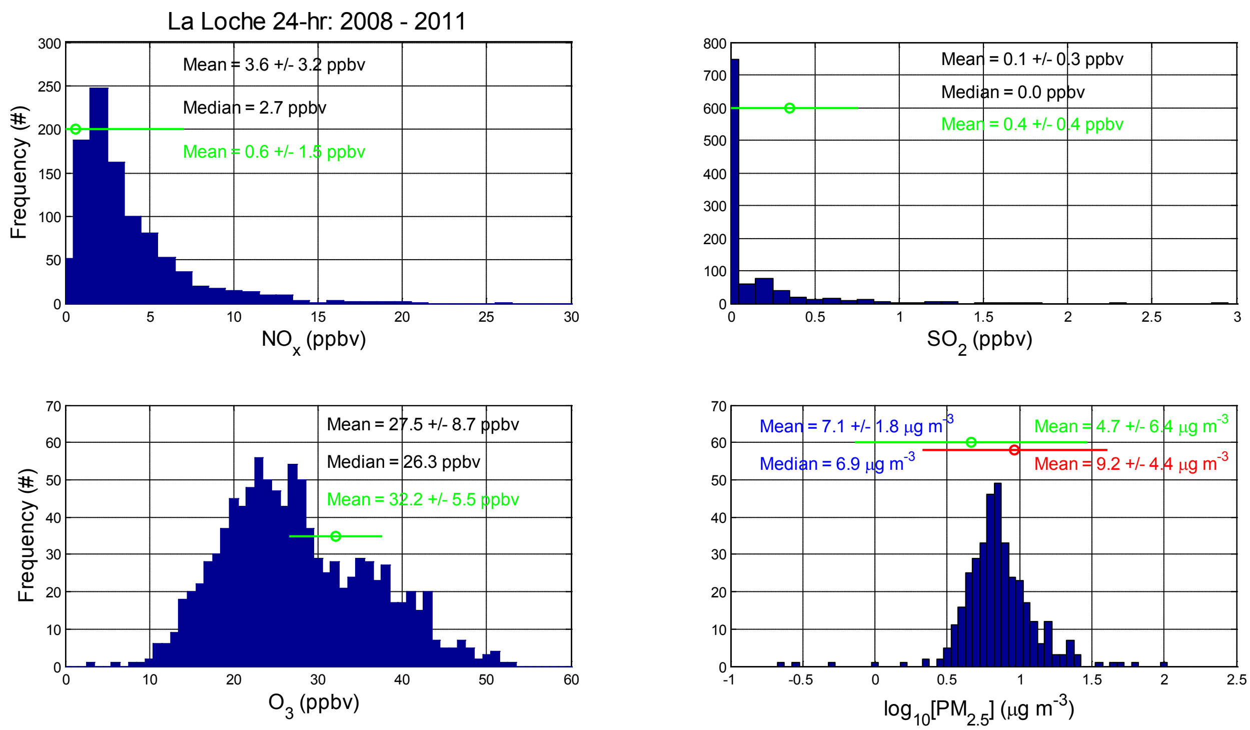
Both NO and NO_2 concentrations are measured at the MOE air quality station at La Loche, Saskatchewan. The sum of these two oxides of nitrogen are referred to as "NO_x", and except for intense plumes close to combustion sources, are typically dominated by NO_2. The MOE modelling guideline does not include a recommend background concentration for NO, but recommends using an annual, 24-hour average NO_2 concentration of 2.0 ppbv as a background value.

The 2008 – 2011 24-hour average and standard deviation of NO_x concentrations measured at La Loche is 3.6 +/- 3.2 ppbv with a median of 2.7 ppbv (top left - Figure 3.4-3). However, like CO, NO_x displays a seasonal trend due to enhanced photo-degradation in summer compared to winter (Lamsal et al. 2010). When the analysis of background concentrations of NO_x for La Loche is restricted to summer (June 21 – September 21), the concentrations are 1.8 +/- 0.9; when restricted to winter (December 21 – March 21), the NO_x concentrations are 6.0 +/- 4.0 ppbv.

NO_x concentrations were not measured aboard the NASA P-3B during ARCTAS. However, there were two independent measurements aboard the DC-8 which both collected 3-hours of data[3] below 1 km altitude. Average concentrations and the standard deviation for NO_x measured by the NASA DC-8 were 0.61 +/- 1.41 ppbv with a median of 0.17 ppbv (top left – Figure 3.4-3).

The NASA DC-8 concentrations of NO_x are statistically lower than the longer-term MOE measurements at La Loche. However, all observed concentrations are well below the annual average Saskatchewan Ambient Air Quality Standards (SAAQS) for NO_x, i.e., 50 ppbv.

Figure 3.4-3: Histograms of Saskatchewan Ministry of Environment Monitoring Data. NASA DC-8 Statistics Included as Green Symbols and Text, NASA P-3B Statistics as Red Symbols and Text During Summer-Phase of ARCTAS.



3.4.1.3 Sulphur Dioxide, SO_2

Sulphur dioxide concentrations measured at La Loche by MOE averaged 0.1 +/- 0.3 ppbv with a median value of 0.0 ppbv from 2008 to 2011 (top right - Figure 3.4-3). These values are consistent with the MOE's modelling guideline which recommends a background annual average concentration of 0 ppbv. Note however that 77% of the 1019 24-hour SO_2 concentrations were recorded at 0.1 ppbv, which corresponds to the limit of detection for the SO_2 instrument used by the MOE.

The two independent instruments measuring SO_2 aboard the NASA DC-8 have instrumental accuracy and precision in the parts-per-trillion range, more than 100 times more sensitive than the ground-based MOE instruments. The DC8 instruments recorded average concentrations of 0.34 +/- 0.36 ppbv with median values of 0.20 ppbv during the summer of 2008 (top right - Figure 3.4-3).

[3] Note that the equivalent duration of surface sampling can be calculated by multiplying the time spent sampling (e.g. 3 hours) by the ratio of the aircraft's true airspeed to the average wind speed. The DC-8 typically travels at true airspeeds of 150-200 meters per second so for surface wind speeds of ~5 meters per second the 3 hours of DC-8 data is equivalent to more than 90 hours of sampling. At a temporal resolution of 1-minute, the DC-8 data are effectively integrated spatially at a resolution of 9-12 kilometers.

All of the observed concentrations are well below the 24-hour average, annual SAAQS for SO_2, i.e., 10 ppbv.

3.4.1.4 Ozone, O_3

The 2008 – 2011, 24-hour average and standard deviation of O_3 concentrations measured at La Loche is 27.5 +/- 8.7 ppbv with a median of 26.3 ppbv (bottom left - Figure 3.4-3). Due to the photochemical nature of its formation and destruction, O_3 displays a seasonal trend in its background atmospheric concentrations. When the analysis of background concentrations of O_3 at La Loche is restricted to summer (June 21 – September 21), the concentrations are 23.0 +/- 5.1 ppbv; when restricted to winter (December 21 – March 21), the concentrations are 29.7 +/- 8.6 ppbv. These seasonal averages are statistically different (α=0.05).

Mean O_3 concentrations measured below 1 km altitude aboard the NASA DC-8 in the summer of 2008 were 32.2 +/- 5.5 ppbv with a median value of 30.3 ppbv. These values are statistically higher (α=0.05) than the 2008 – 2011 MOE data.

The observed ozone concentrations are below the 8-hour average Canada wide standard of 65 ppbv (CCME 2006) and the SAAQS 1-hour standard of 80 ppbv.

3.4.2 Particulate Matter

3.4.2.1 In-situ measurements

In the spring, concentrations of PM near the Project can be elevated because of Arctic Haze (Shaw 1995). This can be attributed to the long-range transport into, and accumulation of mid-latitude air pollution within the Arctic and sub-Arctic atmosphere. In summertime, PM concentrations near the Project can be elevated due to regional forest fires. Particulate matter with aerodynamic diameters smaller than 2.5 micrometers, (i.e., $PM_{2.5}$) are a public health hazard (Seaton et al. 1995; Pope et al. 2009). Consequently, there is a Canada-Wide Standard and an SAAQS for $PM_{2.5}$. Particulate matter with aerodynamic diameters smaller than 10 μm (PM_{10}) includes $PM_{2.5}$ as well as particulate in the 2.5 to 10 μm size range (e.g., sea salt, dust, ash).

Prior to May 2010 the MOE used a TEOM 1405 FDMS dichotomous analyzer to obtain $PM_{2.5}$ data at La Loche, SK. Post processing of the data revealed errors with the mass concentrations and, as a result, the instrument was replaced with a TEOM 1400AB instrument. $PM_{2.5}$ monitoring data collected since May 2010 have passed QA/QC by the MOE, and are approved for scientific analysis (Chris Gray, pers. comm.). As a result, this baseline assessment includes only the La Loche $PM_{2.5}$ monitoring data collected after May 2010. PM_{10} data collected at La Loche by the MOE is not publicly available.

Since May 2010, 24-hour average MOE measurements of $PM_{2.5}$ at La Loche have shown average concentrations of 7.1 +/- 1.8 $\mu g/m^3$ with a median concentration of 6.9 $\mu g/m^3$ (bottom right, Figure 3-4.3). The annual average value recommend for modelling the background concentrations of $PM_{2.5}$ at La Loche is 3.1 $\mu g/m^3$ (MOE 2012).

During the spring-phase of ARCTAS the NASA P-3B aircraft measurements of $PM_{2.5}$ were between 2 and 6 $\mu g/m^3$ below 2 km (right panel - Figure 3.4-1).

In summer the NASA P-3B specifically targeted intense forest fire plumes for sampling. As a result the P-3B $PM_{2.5}$ concentrations are skewed towards large values with a mean concentration of 9.2 +/- 4.4 $\mu g/m^3$. While sampling on a regional basis during the summer-phase of ARCTAS, the NASA DC-8 measured average $PM_{2.5}$ concentrations of 4.7 +/- 6.4 $\mu g/m^3$ with a median of 6.6 $\mu g/m^3$.

Individually the DC-8 and P-3B data are statistically lower (DC-8) and higher (P-3B) than the MOE observations since May 2010 (bottom right, Figure 3.4-3). However, when the data are pooled, the ARCTAS summertime airborne $PM_{2.5}$ measurements below 1 km altitude are statistically indistinguishable from the post May 2010 MOE data.

All of the observed concentrations of $PM_{2.5}$ are below the SAAQS 24-hour average standard of 120 $\mu g/m^3$.

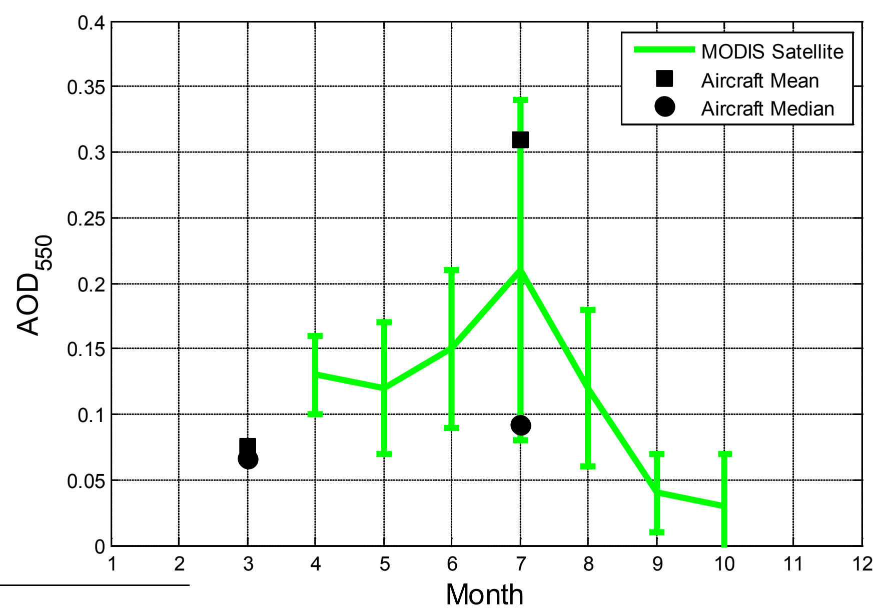
3.4.2.2 Remote Sensing Measurements

NASA's Moderate Resolution Imaging Spectroradiometer sensors (MODIS[4]) have been measuring aerosol optical depth at a wavelength of 550 nm (AOD_{550}), from onboard the TERRA and AQUA spacecraft since February, 2000 and July, 2002 respectively. Figure 3.4-4 plots the pooled monthly averaged AOD and +/-1 standard deviation (1σ) measured over the region (58 to 60°N, 104.5 to 107°W) from March of the year 2000 until December of 2011. As expected, springtime values of AOD are elevated due to Arctic Haze. Summertime values of AOD are highest, and show large standard deviations due to episodic but intense boreal forest fires.

The central panel of Figure 3.4-1 includes 1-minute averages of aerosol light extinction at standard temperature and pressure and at ambient relative humidity on March 31, 2008. As indicated in Figure 3.4-1, springtime concentrations of $PM_{2.5}$ measured from 0 to 7 km altitude are expected to vary between ~1 and 10 $\mu g/m^3$ with corresponding total AOD values of ~0.08. Satellite measurements of AOD are not feasible during winter, however the spring-phase ARCTAS airborne measurements lie mid-way between the low October values ~0.03 and the elevated springtime values of ~0.13.

Summertime values of AOD vary greatly depending on the location and intensity of regional forest fires. During ARCTAS the P-3B aircraft measured AOD directly in order to calibrate/validate satellite retrievals such as MODIS (Shinozuka et al. 2011). AOD measured from onboard the P-3B had an average value of 0.31 (Figure 3.4-4). However the P-3B data are skewed by forest fire smoke due to the study's objectives and the sampling approach. A more representative background value of AOD is the median of only 0.09 (Figure 3.4-4).

Figure 3.4-4: Monthly Average MODIS AOD Compared to Discrete Airborne Measurements in March and July of 2008 over Northern Saskatchewan During NASA's ARCTAS Experiment.



[4] http://modis.gsfc.nasa.gov/

In the rare cases when forest fires are active locally, or where the Project is directly downwind from large or extensive regional fires, satellite AOD values can exceed 1.0, ground-level $PM_{2.5}$ concentrations can be expected to reach 100-200 $\mu g/m^3$, and may exceed the SAAQS 24-hour average standard of 120 $\mu g/m^3$. While such large forest fire events are usually rare, they can pose a significant health risk to workers and/or residents in the area (Seaton et al. 1995; Pope et al. 2009).

4.0 NOISE

4.1 Introduction

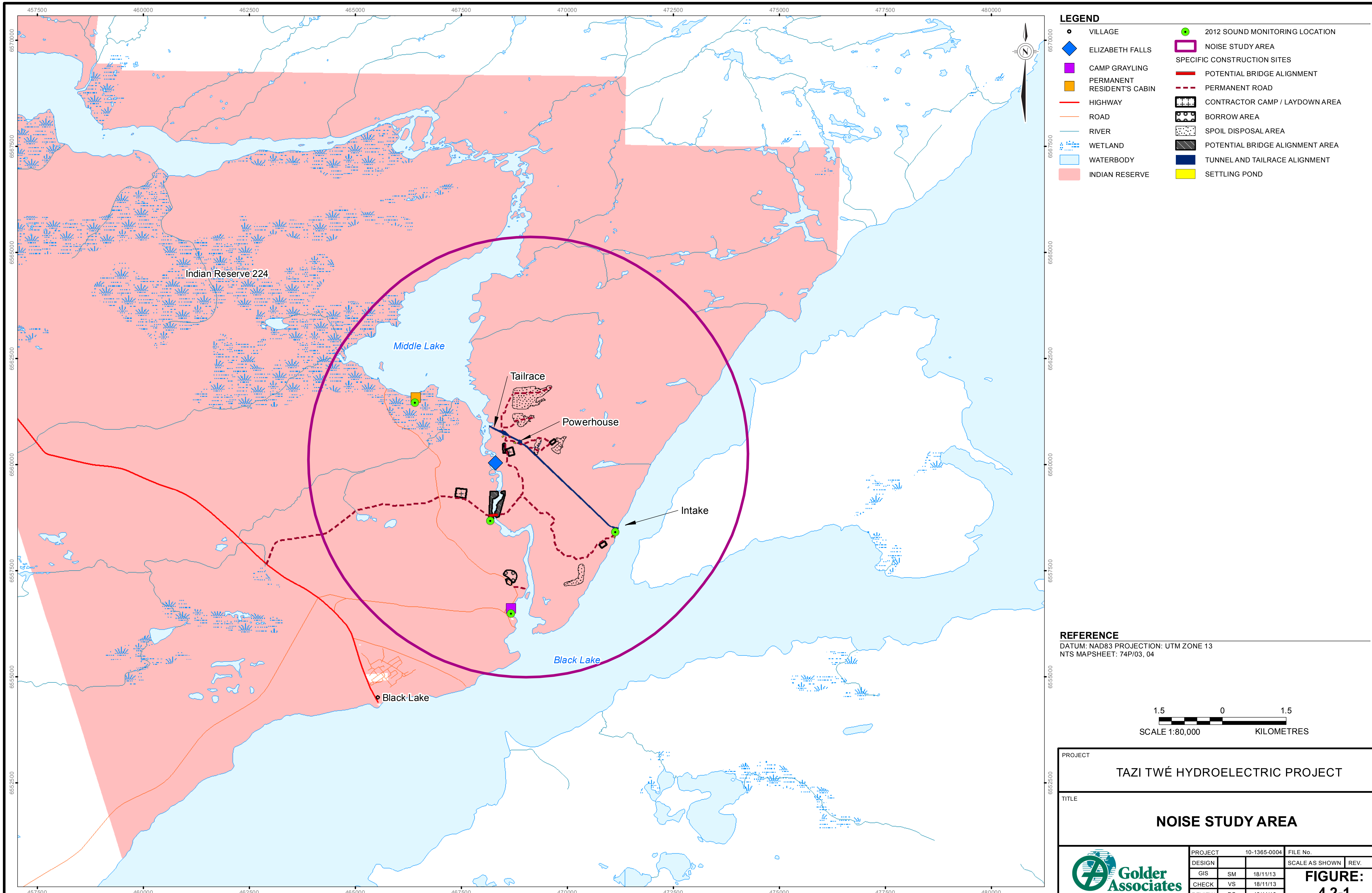
Saskatchewan does not currently have any specific acoustic environmental standard method or guideline/regulation for conducting baseline noise studies. The monitoring methods used were consistent with the requirements of Alberta Utilities Commission (AUC) regulation Rule 012: *Noise Control Directive* (Rule 012) (AUC 2012). The Alberta guidance has been found acceptable by MOE for other environmental assessments. Rule 012 identifies the area within 1.5 km of the Project boundary as the appropriate noise study area for the Project (i.e., the area in which the acoustic environmental could be affected by the Project). By including a wider range of land uses than those recommend by Rule 012, the baseline noise study will also be consistent with Health Canada guidance on environmental noise. Both Rule 012 and Health Canada guidance assess noise from a receptor perspective and recommend monitoring noise levels at locations where humans are likely to be exposed. Rule 012 defines appropriate receptor locations as permanently or seasonally occupied dwellings. Health Canada expands this definition to also include: commercial premises; worker's living quarters; entertainment establishments; active recreation areas; passive recreation areas; places of worship and cemeteries; schools; hospitals; daycare centres; seniors residences; and industrial premises.

The general area can currently be described as a passive recreation area used for hunting and fishing. Otherwise, Golder is not aware of any receptors within the noise study area by either the Rule 012 or Health Canada definitions.

The objective of the acoustic baseline study is to establish the existing acoustic environment within the selected study area. Later, as part of the Environmental Impact Assessment (EIA), this baseline information will be used, in combination with a computer noise model of Project noise sources, to predict changes in sound levels in the area resulting from the Project.

4.2 Study Area

The study area was selected to include a region within the expected zone of influence of the Project and is defined by the AUC 1.5 km Criteria Boundary. Four sound monitoring locations were selected to characterize the existing acoustic environment of the study area for the Project. Sound monitoring locations relative to the Project site are shown in Figure 4.2-1.



Indian Reserve 224
Middle Lake
Tailrace
Powerhouse
Intake
Black Lake
LEGEND
VILLAGE
ELIZABETH FALLS
CAMP GRAYLING
PERMANENT RESIDENT'S CABIN
HIGHWAY
ROAD
RIVER
WETLAND
WATERBODY
INDIAN RESERVE
2012 SOUND MONITORING LOCATION
NOISE STUDY AREA
SPECIFIC CONSTRUCTION SITES
POTENTIAL BRIDGE ALIGNMENT
PERMANENT ROAD
CONTRACTOR CAMP / LAYDOWN AREA
BORROW AREA
SPOIL DISPOSAL AREA
POTENTIAL BRIDGE ALIGNMENT AREA
TUNNEL AND TAILRACE ALIGNMENT
SETTLING POND
REFERENCE
DATUM: NAD83 PROJECTION: UTM ZONE 13
NTS MAPSHEET: 74P/03, 04
1.5 0 1.5
SCALE 1:80,000 KILOMETRES
PROJECT
TAZI TWÉ HYDROELECTRIC PROJECT
TITLE
NOISE STUDY AREA
Golder Associates
Saskatoon, Saskatchewan
PROJECT 10-1365-0004
FILE No.
DESIGN
SCALE AS SHOWN REV. 0
GIS SM 18/11/13
CHECK VS 18/11/13
REVIEW BC 18/11/13
FIGURE: 4.2-1

4.3 Methods

4.3.1 Monitoring Locations

Four locations were selected for 24-hour sound monitoring. These sound monitoring locations were chosen to characterize the acoustic environment surrounding the Project area. As the Project is located in a relatively remote location, there are few dwellings surrounding the Project. Sampling locations (Figure 4.2-1) included two of the nearest human developments, which are within the noise study area, and two unoccupied locations. Further details of the locations are described below with coordinates summarized in Table 4.3-1.

- Permanent Resident's Cabin, a year-round resource use cabin/residence on Middle Lake, is located within the noise study area to the northwest. This receptor is one of the two closest human developments and should be representative of existing noise levels to the north of the Project, along the south shore of Middle Lake. Residents at this location denied permission to monitor at the cabin; therefore, monitoring was conducted from a nearby location further west along the shoreline.
- Camp Grayling, a hunting/fishing camp on the outlet bay of Black Lake, located within the noise study area to the south. This receptor location is one of the two closest human developments and should be representative of existing noise levels to the south of the Project. Management at Camp Grayling allowed baseline monitoring to be conducted from their property;
- Water intake/edge of Black Lake, an unoccupied Black Lake shoreline location within the noise study area to the east of the Project. This receptor is located near the shore of Black Lake in an area adjacent to the proposed location of the Project power tunnel water intake. This location is known to be a popular fishing spot and should be representative of existing noise levels to the east of the Project; and
- Bridge/bank of Fond du Lac River, an unoccupied location within the noise study area and on the west bank of the Fond du Lac River. This receptor is located near the west bank of the Fond du Lac River adjacent to the proposed location of the Project bridge; this location should be representative of existing noise levels to the west of the Project.

Photographs taken at the monitoring locations are presented in Photos 4.3-1 to 4.3-4.

Table 4.3-1: Coordinates for Selected Sound Monitoring Sites

Monitoring Location	Description	Easting (m)	Northing (m)
R1 – Permanent Resident's Cabin	Year-round resource use cabin/residence on Middle Lake (actual monitoring location was slightly west of Permanent Resident's Cabin)	465945	6561488
R2 – Camp Grayling	Hunting/fishing camp on Black Lake	468548	6556465
R3 – Water intake/edge of Black Lake	Black Lake shoreline location	471198	6558515
R4 – Bridge/bank of Fond du Lac River	West bank of the Fond du Lac River	468112	6558615

m = metres

Photo 4.3-1: R1 Sound Monitoring Setup

Photo 4.3-2: R2 Sound Monitoring Setup

Photo 4.3-3: R3 Sound Monitoring Setup

Photo 4.3-4: R4 Sound Monitoring Setup

4.3.2 Monitoring Method

One survey of approximately 24 hours duration was completed at each of the four sound monitoring locations between July 3 and July 6, 2012. Surveys of this type and duration provide information on daily variability in sound levels as well as an expected typical or average daily condition.

Model 2250 Brüel and Kjær Type I integrating sound level meters were used to collect the measurements and sound recordings. This type of meter logs sound levels and records audible sound over set intervals selected by the user. Data parameters logged for the survey periods included:

- equivalent energy sound level on a one minute time scale ($L_{eq,\ 1min}$) in A-weighted decibels (dBA); and
- audible sound continuously in *.wav format audio files.

A Brüel and Kjær Type 4231 calibrator was used for calibrating the meters before and after each monitoring period to ensure the sound meters variance was within 0.5 dB. The calibrator has an estimated uncertainty for sound pressure level of ±0.12 dB at a 99% confidence level. The calibration data were logged by the meter and calibration results were also described in field notes. Calibration results are presented in Appendix I.2.

Rule 012 requires that monitoring be conducted under conditions acceptable for sound measurement, which include wind speeds of less than 15 km/h and the absence of precipitation (AUC 2012).

For this survey, weather data were collected using Kestrel 4500 pocket weather meters from Nielsen Kellerman, set-up near the sound monitoring sites. The weather meters recorded wind speed and direction, temperature and relative humidity data every five minutes. Data from the weather meters were used as required for the interpretation of the recorded sound. Direct observations and field notes made by the study team included precipitation, cloud cover, wind direction, and observed audible sound sources.

4.3.3 Data Analysis Approach

Data were downloaded to a computer for analysis with the Brüel and Kjaer 7820 Evaluator® software program. The data were reviewed to identify sources of sound from the sound recordings and filter out invalid data, such as sound from the following:

- technician activities;
- traffic near microphone;
- humans near microphone;
- airplane flyovers;
- rain;
- thunder; and
- birds, insects and other animal activities very near to the sound level meter microphone.

Sound from these sources was considered not representative of normal conditions at the monitoring locations and was removed as recommended in Rule 012. Measurements that were removed are noted in Appendix I.3.

During analysis of the data, sound sources were identified mainly by sound recordings. Other indicators used to identify sources of sound were time of day and field observations. Hourly equivalent energy sound levels

($L_{eq,1hour}$) values were calculated for each hour of the survey period from the valid one-minute data, and these $L_{eq,1hr}$ values were then used to establish daytime and nighttime baseline levels ($L_{eq,day}$ and $L_{eq,night}$, respectively) as per Rule 012. Rule 012 defines daytime as the time period between 7:00 a.m. to 10:00 p.m., and nighttime as the time period between 10:00 p.m. to 7:00 a.m.

Calculated $L_{eq,1hour}$, $L_{eq,day}$, and $L_{eq.night}$ values in dBA for the sound monitoring locations R1, R2, R3 and R4 are provided in the following sections. All $L_{eq,1hour}$ values were based on at least 30 minutes of valid $L_{eq.1min}$ data.

The overview of valid minutes of sound samples for each monitoring location is shown in Table 4.3-2. Rule 012 requires a minimum of three hours of valid daytime monitoring data and three hours of valid nighttime monitoring data before an acoustic environmental baseline study program is considered sufficient. At the four selected monitoring locations, the three hour requirement was met for both the daytime and nighttime periods.

Table 4.3-2: Overview of Valid Minutes of Sound Samples for Each Monitoring Location

Location	Valid Daytime (minutes)	Excluded Daytime (minutes)	Valid Nighttime (minutes)	Excluded Nighttime (minutes)	Total Valid Day+Night (minutes)	Total Excluded Day+Night (minutes)
R1	634	31	530	10	1,164	41
R2	663	242	483	57	1,146	299
R3	706	800	631	449	1,337	1,249
R4	718	188	539	1	1,257	189

4.4 Results - Measured Baseline Sound Levels

4.4.1 Monitoring Location R1

R1 is located to the northwest of the Project area, approximately 3.4 km from the Project powerhouse. It is at the south bank of Middle Lake, approximately 1.9 km from the Project tailrace channel outlet. This receptor is representative of a sound-sensitive receptor defined by Rule 012 (AUC 2012). This receptor corresponds to Permanent Resident's Cabin: a year-round resource use cabin/residence on Middle Lake, which is located within the noise study area to the northwest. The owners of Permanent Resident's Cabin denied permission to have sound monitoring on their property, so receptor R1 was set-up to the west of Permanent Resident's Cabin. This receptor is a sound-sensitive receptor defined by Rule 012 (AUC 2012). This receptor is located at one of the two closest human developments and should be representative of existing noise levels to the north of the Project, along the south shore of Middle Lake. The landscape at this location consists of trees, shrubs and short grasses (Photo 4.3-1). Middle Lake is to the north of the cabin area. The sound level meter at R1 was influenced by natural sounds from the rustling of leaves, birds and insects, and water sound from the Middle Lake.

Filtered $L_{eq,1hour}$ values along with $L_{eq,day}$ and $L_{eq,night}$ values at this monitoring location are presented in Table 4.4-1. Description of the isolated sound events for R1 is shown in Table B-1 of Appendix I.3. Unfiltered $L_{eq.1min}$ values recorded at R1 are shown in Figure 4.4-1. Weather data, recorded near the R1 monitoring site are presented in Figures 4.4-2 and 4.4-3.

Table 4.4-1: Filtered Hourly Sound Levels at R1

Date	Start Hour	$L_{eq,\ 1hour}$ (dBA)
07/05/2012	12:00 p.m.	44
07/05/12	1:00 p.m.	41
07/05/12	2:00 p.m.	37
07/05/12	3:00 p.m.	36
07/05/12	4:00 p.m.	34
07/05/12	5:00 p.m.	34
07/05/12	6:00 p.m.	31
07/05/12	7:00 p.m.	26
07/05/12	8:00 p.m.	29
07/05/12	9:00 p.m.	32
07/05/12	10:00 p.m.	32
07/05/12	11:00 p.m.	31
07/06/12	12:00 a.m.	31
07/06/12	1:00 a.m.	32
07/06/12	2:00 a.m.	34
07/06/12	3:00 a.m.	38
07/06/12	4:00 a.m.	37
07/06/12	5:00 a.m.	35
07/06/12	6:00 a.m.	33
07/06/12	7:00 a.m.	33
Daytime Average ($L_{eq,day}$)	7:00 a.m. to 10:00 p.m.	37
Nighttime Average ($L_{eq,night}$)	10:00 p.m. to 7:00 a.m.	34

dBA = A-weighted decibels; a.m. = ante meridiem; p.m. = post meridiem

Figure 4.4-1: Unfiltered One-Minute Sound Levels at R1

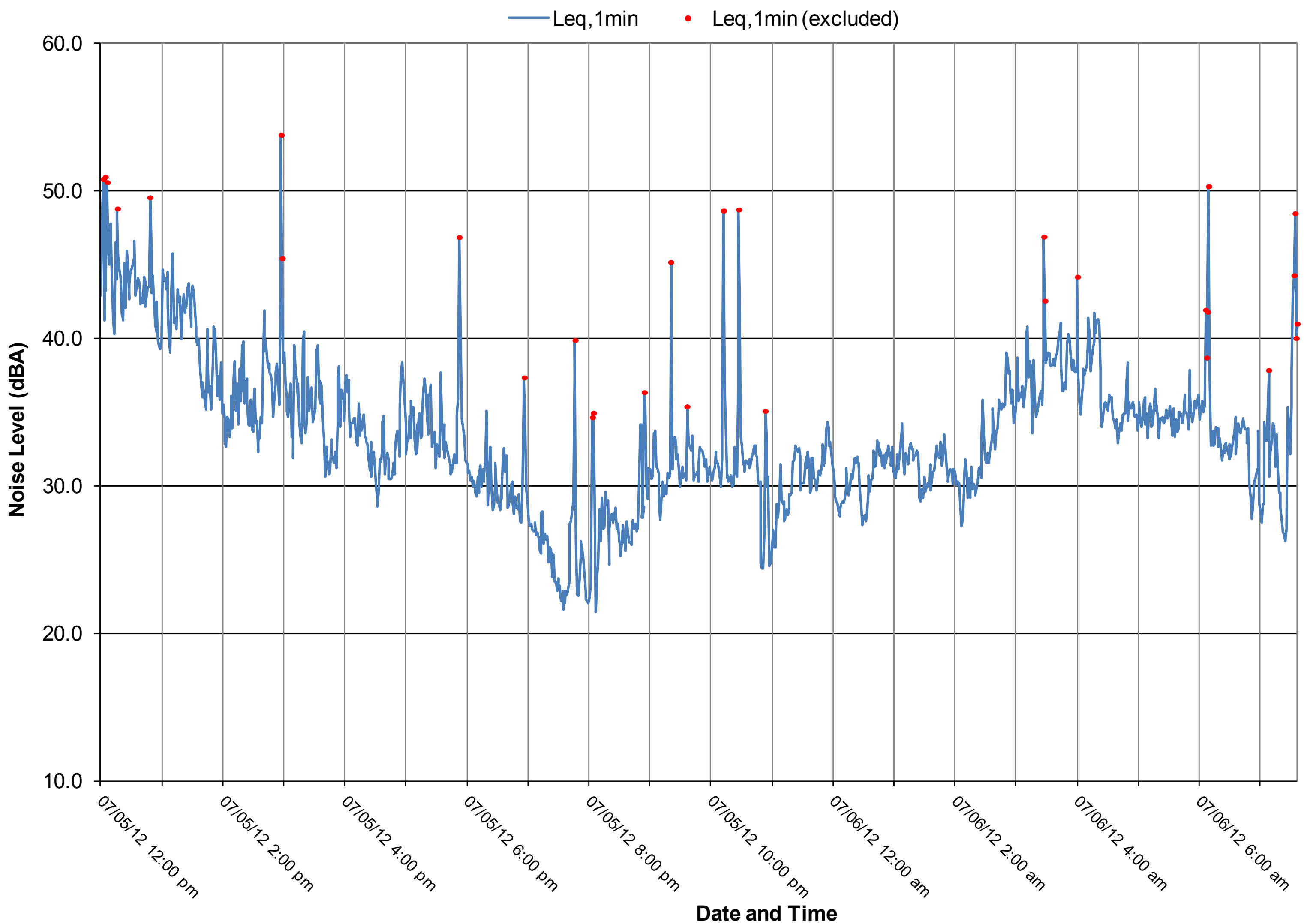


Figure 4.4-2: Weather Information (Temperature and Humidity) for R1

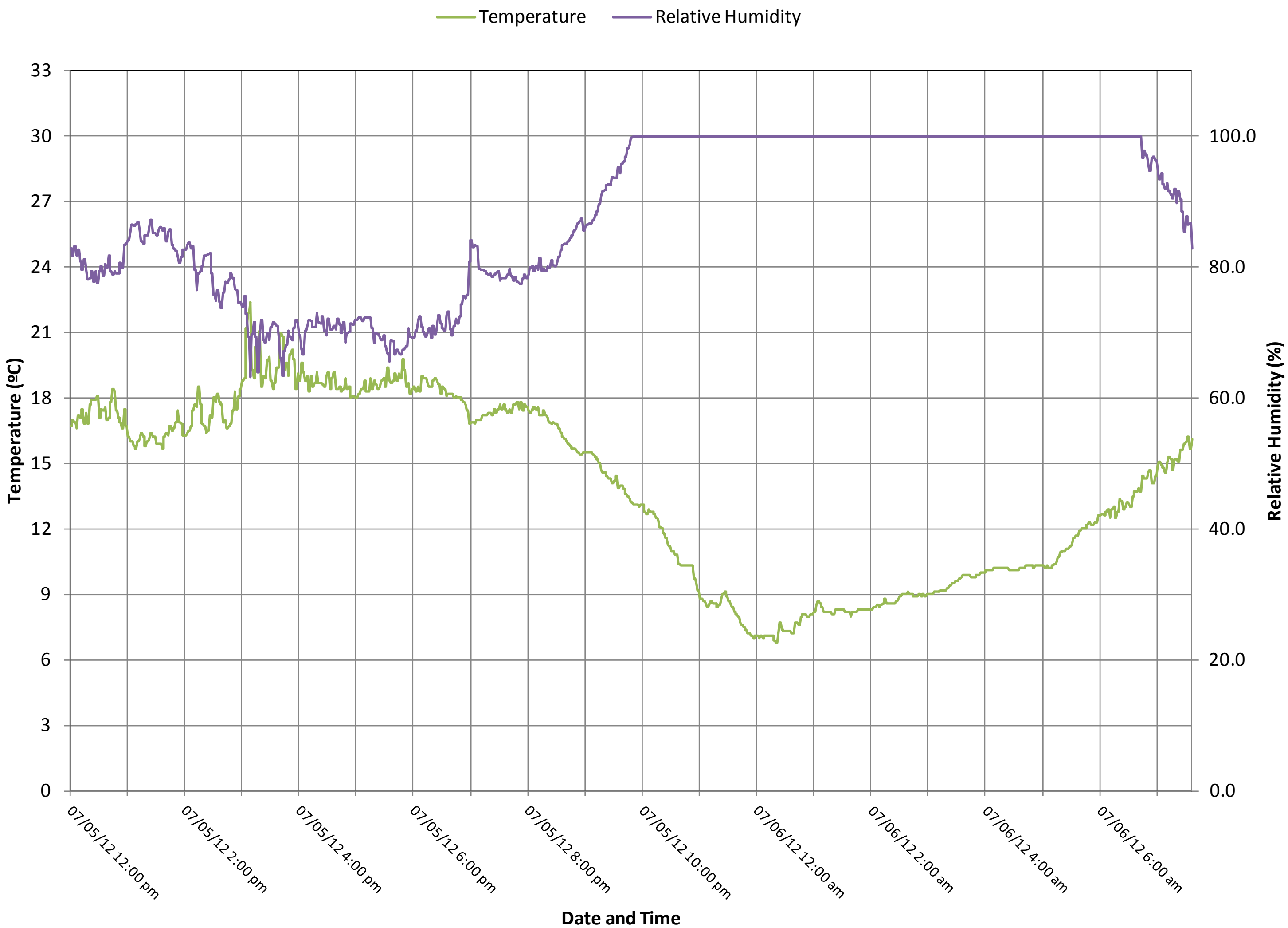
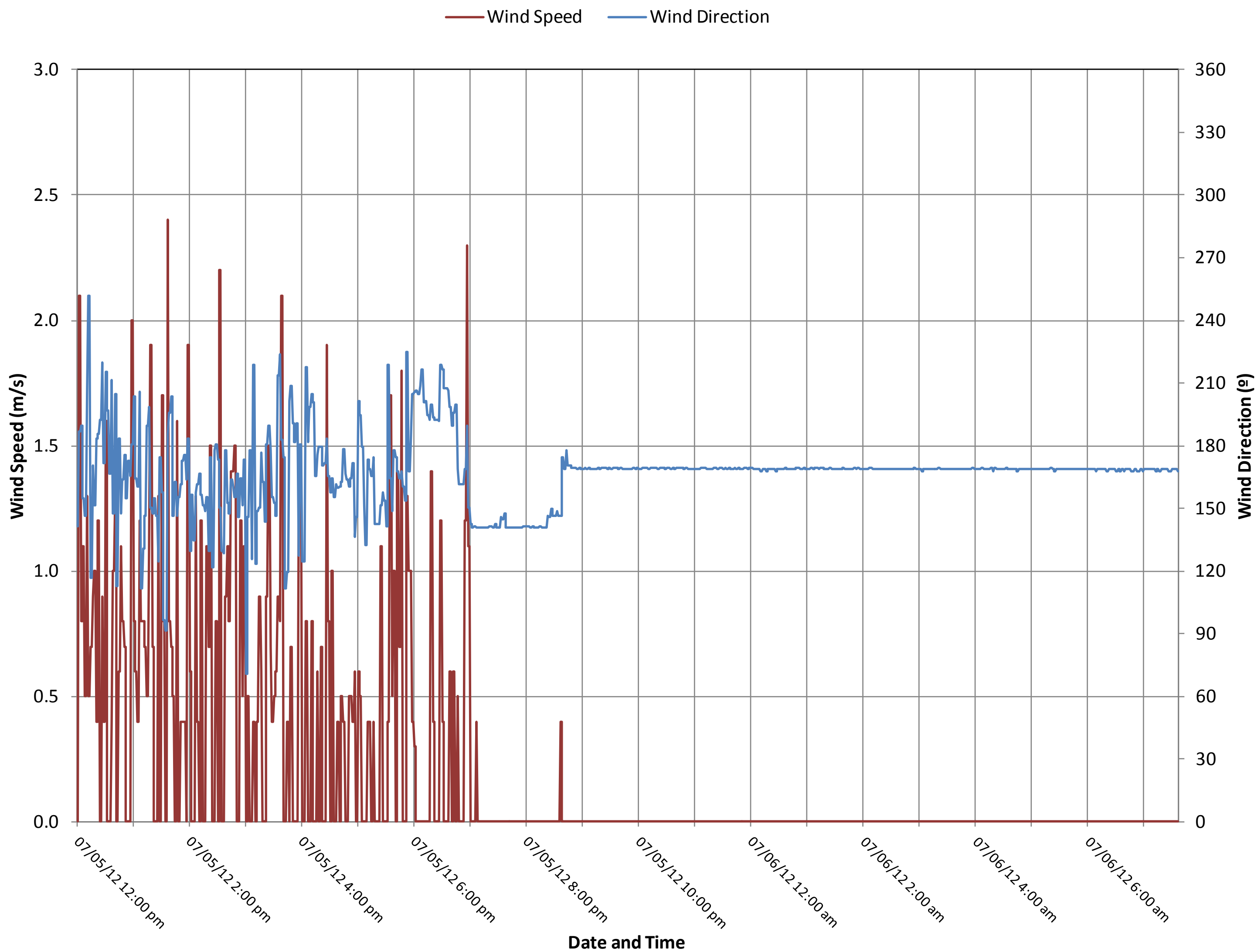


Figure 4.4-3: Weather Information (Wind Speed and Direction) for R1



4.4.2 Monitoring Location R2

R2 is located to the south of the Project area, approximately 3.8 km from the Project powerhouse. It is located on the west bank of the Fond du Lac River. This receptor is a sound-sensitive receptor defined by Rule 012 (AUC 2012). R2 corresponds to Camp Grayling: a sport fishing camp on the outlet bay of Black Lake. This receptor is within the noise study area and is one of the two closest human developments and should be representative of existing noise levels to the south of the Project. The landscape at this location is a camp area consisting of shelters surrounded with trees and shrubs (Photo 4.3-2). The Fond du Lac River is at the east side of the camp area. The sound level meter at R2 was influenced by sounds from campers' activities, water sounds from the river and rapids and from natural sounds such as the rustling of leaves, birds and insects.

Filtered $L_{eq,1hour}$ values along with $L_{eq.day}$ and $L_{eq.night}$ values at this monitoring location are presented in Table 4.4-2. Description of the isolated sound events for R2 is shown in Table B-2 of Appendix I.3. Unfiltered $L_{eq,1min}$ values recorded at R2 are shown in Figure 4.4-4. Weather data, recorded near the R2 monitoring site are presented in Figures 4.4-5 and 4.4-6.

Table 4.4-2: Filtered Hourly Sound Levels at R2

Date	Start Hour	$L_{eq, 1hour}$ (dBA)
07/03/2012	4:00 p.m.	34
07/03/12	5:00 p.m.	36
07/03/12	6:00 p.m.	37
07/03/12	7:00 p.m.	37
07/03/12	8:00 p.m.	39
07/03/12	9:00 p.m.	39
07/03/12	10:00 p.m.	39
07/03/12	11:00 p.m.	40
07/04/12	12:00 a.m.	39
07/04/12	1:00 a.m.	39
07/04/12	2:00 a.m.	41
07/04/12	3:00 a.m.	42
07/04/12	4:00 a.m.	41
07/04/12	5:00 a.m.	43
07/04/12	6:00 a.m.	Not Valid[a]
07/04/12	7:00 a.m.	48
07/04/12	8:00 a.m.	Not Valid[a]
07/04/12	9:00 a.m.	Not Valid[a]
07/04/12	10:00 a.m.	48
07/04/12	11:00 a.m.	47
07/04/12	12:00 p.m.	46
07/04/12	1:00 p.m.	48
07/04/12	2:00 p.m.	45
Daytime Average ($L_{eq,day}$)	7:00 a.m. to 10:00 p.m.	45
Nighttime Average ($L_{eq,night}$)	10:00 p.m. to 7:00 a.m.	41

[a] These hours contained fewer than 30 minutes of valid data
dBA = A-weighted decibels; a.m. = ante meridiem; p.m. = post meridiem

Strong storms/wind resulted in a lack of valid data during the 6 a.m., 8 a.m., and 9 a.m. hours of July 4, 2012.

Figure 4.4-4: Unfiltered One-Minute Sound Levels at R2

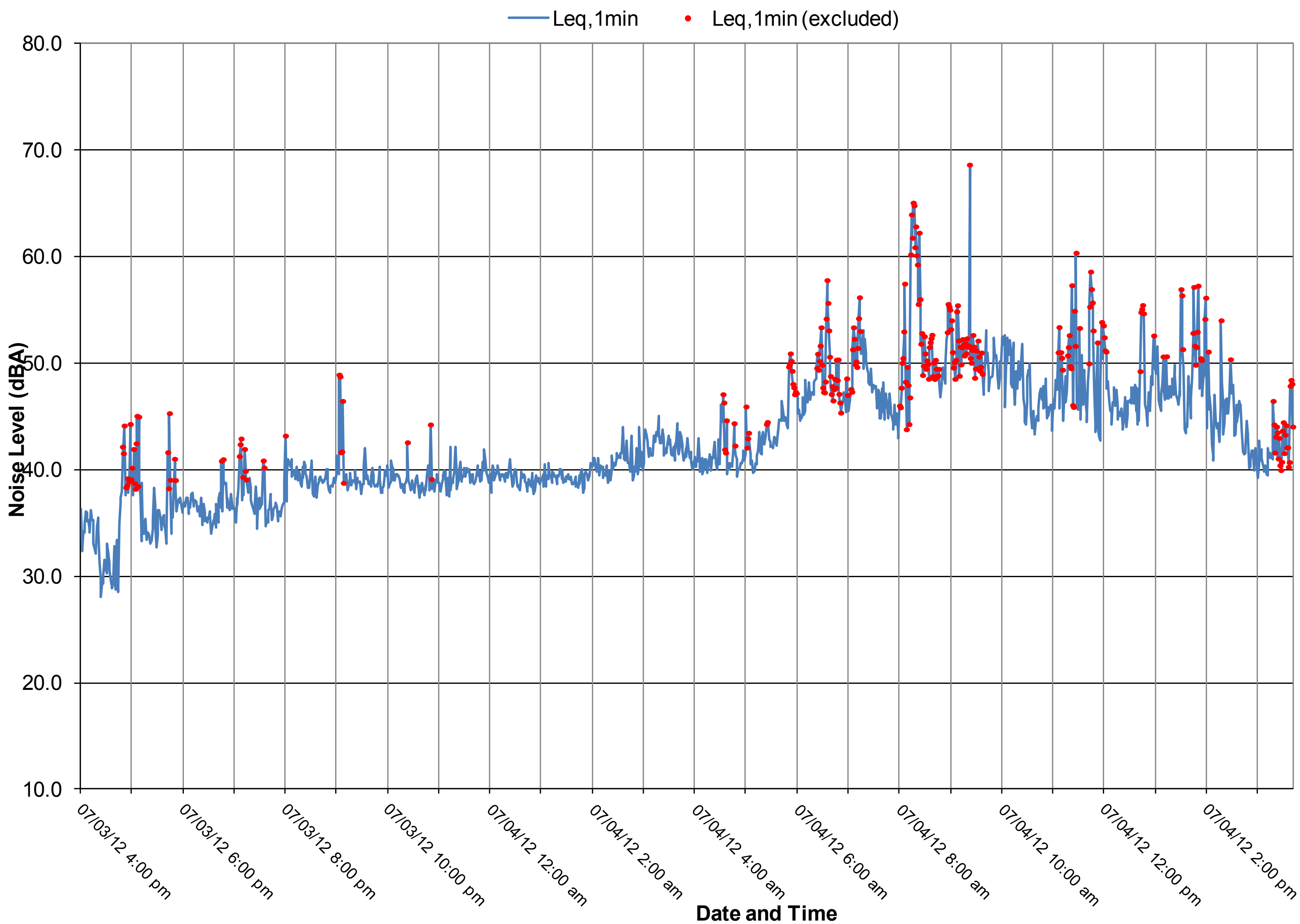


Figure 4.4-5: Weather Information (Temperature and Humidity) for R2

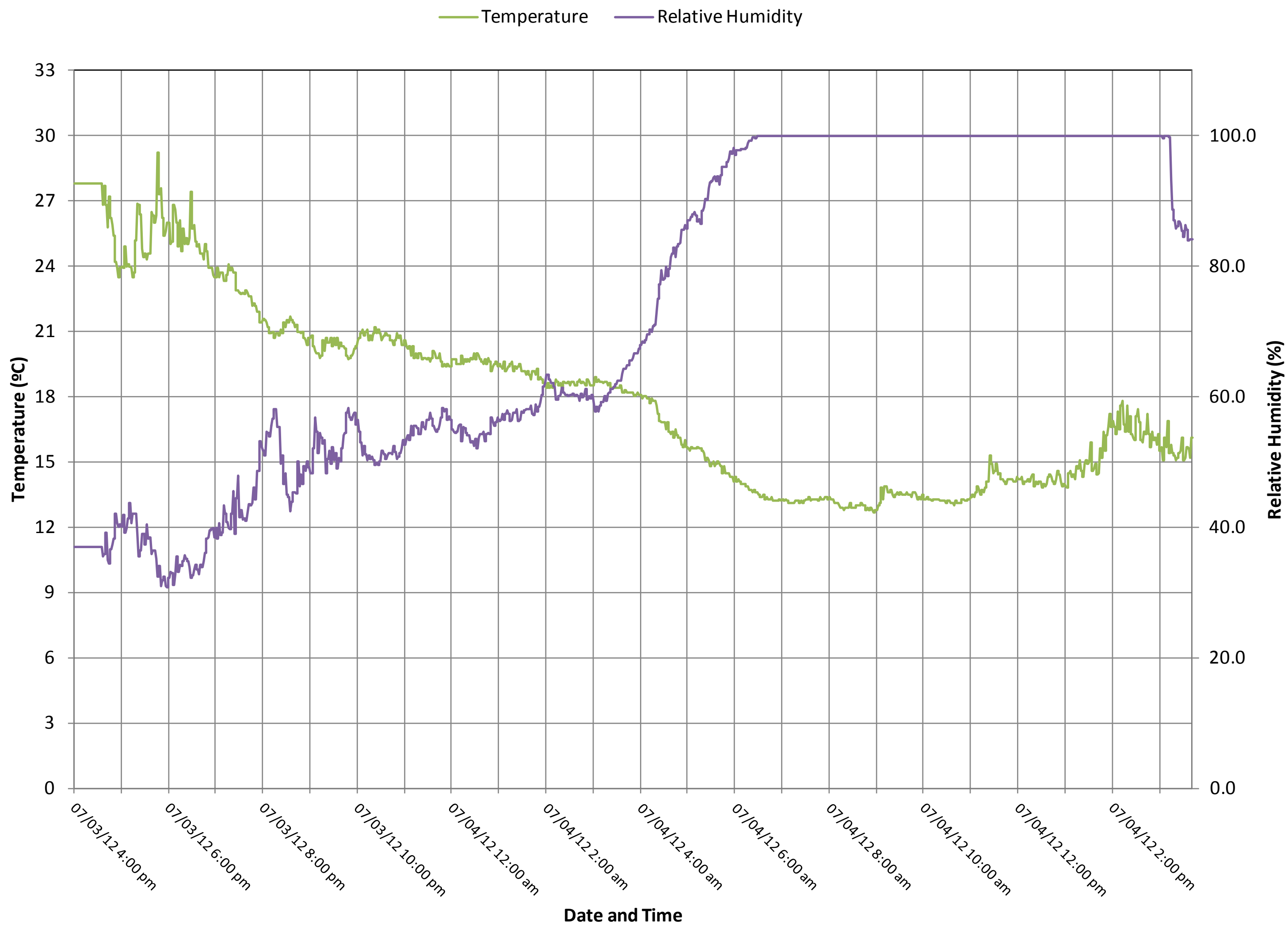
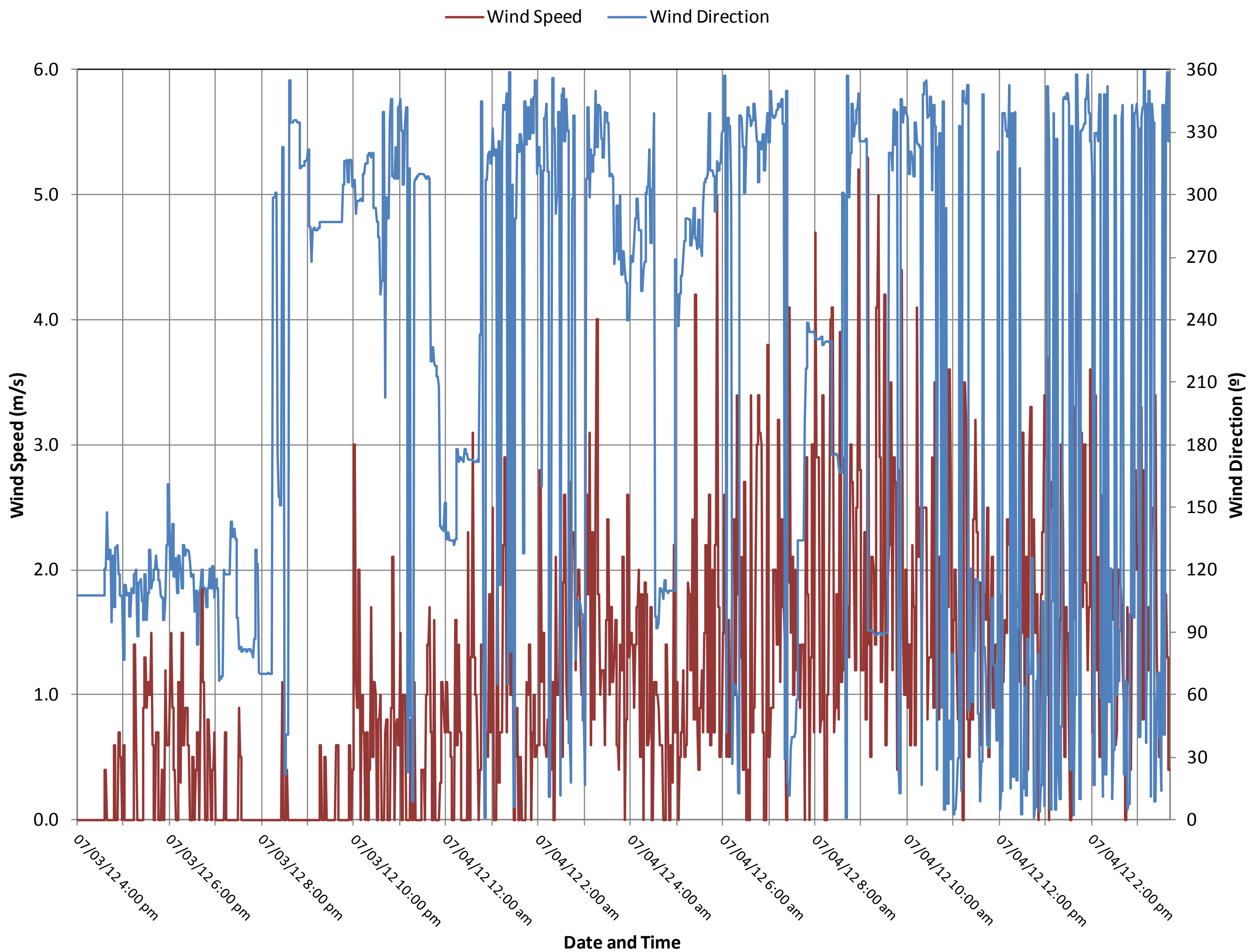


Figure 4.4-6: Weather Information (Wind Speed and Direction) for R2



4.4.3 Monitoring Location R3

R3 is located to the west of the Project area, approximately 2.7 km from the Project powerhouse. It is an unoccupied Black Lake shoreline location to the east of the Project. It is not a sound-sensitive receptor defined by Rule 012 (AUC 2012). This receptor is located near the shore of Black Lake in an area adjacent to the proposed location of the Project power tunnel water intake; this location is known to be a popular fishing spot and should be representative of existing noise levels to the east of the Project. The landscape at this location consists of trees and shrubs (Photo 4.3-3). The sound level meter at R3 was influenced by natural sounds from the rustling of leaves, birds and insects, and water sounds of the lake.

Filtered $L_{eq.1hour}$ values along with $L_{eq,day}$ and $L_{eq.night}$ values at this monitoring location are presented in Table 4.4-3. Description of the isolated sound events for R3 is shown in Table B-3 of Appendix I.3. Unfiltered $L_{eq,1min}$ values recorded at R3 are shown in Figure 4.4-7. Weather data, recorded near the R3 monitoring site are presented in Figures 4.4-8 and 4.4-9.

Table 4.4-3: Filtered Hourly Sound Levels at R3

Date	Start Hour	$L_{eq,\ 1hour}$ (dBA)
07/03/2012	3:00 p.m.	27
07/03/12	4:00 p.m.	Not Valid[a]
07/03/12	5:00 p.m.	34
07/03/12	6:00 p.m.	28
07/03/12	7:00 p.m.	22
07/03/12	8:00 p.m.	29
07/03/12	9:00 p.m.	34
07/03/12	10:00 p.m.	31
07/03/12	11:00 p.m.	37
07/04/12	12:00 a.m.	Not Valid[a]
07/04/12	1:00 a.m.	Not Valid[a]
07/04/12	2:00 a.m.	Not Valid[a]
07/04/12	3:00 a.m.	Not Valid[a]
07/04/12	4:00 a.m.	Not Valid[a]
07/04/12	5:00 a.m.	Not Valid[a]
07/04/12	6:00 a.m.	Not Valid[a]
07/04/12	7:00 a.m.	Not Valid[a]
07/04/12	8:00 a.m.	Not Valid[a]
07/04/12	9:00 a.m.	Not Valid[a]
07/04/12	10:00 a.m.	Not Valid[a]
07/04/12	11:00 a.m.	Not Valid[a]
07/04/12	12:00 p.m.	Not Valid[a]
07/04/12	1:00 p.m.	Not Valid[a]
07/04/12	2:00 p.m.	Not Valid[a]
07/04/12	3:00 p.m.	Not Valid[a]
07/04/12	4:00 p.m.	Not Valid[a]
07/04/12	5:00 p.m.	Not Valid[a]
07/04/12	6:00 p.m.	Not Valid[a]
07/04/12	7:00 p.m.	37
07/04/12	8:00 p.m.	39
07/04/12	9:00 p.m.	35
07/04/12	10:00 p.m.	39
07/04/12	11:00 p.m.	37
07/05/12	12:00 a.m.	34

Table 4.4-3: Filtered Hourly Sound Levels at R3 (continued)

Date	Start Hour	$L_{eq, 1hour}$ (dBA)
07/05/12	1:00 a.m.	19
07/05/12	2:00 a.m.	20
07/05/12	3:00 a.m.	26
07/05/12	4:00 a.m.	23
07/05/12	5:00 a.m.	23
07/05/12	6:00 a.m.	24
07/05/12	7:00 a.m.	25
07/05/12	8:00 a.m.	26
Daytime Average ($L_{eq,day}$)	7:00 a.m. to 10:00 p.m.	33
Nighttime Average ($L_{eq.night}$)	10:00 p.m. to 7:00 a.m.	33

[a] These hours contained fewer than 30 minutes of valid data
dBA = A-weighted decibels; a.m. = ante meridiem; p.m. = post meridiem

Strong storms/wind resulted in a lack of valid data during the 4 p.m. hour of July 3 and between 12 a.m. and 6 p.m. on July 4.

Figure 4.4-7: Unfiltered One-Minute Sound Levels at R3

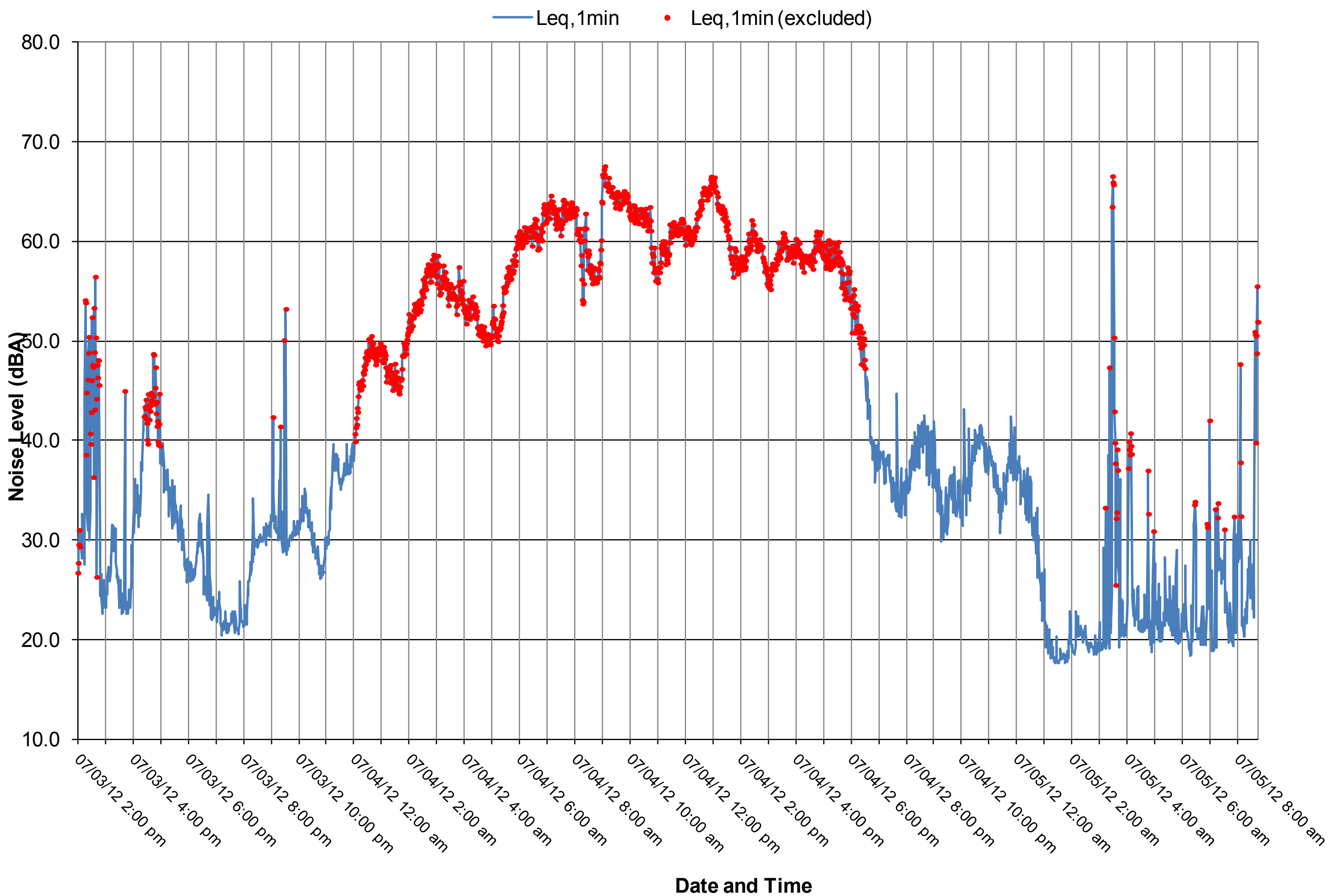


Figure 4.4-8: Weather Information (Temperature and Humidity) for R3

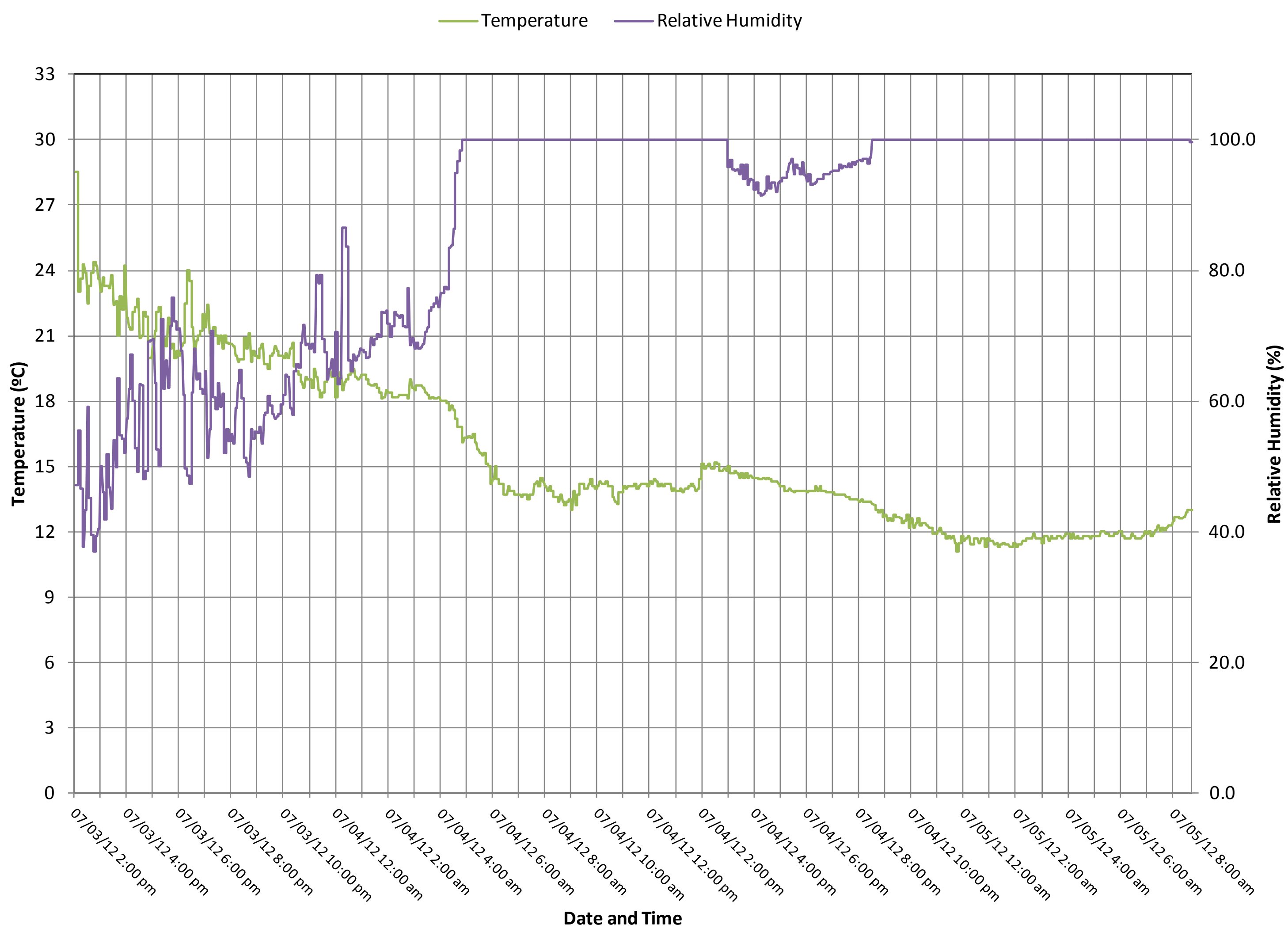
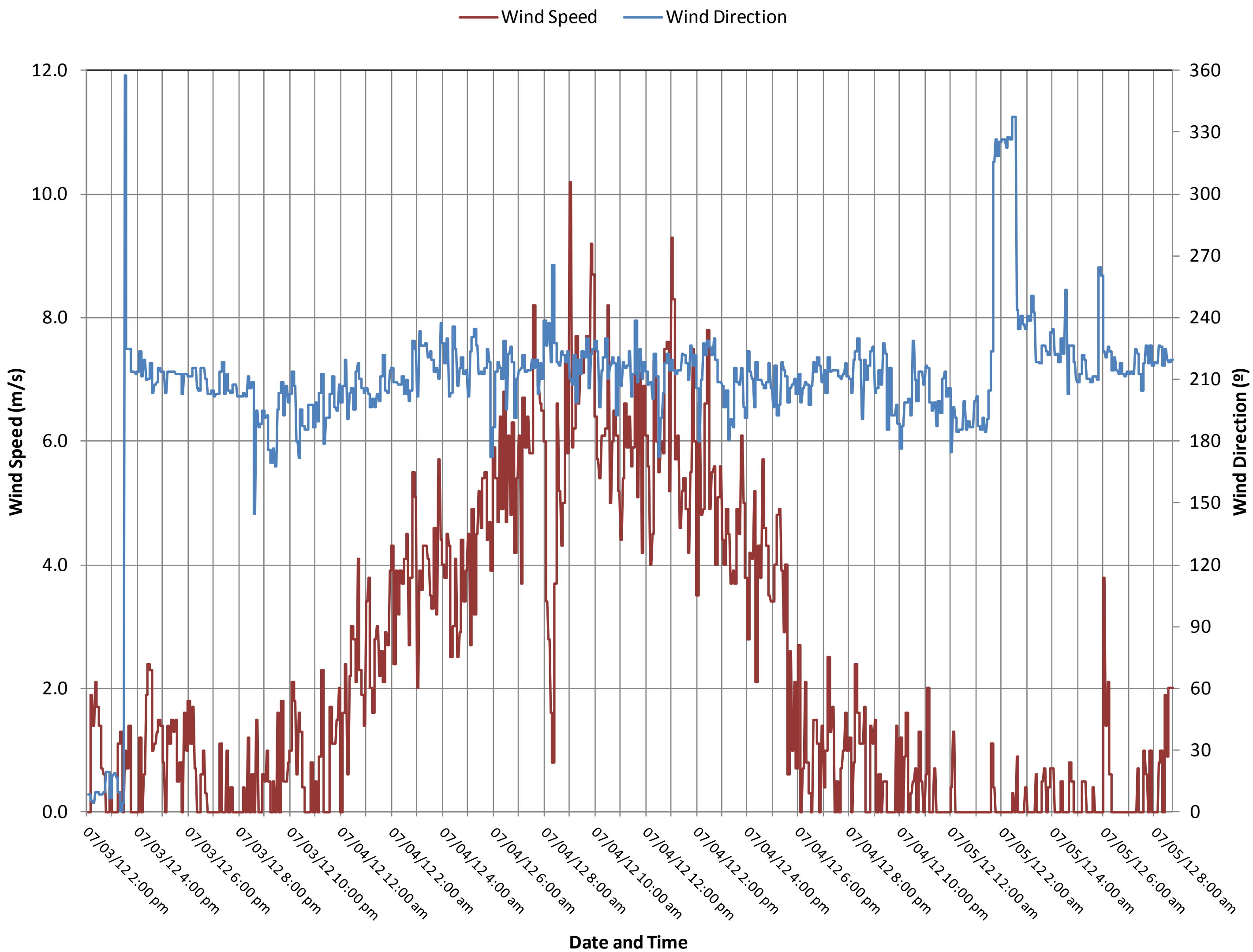


Figure 4.4-9: Weather Information (Wind Speed and Direction) for R3



4.4.4 Monitoring Location R4

R4 is located to the southwest of the Project area, approximately 1.9 km from the Project boundary. It is not a sound-sensitive receptor defined by Rule 012 (AUC 2012). It is an unoccupied location on the west bank of the Fond du Lac River. This receptor is located near the west bank of the Fond du Lac River adjacent to the proposed location of the Project Bridge. This location should be representative of existing noise levels to the west of the Project. The landscape at this location consists of trees and shrubs (Photo 4.3-4). The sound level meter at R4 was influenced by water sound from river and rapids, and natural sounds from the rustling of leaves, birds and insects.

Filtered $L_{eq.1hour}$ values along with $L_{eq,day}$ and $L_{eq.night}$ values at this monitoring location are presented in Table 4.4-4. Description of the isolated sound events for R4 is shown in Table B-4 of Appendix I.3. Unfiltered $L_{eq,1min}$ values recorded at R4 are shown in Figure 4.4-10. Weather data, recorded near the R4 monitoring site are presented in Figures 4.4-11 and 4.4-12.

Table 4.4-4: Filtered Hourly Sound Levels at R4

Date	Start Hour	$L_{eq,\ 1hour}$ (dBA)
07/04/2012	6:00 p.m.	46
07/04/12	7:00 p.m.	46
07/04/12	8:00 p.m.	46
07/04/12	9:00 p.m.	46
07/04/12	10:00 p.m.	47
07/04/12	11:00 p.m.	46
07/05/12	12:00 a.m.	46
07/05/12	1:00 a.m.	45
07/05/12	2:00 a.m.	45
07/05/12	3:00 a.m.	47
07/05/12	4:00 a.m.	45
07/05/12	5:00 a.m.	45
07/05/12	6:00 a.m.	43
07/05/12	7:00 a.m.	45
07/05/12	8:00 a.m.	45
07/05/12	9:00 a.m.	45
07/05/12	10:00 a.m.	45
07/05/12	11:00 a.m.	Not Valid[(a)]
07/05/12	12:00 p.m.	47
07/05/12	1:00 p.m.	47
07/05/12	2:00 p.m.	46
07/05/12	3:00 p.m.	46
07/05/12	4:00 p.m.	46
Daytime Average ($L_{eq,day}$)	7:00 a.m. to 10:00 p.m.	46
Nighttime Average ($L_{eq,night}$)	10:00 p.m. to 7:00 a.m.	46

(a) This hour contained fewer than 30 minutes of valid data
dBA = A-weighted decibels; a.m. = ante meridiem; p.m. = post meridiem

Strong wind was the cause of the invalid data for the 11 a.m. hour of July 5, 2012.

This receptor is close to Elizabeth Falls on the Fond du Lac River. Daytime and nighttime sound levels do not differ very much because water sounds from falls and river dominates the sound recording of monitoring at this site. These sources are consistent throughout the daytime and nighttime periods.

Figure 4.4-10: Unfiltered One-Minute Sound Levels at R4

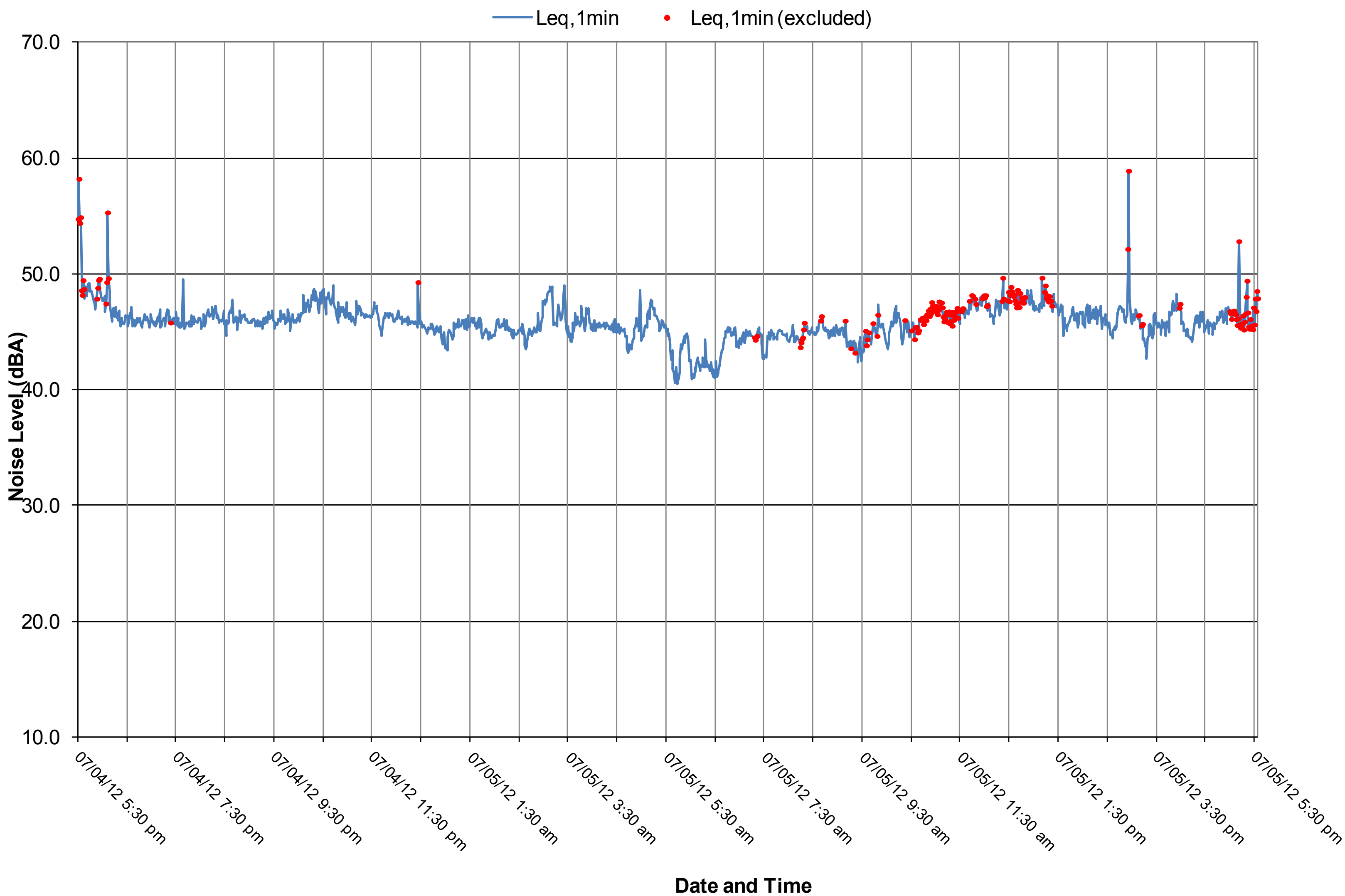


Figure 4.4-11: Weather Information (Temperature and Humidity) for R4

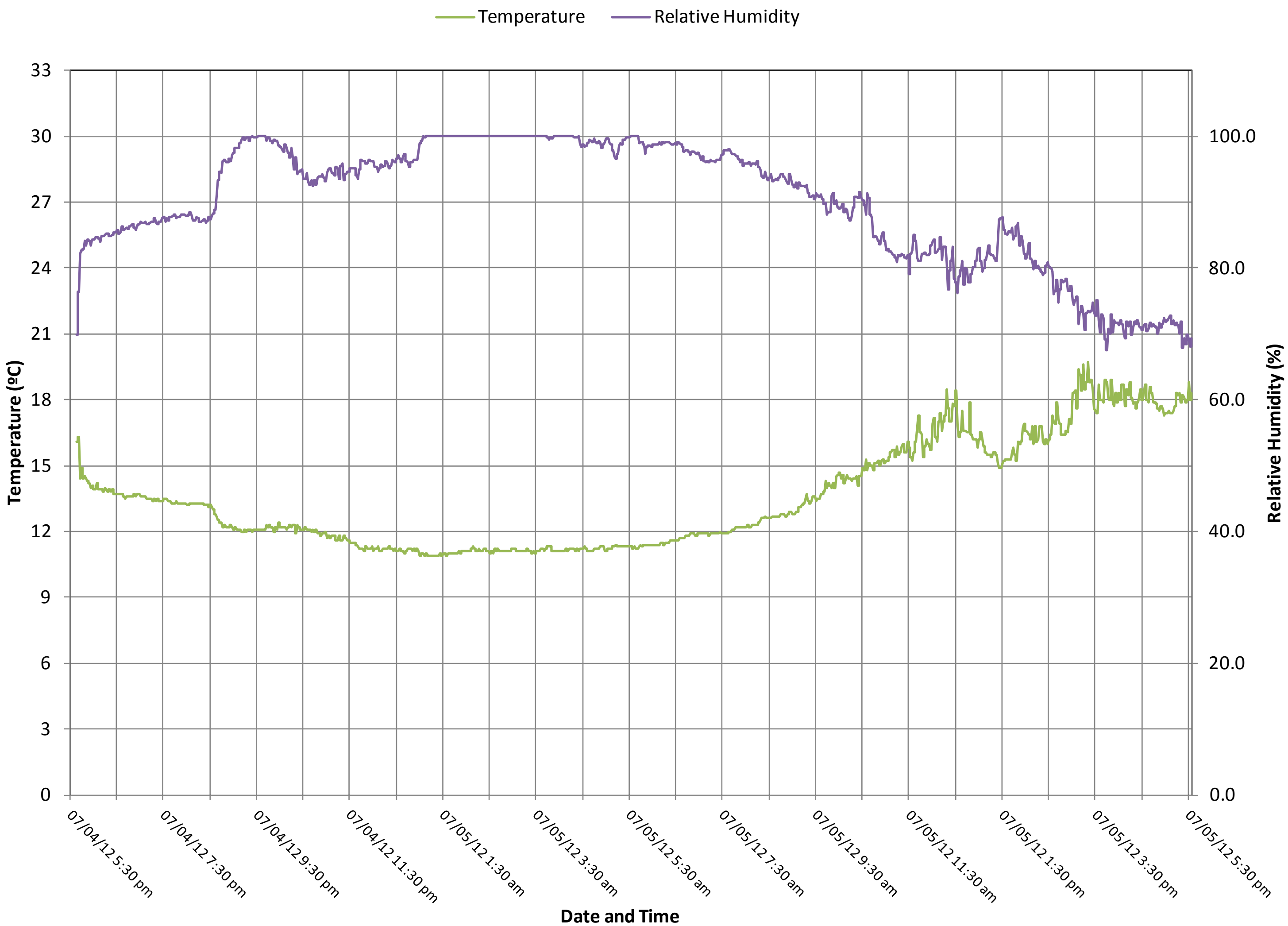
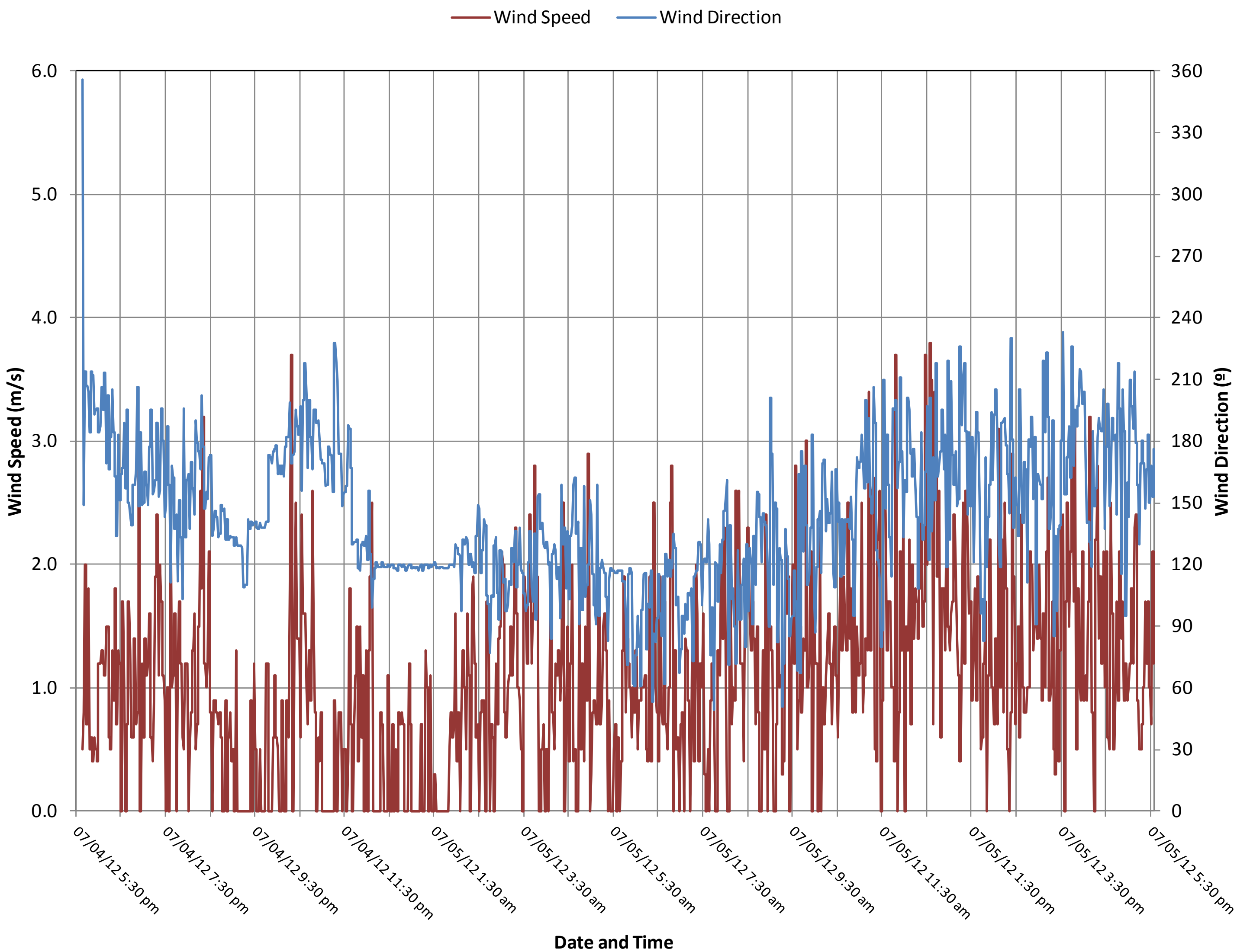


Figure 4.4-12: Weather Information (Wind Speed and Direction) for R4



4.5 Summary

The results of the acoustic environmental baseline surveys at four monitoring locations are summarized in Table 4.5-1. The period averages were based on the hourly data filtered to exclude extraneous sound events and weather conditions.

Table 4.5-1: Baseline Sound Level Survey Results at Monitoring Locations

Monitoring Location	Baseline Sound Measurements (dBA)	
	Day-time, $L_{eq,\ day}$ 7:00 a.m. to 10:00 p.m.	Night-time, $L_{eq,\ night}$ 10:00 p.m. to 7:00 a.m.
R1 – Permanent Resident's Cabin	37	34
R2 – Camp Grayling	45	41
R3 – Intake/Edge of Black Lake	33	33
R4 – Bridge/bank of Fond du Lac River	46	46

dBA = A-weighted decibels; a.m. = ante meridiem; p.m. = post meridiem

The sound levels measured at R1 and R3 were mainly influenced by sounds from natural sources such as the rustling of leaves, birds and insects and water sound from lake. The sound levels measured at R2 and R4 were mainly influenced by water sound from Elizabeth Falls and Fond du Lac River.

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6.0 GLOSSARY

Term	Description
A-weighted decibels	A measure of sound pressure that incorporates the frequency response of the human ear.
Daytime	Hours range from 7:00 a.m. to 10:00 p.m.
Equivalent energy sound level	Equivalent energy sound level, defined as the sound pressure level that, if constant over the stated measurement period, would contain the same sound energy as the actual monitored sound that is fluctuating in level over the measurement period. This type of average takes into account the natural variability of sound. A common descriptor used in outdoor sound measurement (Cowan 1994)
Frequency	Human ear does not respond to all frequencies in the same way. Mid-range frequencies are most readily detected by the human ear, while low and high frequencies are harder to hear.
Monitoring location	Location where the sound meter is setup.
Nighttime	Hours range from 10:00 p.m. to 7:00 a.m.
Noise	Levels that can be heard or measured at a receiver.
Relative humidity	Relative humidity in percent is the ratio of the quantity of water vapour the air contains compared to the maximum amount it can hold at that particular temperature
Sound	Acoustic energy generated by natural or man-made sources, including the Project activities.
Sound level meter	Equipment to measure sound levels.
Sound pressure	Difference between the instantaneous pressure at a fixed point in a sound field, and the pressure at the same point with the sound absent.
Temperature	The temperature of the air in degrees Celsius (°C).
Weather meter	Equipment to measure ambient weather including temperature, humidity, wind speed and direction.
Wind direction	The direction (true or geographic, not magnetic) from which the wind blows. A value of zero (0) denotes a calm wind.
Wind speed	The speed of motion of air in m/s.

Report Signature Page

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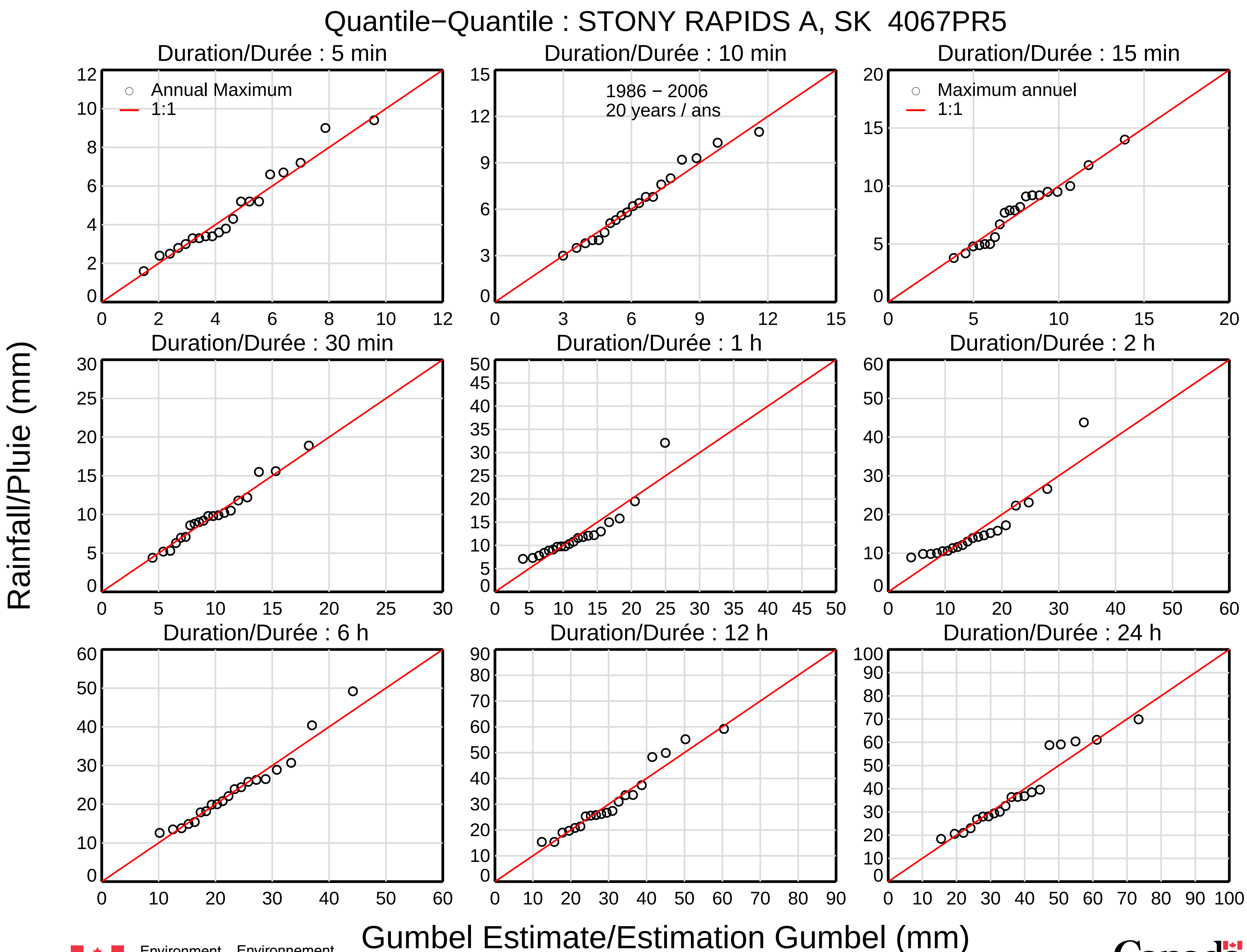
APPENDIX I.1

Short Duration Rainfall Intensity-Duration (IDF), Return Level, and Quantile Curves



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APPENDIX I.2

Calibration Results

Figure I.2-1: Pre-Measurement Calibration for R1

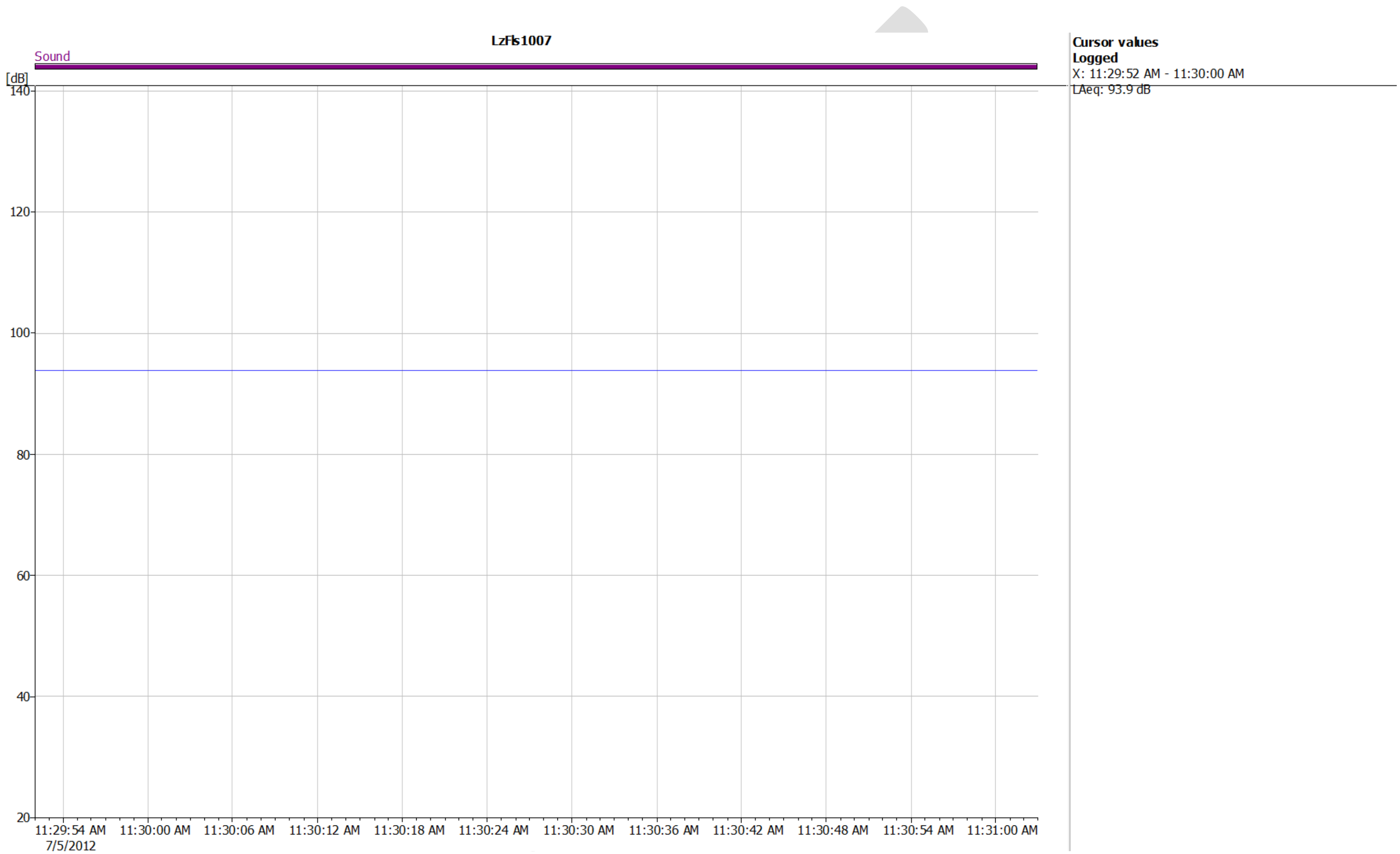


Figure I.2-2: Post-Measurement Calibration Confirmation for R1

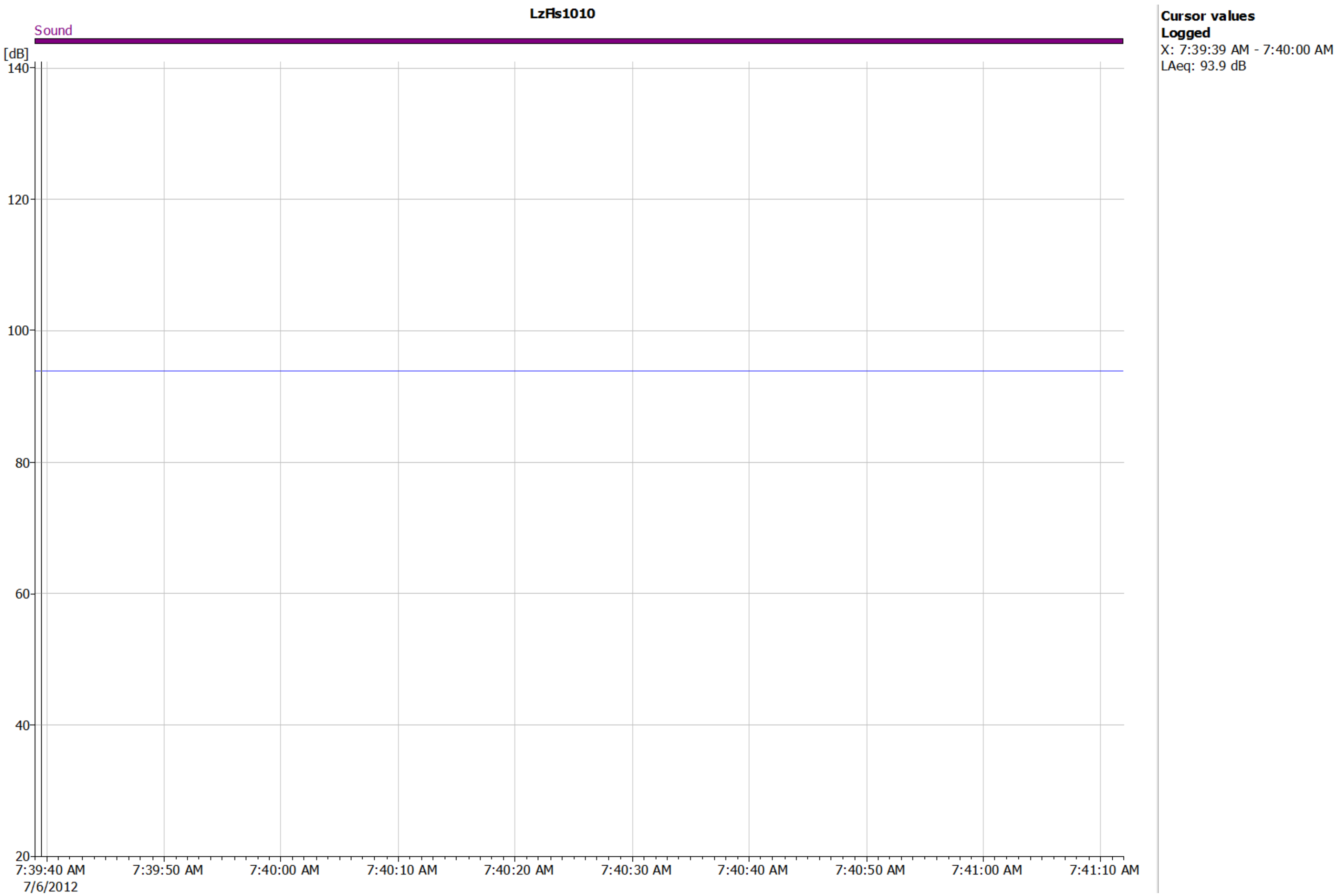


Figure I.2-3: Pre-Measurement Calibration for R2

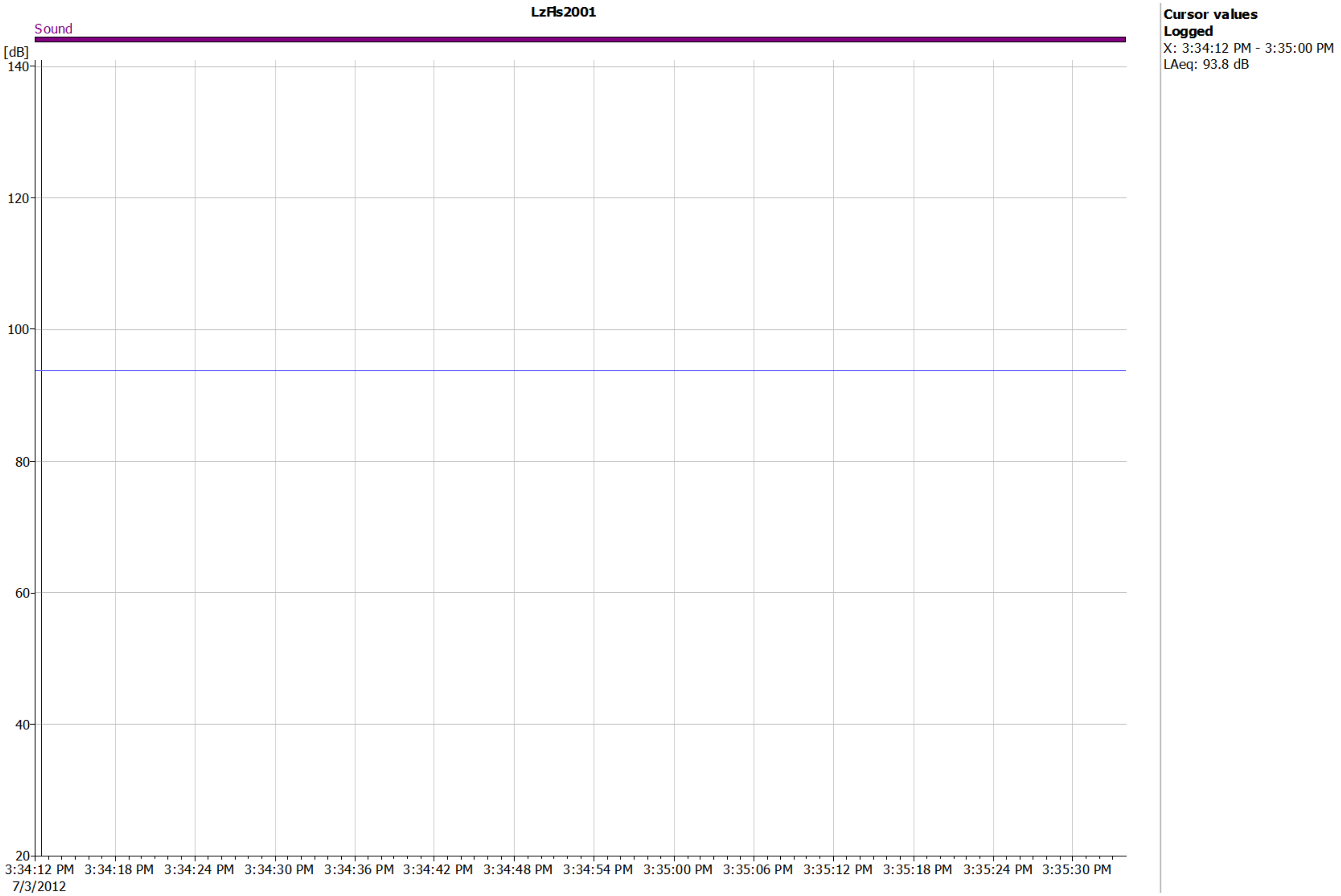


Figure I.2-4: Post-Measurement Calibration Confirmation for R2

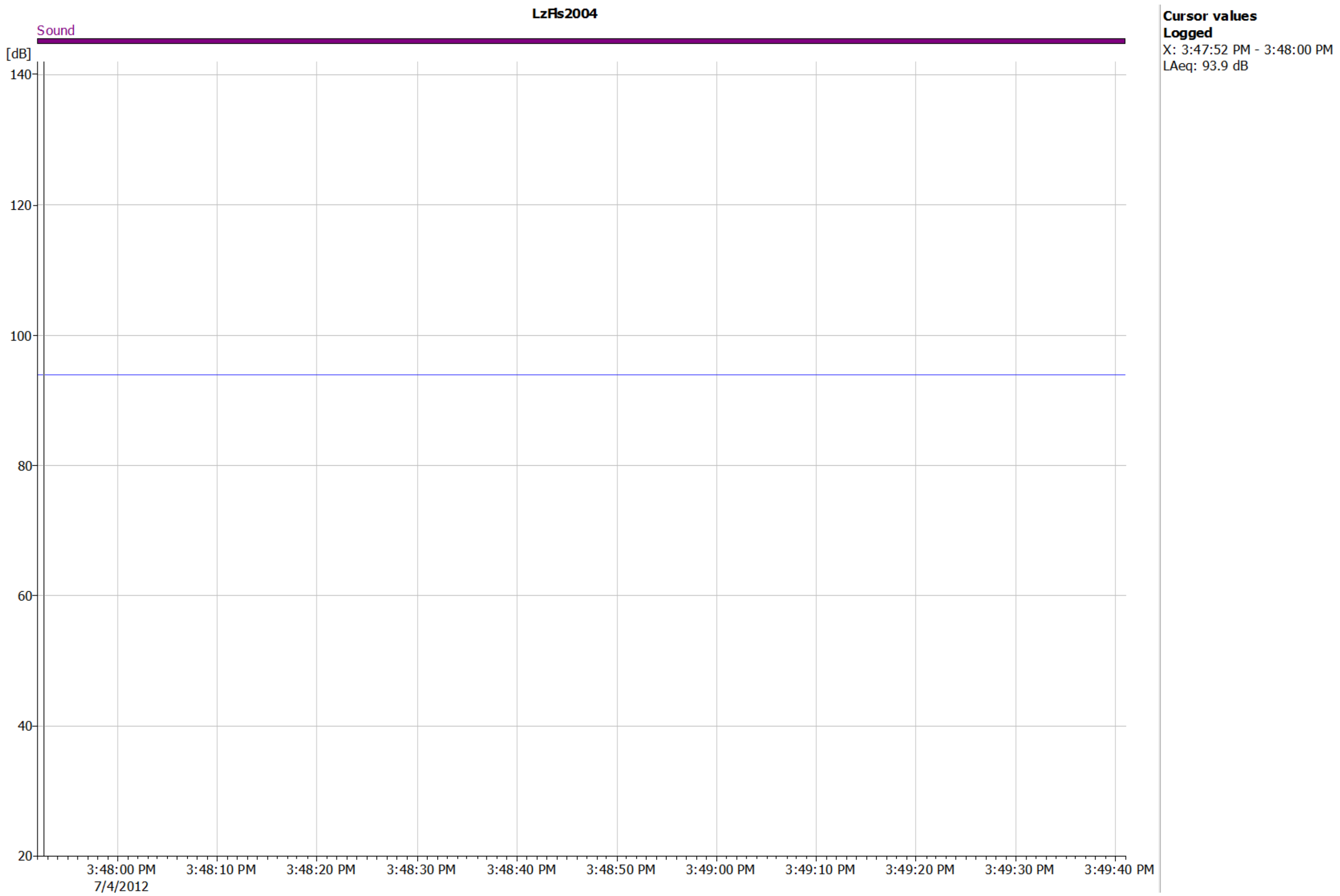


Figure I.2-5: Pre-Measurement Calibration for R3

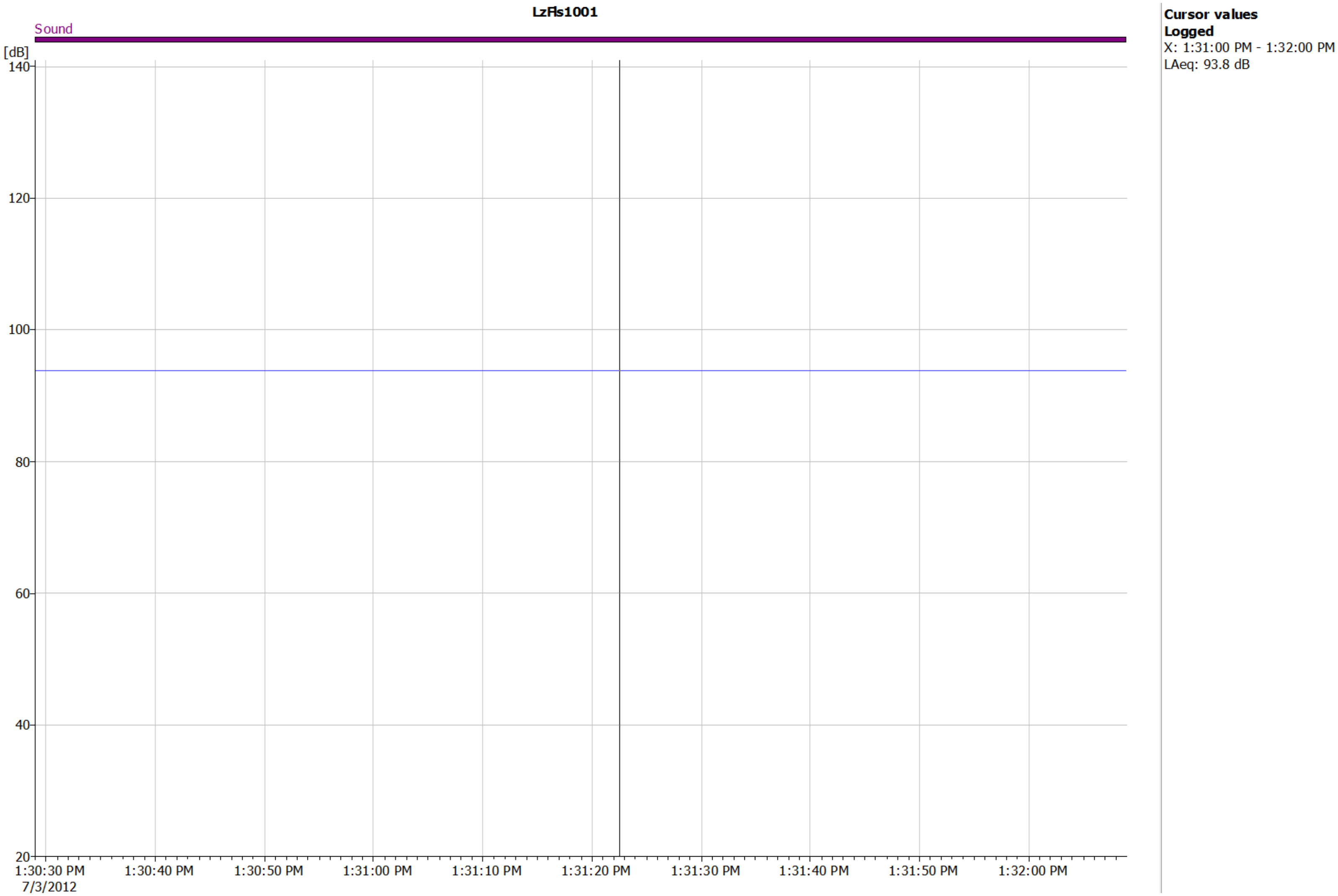


Figure I.2-6: Post-Measurement Calibration Confirmation for R3

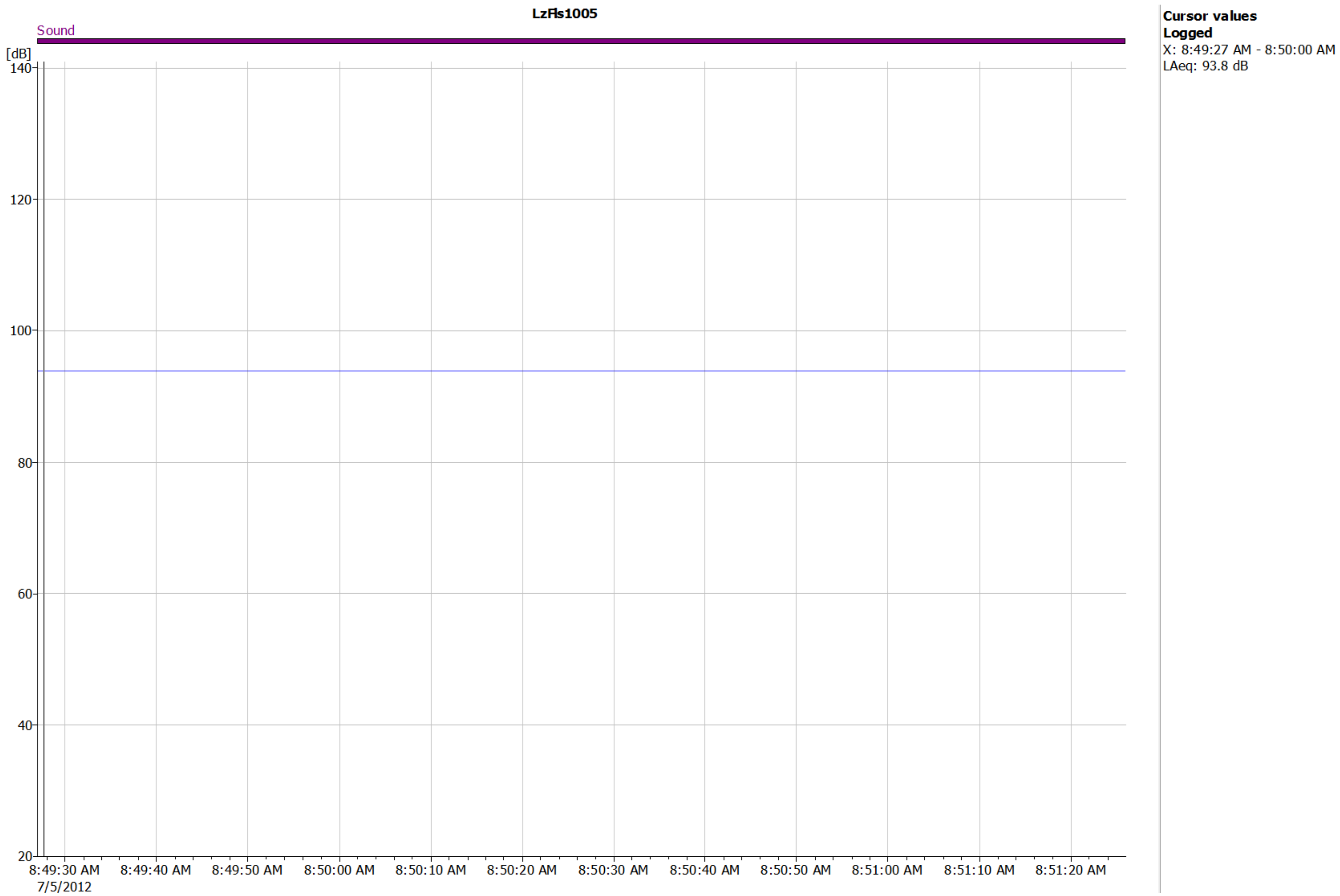


Figure I.2-7: Pre-Measurement Calibration for R4

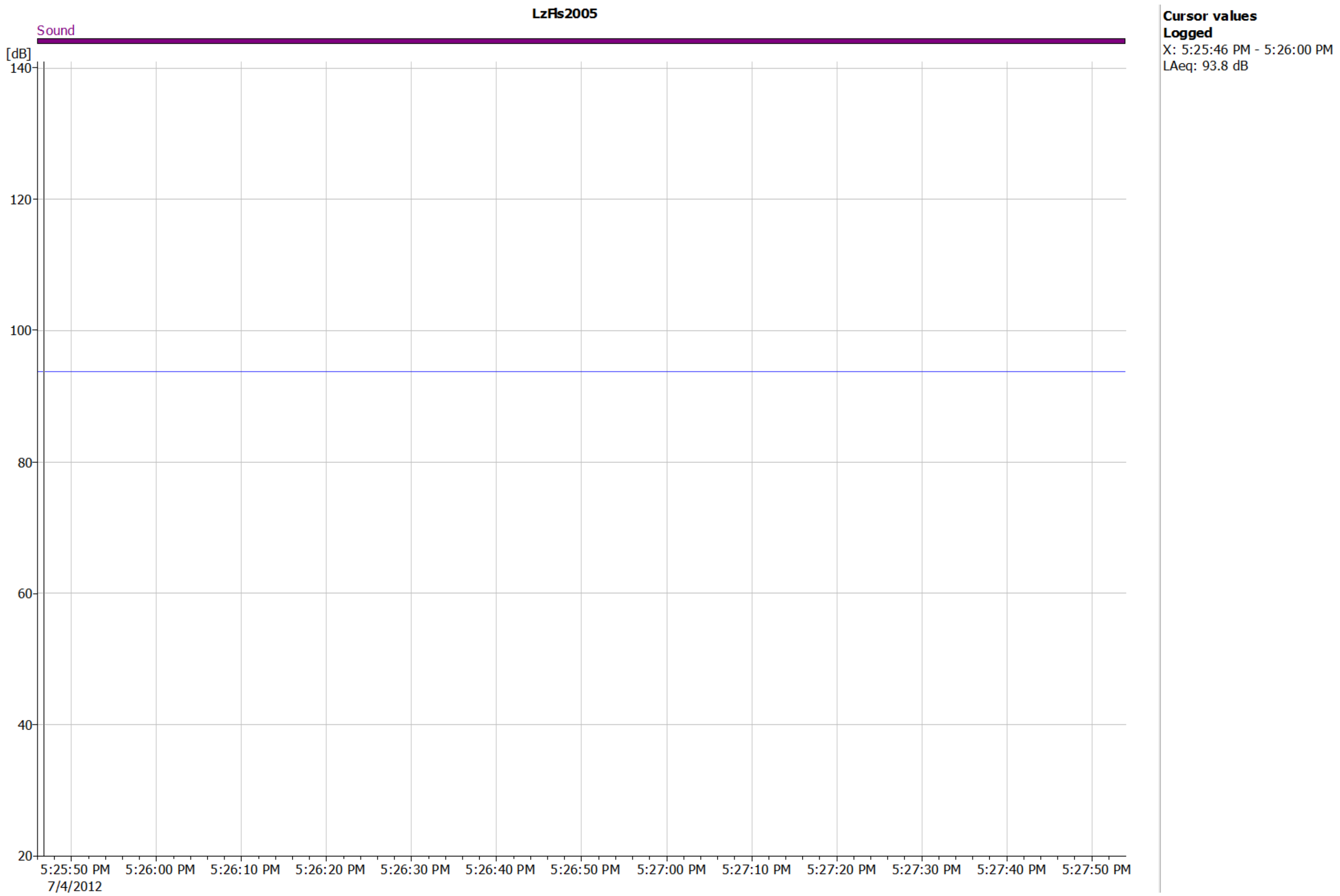
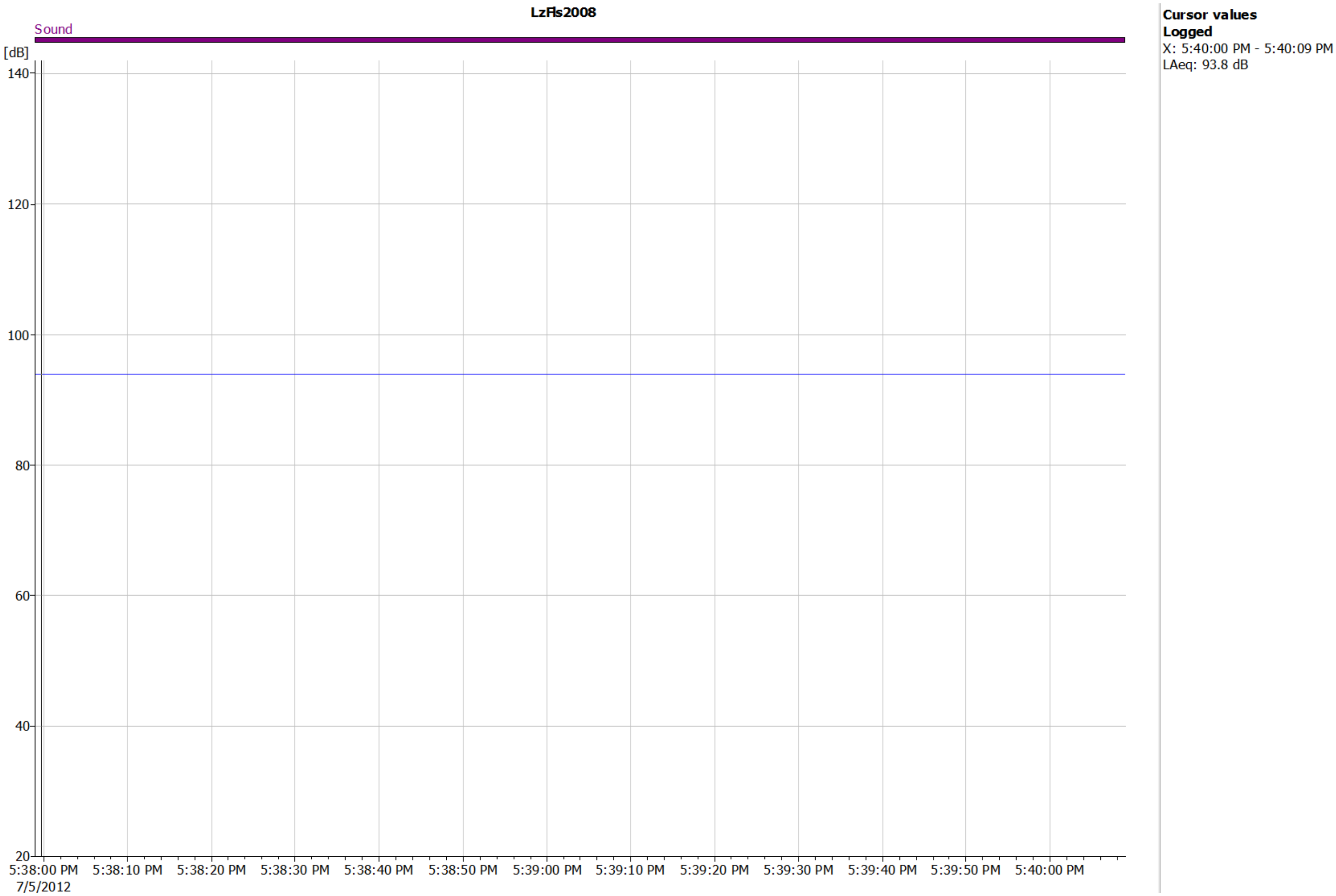


Figure I.2-8: Post-Measurement Calibration Confirmation for R4



APPENDIX I.3

Isolated Sound Levels Description

Table I.3-1: Isolated Sound Levels Description – R1

Date	Time	Description
7/5/2012	11:57 a.m.	technician
7/5/2012	12:02 p.m.	technician
7/5/2012	12:04 p.m.	technician
7/5/2012	12:06 p.m.	technician
7/5/2012	12:16 p.m.	wind
7/5/2012	12:48 p.m.	birds nearby
7/5/2012	2:57 p.m. to 2:58 p.m.	airplane nearby
7/5/2012	5:52 p.m.	birds nearby
7/5/2012	6:56 p.m.	wind
7/5/2012	7:46 p.m.	insect nearby
7/5/2012	8:03 p.m. to 8:04 p.m.	wildlife nearby
7/5/2012	8:54 p.m.	birds nearby
7/5/2012	9:20 p.m.	birds nearby
7/5/2012	9:36 p.m.	birds nearby
7/5/2012	10:12 p.m.	wind
7/5/2012	10:27 p.m.	birds nearby
7/5/2012	10:53 p.m.	wind
7/6/2012	3:27 a.m. to 3:27 a.m.	wind
7/6/2012	4:00 a.m.	birds nearby
7/6/2012	6:06 a.m. to 6:09 a.m.	birds nearby
7/6/2012	7:08 a.m.	wind
7/6/2012	7:33 a.m. to 7:36 a.m.	technician

a.m. = ante meridiem; p.m. = post meridiem

Table I.3-2: Isolated Sound Levels Description – R2

Date	Time	Description
7/3/2012	3:37 p.m. to 3:42 p.m.	technician
7/3/2012	3:48 p.m.	technician
7/3/2012	3:57 p.m. to 3:58 p.m.	technician
7/3/2012	4:49 p.m. to 4:50 p.m.	birds nearby
7/3/2012	4:51 p.m.	people nearby
7/3/2012	4:53 p.m. to 5:00 p.m.	rain
7/3/2012	5:02 p.m. to 5:06 p.m.	technician
7/3/2012	5:07 p.m. to 5:08 p.m.	traffic nearby
7/3/2012	5:42 p.m. to 5:51 p.m.	birds nearby
7/3/2012	6:45 p.m.	insect nearby
7/3/2012	6:47 p.m.	birds nearby
7/3/2012	7:06 p.m. to 7:08 p.m.	birds nearby
7/3/2012	7:10 p.m.	birds nearby
7/3/2012	7:12 p.m. to 7:14 p.m.	helicopter nearby
7/3/2012	7:34 p.m. to 7:35 p.m.	dog nearby
7/3/2012	8:00 p.m.	dog nearby
7/3/2012	9:03 p.m. to 9:04 p.m.	birds nearby
7/3/2012	9:05 p.m. to 9:08 p.m.	technician
7/3/2012	10:23 p.m.	dog nearby
7/3/2012	10:50 p.m. to 10:51 p.m.	dog nearby
7/4/2012	4:33 a.m. to 4:37 a.m.	birds nearby
7/4/2012	4:46 a.m. to 4:47 a.m.	insect nearby
7/4/2012	5:00 a.m. to 5:03 a.m.	people nearby
7/4/2012	5:50 a.m. to 5:59 a.m.	wind
7/4/2012	6:23 a.m. to 6:59 a.m.	wind
7/4/2012	7:03 a.m. to 7:14 a.m.	wind
7/4/2012	8:02 a.m. to 9:37 a.m.	wind
7/4/2012	11:06 a.m. to 11:31 a.m.	wind
7/4/2012	11:42 a.m. to 12:02 p.m.	wind
7/4/2012	12:42 p.m. to 12:58 p.m.	wind
7/4/2012	1:09 p.m.	wind
7/4/2012	1:12 p.m. to 1:13 p.m.	wind
7/4/2012	1:30 p.m. to 1:31 p.m.	wind
7/4/2012	1:40 p.m. to 1:59 p.m.	wind
7/4/2012	2:02 p.m.	wind
7/4/2012	2:17 p.m.	wind

Table I.3-2: Isolated Sound Levels Description – R2 (continued)

Date	Time	Description
7/4/2012	2:28 p.m.	wind
7/4/2012	3:18 p.m. to 3:25 p.m.	traffic nearby
7/4/2012	3:26 p.m. to 3:41 p.m.	technician

a.m. = ante meridiem; p.m. = post meridiem

Table I.3-3: Isolated Sound Levels Description – R3

Date	Time	Description
7/3/2012	2:16 p.m. to 2:36 p.m.	technician
7/3/2012	2:37 p.m. to 2:46 p.m.	traffic nearby
7/3/2012	3:42 p.m.	airplane nearby
7/3/2012	4:24 p.m. to 4:58 p.m.	rain
7/3/2012	9:04 p.m.	birds nearby
7/3/2012	9:20 p.m.	airplane nearby
7/3/2012	9:28 p.m.	birds nearby
7/3/2012	9:32 p.m.	birds nearby
7/4/2012	12:02 a.m. to 1:59 a.m.	rain
7/4/2012	2:05 a.m. to 6:30 p.m.	rain and wind
7/5/2012	3:12 a.m.	birds nearby
7/5/2012	3:21 a.m.	birds nearby
7/5/2012	3:27 a.m.	birds nearby
7/5/2012	3:28 a.m. to 3:39 a.m.	wind
7/5/2012	4:02 a.m. to 4:09 a.m.	birds nearby
7/5/2012	4:45 a.m.	birds nearby
7/5/2012	4:46 a.m.	birds nearby
7/5/2012	4:57 a.m.	birds nearby
7/5/2012	6:26 a.m.	birds nearby
7/5/2012	6:27 a.m.	wind
7/5/2012	6:53 a.m. to 6:54 p.m.	wind
7/5/2012	6:59 a.m.	wind
7/5/2012	7:11 a.m.	birds nearby
7/5/2012	7:16 a.m. to 7:17 a.m.	birds nearby
7/5/2012	7:31 a.m.	birds nearby
7/5/2012	7:52 a.m.	birds nearby
7/5/2012	8:05 a.m. to 8:07 a.m.	birds nearby
7/5/2012	8:37 a.m. to 8:44 a.m.	traffic nearby

a.m. = ante meridiem; p.m. = post meridiem

Table I.3-4: Isolated Sound Levels Description – R4

Date	Time	Description
7/4/2012	5:29 p.m. to 5:34 p.m.	technician
7/4/2012	5:53 p.m. to 5:56 p.m.	technician
7/4/2012	6:04 p.m. to 6:07 p.m.	technician
7/4/2012	7:23 p.m.	unknown tapping
7/5/2012	12:26 a.m.	birds nearby
7/5/2012	7:18 a.m. to 7:21 a.m.	rain
7/5/2012	8:14 a.m. to 8:19 a.m.	wind
7/5/2012	8:39 a.m. to 8:40 a.m.	wind
7/5/2012	9:09 a.m.	wind
7/5/2012	9:16 a.m.	wind
7/5/2012	9:21 a.m.	wind
7/5/2012	9:34 a.m. to 9:38 a.m.	wind
7/5/2012	9:43 a.m.	wind
7/5/2012	9:48 a.m.	wind
7/5/2012	9:49 a.m.	wind
7/5/2012	10:22 a.m.	wind
7/5/2012	10:30 a.m.	wind
7/5/2012	10:34 a.m. to 11:33 a.m.	wind
7/5/2012	11:41 a.m.	wind
7/5/2012	11:44 a.m. to 11:45 a.m.	wind
7/5/2012	11:45 a.m.	wind
7/5/2012	11:48 a.m. to 11:49 a.m.	wind
7/5/2012	11:57 a.m. to 11:59 a.m.	wind
7/5/2012	12:00 p.m. to 12:03 p.m.	wind
7/5/2012	12:21 p.m. to 12:23 p.m.	wind
7/5/2012	12:28 p.m. to 12:49 p.m.	wind
7/5/2012	1:10 p.m.	wind
7/5/2012	1:13 p.m. to 1:22 p.m.	wind
7/5/2012	2:55 p.m.	airplane
7/5/2012	2:56 p.m.	airplane
7/5/2012	3:08 p.m. to 3:09 p.m.	wind
7/5/2012	3:12 p.m. to 3:13 p.m.	wind
7/5/2012	3:58 p.m. to 3:59 p.m.	wind
7/5/2012	5:00 p.m. to 5:34 p.m.	technician

a.m. = ante meridiem; p.m. = post meridiem