Mobile Environmental Monitoring Platform

Principles of Operation

Government of Newfoundland & Labrador
Department of Environment and Conservation
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Foreword

The Mobile Environmental Monitoring Platform (MEMP) is intended for rapid-response observation of water quality, water quantity, and climate events. The MEMP is outfitted with a series of instruments capable of monitoring numerous parameters and automatically withdrawing a grab sample based on user-set thresholds.

This manual aims to outline the major features of the MEMP and required maintenance.

Introduction

In total five MEMPs were designed and built by Grantec Engineering in Nova Scotia using concept sketches from Environment Canada. Four MEMPs are located in the Maritimes while one unit is dedicated to Newfoundland and Labrador for emergency monitoring of spills and shorter term seasonal monitoring.

To ensure that the MEMP is always available in case of urgent need, every endeavor should be made to maintain the trailer in good condition; including water quality/quantity and climate monitoring equipment, datalogger, telemetry, power supply, and running gear.

MEMP Components

Trailer Details and Running Gear

Figure 1: MEMP running gear

The MEMP is housed in a custom-built 17’ x 6’ twin axle trailer, intended to be towed by a pickup truck with at least 5000 lbs. in towing capacity and outfitted with a Class III hitch.

Those responsible for towing the MEMP must be competent in maneuvering trailers and be cognizant of the height and side clearances necessary while under way. Training opportunities should be sought if the operator is not confident in their abilities – especially since maneuvering the MEMP into confined areas while on rough roads is the norm.

Due to the MEMP’s weight and size, it is outfitted with a Tekonsha Voyager 9030 inertia–activated proportional braking system. When hitching the pickup to the MEMP, drivers should ensure that the braking unit connection is made and the device is calibrated to the current weight of the trailer and road conditions. Complete instructions can be found in Appendix I.

Prior to hitching the trailer and truck, it is important to inspect the critical components of the trailer. Ensure tire pressures are sufficient (see tire sidewall specifications), the hitch receiver is firmly mounted to the trailer, the emergency brake battery is fully charged and in good condition, and loose materials inside the trailer are secured. After hitching the trailer and making all connections (ball firmly socketed into receiver, emergency brake cable attached to the truck, and electrical connection), ensure all running lights are operational. Also, ensure that a spare tire is available in the MEMP in case of a flat tire or blowout while on the road.

Climate Monitoring Sensors

Climate sensors are affixed to the aluminum mast at about 20’ above the ground. When positioning the MEMP, thought should be made regarding the orientation of the mast, as it is a square pole which will limit orientation of mast-mounted equipment once affixed with bolts. Ideally, sensors should be located in as open a space as practical to reduce undue influence of obstructions, such as buildings and trees. Since the mast is affixed to the MEMP itself, level and open space should be chosen for deployment.

Maintenance procedures and calibration intervals should be followed according to *Protocol Manual for the Operation and Maintenance of Campbell Scientific Canada Corp. Quick Deploy Weather Systems* (Campbell Scientific Canada, 2012. See Appendix I).

Table 1: Mast-mounted sensors and equipment

Temperature/Relative Humidity (HC-S3)
The HygroClip by Rotronic Instrument Corporation temperature and relative humidity probe has a humidity accuracy of +/- 1.5% at 23^{o}C and a temperature accuracy of +/- 0.2^{o}C from -30^{o}C to 60^{o}C. The sensor is protected by a radiation shield to reduce the impact of direct sunlight on readings. Performance should be evaluated on an annual basis.

Figure 2: Temp/RH outfitted with Model 41003-X radiation shield

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Tipping-bucket rain gauge (TE525M)
This metric tipping bucket rain gauge manufactured by Texas Electronics measures precipitation to an accuracy of 0.1 mm with each tip. The bucket is outfitted with a magnetic reed switch which closes a circuit each time the bucket falls – each closure represents accumulation of 0.1 mm. For optimum performance, the bucket should be as close to level as possible. A level bubble can be found inside the gauge; however, its location at the top of the mast during deployment will preclude its use. To level the sensor, it is best to ensure the MEMP itself is as level as possible. Accuracy of the gauge should be checked annually and calibrated if required.

Figure 3: TE525M Tipping Bucket Rain Gauge

Anemometer (05103-10)
The wind speed and direction monitor is manufactured by R. M. Young. Wind speed is considered accurate to 1% (0.3 m/s) from 0 to 100 m/s. Wind direction is accurate to +/- 3o. Proper wind direction measurement relies on proper orientation of the sensor - when deploying the anemometer, ensure that the small black plastic junction box points due south. Nose cone and vertical bearings should be checked annually and replaced if necessary.

Figure 4: 05103-10 R. M. Young Anemometer

Other Equipment
In addition to the climate sensors, the mast head is fitted with a webcam (CC5MPX) and a Yagi (directional) cell antenna for the Raven X Cell Modem/Gateway. The webcam has adjustments for pan, zoom, tilt, zoom and focus that must be adjusted upon fixing the mast in place. The cell phone antenna, if cellular telemetry is to be used, should be aimed directly at a cell tower with optimum line-of-sight.

CC5MPX Web Camera
The CC5MPX web camera from Campbell Scientific allows for the timed or triggered acquisition of high definition imagery or video. The camera leaves standby mode upon receipt of a trigger from the datalogger, acquires an image, and transfers the file to the datalogger or remote FTP server.

Figure 5: CC5MPX web cam

Raven X Modem/Gateway
The gateway provides an interface between the Internet and the MEMP's Local Area Network (LAN) allowing high-speed access to data, imagery, and programming. Since cellular signals may be weak in remote locations, a directional Yagi antenna boosts the signal within a narrow line-of-sight of a 3G enabled cellular tower.

Figure 6: Wilson 10 dBi Yagi Cellular Antenna

Water Quality Monitoring Equipment

Datasonde 5X

The MEMP is outfitted with a Hydrolab Datasonde (DS5) multi-parameter probe that measures temperature, pH, specific conductivity, Total Dissolved Solids (TDS), dissolved oxygen (DO), and turbidity. The Hydrolab is deployed in the nearby water body using a 50 m cable to provide flexibility in deployment methods and MEMP placement. Care should be taken to avoid damaging the cable while deployed – protective conduit is recommended. Additionally, the Hydrolab should be deployed in a protective casing to prevent damage to the instrument from vigorous flow and streambed movement. For extra security, a wire rope should be connected from the instrument casing to a fixed shoreline structure such as a stout tree or rebar driven into the ground.

Maintenance of the DS5 is performed according to *Hydrolab DS5, DS5, and MS5 Water Quality Multiprobes* (Hach Company, 2006. See Appendix I) and calibration should be performed according to *Protocols Manual for RTWQ Monitoring in NL* (Environment and Conservation, 2013. See Appendix I).

Table 2: Hydrolab DS5 sensors

Water Temperature (Not pictured) Range: -5°C to 50 °C Accuracy: +/- 0.10 °C
pH Range: 0 to 14 Accuracy: +/- 0.2
Conductivity Range: 0 mS/cm to 100 mS/cm Accuracy: +/- 0.001 mS/cm
Luminescent Dissolved Oxygen (LDO) Range: 0 mg/l to 30 mg/l Accuracy: +/- 0.01 mg/l for 0 to 8 mg/l; +/- 0.02 mg/l for > 8 mg/l
Turbidity Range: 0 NTU to 3000 NTU Accuracy: +/- 1% from 0 NTU to 100 NTU, +/- 3% from 100 NTU to 400 NTU, +/- 5% from 400 NTU to 3000 NTU.

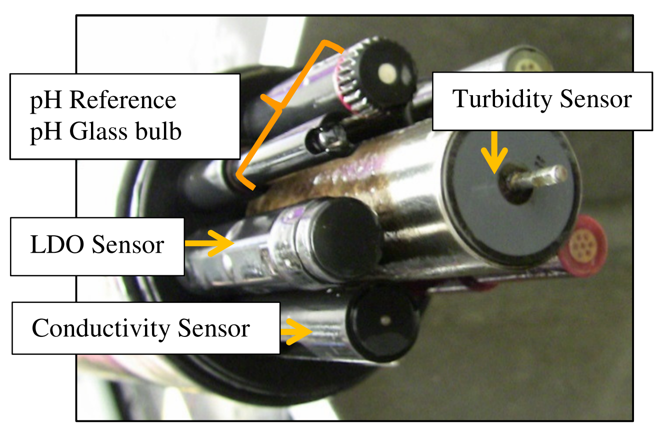


Figure 7: Hydrolab Datasonde

Water Quantity Monitoring Equipment

An OTT CBS bubbler unit is used to monitor water level. To deploy, an air tube is run from the sensor inside the MEMP to a firm and stable deployment structure in the water body. The sensor compares the pressure pushing up the tube to barometric pressure, thereby determining water depth. If necessary, the deployment structure can be referenced to geodetic elevation for true water surface height. Also, if there is a flow component to the water body, repeated cross-sectional stream velocity measurements at various water levels can be combined with the water level to produce a volumetric flow rate.

Table 3: Ott CBS water level sensor

Water Depth
Range: 0 m to 15 m
Accuracy: +/- 0.006 m

Figure 8: Ott CBS Bubbler

Additional Electronics

Datalogger

All station functions are orchestrated through the CR1000 datalogger. Depending on the intended monitoring application, the programming is flexible and can be adjusted (see Appendix II for programming as of September 2014). In general, the datalogger will record measurements every fifteen minutes from all sensors. The process varies slightly for each parameter.

Webcam

At the top of each hour, the datalogger triggers a photo to be taken by the CC5MPX webcam and activates a relay providing ten minutes of power to an Ethernet switch. Once the camera powers up from its low-power state and acquires a picture, the camera stores the picture internally to the SD card and FTPs the photo to a server on the datalogger or a remote server at drivehq.com.

Telemetry

A LAN comprising of the datalogger, CC5MPX webcam and Raven X Modem/Gateway allows for high-speed access to the MEMP for ten minutes at the top of every hour. During this window, data and imagery may be accessed and alterations to the CRBasic programming can be made. High-speed connectivity requires 3G cellular access, which is generally found in urban areas and along the TCH.

Connectivity in remote areas can be provided by Iridium; however, this method is much more expensive and should be considered on an as-needed basis.

Teledyne ISCO 6712 Autosamplers / Thermo King MD-100 Reefer Unit

Two autosamplers are located inside the MEMP for unattended retrieval of water samples for later analysis in a laboratory setting. Samples can be analyzed for a more complete workup, such as nutrients, metals, pharmaceuticals, and many other parameters. Samples are taken depending on user-set thresholds for stage level, rainfall, conductivity, turbidity, DO, or water temperature. The number of samples that can be held in the autosampler depends on the size of the bottles used (as many as 24 small bottles or a single large one). Once a sample has been taken by the autosampler, an email is sent to Environment and Conservation staff requesting a sample pick up.

As the autosamplers are triggered, the Thermoking MD-100 reefer unit is activated to maintain the air temperature inside the MEMP between 3 – 5^{o}C to avoid degradation of water chemistry. The reefer unit is a diesel-powered and capable of heating or cooling, depending on ambient conditions.

Figure 9: Teledyne ISCO 6712

Figure 10: MEMP side profile, showing MD-100

Power Supply

The power supply in the MEMP is divided into two main circuits: the Equipment Circuit and the Reefer Circuit. The Equipment Circuit is intended to power the datalogger, telemetry, sensors, and sampling pumps. The second circuit is the Reefer Circuit which is responsible for starting the reefer unit.

Equipment Circuit

The Equipment Circuit consists of a pair of 12V, 100 Ah, deep cycle batteries wired together in parallel to maintain voltage but double capacity. These batteries provide power to the CR1000 datalogger, water samplers, sensors, and telemetry equipment and are charged by a 30W solar panel via a SunSaver 6 charge/regulator.

A sub-circuit, powering a cellular modem and Ethernet switch is controlled by the CR1000 datalogger via a relay for ten minutes at the top of each hour.

Reefer Circuit

The reefer unit consists of two 12V heavy-duty truck starter batteries wired in series to boost the starting voltage. The batteries are maintained by the alternator in the engine of the reefer unit.

General Usage Instructions

Site Selection

In general, the deployment location of the MEMP should follow the Site Selection principles outlined in *Protocols Manual for RTWQ Monitoring in NL* (Environment and Conservation, 2013. See Appendix I).

The choice of a deployment location often balances the MEMP's ability to monitor optimum water quality, quantity, and climate data. It is likely that no particular location will allow ideal monitoring of all three data types. Consideration of the deployment objective is critical.

Deployment

The MEMP should be deployed in as level an area as possible to ensure the mast is vertical, since the mast is fixed in relation to the trailer orientation. In some circumstances, the land may need to be altered to provide a suitable level spot or to allow access in difficult terrain.

When maneuvering the trailer to its deployment location, it is often wise to place wooden boards beneath the tires to avoid them sinking into soft soil over the course of the deployment. In cases where terrain is uneven, additional boards on one side or the other may be useful in levelling the MEMP. To un-hitch the trailer, place wheel chocks to steady the trailer, release the tongue clasp and lower the trailer stand such that it raises the tongue off the ball (consider using another board to avoid the stand sinking into soft ground). The truck can then be moved to a more convenient location.

To prevent dangerous "see-sawing" of the MEMP during use, axel stands must be placed under the door sill. Raise the trailer stand to pivot the rear of the trailer upwards. Adjust the height of the axel stands and place them evenly under the rear sill of the MEMP. Lower the trailer stand to seat the trailer on the axel stands.

Mast Setup

During setup, the mast head fitted with sensors and equipment is socketed into the square aluminum mast and affixed with three bolts passing perpendicularly through both the mast head and mast. This step is best done while the mast is at ground level, taking care not to bump sensitive equipment on the ground. Once the mast head is mounted, with two or more people, place the mast vertical, next to the receptacle/bracket on the front right of the trailer. With one person standing or sitting on the lower front ledge of the MEMP, hoist the mast vertically and guide into the top of the receptacle/bracket. Align the three holes on the mast with the corresponding holes on the receptacle/bracket and secure with bolts.

A 30 watt solar panel is affixed to the mast below the mast head fixture. Two pins are used to secure the solar panel to the mast.

Figure 11: MEMP showing full mast setup

Figure 12: Mast socket

Datalogger Operation

All MEMP functions are routed and controlled via the datalogger using CRBasic code (see manual referenced in Appendix I). The programming can be conceptualized as a loop (or series of loops) called a scan that occurs on a defined interval. Within the scan is a sequence of events such as reading a sensor, setting a control port to high/low voltage, or recording data to a table. Table 1 outlines critical Main Scan events that take place within the CRBasic programming.

Main Scan Sequence

In the current configuration, the datalogger makes a scan of the meteorological sensors every fifteen seconds and holds the data in a buffer. Every fifteen minutes, buffered meteorological data is averaged and summed, water quality and quantity data is sampled, and all results saved to the data table (see Table 1 for details).

Table 4: Outline of Main Scan Sequence

Interval (hh:mm:ss)	Activity
00:00:05	**Store in buffer** • Air Temperature (°C) • Relative Humidity (%) • Wind Speed (km/h) • Wind Direction (°) • Precipitation (mm)
00:15:00	**Store in buffer** • Water Temperature (°C) • pH (units) • Specific Conductivity (uS/cm) • TDS (g/l) • DO (% saturation) • DO (mg/l) • Turbidity (NTU) • Stage (m)
00:15:00	**Write to DataTable** • Average Air Temperature (°C) • Average Relative Humidity (%) • Average Wind Speed (km/h) • Average Wind Direction (°) • Gust Speed (km/h) • Gust Direction (°) • Total Precipitation (mm) • Average Water Temperature (°C) • Average pH (units) • Average Specific Conductivity (uS/cm) • Average TDS (g/l) • Average DO (% saturation) • Average DO (mg/l) • Average Turbidity (NTU) • Average Stage (m)
01:00:00	**Trigger Webcam Picture**
01:00:00 – 01:10:00	**Close Relay** • Power Cell Modem • Power Ethernet Switch
Upon Exceeding Trigger Value	**Activate reefer unit** **Activate grab sampler**

Slow Scan Sequence

Outside of the Main Sequence, an additional loop is run where an email alert is sent notifying of a sample available for pickup. The email is sent via the Google Gmail SMTP server (see Appendix III for SMTP credentials).

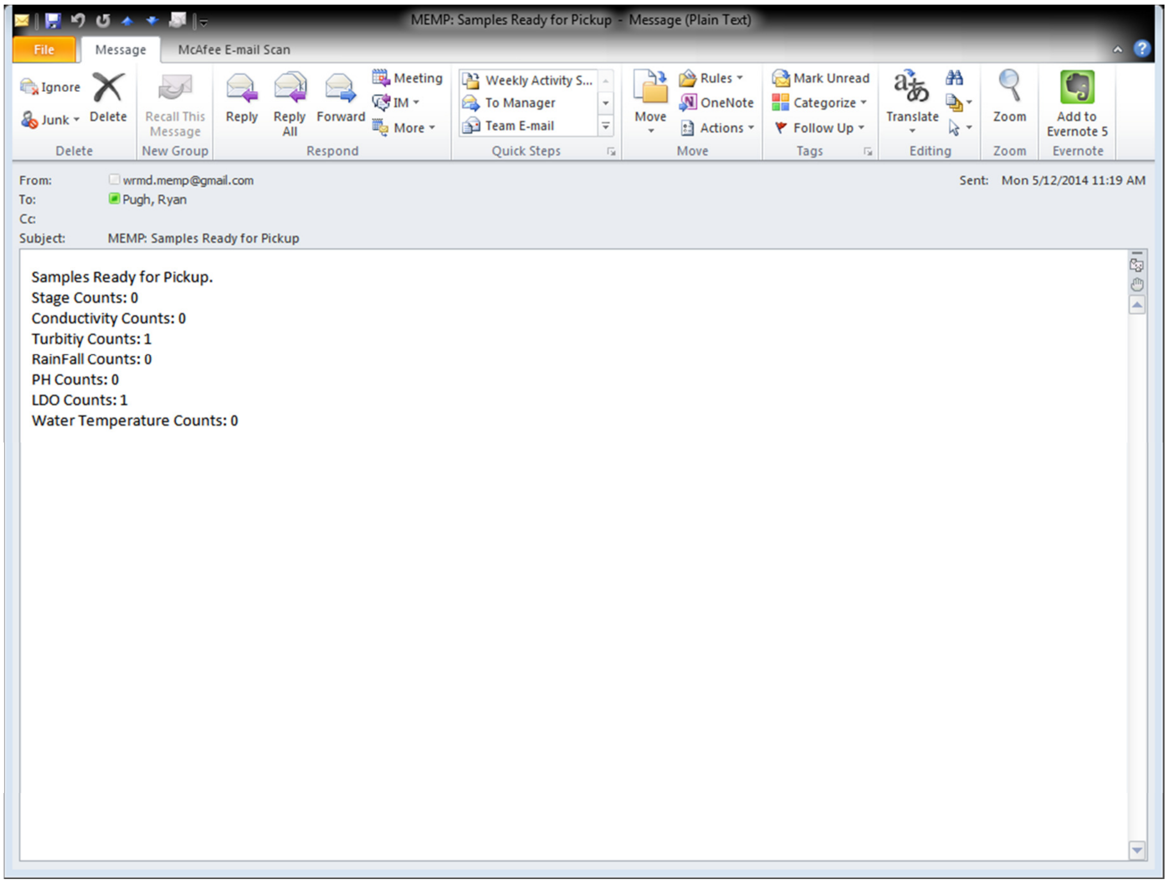


Figure 13: Example email from MEMP

Program Flags

A series of flags or switches are available to the user to control the operation of the datalogger without altering the CRBasic program. The flags can be manipulated when connected to the MEMP via LoggerNet. The flags are described below.

`CC5MPX_Trigger_Flag`: Setting this flag to true will cause the webcam to take a picture at the top of each hour.

`Sample_Trigger`: With auto-samplers in standby mode, setting this flag to true will cause the auto-samplers to begin withdrawing a sample of water from the water body, regardless of Alarm Values (see next section for setting Alarm Values).

`Reefer_on_Flag`: When the reefer unit is in standby mode, activating this flag will cause the unit to run and begin controlling the interior temperature of the MEMP.

`Reefer_off_Flag`: When the reefer unit is running, activating this flag will cause the unit to turn off and remain in standby mode.

`Email_Send_Flag`: With this value set to true, an email will be sent alerting the user that samples are available for pickup from the MEMP. Emails addresses must be changed via CRBasic.

Parameter Alarm Values and Autosampling

Several of the parameters monitored by the MEMP (temperature, pH, conductivity, dissolved oxygen, turbidity, stage level, precipitation) can have thresholds assigned to them whereby the datalogger counts the number of threshold transgressions.

To set alarm values, open Notepad in Windows and input the desired values in the following order, separated by commas (with no spaces): temperature, pH, conductivity, DO, turbidity, stage, and hourly rainfall rain.

Save with the filename config.txt. When connected to the datalogger via Loggernet, upload the file to the Usr drive and activate the flag Text_read_flag. This will set the alarm values into the program.

With alarm values set, ensure that the desired parameter Check_Flag is activated. With alarm values and any relevant parameter Check_Flag activated, the datalogger will cause a grab sample to be taken and the reefer unit activated to keep the trailer interior cool for sample-holding purposes.

Figure 14 shows an example config.txt file that will trigger samples to be taken if water temperature > 25 ^{o}C, pH > 8 units, conductivity > 1000 uS/cm, stage > 5 m, turbidity > 5000 NTU, rainfall > 30 mm.

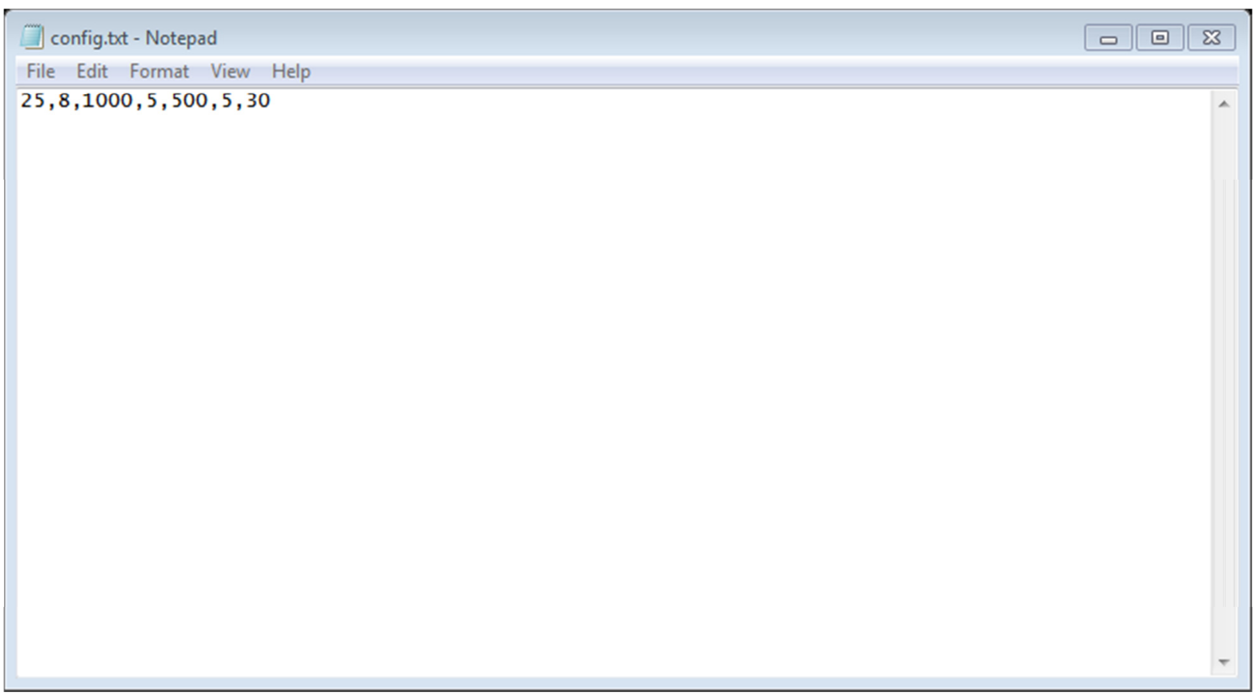


Figure 14: Example Config.txt

To receive an email alert when a grab sample is taken, ensure that the `Email_Send_Flag` is active.

When arriving at the MEMP to gather grab samples for lab analysis, the reefer unit can be deactivated and sample counters returned to zero by pressing and holding the red button on the side of the datalogger enclosure for five seconds.

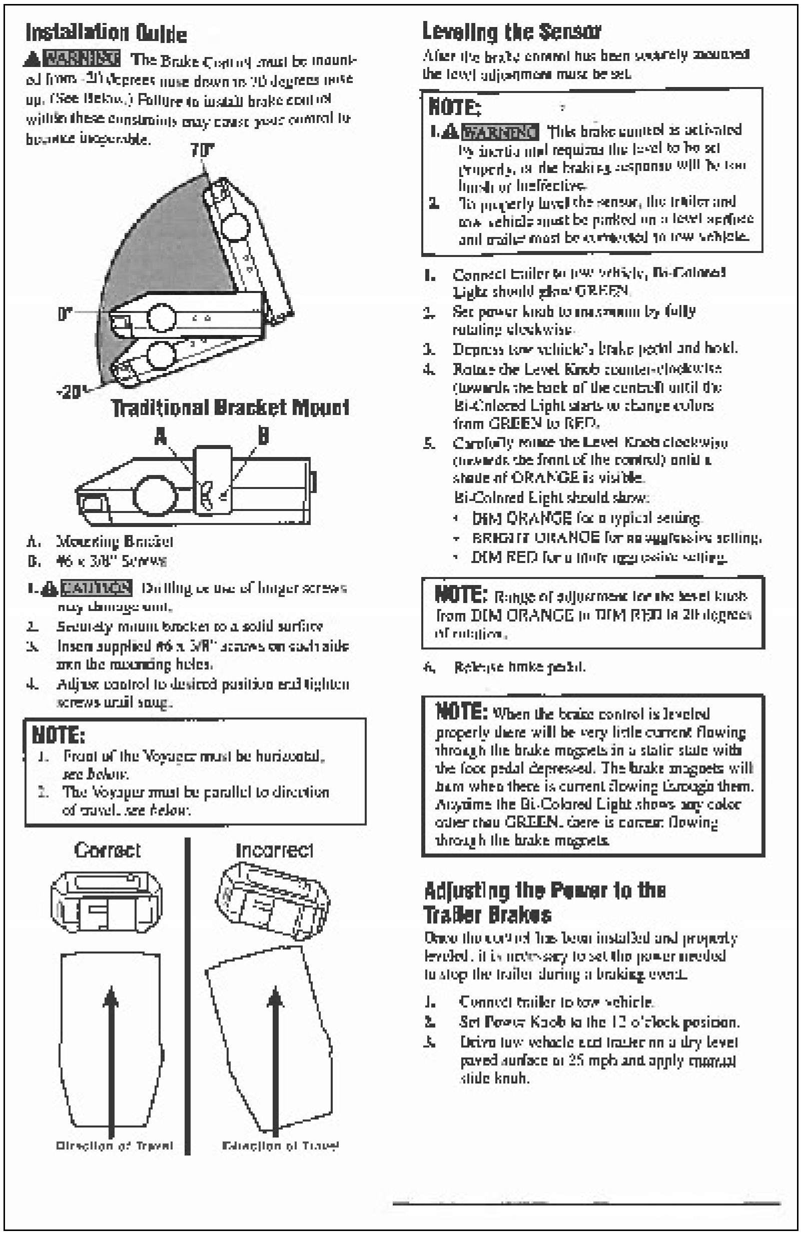
Summary

Effective operation of the MEMP requires a diverse range of background knowledge in safe trailering techniques, weather and water monitoring station setup, and equipment programming. This manual can only provide a brief overview of the principles of use and any user should be familiar with the attached documents in Appendix I – including an understanding of LAN administration and off-grid power budgeting.

Appendix I. Documents and Manuals

Electric Braking Unit

Double-click for contents.



Installation Guide

WARNING The Brake Control must be mounted from -20 degrees nose down to 70 degrees nose up. (See Below.) Failure to install brake control within these constraints may cause your control to become inoperable.

70°

0°

-20°

Traditional Bracket Mount

A B

A. Mounting Bracket
B. #6 x 3/8" Screws

1. **CAUTION** Drilling or use of longer screws may damage unit.
2. Securely mount bracket to a solid surface.
3. Insert supplied #6 x 3/8" screws on each side into the mounting holes.
4. Adjust control to desired position and tighten screws until snug.

NOTE:
1. Front of the Voyager must be horizontal, *see below.*
2. The Voyager must be parallel to direction of travel, *see below.*

Correct | Incorrect

Direction of Travel | Direction of Travel

Leveling the Sensor

After the brake control has been securely mounted the level adjustment must be set.

NOTE:
1. **WARNING** This brake control is activated by inertia and requires the level to be set properly, or the braking response will be too harsh or ineffective.
2. To properly level the sensor, the trailer and tow vehicle must be parked on a level surface and trailer must be connected to tow vehicle.

1. Connect trailer to tow vehicle, Bi-Colored Light should glow GREEN.
2. Set power knob to maximum by fully rotating clockwise.
3. Depress tow vehicle's brake pedal and hold.
4. Rotate the Level Knob counter-clockwise (towards the back of the control) until the Bi-Colored Light starts to change colors from GREEN to RED.
5. Carefully rotate the Level Knob clockwise (towards the front of the control) until a shade of ORANGE is visible.
   Bi-Colored Light should show:
   - DIM ORANGE for a typical setting.
   - BRIGHT ORANGE for an aggressive setting.
   - DIM RED for a more aggressive setting.

NOTE: Range of adjustment for the level knob from DIM ORANGE to DIM RED is 20 degrees of rotation.

6. Release brake pedal.

NOTE: When the brake control is leveled properly there will be very little current flowing through the brake magnets in a static state with the foot pedal depressed. The brake magnets will burn when there is current flowing through them. Anytime the Bi-Colored Light shows any color other than GREEN, there is current flowing through the brake magnets.

Adjusting the Power to the Trailer Brakes

Once the control has been installed and properly leveled, it is necessary to set the power needed to stop the trailer during a braking event.

1. Connect trailer to tow vehicle.
2. Set Power Knob to the 12 o'clock position.
3. Drive tow vehicle and trailer on a dry level paved surface at 25 mph and apply manual slide knob.

Electronic Documents

Protocol Manual for the Operation and Maintenance of Campbell Scientific Canada Corp. Quick Deploy Weather Systems. (2012). Campbell Scientific Canada Corp.

- Not yet published

Hydrolab DS5, DS5, and MS5 Water Quality Multiprobes. (2006). Hach Company.

- http://s.campbellsci.com/documents/ca/manuals/series_5_man.pdf

Protocols Manual for Real-Time Water Quality Monitoring in NL. (2013). Environment and Conservation.

- http://www.env.gov.nl.ca/env/waterres/rti/rtwq/NL_RTWQ_Manual.pdf

Temperature / Relative Humidity Sensor (HC-S3)

- http://www.campbellsci.ca/hc-s3

Tipping Bucket Rain Gauge (TE525M-L)

- http://s.campbellsci.com/documents/ca/manuals/te525_man.pdf

Anemometer (05103-10)

- http://s.campbellsci.com/documents/ca/manuals/rmy_man.pdf

CC5MPX Digital Network Camera

- http://s.campbellsci.com/documents/ca/manuals/cc5mpx_man.pdf

Raven X Sierra Wireless Cellular Modem

- http://s.campbellsci.com/documents/ca/manuals/ravenx_hspa_man.pdf

Ott Compact Bubble Sensor (CBS)

- http://s.campbellsci.com/documents/ca/manuals/cbs_man.pdf

CR1000 Measurement and Control System

- http://s.campbellsci.com/documents/ca/manuals/cr1000_man.pdf

Teledyne ISCO 6712 Autosampler

- http://www.isco.com/pcfiles/PartPDF/SL000005/UP001BM3.pdf

Spill Contingency Plan

Double-click for contents.

Spill Contingency Plan
Mobile Environmental Monitoring Platforms
(MEMPs)

A Document to Accompany MEMP Deployments and Maintenance at different near-water locations in PEI, Nova Scotia, New Brunswick, and Newfoundland Island

The Atlantic Water Quality Monitoring and Surveillance Group,
Department of Environment
August 2010

Appendix II. CRBasic Program

```
'Program for MEMP trailer
'Author DJ Snodgrass - Campbell Scientific Canada
and Ryan Pugh - Gov NFLD
'Date: June 2, 2011

'Current Revision: August 2, 2014

'Program Notes
'
'Checks for Autosamples are taken no more
frequently than every 2 hours.
'Note that when program is first compiled, the
first autosample cannot be taken
'for 2 hours after commencement of program
operation.
'
'Relay powering cell modem provides ten minutes of
connectivity at the top of each hour.

'Declare Public Variables
Public PTemp
Public batt_volt
Public AirTemp
Public RH
Public WS_kph
Public WindDir
Public Rain
Public DS5(7)
Public CBS(7)

'Sample Trigger Counters
Public STC
Public CTC
Public PTC
Public TTC
Public RTC
Public LTC
Public WTTC

'Variables used for email send out of sample
counts
Public EmailServerResponse As String
Public EmailResult
Public EmailBody As String * 300
Public EmailSTR1 As String * 120
Public EmailSTR2 As String * 120
Public EmailSTR3 As String * 30

'Variables used for File Handling
Public FileHandle
Public File_Text As String * 50
Public File_Parse(7)
Public Text_Write_Flag As Boolean
Public Text_Read_Flag As Boolean

Public Timer_Count
Public Daily_Rainfall

'**************************************************
****************************
'Program Functionality Flags. Set flags as
necessary to enable communications.
'**************************************************
****************************
'Threshold Triggers
Public Stage_Check_Flag As Boolean
Public Cond_Check_Flag As Boolean
Public Turb_Check_Flag As Boolean
Public PH_Check_Flag As Boolean
Public LDO_Check_Flag As Boolean
Public WaterTmp_Check_Flag As Boolean
Public Rain_Check_Flag As Boolean
'Email Triggers
Public Email_Send_Flag As Boolean
Public Email_Test_Flag As Boolean
'CC5MPX Camera Trigger
Public CC5MPX_Trigger_Flag As Boolean
'Autosampler and Reefer Triggers
Public Sample_Trigger As Boolean
Public Reefer_on_Flag As Boolean
Public Reefer_off_Flag As Boolean
'Reset Sample counts and Call Reefer_Off
Public Port5Status As Boolean

Dim CBS_Purge

Alias DS5(1) = Water_Temperature
Alias DS5(2) = PH
Alias DS5(3) = Conductivity
Alias DS5(4) = TDS
Alias DS5(5) = LDO_sat
Alias DS5(6) = LDO_mg_L
Alias DS5(7) = Turbidity

Alias CBS(1) = Stage_m
Alias CBS(2) = Stage_cm
Alias CBS(3) = Stage_ft
Alias CBS(4) = CBS_Pressure_mbar
Alias CBS(5) = CBS_Pressure_psi
Alias CBS(6) = CBS_Temperature
Alias CBS(7) = CBS_Status

'Met Units
Units PTemp = DegC
Units batt_volt = VoltsDC
Units AirTemp = DegC
Units RH = %
Units WS_kph = Km/Hr
Units WindDir = Degrees
Units Rain = mm

'DS5 Units
Units Water_Temperature = DegC
Units PH = Unit.s
Units Conductivity = uS/cm
Units TDS = g/L
Units LDO_sat = %
Units LDO_mg_L = mg/L
Units Turbidity = NTU

'CBS Units
Units Stage_m = m
Units Stage_cm = cm
Units Stage_ft = ft
Units CBS_Pressure_mbar = mbar
Units CBS_Pressure_psi = PSI

'**************************************************
****************************
'Enter Threshold Values here!
'**************************************************
****************************
Public Stage_Trig_Value
Public Rain_Trig_Value
Public Cond_Trig_Value
Public Turb_Trig_Value
Public PH_trig_Value
Public LDO_Trig_Value
Public Water_Tmp_Trig_Value

Const CRLF = CHR(13) + CHR(10)

'**************************************************
***************************
'Enter Email Address(es) here for notification of
Samples
'**************************************************
***************************
Const EmailAddress = "RyanPugh@gov.nl.ca"

Const Sample_Trig_Time = 120 'Enter Time in
minutes for autosample interval

'Add Daily Troubleshotting table.
DataTable (TrbleSht,1,-1)
  DataInterval (0,1440,Min,10)
  Maximum (1,batt_volt,FP2,False,False)
  Minimum (1,batt_volt,FP2,False,True)
  Maximum (1,PTemp,FP2,False,False)
  Minimum (1,PTemp,FP2,False,False)
  Sample (1,CBS_Status,FP2)
EndTable

'Add Main Data table
DataTable (FifteenMin,1,-1)
  DataInterval (0,15,Min,10)
  Average (1,AirTemp,FP2,False)
  FieldNames ("AirTemp:TA")
  Average (1,RH,FP2,False)
  FieldNames ("RH:XR")
  Average (1,WS_kph,FP2,False)
  FieldNames ("WS_kph_avg:US")
  Maximum (1,WS_kph,FP2,False,True)
  FieldNames ("WS_kph_Gust:UP")
  SampleMaxMin (1,WindDir,FP2,False)
  FieldNames ("WindDir_Gust:UR")
  Average(1,WindDir,FP2,False)
  FieldNames ("WindDir:UD")
  Totalize (1,Rain,FP2,False)
  FieldNames ("Rain:PU")
  Sample (1,Water_Temperature,FP2)
  FieldNames ("Water_Temperature:TW")
  Sample (1,PH,FP2)
  FieldNames ("PH:WP")
  Sample (1,Conductivity,FP2)
  FieldNames ("Conductivity:WC")
  Sample (1,TDS,IEEE4)
  FieldNames ("TDS:WZ")
  Sample (1,LDO_sat,FP2)
  FieldNames ("LDO_Sat:WX")
  Sample (1,LDO_mg_L,FP2)
  FieldNames ("LDO_mg:WO")
  Sample (1,Turbidity,FP2)
  FieldNames ("Turbidity:WT")
  Sample (1,Stage_m,IEEE4)
  FieldNames ("Stage_m:HG")
EndTable

DataTable (Daily_Rainfall,True,5)
  TableHide
  DataInterval (0,1,Day,10)
  Totalize (1,Rain,FP2,False)
EndTable

Sub Text_Write

  File_Text = Water_Tmp_Trig_Value + "," +
PH_trig_Value + "," + Cond_Trig_Value + "," +
LDO_Trig_Value + "," + Turb_Trig_Value + "," +
Stage_Trig_Value + "," + Rain_Trig_Value + CRLF
  FileHandle = FileOpen ("USR:Config.txt","w",-1)
  FileWrite (FileHandle,File_Text,0)
  FileClose (FileHandle)

EndSub

Sub Text_Read
  FileHandle = FileOpen ("USR:Config.txt","r",0)
  FileReadLine (FileHandle,File_Text,50)
  SplitStr (File_Parse(1),File_Text,"",7,0)

  Water_Tmp_Trig_Value = File_Parse(1)
  PH_trig_Value = File_Parse(2)
  Cond_Trig_Value = File_Parse(3)
  LDO_Trig_Value = File_Parse(4)
  Turb_Trig_Value = File_Parse(5)
  Stage_Trig_Value = File_Parse(6)
  Rain_Trig_Value = File_Parse(7)

  FileClose (FileHandle)

EndSub

Sub Reefer_on

  'Pulse Port 2 to turn on reefer unit
  PortSet(2,1)
  'Delay 2 seconds to ensure pulse recieved
  Delay(1,2,2)
  'Turn off port after pulse completion
  PortSet(2,0)

EndSub

Sub Reefer_off

  'Pulse Port 8 to turn off reefer unit
  PortSet(8,1)
  'Delay 2 seconds to ensure pulse recieved
  Delay(1,2,2)
  'Turn off port after pulse completion
  PortSet(8,0)

EndSub

Sub Timer_Sub
  Timer(1,Min,2)
EndSub

Sub Check_for_Sample_Triggers

  Timer_Count = Timer(1,Min,4)

  If Timer_Count >= Sample_Trig_Time Then

    If Stage_Check_Flag = True Then

      If Stage_m >=Stage_Trig_Value Then

        ''Send a pulse to port 6
        PortSet(6,1)

        'Delay for 5 seconds (hold pulse)
        Delay(1,5,2)

        'Turn off pulse at ports 6
        PortSet(6,0)

        Call Reefer_on

      EndIf

    EndIf

    If Cond_Check_Flag = True Then

      If Conductivity >=Cond_Trig_Value Then

        ''Send a pulse to port 6
        PortSet(6,1)

        'Delay for 5 seconds (hold pulse)
        Delay(1,5,2)

        'Turn off pulse at ports 6
        PortSet(6,0)

        Call Reefer_on
        Call Timer_Sub

      EndIf

    EndIf

    If Turb_Check_Flag = True Then

      If Turbidity >= Turb_Trig_Value Then
        ''Send a pulse to port 6
        PortSet(6,1)

        'Delay for 5 seconds (hold pulse)
        Delay(1,5,2)

        'Turn off pulse at ports 6
        PortSet(6,0)

        Call Reefer_on

      EndIf

    EndIf

    If PH_Check_Flag = True Then

      If PH >= PH_trig_Value Then
        ''Send a pulse to port 6
        PortSet(6,1)

        'Delay for 5 seconds (hold pulse)
        Delay(1,5,2)

        'Turn off pulse at ports 6
        PortSet(6,0)

        Call Reefer_on

      EndIf

    EndIf

    If LDO_Check_Flag = True Then

      If LDO_mg_L <=LDO_Trig_Value Then
        ''Send a pulse to port 6
        PortSet(6,1)
```

```
        'Delay for 5 seconds (hold pulse)
        Delay(1,5,2)

        'Turn off pulse at ports 6
        PortSet(6,0)

        Call Reefer_on

      EndIf

    EndIf

    If WaterTmp_Check_Flag = True Then

      If Water_Temperature >= Water_Tmp_Trig_Value
Then
        ''Send a pulse to port 6
        PortSet(6,1)

        'Delay for 5 seconds (hold pulse)
        Delay(1,5,2)

        'Turn off pulse at ports 6
        PortSet(6,0)

        Call Reefer_on

      EndIf

      Call Timer_Sub

    EndIf

  EndIf

  If TimeIntoInterval(0,15,min) Then
    If Stage_Check_Flag = TRUE AND Stage_m >=
Stage_Trig_Value Then STC = STC + 1
    If Cond_Check_Flag = TRUE AND Conductivity >=
Cond_Trig_Value Then CTC = CTC + 1
    If Turb_Check_Flag = TRUE AND Turbidity >=
Turb_Trig_Value Then TTC = TTC + 1
    If PH_Check_Flag = TRUE AND PH >=
PH_trig_Value Then PTC = PTC + 1
    If LDO_Check_Flag = TRUE AND LDO_mg_L <=
LDO_Trig_Value OR LDO_mg_L <> 0 Then LTC = LTC + 1
    If WaterTmp_Check_Flag = TRUE AND
Water_Temperature >= Water_Tmp_Trig_Value Then
WTTC = WTTC + 1
  EndIf

EndSub

Sub Daily_Rainfall_Check

  GetRecord (Daily_Rainfall,Daily_Rainfall,1)
  If Daily_Rainfall >= Rain_Trig_Value Then

    RTC = RTC + 1
    ''Send a pulse to port 6
    PortSet(6,1)

    'Delay for 5 seconds (hold pulse)
    Delay(1,5,2)

    'Turn off pulse at ports 6
    PortSet(6,0)

    Call Reefer_on

  EndIf

EndSub


'Main Program
BeginProg

  SetStatus ("UsrDriveSize","3146512")

  FileHandle = FileOpen ("USR:config.txt","r",-1)
  If FileHandle > 0 Then
    Call Text_Read
  EndIf

  'configure Port 5 as input
  PortsConfig (&B10110010,&B10100010)

  Scan (5,Sec,0,0)

    If Reefer_on_Flag = True Then
      Call Reefer_on
      Reefer_on_Flag = False
    EndIf

    If Reefer_off_Flag = True Then
      Call Reefer_off
      Reefer_off_Flag = False
    EndIf

    If Sample_Trigger = True Then
      PortSet(6,1)

      Delay (1,2,Sec)

      PortSet(6,0)
    EndIf

    If Text_Write_Flag = True Then
      Call Text_Write
      Text_Write_Flag = False
    EndIf

    If Text_Read_Flag = True Then
      Call Text_Read
      Text_Read_Flag = False
    EndIf

    'Pulse Port 7 to trigger CC5MPX camera
    If TimeIntoInterval(0,60,Min) AND
CC5MPX_Trigger_Flag = TRUE Then
      PortSet(7,1)
    ElseIf TimeIntoInterval(1,60,Min) Then
      PortSet(7,0)
    EndIf

    'Turn on Relay Power (Switch and Modem) at the
top of the hour for 10 minutes
    If TimeIntoInterval(0,60,Min) Then
      SW12(1)
    ElseIf TimeIntoInterval(10,60,Min) Then
      SW12(0)
    EndIf

    Timer(1,Min,0)

    'Check for button press on Port 5 and reset
Reefer to Off position and clear counter Values
    PortGet (Port5Status,5)
    If Port5Status = True Then
      Call Reefer_off
      STC = 0
      CTC = 0
      TTC = 0
      PTC = 0
      LTC = 0
      WTTC = 0
      RTC = 0
    EndIf

    PanelTemp (PTemp,_60Hz)
    Battery (batt_volt)

    'Measure TTH-1315 Temperature and RH Sensor.
    'For other trailers (port 3/4)
    'consider adjusting settling time (make it
greater than 0)
    VoltSe (AirTemp,1,mV2500,3,True,0,_60Hz,0.1,-
40)
    VoltSe (RH,1,mV2500,4,True,0,_60Hz,0.1,0)

    'Measure Wind Speed / Direction: 05103-10-L
Anemometer
    PulseCount (WS_kph,1,1,1,1,0.3528,0)
    BrHalf (WindDir,1,mV2500,1,1,1,2500,True
,0,_60Hz,355,0)

    'Correct Wind direction over ranges:
    If WindDir>=360 Then WindDir=0
    If WindDir < 0 Then WindDir = 0

    'Measure one TE525M rain gauge.
    PulseCount (Rain,1,2,2,0,0.1,0)

    'Mesure Hydrolab, OTT CBS bubbler and
Spectro::lyser every 15 Minutes (on the hour -
system clock)

    If TimeIntoInterval (0,15,Min) Then

      'Measure the  Hydrolab sonde
      SDI12Recorder (DS5(),1,0,"C!",1.0,0)

      'Measure CBS bubbler
      SDI12Recorder(CBS(),1,1,"C!",1,0)

    EndIf

    'Perform a purge of the CBS during the first
minute of every day.
    If TimeIntoInterval (0,1440,Min) Then
      SDI12Recorder (CBS_Purge,1,0,"OXP1!",1.0,0)
    EndIf

    If TimeIntoInterval(1,1440,Min) Then
      SDI12Recorder (CBS_Purge,1,0,"OXP0!",1.0,0)
    EndIf

    If Rain_Check_Flag = True Then

      CallTable Daily_Rainfall

      If TimeIntoInterval(1,1440,min) Then
        Call Daily_Rainfall_Check
      EndIf

    EndIf

    Call Check_for_Sample_Triggers

    CallTable TrbleSht
    CallTable FifteenMin

  NextScan

  SlowSequence
  'Every six hours, check for water samples. If
samples are present, build the email string and
send to addresses specified.
  Scan (1,Min,0,0)

    If Email_Send_Flag = True OR Email_Test_Flag =
TRUE Then
      If TimeIntoInterval(0,6,hr) OR
Email_Test_Flag = TRUE Then
        'check for Samples
        If STC >0 OR CTC >0 OR TTC >0 OR PTC >0 OR
LTC >0 OR WTTC >0 OR Email_Test_Flag = TRUE Then

          EmailSTR1 = "Samples Ready for Pickup."
+ CRLF + "Stage Counts: " + STC + CRLF +
"Conductivity Counts: " + CTC + CRLF + "Turbitiy
Counts: "
          EmailSTR2 = TTC + CRLF + "RainFall
Counts: " + RTC + CRLF + "PH Counts: " + PTC +
CRLF + "LDO Counts: " + LTC + CRLF
          EmailSTR3 = "Water Temperature Counts: "
+ WTTC + CRLF
          EmailBody = EmailSTR1 + EmailSTR2 +
EmailSTR3

          EmailResult = EmailSend
("smtp.gmail.com",EmailAddress,"wrmd.memp@gmail.co
m","MEMP: Samples Ready for
Pickup",EmailBody,"","wrmd.memp@gmail.com","envcwr
md",EmailServerResponse)

        EndIf
      EndIf
    EndIf
    Email_Test_Flag = FALSE
  NextScan

  EndSequence
EndProg
```

Appendix III.Important Login Information

Login Information

Telus APN

Username: 9028024631@1x.telusmobility.com
Password: 09608987183

Gmail SMTP Server Login

Server: smtp.gmail.com
Username: wrmd.memp@gmail.com
Password: envcwrmd.

CR1000 FTP Server

User: wrmd
Password: AX59*$

DriveHQ.com FTP Server Login

Username: wrmdgovnl
Password: wrmd3597

Raven X Modem/Gateway Login

Username: user
Password: AX59*$

CC5MPX Login

Username: wrmd
Password: AX59*$

MEMP LAN Information

CR1000 IP Address

External IP: 74.49.37.14:6785
LAN IP: 192.168.1.91

Raven X IP Address

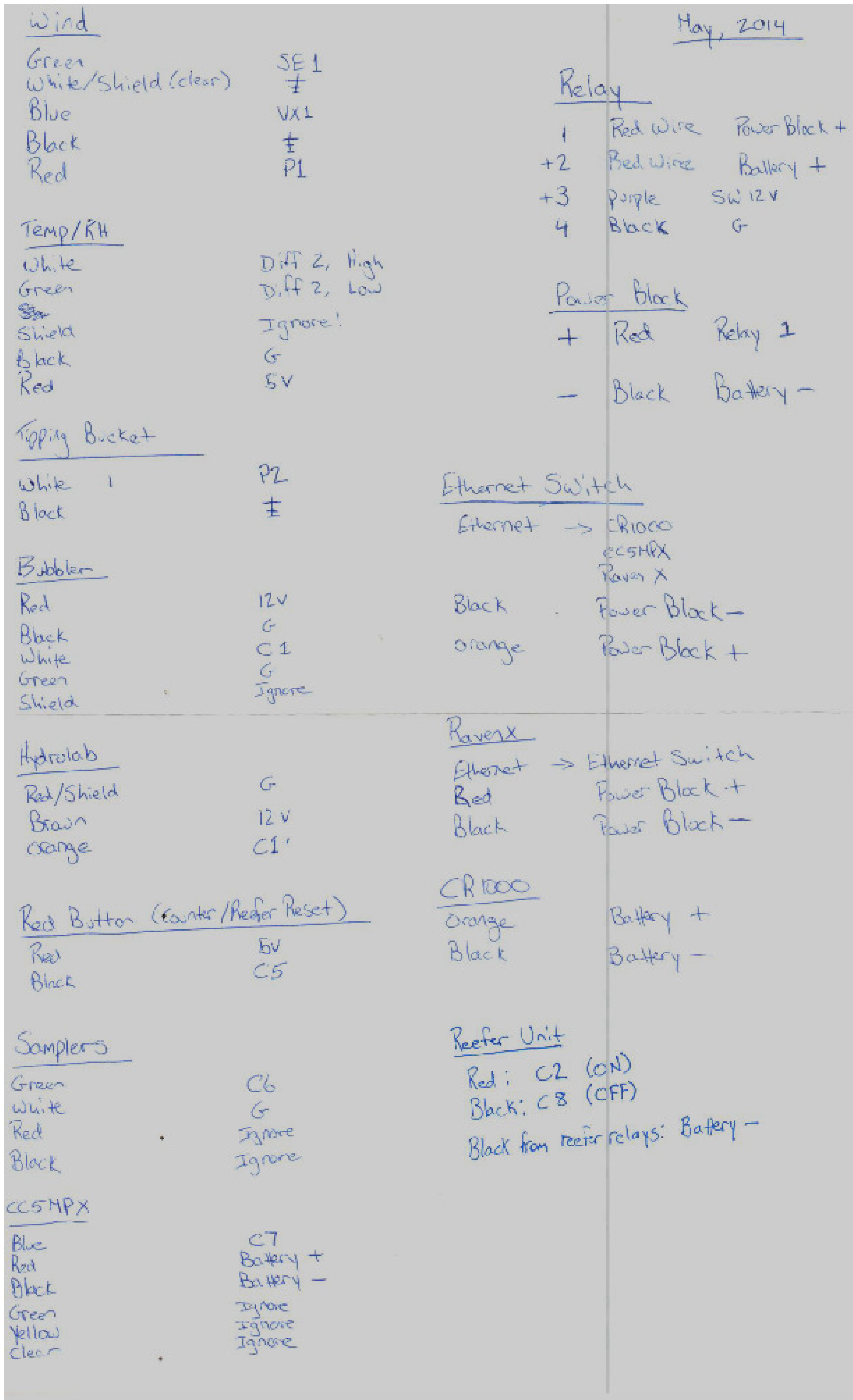
External IP: 74.49.37.14
Gateway IP: 192.168.1.1
DHCP Range: 192.168.1.95 – 192.168.1.100

CC5MPX

LAN IP: 192.168.1.90:80

Appendix IV. Wiring Diagrams

CR1000 wiring panel as of October, 2014.



May, 2014

Wind
Green — SE 1
White/Shield (clear) — ⏚
Blue — VX1
Black — ⏚
Red — P1

Temp/RH
White — Diff 2, High
Green — Diff 2, Low
Shield — Ignore!
Black — G
Red — 5V

Tipping Bucket
White 1 — P2
Black — ⏚

Bubbler
Red — 12V
Black — G
White — C1
Green — G
Shield — Ignore

Hydrolab
Red/Shield — G
Brown — 12 V
Orange — C1'

Red Button (Counter/Reefer Reset)
Red — 5V
Black — C5

Samplers
Green — C6
White — G
Red — Ignore
Black — Ignore

CC5MPX
Blue — C7
Red — Battery +
Black — Battery −
Green — Ignore
Yellow — Ignore
Clear — Ignore

Relay
1 — Red Wire — Power Block +
+2 — Red Wire — Battery +
+3 — Purple — SW 12 V
4 — Black — G

Power Block
+ — Red — Relay 1
− — Black — Battery −

Ethernet Switch
Ethernet -> CR1000, CC5MPX, Raven X
Black — Power Block −
Orange — Power Block +

RavenX
Ethernet -> Ethernet Switch
Red — Power Block +
Black — Power Block −

CR1000
Orange — Battery +
Black — Battery −

Reefer Unit
Red: C2 (ON)
Black: C8 (OFF)
Black from reefer relays: Battery −

Thermo King MD-100 Reefer Unit Relay Wiring