Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Groundwater Study (7.5)

Part A - Appendix A
Example 1970 and 2011 Focus Area Aerial Imagery

Initial Study Report

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

Geo-Watersheds Scientific

June 2014

PART A - APPENDIX A: EXAMPLE 1970 AND 2011 FOCUS AREA AERIAL IMAGERY

The selected images in this appendix include paired aerial images from the 1970s[1] and 2011, an approximate span of 40 years. The selected aerial images are provided in order to compare these Focus Areas over a span of nearly 40 years in order to inform study objectives.

[1]The date of the 1970s images is under investigation.

Table A-1. This table lists example paired aerial images from the 1970s[1] and 2011, a comparison of images spanning approximately 40 years. Following the table, example images are provided in downstream Focus Area order.

Stations Comparing 1970s and 2011 Aerial Images
FA-138 (Gold Creek)
FA-128 (Slough 8A) Large-scale images
FA-128 (Slough 8A) Small-scale images
FA-113 (Oxbow 1)
FA-104 (Whiskers Slough)

[1]The exact date of the 1970s images is under investigation.

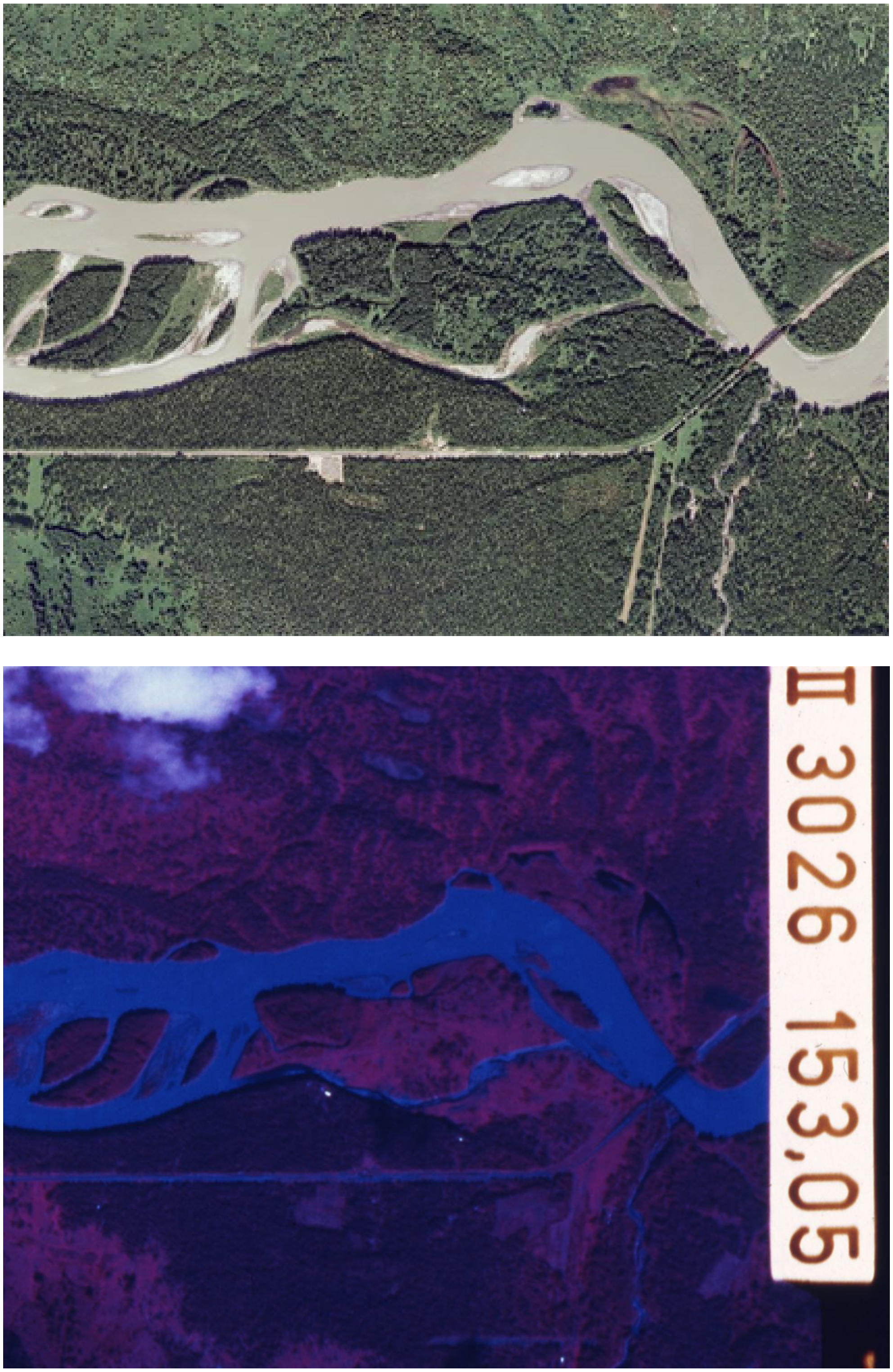

Figure A-1. These aerial images provide a point of comparison between FA-138 (Gold Creek) in the 1970s versus 2011. The top image depicts FA-138 (Gold Creek) in 2011, and the bottom image depicts this FA in the 1970s. The images will help improve the understanding of the riparian vegetation changes, geomorphology changes and potential changes to the groundwater/surface-water relationships.

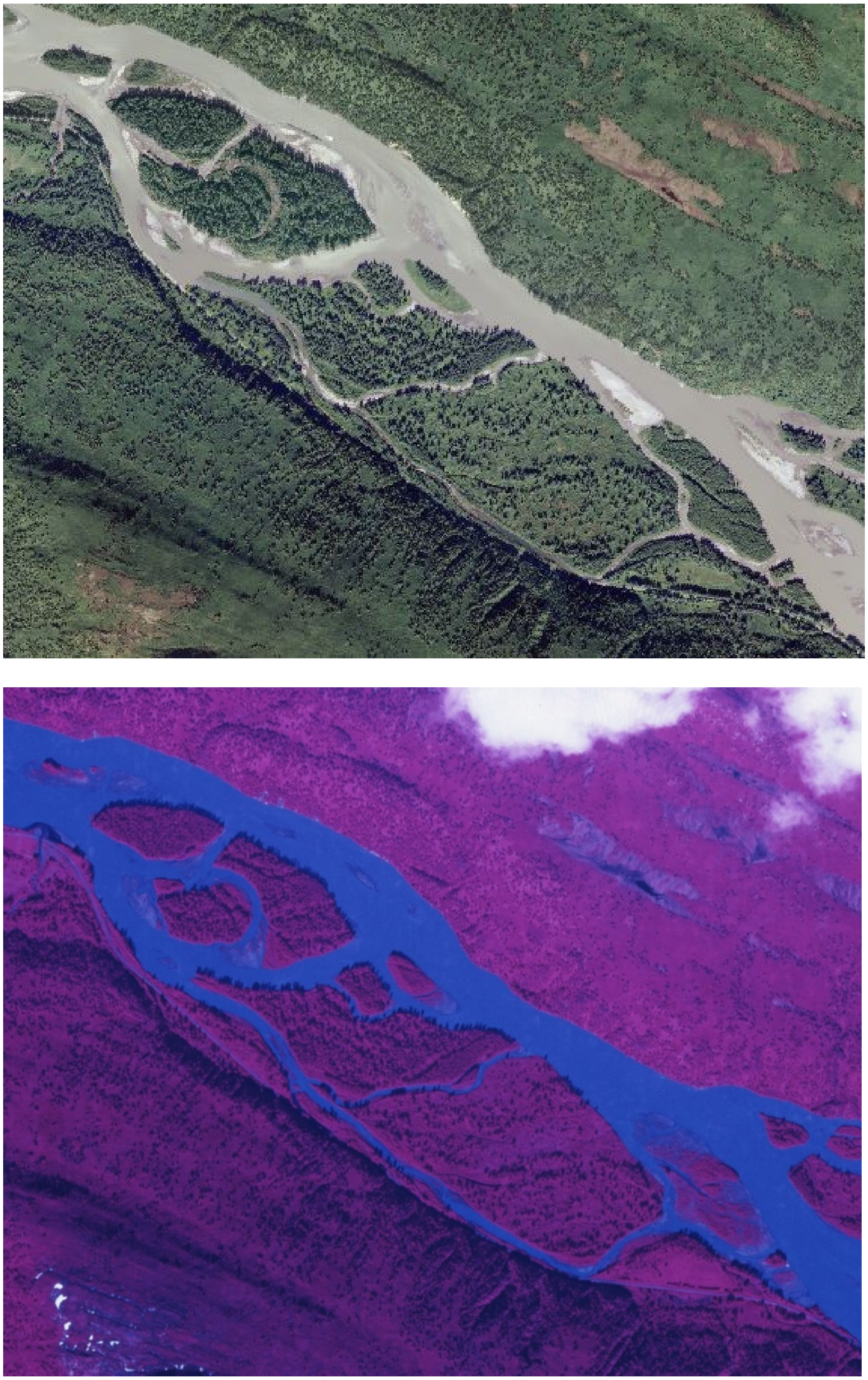

Figure A-2. These aerial images provide a point of comparison between FA-128 (Slough 8A) in the 1970s versus 2011 from a large-scale perspective. The top image depicts FA-128 (Slough 8A) in 2011, and the bottom image depicts this FA in the 1970s. The images will help improve the understanding of the riparian vegetation changes, geomorphology changes and potential changes to the groundwater/surface-water relationships.

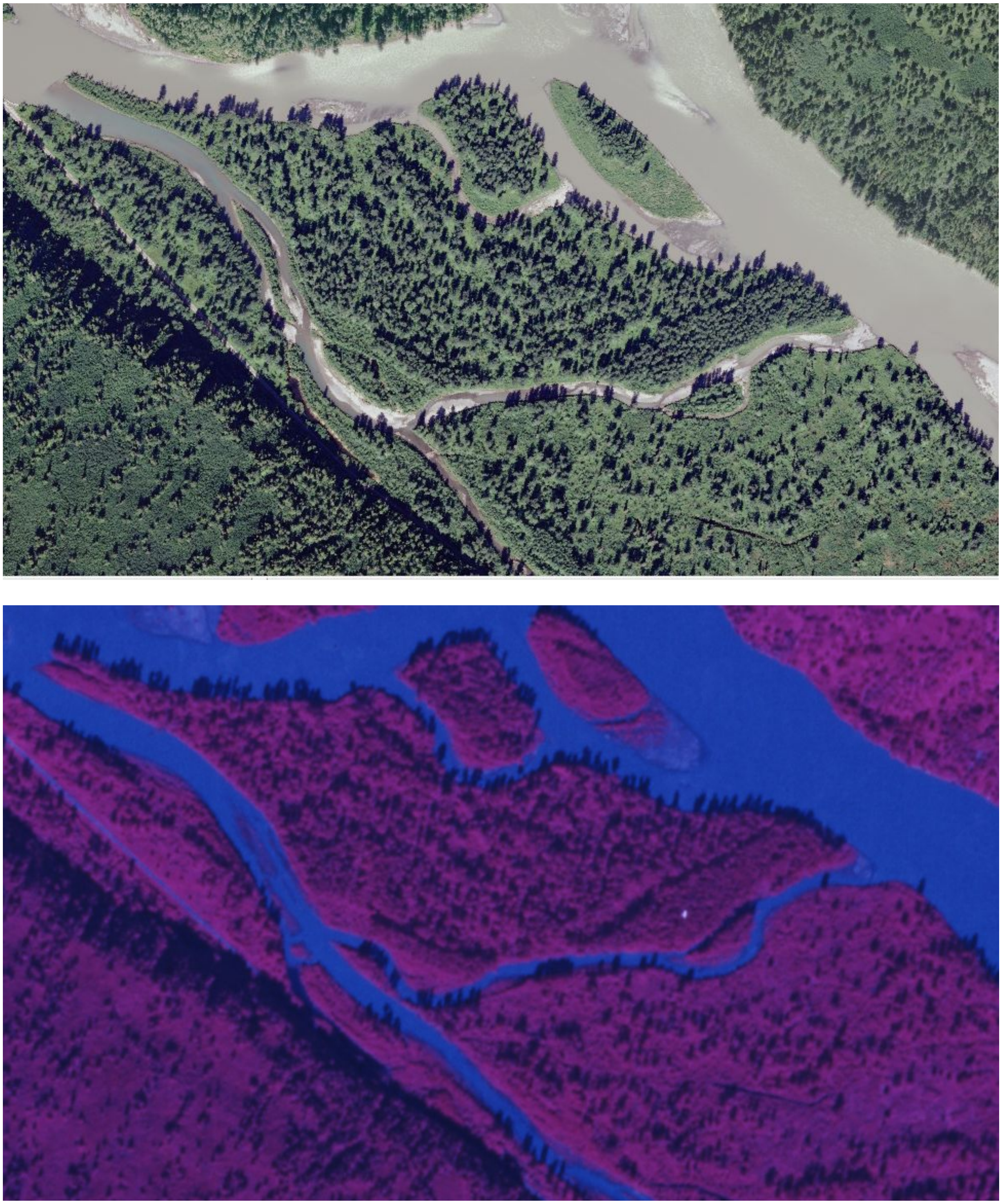

Figure A-3. These aerial images provide a point of comparison between FA-128 (Slough 8A) in the 1970s versus 2011 from a small-scale perspective. The top image depicts FA-128 (Slough 8A) in 2011, and the bottom image depicts this FA in the 1970s. The images will help improve the understanding of the riparian vegetation changes, geomorphology changes and potential changes to the groundwater/surface-water relationships.

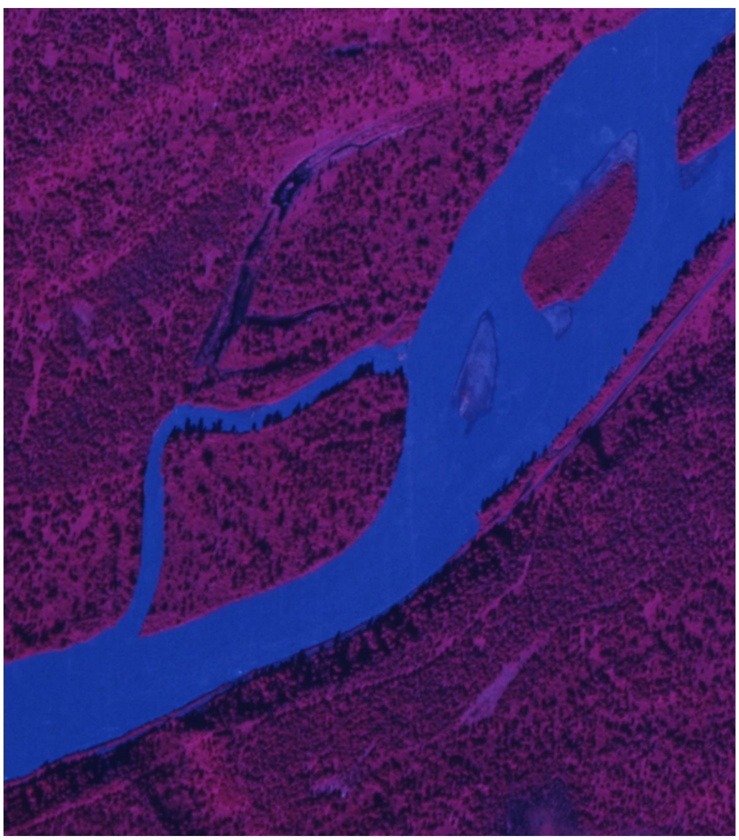

Figure A-4. These aerial images provide a point of comparison between FA-113 (Oxbow 1) in the 1970s versus 2011. The top image depicts FA-113 (Oxbow 1) in 2011, and the bottom image depicts this FA in the 1970s. The images will help improve the understanding of the riparian vegetation changes, geomorphology changes and potential changes to the groundwater/surface-water relationships.

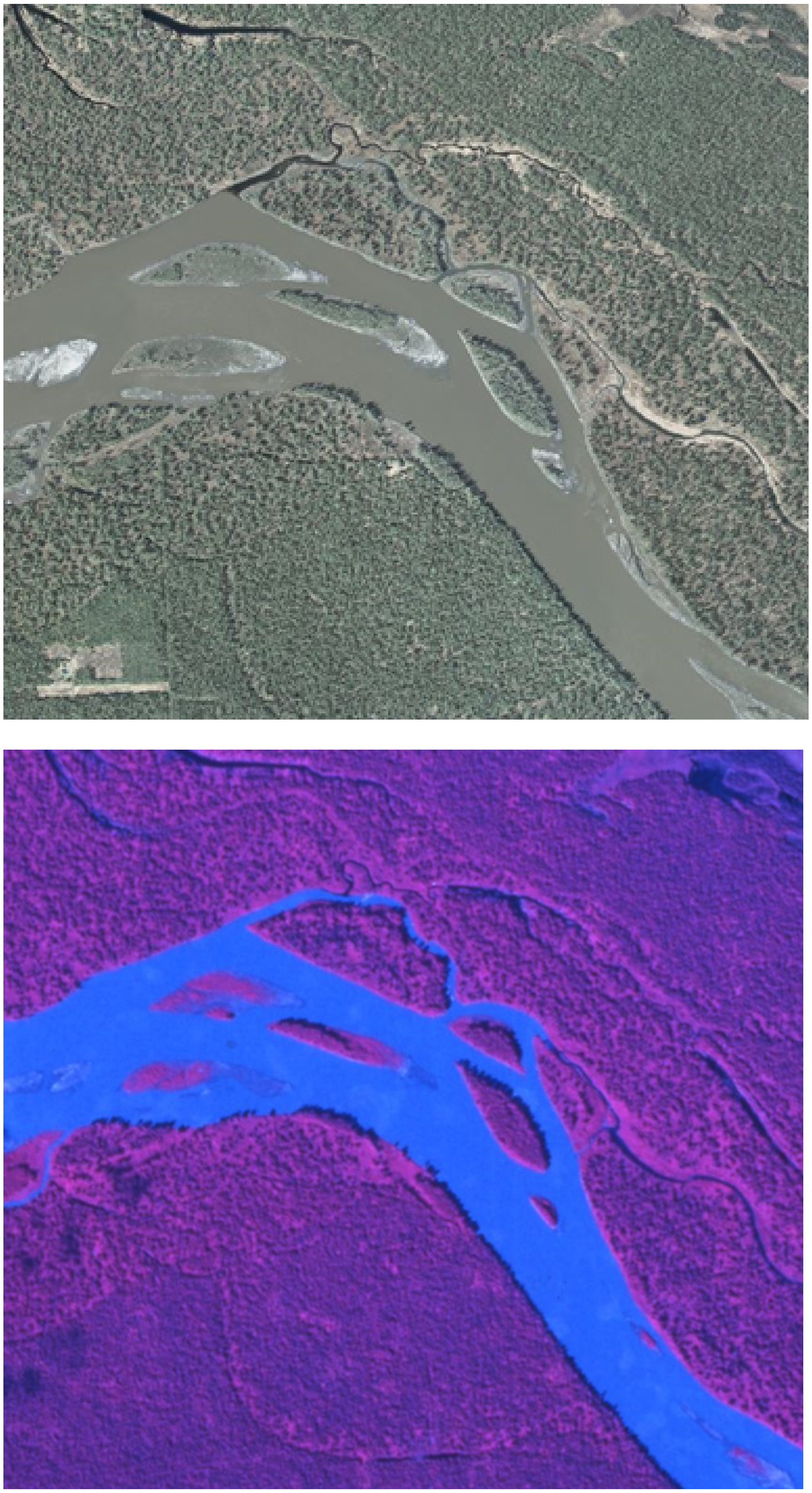

Figure A-5. These aerial images provide a point of comparison between FA-104 (Whiskers Slough) in the 1970s versus 2011. The top image depicts FA-104 (Whiskers Slough) in 2011, and the bottom image depicts this FA in the 1970s. The images will help improve the understanding of the riparian vegetation changes, geomorphology changes and potential changes to the groundwater/surface-water relationships.

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Part A - Appendix B
Groundwater Study Data-Collection Station Metadata Examples

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PART A - APPENDIX B: GROUNDWATER STUDY DATA-COLLECTION STATION METADATA EXAMPLES

The Groundwater Study data-collection station measurement standards help ensure the collection of quality datasets. The examples within this appendix show the range of standard metadata that are being tracked for different types of stations. These metadata meet study objectives for a range of diverse study collection objectives for different station types: surface-water, groundwater, and meteorological primary station types. The standard data collection platform is the Campbell Scientific Inc. (CSI) CR1000 data logger. At some simpler stations, a CSI CR200X data logger is used when minimal measurements are needed. For those sites that do not require real-time reporting, an Instrumentation Northwest (INW) self-logging pressure transducer is used. There are variations within the CSI stations depending on the study analysis needs in different locations. These variations range from measuring streambed temperature profiles in lateral habitats to sap flow sensors in riparian forests. Written data standards have been established for each station type. All of these data measurement and recording standards files are found on the GINA supporting website for the project. The data can be accessed at http://gis.suhydro.org/reports/isr.

Table B-1. This table lists representative station types with corresponding metadata for each station type. Following the table, example metadata files for surface-water, groundwater, and meteorological stations are provided.

Focus Area	**Primary Station Purpose (variation)**	**Representative Station**
FA-128 (Slough 8A)	Surface Water (CSI CR1000)	ESSFA128-1
FA-115 (Slough 6A)	Groundwater (INW PT2X)	ESGFA115-8
FA-104 (Whiskers Slough)	Meteorological (CSI CR1000)	ESMFA104-2
FA-104 (Whiskers Slough)	Groundwater (CSI CR200X)	ESGFA104-3
FA-104 (Whiskers Slough)	Groundwater (CR1000, sap flow sensors)	ESGFA104-4
FA-104 (Whiskers Slough)	Groundwater (CSI CR1000, stream-bed profiles)	ESGFA104-10

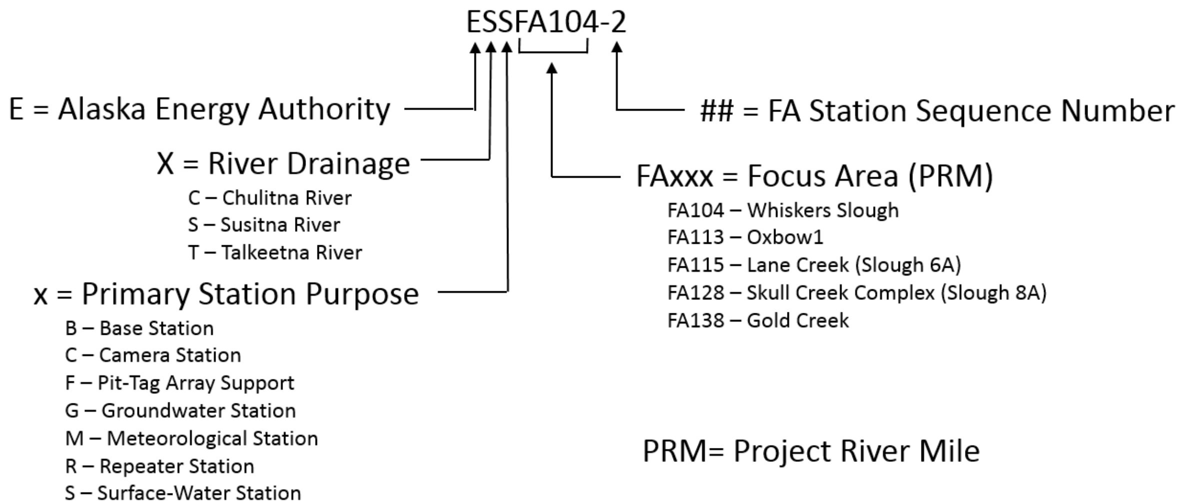

Figure B-1. Data collection station short name convention used for continuously monitored stations. Most stations collect data for multiple study objectives. This allows for improved efficiency of synoptic data collection and data collection standards.

The following describes surface-water data measurement and recording standards for FA-128 (Slough 8A) station ESSFA128-1, representative of a surface-water CSI CR1000 type station:

Susitna Hydrology Project
ESSFA128-1 Focus Area Station
Data Measurement and Recording Standards
Last Update: 06/25/2013
Last Update By: R Paetzold

Focus Area Station

Data-Collection Objectives: Meteorological data to evaluate the potential for hydro-electric power generation in the Susitna River region.
Time Recording Standard: **Always** Alaska Standard Time (UTC – 9).
Datalogger Scan Interval Standard: 60 seconds.
Time Measurement Standards:

Hourly readings are recorded at the end of the hour; therefore, the hourly average water temperature, for example, with a 60-second scan interval and a time stamp of 14:00 is measured from 13:01 to 14:00:00. For a 60-second scan interval, the hourly average would be the average of 60 min = 60 values.

Quarter-hourly readings are recorded every fifteen minutes starting at the top of the hour.

Instantaneous readings are taken at the time specified by the time stamp.

A day begins at midnight (00:00:00) and ends at midnight (23:59:55). All daily data are from the day prior to the date of the time stamp. For example, if the time stamp reads 09/09/2007 00:00 or 09/09/2007 12:00:00 AM, the data are from 09/08/2007.

Data Retrieval Interval: Data will be retrieved hourly.
Data Reporting Interval: Hourly

Images
Camera: Two CC5MPXWD digital cameras.
Memory Card: 8G Flash Memory Card
Flash Card Capacity: ~20,000 Images or over 2 years.

Lo Resolution Image Size: ~50k bytes each (640x480 resolution; Hi compression)
Hi Resolution Images Size: ~250k bytes each (1280x960 resolution; Lo compression)

Images Taken: Both on camera's internal time interval and external trigger. External trigger from datalogger control port allows for manually-initiated image.
Images Saved on Camera Memory Card: Both Hourly Hi-Resolution and Hourly Lo-Resolution
Images Saved on Datalogger: Up to the ten most recent Hourly Lo-Resolution images.
Image Trigger Interval: 60-minutes
Data Retrieval Interval: One image every hour.
Connection: Direct MD485 for two cameras
Lens Defrost: enabled as automated or manual
Remote Camera Powerup: Enabled. Allows for remote control of camera PakBus settings
Start and Stop Image Taking Times: manually adjustable for externally triggered images.

Air Temperature

Sensor: Triplicate YSI Series 44033 thermistors

Operating Range: -80°C to +75°C

Installation: In 6-gill radiation shield, non-aspirated.

Height: 2 meters

Output Units: kΩ, °C.

Scan Interval: 60 seconds

Output to Tables:

Hourly Atmospheric Table:

> Hourly Sample Air Temperature: Recorded at the top of each hour. (three values, one for each thermistor).
>
> Hourly Average Air Temperature: Average of the 60 one-minute readings for the previous hour. (three values, one for each thermistor).

Daily Table:

> Daily Average Air Temperature: Average of all temperature readings for the previous day ending at midnight AST. (three values, one for each thermistor).
>
> Daily Maximum Air Temperature: The highest reading from the previous day. (three values, one for each thermistor).
>
> Daily Minimum Air Temperature: The lowest reading from the previous day. (three values, one for each thermistor).

Hourly Raw Table:

> Hourly Sample Sensor Resistance: Recorded at the top of each hour. "Raw" data in kΩ. (three values, one for each thermistor)
>
> Hourly Average Sensor Resistance: Average of the 60 one-minute readings for the previous hour. "Raw" data in kΩ. (three values, one for each thermistor).

Water Height

Sensor: Two CS450 (Campbell Scientific, inc) pressure transducer, SDI-12 type sensors

Pressure Measurement Range: 0-7.25 psig

Output Units: cm, ft (water height above sensor), psig

Scan Interval: 60 seconds

Output to Tables:

Fifteen-Minute Water Height Table:

> Fifteen-Minute Sample Water Height: Fifteen minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
>
> Fifteen-Minute Average Water Height: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
>
> Fifteen-Minute Maximum Water Height: Fifteen minute maximum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
>
> Fifteen-Minute Minimum Water Height: Fifteen minute minimum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Daily Table:

> Daily Average Water Height: Average of all readings for the previous day.
>
> Daily Maximum Water Height: Maximum water height for the previous day.
>
> Daily Minimum Water Height: Minimum water height for the previous day.

Water Temperature
Sensor: Two CS450 (Campbell Scientific, inc) SDI-12 Sensors
Operating Range: -10°C to 80°C
Output Units: °C
Scan Interval: 60 seconds
Output to Tables:
Fifteen-Minute Water Level Table:

Fifteen-Minute Sample Water Temperature: Fifteen minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
Fifteen-Minute Average Water Temperature: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
Fifteen-Minute Maximum Water Temperature: The highest reading taken during the previous fifteen minutes.
Fifteen-Minute Minimum Water Temperature: The lowest reading taken during the previous fifteen minutes.

Daily Table:

Daily Average Water Temperature: Average of all readings for the previous day.
Daily Maximum Water Temperature: the highest reading taken during the previous day.
Daily Minimum Water Temperature: the lowest reading taken during the previous day.

Water Temperature, Independent (Not Installed at this Station)
Sensor: Five Model 109 (Campbell Scientific, inc) Sensors
Operating Range: -50°C to 70°C
Output Units: °C
Scan Interval: 60 seconds
Output to Tables:
Fifteen-Minute Water Level Table:

Fifteen-Minute Sample Water Temperature: Fifteen minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
Fifteen-Minute Average Water Temperature: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
Fifteen-Minute Maximum Water Temperature: The highest reading taken during the previous fifteen minutes.
Fifteen-Minute Minimum Water Temperature: The lowest reading taken during the previous fifteen minutes.

Daily Table:

Daily Average Water Temperature: Average of all readings for the previous day.
Daily Maximum Water Temperature: the highest reading taken during the previous day.
Daily Minimum Water Temperature: the lowest reading taken during the previous day.

Soil Temperature Profile
Sensor: Twelve YSI Series 44033 thermistors
Operating Range: -80°C to +75°C
Installation: In back-filled bored hole.
Depths: 0, 5, 10, 15, 20, 30, 40, 60, 80, 100, 120, 150 cm, 1-12 thermistors (based on actual depth of bored drill hole)

Output Units: kΩ, °C.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Subsurface Table:
    - Hourly Sample Soil Temperature: Recorded at the top of each hour. (twelve values, one for each thermistor).
    - Hourly Average Soil Temperature: Average of the 60 one-minute readings for the previous hour. (twelve values, one for each thermistor).
- Daily Table:
    - Daily Average Soil Temperature: Average of all temperature readings for the previous day ending at midnight AST. (twelve values, one for each thermistor).
- Hourly Raw Table:
    - Hourly Sample Sensor Resistance: Recorded at the top of each hour. "Raw" data in kΩ. (twelve values, one for each thermistor)
    - Hourly Average Sensor Resistance: Average of the 60 one-minute readings for the previous hour. "Raw" data in kΩ. (twelve values, one for each thermistor).

Battery Voltage
Sensor: CH200
Output Units: V.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
    - Hourly Sample CR1000 Battery Voltage: Measured at the top of the hour.
    - Hourly Average CR1000 Battery Voltage: Average of the 60 one-minute readings for the previous hour.
    - Hourly Maximum CR1000 Battery Voltage: The highest reading from the previous hour.
    - Hourly Minimum CR1000 Battery Voltage: The lowest reading from the previous hour.

Battery Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
    - Hourly Sample CR1000 Battery Current: Measured at the top of the hour.
    - Hourly Average CR1000 Battery Current: Average of the 60 one-minute readings for the previous hour.
    - Hourly Maximum CR1000 Battery Current: The highest reading from the previous hour.
    - Hourly Minimum CR1000 Battery Current: The lowest reading from the previous hour.

Load Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

> Hourly Sample Load Current: Measured at the top of the hour.
> Hourly Average Load Current: Average of the 60 one-minute readings for the previous hour.
> Hourly Maximum Load Current: The highest reading from the previous hour.
> Hourly Minimum CR1000 Battery Current: The lowest reading from the previous hour.

Solar Panel Voltage
Sensor: CH200
Output Units: V.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

> Hourly Sample Solar Panel Voltage: Hourly reading at the top of the hour.
> Hourly Average Solar Panel Voltage: Average of the 60 one-minute readings for the previous hour.
> Hourly Maximum Solar Panel Voltage: The highest reading from the previous hour.
> Hourly Minimum Solar Panel Voltage: The lowest reading from the previous hour.

Solar Panel Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

> Hourly Sample Solar Panel Current: Hourly reading at the top of the hour.
> Hourly Average Solar Panel Current: Average of the 60 one-minute readings for the previous hour.
> Hourly Maximum Solar Panel Current: The highest reading from the previous hour.
> Hourly Minimum Solar Panel Current: The lowest reading from the previous hour.

Datalogger (CR1000) Panel Temperature
Sensor: CR1000 Internal thermistor
Output Units: °C.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

> Hourly Average CR1000 Panel Temperature: Average of the 60 one-minute readings for the previous hour.

Voltage Regulator (CH200) Temperature
Sensor: CH200
Output Units: °C.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:
Hourly Average CR1000 Panel Temperature: Average of the 60 one-minute readings for the previous hour.

Resulting Final Storage Data Tables:
See Datalogger Output Files Excel Document

Notes
Definitions:
Scan interval = sampling duration = scan rate
Time of maximum or minimum values is not recorded
Sample reading = instantaneous reading
Beginning of the hour = top of the hour

Table B-2. This table is a condensed version of the Data Measurement and Recording surface-water metadata standards shown above for FA-128 (Slough 8A) site ESSFA128-1. This table is particularly useful in the programming of the dataloggers

Susitna ESSFAW2 Focus Area Station Data Standards
Surface Water
Last Update: 6/25/2013
Last Update By: R Paetzold

Key Analysis and Demonstration Questions
Determine the potential for generating hydroelectric power.

Data Files		Table
A	Station Diagnostics	HourlyDiag
B	Hourly met table	Hourly
S	Hourly subsurface table	HrlySubs
P	15-min water table	QuarterHourlyWater
L	Hourly Raw Data (collected for field diagnostics)	HourlyRaw
M	Overall daily output	Daily

CSI Data Station Collection Standards Summary Table

			Data Tables											
			Hourly Data				Fifteen-Minute Data				Daily Data			
Parameters	# Sensors	Units	Sample Point	Avg	Max	Min	Sample Point	Avg	Max	Min	Sample Point	Avg	Max	Min
- Air Temperature (YSI 44033)	3	°C	B	B								M	M	M
- Air Temperature (YSI 44033)	3	ohms	L	L										
- Water Ht (CS450)	2	cm, ft, psig					P	P	P	P		M	M	M
- Surface Water Temperature (CS450)	2	°C					P	P	P	P		M	M	M
- Surface Water Temperature (CSI 109)*	5	°C					P	P	P	P		M	M	M
- Soil Profile Temperature (YSI 44033)	12	°C	S	S								M		
- Soil Profile Temperature (YSI 44033)	12	ohms	L	L										
Monitoring System Diagnostic Conditions														
- Station ID	na	number	A,B,L,S				P				M			
- Battery Voltage	1	V	A	A	A	A								
- Battery Current	1	A	A	A	A	A								
- Load Current	1	A	A	A	A	A								
- Solar Panel Voltage	1	V	A	A	A	A								
- Solar Panel Current	1	A	A	A	A	A								
- CR1000 Temperature	1	°C		A										
- CH200 Voltage RegulatorTemperature	1	°C		A										

* Sensor Not Installed

The following describes self-logger data measurement and recording standards for FA-115 (Slough 6A) station ESGFA115-8, representative of a groundwater station with an INW PT2X type station:

SUSITNA HYDROLOGY PROJECT

ESGFA115-8 MONITORING WELL STATION

DATA MEASUREMENT AND RECORDING STANDARDS

Last Update: 07/04/2013
Last Update By: R Paetzold

Monitoring Well Station

Data-Collection Objectives: Meteorological data to evaluate the potential for hydro-electric power generation in the Susitna River region.
Time Recording Standard: **Always** Alaska Standard Time (UTC – 9).
Datalogger Scan Interval Standard: 15 minutes.
Time Measurement Standards:

- Hourly readings are recorded at the end of the hour; therefore, the hourly average water temperature, for example, with a 60-second scan interval and a time stamp of 14:00 is measured from 13:01 to 14:00:00. For a 60-second scan interval, the hourly average would be the average of 60 min = 60 values.
- Quarter-hourly readings are recorded every fifteen minutes starting at the top of the hour.
- Instantaneous readings are taken at the time specified by the time stamp.
- A day begins at midnight (00:00:00) and ends at midnight (23:59:55). All daily data are from the day prior to the date of the time stamp. For example, if the time stamp reads 09/09/2007 00:00 or 09/09/2007 12:00:00 AM, the data are from 09/08/2007.

Data Retrieval Interval: Data will be retrieved manually.
Data Reporting Interval: Quarter-hourly.

WATER HEIGHT

Sensor: INW PT2X integrated datalogger and pressure/temperature sensor.
Pressure Measurement Range: 0-15 psig
Output Units: psig
Scan Interval: 15 minutes
Output:
Fifteen-Minute Sample Water Height: Fifteen minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

WATER TEMPERATURE

Sensor: INW PT2X integrated datalogger and pressure/temperature sensor.
Sensor Range: -40°C to 125°C
Output Units: °C
Scan Interval: 15 minutes
Output:
Fifteen-Minute Sample Water Temperature: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

RESULTING FINAL STORAGE DATA TABLES:

See Datalogger Output Files Excel Document

Notes

Definitions:
Scan interval = sampling duration = scan rate
Time of maximum or minimum values is not recorded
Sample reading = instantaneous reading
Beginning of the hour = top of the hour

The following describes meteorological data measurement and recording standards for FA-104 (Whiskers Slough) station ESMFA104-2, representative of a meteorological CSI CR1000 type station:

SUSITNA HYDROLOGY PROJECT

ESMFA104-2 Focus Area Clearing Met Station
Data Measurement and Recording Standards
Last Update: 06/28/2013
Last Update By: AMcHugh

Focus Area Station

Data-Collection Objectives: Meteorological data to evaluate the potential for hydro-electric power generation in the Susitna River region.
Time Recording Standard: **Always** Alaska Standard Time (UTC – 9).
Datalogger Scan Interval Standard: 60 seconds.
Time Measurement Standards:

> Hourly readings are recorded at the end of the hour; therefore, the hourly average water temperature, for example, with a 60-second scan interval and a time stamp of 14:00 is measured from 13:01 to 14:00:00. For a 60-second scan interval, the hourly average would be the average of 60 min = 60 values.
> Quarter-hourly readings are recorded every fifteen minutes starting at the top of the hour.
> Instantaneous readings are taken at the time specified by the time stamp.
> A day begins at midnight (00:00:00) and ends at midnight (23:59:55). All daily data are from the day prior to the date of the time stamp. For example, if the time stamp reads 09/09/2007 00:00 or 09/09/2007 12:00:00 AM, the data are from 09/08/2007.

Data Retrieval Interval: Data will be retrieved hourly.
Data Reporting Interval: Hourly

Images
Camera: Moultrie Game camera; not connected to data logger.
Memory Card: 16GB SD Flash Memory Card
Flash Card Capacity: ~20,000 Images or over 1 year
Images Taken: On camera's internal time interval.
Images Saved on Camera Memory Card: Half-hourly Lo-Resolution
Images Saved on Datalogger: Not connected to data logger.
Image Trigger Interval: 30-minutes
Data Retrieval: Manually, during station visits.

Air Temperature
Sensor: HC2S3 AT/RH sensor (PT100 RTD, IEC 751 1/3 Class B, with calibrated signal conditioning).
Measurement Range: -40°C to +60°C.
Accuracy: ±0.1°C @23°C (~±0.3°C at -40°C).

Installation: In 10-plate radiation shield, non-aspirated.
Height: 2 meters.
Output Units: °C.
Scan Interval: 60 seconds.
Output to Tables:

- Hourly Table:
  - Hourly Sample Air Temperature: Recorded at the top of each hour.
  - Hourly Average Air Temperature: 60 readings from the beginning of the hour to the end of the hour, averaged and recorded at the end of the hour.
  - Hourly Maximum Air Temperature: The highest reading from the previous hour.
  - Hourly Minimum Air Temperature: The lowest reading from the previous hour.
- Hourly Climate Table:
  - Hourly Minimum Air Temperature: Recorded at the top of each hour.
- Fifteen-Minute Met Table:
  - Fifteen-Minute Sample Air Temperature: Fifteen-minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Average Air Temperature: Fifteen-minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Maximum Air Temperature: The highest reading from the previous fifteen minutes.
  - Fifteen-Minute Minimum Air Temperature: The lowest reading from the previous fifteen minutes.
- Daily Table:
  - Daily Average Air Temperature: Average of all temperature readings for the previous day ending at midnight AST.
  - Daily Maximum Air Temperature: The highest reading taken during the previous day.
  - Daily Minimum Air Temperature: The lowest reading taken during the previous day.

Relative Humidity
Sensor: HC2S3 AT/RH sensor (ROTRONIC Hygromer® IN1.
Operating Range: 0 to 100% RH.
Accuracy: ±0.8% @23°C (~±0.3% at -40°C).
Installation: In 12-gill radiation shield, non-aspirated.
Height: 2 meters
Output Units: % Relative Humidity
Scan Interval: 60 seconds
Output to Tables:
Hourly Atmospheric Table:

Hourly Sample Relative Humidity: Recorded at the top of each hour.
Hourly Average Relative Humidity: 60 readings from the beginning of the hour to the end of the hour, averaged and recorded at the end of the hour.
Hourly Maximum Relative Humidity: The highest reading from the previous hour.
Hourly Minimum Relative Humidity: The lowest reading from the previous hour.

Fifteen-Minute Met Table:

Fifteen-Minute Sample Relative Humidity: Fifteen-minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Fifteen-Minute Average Relative Humidity: Fifteen-minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

- Fifteen-Minute Maximum Relative Humidity: The highest reading from the previous fifteen minutes.
- Fifteen-Minute Minimum Relative Humidity: The lowest reading from the previous fifteen minutes.

- Hourly Climate Table:
  - Hourly Sample Relative Humidity: Recorded at the top of each hour.
- Daily Table:
  - Daily Maximum Relative Humidity: the highest reading taken during the previous day.
  - Daily Minimum Relative Humidity: the lowest reading taken during the previous day.

Dew Point Temperature

Sensor: Calculated value from AT/RH

Scan Interval: N/A, calculated

Output to Tables:

Hourly Table:

Hourly Sample Dew Point: Calculated from the Sample Air Temperature and Relative Humidity values at the top of each hour.

Hourly Average Dew Point: Average of the 60 values calculated from the 60-second Air Temperature and Relative Humidity values.

Hourly Maximum Dew Point: The highest reading from the previous hour.

Hourly Minimum Dew Point: The lowest reading from the previous hour.

Fifteen-Minute Met Table:

Fifteen-Minute Sample Dew Point: Fifteen-minute sample (point) calculation recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Fifteen-Minute Average Dew Point: Fifteen-minute average of all 15 calculations recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Fifteen-Minute Maximum Dew Point: The highest reading from the previous fifteen minutes.

Fifteen-Minute Minimum Dew Point: The lowest reading from the previous fifteen minutes.

Hourly Climate Table:

Hourly Sample Dew Point: Recorded at the top of each hour.

Daily Table:

Daily Maximum Dew Point: The highest calculated value during the previous day.

Daily Minimum Dew Point: The lowest calculated value during the previous day.

Vapor Pressure

Sensor: Vapor Pressure Actual, Saturated and Deficit calculated value from AT/RH

Scan Interval: N/A, calculated

Output to Tables:

Hourly Table:

Hourly Sample Dew Point: Calculated from the Sample Air Temperature and Relative Humidity values at the top of each hour.

Hourly Average Dew Point: Average of the 60 values calculated from the 60-second Air Temperature and Relative Humidity values.

- Hourly Maximum Dew Point: The highest reading from the previous hour.
- Hourly Minimum Dew Point: The lowest reading from the previous hour.

- Fifteen-Minute Met Table:
  - Fifteen-Minute Sample Dew Point: Fifteen-minute sample (point) calculation recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Average Dew Point: Fifteen-minute average of all 15 calculations recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Maximum Dew Point: The highest reading from the previous fifteen minutes.
  - Fifteen-Minute Minimum Dew Point: The lowest reading from the previous fifteen minutes.
- Hourly Climate Table:
  - Hourly Sample Dew Point: Recorded at the top of each hour.
- Daily Table:
  - Daily Maximum Dew Point: The highest calculated value during the previous day.
  - Daily Minimum Dew Point: The lowest calculated value during the previous day.

Wind Speed

Sensor: RM Young 05103-45 Wind Monitor (Alpine).
Operating Range: 0 to 100 m/s (0 to 224 mph).
Accuracy: ± 0.3 m/s (±0.6 mph) or 1% of reading.
Starting Threshold: 1 m/s (2.2 mph).
Installation: 30 m from nearest obstruction.
Height: 3 m.
Output Units: meters per second.
Scan Interval: 3s.
Output to Tables:
Hourly Met Table:

Instantaneous Wind Speed: The 3-second wind speed sampled at the top of the hour.

Hourly Average Wind Speed: Hourly average of 1200 three-second wind speed readings for the previous hour.

Hourly Peak Wind Speed: the highest recorded 3-second wind observation from the reporting interval of the past hour (max wind).

Fifteen-Minute Met Table:

Instantaneous Wind Speed: The 3-second wind speed sampled at the top of the hour, 15, 30, and 45 minutes past the hour.

Fifteen-Minute Average Wind Speed: Fifteen-minute average of all three hundred 3-second readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Fifteen-Minute Peak Wind Speed: the highest recorded 3-second wind observation from the reporting interval of the past fifteen minutes (max wind).

Two-Minute Wind Table:

Two-Minute Average Wind Speed: 2-minute average of 3-second wind speeds.

Two-Minute Peak Wind Speed: the highest recorded 3-second wind observation from the reporting interval of the past 2 minutes (max wind).

Hourly Climate Table:

Hourly Sample Wind Speed: Recorded at the top of each hour.

- Daily Table:
    - Daily Average Wind Speed: The daily average of all 5-second wind speeds for the previous day.
    - Daily Peak Wind Speed: The highest recorded 5-sec wind speed for the previous day.

Wind Direction

Sensor: RM Young 05103-45 Wind Monitor (Alpine).
Operating Range: 0 to 360 deg (mechanical) True North (0 to 355 electrical, 5 deg open).
Accuracy: ±5°.
Starting Threshold: 1.1 m/s (2.4 mph) 10 deg displacement.
Installation: Align true north.
Height: 3 meters.
Output Units: degrees true north.
Scan Interval: 3s.
Output to Tables:
Hourly Atmospheric Table:

Instantaneous Wind Direction: Wind direction sample at the top of the hour.

Hourly Average Wind Direction: Hourly average of 3-second wind direction vector for the previous hour.

Fifteen-Minute Met Table:

Instantaneous Wind Direction: The 3-second wind direction vector sampled at the top of the hour, 15, 30, and 45 minutes past the hour.

Fifteen-Minute Average Wind Direction: Fifteen-minute average of all three hundred 3-second readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Two-Minute Wind Table:

Two-Minute Average Wind Direction: 2-minute average of 3-second wind direction vector.

Hourly Climate Table:

Hourly Sample Wind Direction: Recorded at the top of each hour.

Daily Table:

Daily Wind Direction: Vector mean of all wind direction readings for the previous day.

Wind Direction Standard Deviation

Sensor: Calculated.
Scan Interval: 3s.
Output to Tables:
Hourly Atmospheric Table:

Hourly Wind Direction Standard Deviation: The standard deviation (computed by the datalogger) of the wind direction over the one hour recording period.

Fifteen-Minute Met Table:

Fifteen-Minute Wind Direction Standard Deviation: The standard deviation (computed by the datalogger) of the wind direction over the fifteen-minute recording period.

Two-Minute Wind Table:
- Two-Minute Wind Direction Standard Deviation: The standard deviation (computed by the datalogger) of the wind direction over the 2-minute recording period)

- Daily Table:
  - Daily Wind Direction Standard Deviation: The standard deviation (computed by the datalogger) of the wind direction for the previous 24 hours.

Wind Chill Temperature
Sensor: Calculated from Air Temperature & Wind Speed. Wind Sensor
Output Units: °C.
Scan Interval: N/A, calculated.
Algorithms: $WC = 35.74 + 0.6215\ T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$

where:

WC = Wind Chill (°F)
T = Air Temperature (°F)
V = Wind Speed (mph)

Source: Alaska Safety Handbook. 2006. p180.

$WC\ (°C) = (WC - 32) * 5/9$

where:

WC (°C) = Wind Chill (°C)

Output to Tables:
- Hourly Atmospheric Table:
  - Instantaneous Wind Chill: Calculated from the Instantaneous Air Temperature and Wind Speed values sampled at the top of the hour.
  - Hourly Average Wind Chill: Average of the 60 values calculated from the 60-second sample Air Temperature and the average of the 60 corresponding 3-second sample wind speed values.
  - Hourly Maximum Wind Chill: The highest reading from the previous hour.
  - Hourly Minimum Wind Chill: The lowest reading from the previous hour.
- Fifteen-Minute Met Table:
  - Instantaneous Wind Chill: Calculated from the Instantaneous Air Temperature and Wind Speed values sampled at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Average Wind Chill: Average of the 15 values calculated from the 60-second sample Air Temperature and the average of the 15 corresponding 3-second sample wind speed values.
  - Fifteen-Minute Maximum Wind Chill: The highest reading from the previous fifteen minutes.
  - Fifteen-Minute Minimum Wind Chill: The lowest reading from the previous fifteen minutes.
- Hourly Climate Table:
  - Hourly Sample Wind Chill: Recorded at the top of each hour.
- Daily Table:
  - Daily Maximum Wind Chill: The highest calculated value during the previous day.
  - Daily Minimum Wind Chill: The lowest calculated value during the previous day.

Solar Radiation
Sensor: Campbell Scientific LI200X, LiCor LI200 pyranometer.
Height: 2 meters.
Output Units: mV, converted by datalogger to W/m^2.
Scan Interval: 60 seconds.
Output to Tables:
Hourly Met Table:

Hourly Average Solar Radiation: 60 readings from the beginning of the hour to the end of the hour, averaged and recorded at the end of the hour.

Hourly Average Solar Radiation: 60 readings from the beginning of the hour to the end of the hour, averaged and recorded at the end of the hour.

Fifteen-Minute Met Table:

Fifteen-Minute Average Solar Radiation: Fifteen-minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Hourly Climate Table:

Hourly Sample Solar Radiation: Recorded at the top of each hour.

Daily Table:

Daily Average Solar Radiation: The daily average of all solar radiation measurements for the previous day.

Barometric Pressure
Sensor: Campbell Scientific CS100, Setra 278
Height: 2 meters.
Range: 600 to 1100mBar
Output Units: mBar, Not Corrected to sea level
Scan Interval: 60 seconds.
Output to Tables:
Hourly Atmospheric Table:

Hourly Sample Barometric Pressure: Recorded at the top of each hour.

Fifteen-Minute Met Table:

Fifteen-Minute Sample Barometric Pressure: Fifteen-minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Hourly Climate Table:

Hourly Sample Barometric Pressure: Recorded at the top of each hour.

Net Radiation
Sensor: Kipp and Zonen NR Lite2 Net Radiometer
Height: 2 meters.
Output Units: mV converted by datalogger to W/m^2, Wind Corrected W/m2
Scan Interval: 60 seconds.
Output to Tables:
Hourly Met Table:

Hourly Sample Net Radiation, Net Radiation w/ Wind Correction: Recorded at the top of each hour.

    - Hourly Average Net Radiation, Net Radiation w/ Wind Correction: 60 readings from the beginning of the hour to the end of the hour, averaged and recorded at the end of the hour.
- Fifteen-Minute Met Table:
    - Fifteen-Minute Sample Net Radiation, Net Radiation w/ Wind Correction: Recorded at the top of each hour.
    - Fifteen-Minute Average Net Radiation, Net Radiation w/ Wind Correction: Fifteen-minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
- Hourly Climate Table:
    - Hourly Sample Net Radiation, Net Radiation w/ Wind Correction: Recorded at the top of each hour.
- Hourly Raw Table:
    - Hourly Sample Sensor mV: Recorded at the top of each hour. "Raw" data in mV.
    - Hourly Average Sensor mV: Average of the 60 one-minute readings for the previous hour. "Raw" data in mV.

Air Temperature - Back Up

Sensor: Triplicate YSI Series 44033 thermistors
Operating Range: -80°C to +75°C
Installation: In 6-gill radiation shield, non-aspirated.
Height: 2 meters
Output Units: kΩ, °C.
Scan Interval: 60 seconds
Output to Tables:
Hourly Atmospheric Table:

Hourly Sample Air Temperature: Recorded at the top of each hour. (three values, one for each thermistor).
Hourly Average Air Temperature: Average of the 60 one-minute readings for the previous hour. (three values, one for each thermistor).
Hourly Maximum Air Temperature: The highest reading from the previous hour.
Hourly Minimum Air Temperature: The lowest reading from the previous hour.

Hourly Climate Table:

Hourly Sample Air Temperature: Recorded at the top of each hour. (three values, one for each thermistor).

Fifteen-Minute Met Table:

Fifteen-Minute Sample Air Temperature: Fifteen-minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
Fifteen-Minute Average Air Temperature: Fifteen-minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
Fifteen-Minute Maximum Air Temperature: The highest reading from the previous fifteen minutes.
Fifteen-Minute Minimum Air Temperature: The lowest reading from the previous fifteen minutes.

Hourly Raw Table:

- Hourly Sample Sensor Resistance: Recorded at the top of each hour. "Raw" data in kΩ. (three values, one for each thermistor)
- Hourly Average Sensor Resistance: Average of the 60 one-minute readings for the previous hour. "Raw" data in kΩ. (three values, one for each thermistor).

- Daily Table:
  - Daily Average Air Temperature: Average of all temperature readings for the previous day ending at midnight AST. (three values, one for each thermistor).
  - Daily Maximum Air Temperature: The highest reading from the previous day. (three values, one for each thermistor).
  - Daily Minimum Air Temperature: The lowest reading from the previous day. (three values, one for each thermistor).

Water Height

Sensor: One CS451 (Campbell Scientific, inc) pressure transducer, SDI-12 type sensor or one INW PT12 (Instruments North West) pressure transducer, SDI-12 type sensor.

Pressure Measurement Range: 0-7.25 psig

Output Units: cm, ft (water height above sensor), psig

Scan Interval: 60 seconds

Output to Tables:

Fifteen-Minute Water Table:

Fifteen-Minute Sample Water Height: Fifteen minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Fifteen-Minute Average Water Height: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Fifteen-Minute Maximum Water Height: Fifteen minute maximum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Fifteen-Minute Minimum Water Height: Fifteen minute minimum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Hourly Climate Table:

Hourly Sample Water Height: Sample at the top of each hour.

Daily Table:

Daily Average Water Height: Average of all readings for the previous day.

Daily Maximum Water Height: Maximum water height for the previous day.

Daily Minimum Water Height: Minimum water height for the previous day.

Water Temperature

Sensor: One CS451 (Campbell Scientific, inc) SDI-12 sensor or one INW PT12 (Instruments North West) SDI-12 type sensor.

Operating Range: -10°C to 80°C

Output Units: °C

Scan Interval: 60 seconds

Output to Tables:

Fifteen-Minute Water Table:

Fifteen-Minute Sample Water Temperature: Fifteen minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

  - Fifteen-Minute Average Water Temperature: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Maximum Water Temperature: The highest reading taken during the previous fifteen minutes.
  - Fifteen-Minute Minimum Water Temperature: The lowest reading taken during the previous fifteen minutes.
- Hourly Climate Table:
  - Hourly Sample Water Temperature: Sample at the top of each hour.
- Daily Table:
  - Daily Average Water Temperature: Average of all readings for the previous day.
  - Daily Maximum Water Temperature: the highest reading taken during the previous day.
  - Daily Minimum Water Temperature: the lowest reading taken during the previous day.

Soil Temperature Profile

Sensor: Twelve YSI Series 44033 thermistors

Operating Range: -80°C to +75°C

Installation: In back-filled bored hole.

Depths: 0, 5, 10, 15, 20, 30, 40, 60, 80, 100, 120, 150 cm, 1-12 thermistors (based on actual depth of bored drill hole)

Output Units: kΩ, °C.

Scan Interval: 60 seconds

Output to Tables:

Hourly Subsurface Table:

Hourly Sample Soil Temperature: Recorded at the top of each hour. (twelve values, one for each thermistor).

Hourly Average Soil Temperature: Average of the 60 one-minute readings for the previous hour. (twelve values, one for each thermistor).

Hourly Raw Table:

Hourly Sample Sensor Resistance: Recorded at the top of each hour. "Raw" data in kΩ. (twelve values, one for each thermistor)

Hourly Average Sensor Resistance: Average of the 60 one-minute readings for the previous hour. "Raw" data in kΩ. (twelve values, one for each thermistor).

Hourly Climate Table:

Hourly Sample Soil Temperature: Recorded at the top of each hour. (twelve values, one for each thermistor).

Daily Table:

Daily Average Soil Temperature: Average of all temperature readings for the previous day ending at midnight AST. (twelve values, one for each thermistor).

Soil Moisture Profile

Sensor: Four sensors: CSI 650 Unfrozen Soil-Moisture/Soil Temperature Probes

Installation: Horizontal orientation in back-filled hole

Depths: 10, 20, 30, 40 cm

Output Units: µs, volumetric soil water content (v/v). Electrical Conductivity

Scan Interval: Hourly
Output to Tables:

- Hourly subsurface Table:
  - Hourly Instantaneous Soil Moisture: Hourly volumetric soil water content taken at the top of the hour (four values). Unitless volume ratio (water volume/soil volume).
- Hourly Raw Table:
  - Hourly Instantaneous Soil Moisture: Hourly "raw" volumetric soil water content taken at the top of the hour (four values). Units are µs.
- Hourly Climate Table:
  - Hourly Sample Soil Moisture: Recorded at the top of each hour(four values). Unitless volume ratio (water volume/soil volume).
- Daily Table:
  - Daily Average Soil Moisture: Average of all readings for the previous day ending at midnight AST (four values).
- Hourly Raw Table:
  - Hourly Sample Sensor Period: Recorded at the top of each hour. "Raw" data in µSec

Soil Temperature Profile 2
Sensor: Four sensors: CSI 650 Unfrozen Soil-Moisture/Soil Temperature Probes
Installation: Horizontal orientation in back-filled hole
Depths: 10, 20, 30, 40 cm
Output Units: °C.
Scan Interval: Hourly
Output to Tables:
Hourly subsurface Table:
Hourly Instantaneous Soil Temperature: Hourly volumetric soil water content taken at the top of the hour (four values). Unitless volume ratio (water volume/soil volume).
Hourly Climate Table:
Hourly Sample Soil Temperature: Recorded at the top of each hour. (four values).
Daily Table:
Daily Average Soil Temperature: Average of all temperature readings for the previous day ending at midnight AST (four values).

Soil Moisture Electrical Conductivity
Sensor: Four sensors: CSI 650 Unfrozen Soil-Moisture/Soil Temperature Probes
Installation: Horizontal orientation in back-filled hole
Depths: 10, 20, 30, 40 cm
Output Units: dS/m
Scan Interval: Hourly
Output to Tables:
Hourly Subsurface Table:
Hourly Instantaneous Soil Moisture Electrical Conductivity: Hourly soil water electrical conductivity taken at the top of the hour (four values).
Hourly Climate Table:
- Hourly Sample Soil Moisture Electrical Conductivity: Recorded at the top of each hour(four values). Unitless volume ratio (water volume/soil volume).

- Daily Table:
    - Daily Average Soil Moisture Electrical Conductivity: Average of all readings for the previous day ending at midnight AST (four values).

Soil Heat Flux
Sensor: HFP01-L Hukseflux Soil heat Flux Plate
Operating Range: -2000 W/m^2 to +2000 W/m^2
Installation: Horizontally in back-filled bored hole.
Depth: 8 cm
Output Units: W/m^2, mV
Scan Interval: 60 seconds
Output to Tables:
Hourly Subsurface Table:
Hourly Average Soil Heat Flux: Average of the 60 one-minute readings for the previous hour.
Hourly Sample Soil Heat Flux: Recorded at the top of each hour.
Hourly Climate Table:
Hourly Sample Soil Heat Flux: Recorded at the top of each hour.
Daily Table:
Daily Average Soil Heat Flux: Average of all readings for the previous day ending at midnight AST.
Hourly Raw Table:
Hourly Sample Sensor mV: Recorded at the top of each hour. "Raw" data in mV.
Hourly Average Sensor mV: Average of the 60 one-minute readings for the previous hour. "Raw" data in mV.

Battery Voltage
Sensor: CH200
Output Units: V.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:
Hourly Sample CR1000 Battery Voltage: Measured at the top of the hour.
Hourly Average CR1000 Battery Voltage: Average of the 60 one-minute readings for the previous hour.
Hourly Maximum CR1000 Battery Voltage: The highest reading from the previous hour.
Hourly Minimum CR1000 Battery Voltage: The lowest reading from the previous hour.

Battery Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:
- Hourly Sample CR1000 Battery Current: Measured at the top of the hour.

- Hourly Average CR1000 Battery Current: Average of the 60 one-minute readings for the previous hour.
- Hourly Maximum CR1000 Battery Current: The highest reading from the previous hour.
- Hourly Minimum CR1000 Battery Current: The lowest reading from the previous hour.

Load Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

Hourly Sample Load Current: Measured at the top of the hour.
Hourly Average Load Current: Average of the 60 one-minute readings for the previous hour.
Hourly Maximum Load Current: The highest reading from the previous hour.
Hourly Minimum CR1000 Battery Current: The lowest reading from the previous hour.

Solar Panel Voltage
Sensor: CH200
Output Units: V.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

Hourly Sample Solar Panel Voltage: Hourly reading at the top of the hour.
Hourly Average Solar Panel Voltage: Average of the 60 one-minute readings for the previous hour.
Hourly Maximum Solar Panel Voltage: The highest reading from the previous hour.
Hourly Minimum Solar Panel Voltage: The lowest reading from the previous hour.

Solar Panel Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

Hourly Sample Solar Panel Current: Hourly reading at the top of the hour.
Hourly Average Solar Panel Current: Average of the 60 one-minute readings for the previous hour.
Hourly Maximum Solar Panel Current: The highest reading from the previous hour.
Hourly Minimum Solar Panel Current: The lowest reading from the previous hour.

Datalogger (CR1000) Panel Temperature
Sensor: CR1000 Internal thermistor
Output Units: °C.

Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Average CR1000 Panel Temperature: Average of the 60 one-minute readings for the previous hour.

Voltage Regulator (CH200) Temperature
Sensor: CH200
Output Units: °C.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

Hourly Average CR1000 Panel Temperature: Average of the 60 one-minute readings for the previous hour.

Resulting Final Storage Data Tables:
See Datalogger Output Files Excel Document

Notes
Definitions:
Scan interval = sampling duration = scan rate
Time of maximum or minimum values is not recorded
Sample reading = instantaneous reading
Beginning of the hour = top of the hour

Table B-3. This table is a condensed version of the Data Measurement and Recording metadata standards shown above for FA-104 (Whiskers Slough) site ESMFA104-2.

Susitna ESMFA104-2 Clearing Met Station Data Standards
Surface Water
Last Update: 6/28/2013
Last Update By: AMcHugh

Key Analysis and Demonstration Questions
Determine the potential for generating hydroelectric power.

Data Files		Table
A	Station Diagnostics	HourlyDiag
B	Hourly table for all measurements	Hourly
C	15-min met data	QuarterHrlyMet
K	2-minute table for wind	TwoMinWd
P	15-min water table	QuarterHourlyWater
L	Hourly Raw Data (collected for field diagnostics)	HourlyRaw
M	Overall daily output	Daily
D	Data for the Current Conditions Page	HrlyClimate
O	Hourly subsurface measurements	HourlySubs

CSI Data Station Collection Standards Summary Table

			Data Tables															
			Hourly Data				Fifteen-Minute Data				Two-Minute Data				Daily Data			
Parameters	# Sensors	Units	Sample Point	Avg	Max	Min	Sample Point	Avg	Max	Min	Sample Point	Avg	Max	Min	Sample Point	Avg	Max	Min
- Air Temperature (3 YSI 44033 thermistors)	1	°C	B,D	B	B	B	C	C	C	C						M	M	M
- Air Temperature (Triplicate YSI 44033 thermistors)	1	ohms	L	L	L	L												
- Water Ht (CS451 or INW PT12)	1	cm, ft, psig	D				P	P	P	P						M	M	M
- Water Temperature (CS451 or INW PT12)	1	°C	D				P	P	P	P						M	M	M
- Air Temperature (HC2S3)	1	°C	B,D	B	B	B	C	C	C	C						M	M	M
- Relative Humidity (HC2S3)	1	%	B,D	B	B	B	C	C	C	C							M	M
- Dew Point (Calculated)		°C	B,D	B	B	B	C	C	C	C							M	M
- Vapor Pressure Actual (Calculated)		kPA	B,D	B	B	B	C	C	C	C							M	M
- Vapor Pressure Saturated (Calculated)		kPA	B,D	B	B	B	C	C	C	C							M	M
- Vapor Pressure Deficit (Calculated)		kPA	B,D	B	B	B	C	C	C	C							M	M
- Wind Speed (RM Young 05103-45)	1	m/s	B,D	B	B		C	C	C			K	K			M	M	
- Wind Direction (RM Young 05103-45)	1	°	B,D	B			C	C				K				M		
- Wind Direction Standard Deviation (RM Young 05103-45)		Unitless		B				C				K				M		
- Wind Chill Temperature (Calculated)		°C	B,D	B	B	B	C	C	C	C							M	M
- Solar Radiation (LI200X Pyranometer)	1	W/m²	B,D	B			C	C								M		
- Net Radiation (NR-LITE Kipp & Zonen Net Radiometer)	1	mV, W/m²	B,D,L	B,L			C	C								M		
- Net Radiation Wind Corrected (Calculated)	1	mV, W/m²	B,D,L	B,L			C	C								M		
- Precipitation (TE525MM Tipping Bucket Rain Gage)	1	mm	B[1],D[1]					C[1]								M[1]		
-Soil Water Content (CS650 TDR Soil Water/T sensor)	4	v/v	D,O													M		
-Soil Temperature (CS650 TDR Soil Water/T sensor)	4	°C	D,O													M		
-Soil Moisture EC (CS650 TDR Soil Water/T sensor)	4	dS/m	D,O													M		
-Soil Moisture period (CS650 TDR Soil Water/T sensor)	4	uS	L															
-Soil Temperature Profile (12 GWS YSI Thermistor Strinc	1	°C	D,O	O												M		
-Soil Temperature Profile (12 GWS YSI Thermistor Strinc	1	Kohms	L	L														
-Soil Heat Flux (Hukseflux)	1	W/m²	D,O	O												M		
-Soil Heat Flux (Hukseflux) raw	1	mV	L	L														
-Barometric Pressure CS100	1	mBar	B, D				C											
Monitoring System Diagnostic Conditions																		
- Station ID	na	number	A,B,D,L				C,P				K				M			
- Battery Voltage	1	V	A	A	A	A												
- Battery Current	1	A	A	A	A	A												
- Load Current	1	A	A	A	A	A												
- Solar Panel Voltage	1	V	A	A	A	A												
- Solar Panel Current	1	A	A	A	A	A												
- CR1000 Temperature	1	°C		A														
- CH200 Voltage RegulatorTemperature	1	°C		A														

[1]Total

Manually collected images from Moultrie Game Camera

The following describes groundwater (CR200X logger) data measurement and recording standards for FA-104 (Whiskers Slough) station ESMFA104-3, representative of a groundwater CSI CR200X type station:

Susitna Hydrology Project
ESSFA04-3 Groundwater Station
Data Measurement and Recording Standards
Last Update: 06/13/2013
Last Update By: AMcHugh

Monitoring Well Station

Data-Collection Objectives: Meteorological data to evaluate the potential for hydro-electric power generation in the Susitna River region.
Time Recording Standard: **Always** Alaska Standard Time (UTC – 9).
Datalogger Scan Interval Standard: 60 seconds.
Time Measurement Standards:

Hourly readings are recorded at the end of the hour; therefore, the hourly average water temperature, for example, with a 60-second scan interval and a time stamp of 14:00 is measured from 13:01 to 14:00:00. For a 60-second scan interval, the hourly average would be the average of 60 min = 60 values.

Quarter-hourly readings are recorded every fifteen minutes starting at the top of the hour.

Instantaneous readings are taken at the time specified by the time stamp.

A day begins at midnight (00:00:00) and ends at midnight (23:59:55). All daily data are from the day prior to the date of the time stamp. For example, if the time stamp reads 09/09/2007 00:00 or 09/09/2007 12:00:00 AM, the data are from 09/08/2007.

Data Retrieval Interval: Data will be retrieved hourly.
Data Reporting Interval: Hourly

Water Height
Sensor: Three CS451 (Campbell Scientific, inc) pressure transducer, SDI-12 type sensors
Pressure Measurement Range: 0-7.25 psig
Output Units: ft (water height above sensor), psig
Scan Interval: 60 seconds
Output to Tables:
Fifteen-Minute Water Height Table:

Fifteen-Minute Sample Water Height: Fifteen minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Fifteen-Minute Average Water Height: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Hourly Climate Table:

Hourly Sample Water Height: Sample reading at the top of the hour.

Daily Table:

Daily Maximum Water Height: Maximum water height (in Feet only) for the previous day.

- Daily Minimum Water Height: Minimum water height (in Feet only) for the previous day.

Surface-Water Temperature

Sensor: Three CS451 (Campbell Scientific, inc) SDI-12 Sensors
Operating Range: -10°C to 80°C
Output Units: °C
Scan Interval: 60 seconds
Output to Tables:
Fifteen-Minute Water Level Table:

Fifteen-Minute Average Water Temperature: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Hourly Climate Table:

Hourly Sample Water Temperature: Sample reading at the top of the hour.

Daily Table:

Daily Maximum Water Temperature: the highest reading taken during the previous day.
Daily Minimum Water Temperature: the lowest reading taken during the previous day.

Battery Voltage

Sensor: CH200
Output Units: V.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

Hourly Sample CR1000 Battery Voltage: Measured at the top of the hour.
Hourly Average CR1000 Battery Voltage: Average of the 60 one-minute readings for the previous hour.

Battery Current

Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

Hourly Sample CR1000 Battery Current: Measured at the top of the hour.
Hourly Average CR1000 Battery Current: Average of the 60 one-minute readings for the previous hour.

Load Current

Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Sample Load Current: Measured at the top of the hour.
  - Hourly Average Load Current: Average of the 60 one-minute readings for the previous hour.

Solar Panel Voltage
Sensor: CH200
Output Units: V.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:
Hourly Sample Solar Panel Voltage: Hourly reading at the top of the hour.
Hourly Average Solar Panel Voltage: Average of the 60 one-minute readings for the previous hour.

Solar Panel Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:
Hourly Sample Solar Panel Current: Hourly reading at the top of the hour.
Hourly Average Solar Panel Current: Average of the 60 one-minute readings for the previous hour.

Voltage Regulator (CH200) Temperature
Sensor: CH200
Output Units: °C.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:
Hourly Average CR1000 Panel Temperature: Average of the 60 one-minute readings for the previous hour.

Resulting Final Storage Data Tables:
See Datalogger Output Files Excel Document

Notes
Definitions:
Scan interval = sampling duration = scan rate
Time of maximum or minimum values is not recorded
Sample reading = instantaneous reading
Beginning of the hour = top of the hour

Table B-4. This table is a condensed version of the Data Measurement and Recording groundwater (CR200X logger) metadata standards shown above for FA-104 (Whiskers Slough) site ESMFA104-3.

Susitna ESSFA104-3 Groundwater Station Data Standards
Ground Water
Last Update: 6/28/2013
Last Update By: AMcHugh

Data Files	File Description	Table
A	Station Diagnostics	HourlyDiag
D	Data for the Current Conditions Page	HrlyClimate
P	15-min water table	QuarterHrWater
M	Overall daily output	Daily

Key Analysis and Demonstration Questions

Determine the potential for generating hydroelectric power.

CSI Data Station Collection Standards Summary Table

			Data Tables											
			Hourly Data				Fifteen-Minute Data				Daily Data			
Parameters	# Sensors	Units	Sample Point	Avg	Max	Min	Sample Point	Avg	Max	Min	Sample Point	Avg	Max	Min
- Water Ht (CS451)	3	ft, psig	D				P	P					M	M
- Surface Water Temperature (CS451)	3	°C	D				P						M	M
Monitoring System Diagnostic Conditions														
- Station ID	na	number	A,D				P				M			
- Battery Voltage	1	V	A	A										
- Battery Current	1	A	A	A										
- Load Current	1	A	A	A										
- Solar Panel Voltage	1	V	A	A										
- Solar Panel Current	1	A	A	A										
- CH200 Voltage RegulatorTemperature	1	°C		A										

* Sensor Not Installed

The following describes groundwater with sap flow data measurement and recording standards for FA-104 (Whiskers Slough) station ESMFA104-4, representative of a groundwater CSI CR1000 with sap flow sensors type station:

Susitna Hydrology Project
ESGFA104-6 Focus Area Well Head with Sap Flow Station
Data Measurement and Recording Standards
Last Update: 07/23/2013
Last Update By: R Paetzold

Focus Area Station

Data-Collection Objectives: Meteorological data to evaluate the potential for hydro-electric power generation in the Susitna River region.
Time Recording Standard: **Always** Alaska Standard Time (UTC – 9).
Datalogger Scan Interval Standard: 60 seconds.
Time Measurement Standards:

Hourly readings are recorded at the end of the hour; therefore, the hourly average water temperature, for example, with a 60-second scan interval and a time stamp of 14:00 is measured from 13:01 to 14:00:00. For a 60-second scan interval, the hourly average would be the average of 60 min = 60 values.

Quarter-hourly readings are recorded every fifteen minutes starting at the top of the hour.

Instantaneous readings are taken at the time specified by the time stamp.

A day begins at midnight (00:00:00) and ends at midnight (23:59:55). All daily data are from the day prior to the date of the time stamp. For example, if the time stamp reads 09/09/2007 00:00 or 09/09/2007 12:00:00 AM, the data are from 09/08/2007.

Data Retrieval Interval: Data will be retrieved hourly.
Data Reporting Interval: Hourly

Sap Flow Measurements 1
Sensor: 22 TDP30 Thermal Dissipation Probe Sensors
Installation: Sensors comprised of two thermocouples and heater are inserted in tree. Three or four sensors per tree.
Height: TBD meters
Output Units: Depends on the measurement.
Scan Interval: 60 seconds
Output to Tables:
TableDT (Hourly):

Hourly Average Differential Thermocouple Temperature (°C): Average of the 60 one-minute readings for the previous hour. (one value for each sensor).

TableHR (Hourly):

Hourly Accumulated Sap Flow (g/hr): Accumulated sap flow, sum of the 60 one-minute readings for the previous hour. (one value).

TableTC (Hourly):

Hourly Sample Average Differential Thermocouple Temperature (°C): Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)

- Hourly Sample Maximum Differential Thermocouple Temperature (°C): Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)
- Hourly Sample Thermocouple Sap Velocity (cm/hr): Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)
- Hourly Sample Thermocouple Sap Flow (g/hr): Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)
- Hourly Sample Thermocouple Status: Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)
- Hourly Sample Thermocouple Heater Voltage (V): Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)

- TableTDP (Hourly):
  - Hourly Sample TDP Sap Flow (g/hr): Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)
  - Hourly Sample TDP Sap Flow Index: Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)
  - Hourly Sample TDP Status: Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)
- Daily Raw Table:
  - Hourly Sample Sensor String: Recorded at the top of each day (midnight AST). TDP Type, Index Area, dTM1, SA1, dTM2, SA2, dTM3, SA3 for each sensor.
- TableDY (Daily):
  - Sample Daily Total Sap Flow: Accumulated total daily sap flow for the previous day ending at midnight AST. (one value for all sensors).
  - Sample Daily Maximum Sap Flow: The highest reading from the previous day. (one value for each sensor).

Sap Flow Measurements 2

Sensor: 10 TDP50 Thermal Dissipation Probe Sensors

Installation: Sensors comprised of two thermocouples and heater are inserted in tree. Three or four sensors per tree.

Height: TBD meters

Output Units: Depends on the measurement.

Scan Interval: 60 seconds

Output to Tables:

TableDT (Hourly):

Hourly Average Differential Thermocouple Temperature (°C): Average of the 60 one-minute readings for the previous hour. (one value for each sensor).

TableHR (Hourly):

Hourly Accumulated Sap Flow (g/hr): Accumulated sap flow, sum of the 60 one-minute readings for the previous hour. (one value).

TableTC (Hourly):

Hourly Sample Average Differential Thermocouple Temperature (°C): Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)

Hourly Sample Maximum Differential Thermocouple Temperature (°C): Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)

- Hourly Sample Thermocouple Sap Velocity (cm/hr): Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)
- Hourly Sample Thermocouple Sap Flow (g/hr): Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)
- Hourly Sample Thermocouple Status: Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)
- Hourly Sample Thermocouple Heater Voltage (V): Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)

- TableTDP (Hourly):
  - Hourly Sample TDP Sap Flow (g/hr): Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)
  - Hourly Sample TDP Sap Flow Index: Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)
  - Hourly Sample TDP Status: Hourly sample (point) reading recorded at the top of the hour. (one value for each sensor)
- Daily Raw Table:
  - Hourly Sample Sensor String: Recorded at the top of each day (midnight AST). TDP Type, Index Area, dTM1, SA1, dTM2, SA2, dTM3, SA3 for each sensor.
- TableDY (Daily):
  - Sample Daily Total Sap Flow: Accumulated total daily sap flow for the previous day ending at midnight AST. (one value for all sensors).
  - Sample Daily Maximum Sap Flow: The highest reading from the previous day. (one value for each sensor).

Water Height

Sensor: One CS451 (Campbell Scientific, inc) pressure transducer, SDI-12 type sensors
Pressure Measurement Range: 0-7.25 psig
Output Units: cm, ft (water height above sensor), psig
Scan Interval: 60 seconds
Output to Tables:
Fifteen-Minute Water Height Table:

Fifteen-Minute Sample Water Height: Fifteen minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Fifteen-Minute Average Water Height: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Fifteen-Minute Maximum Water Height: Fifteen minute maximum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Fifteen-Minute Minimum Water Height: Fifteen minute minimum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.

Hourly Climate Table:

Hourly Sample Water Height: Sample at the top of each hour. This table is for the Current Conditions page on the Diag Site only.

Daily Table:

Daily Average Water Height: Average of all readings for the previous day.

Daily Maximum Water Height: Maximum water height for the previous day.
- Daily Minimum Water Height: Minimum water height for the previous day.

Water Temperature
Sensor: One CS451 (Campbell Scientific, inc) SDI-12 Sensors
Operating Range: -10°C to 80°C
Output Units: °C
Scan Interval: 60 seconds
Output to Tables:
Fifteen-Minute Water Level Table:

Fifteen-Minute Sample Water Temperature: Fifteen minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
Fifteen-Minute Average Water Temperature: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
Fifteen-Minute Maximum Water Temperature: The highest reading taken during the previous fifteen minutes.
Fifteen-Minute Minimum Water Temperature: The lowest reading taken during the previous fifteen minutes.

Hourly Climate Table:

Hourly Sample Water Temperature: Sample at the top of each hour. This table is for the Current Conditions page on the Diag Site only.

Daily Table:

Daily Average Water Temperature: Average of all readings for the previous day.
Daily Maximum Water Temperature: the highest reading taken during the previous day.
Daily Minimum Water Temperature: the lowest reading taken during the previous day.

Battery Voltage
Sensor: CH200
Output Units: V.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

Hourly Sample CR1000 Battery Voltage: Measured at the top of the hour.
Hourly Average CR1000 Battery Voltage: Average of the 60 one-minute readings for the previous hour.
Hourly Maximum CR1000 Battery Voltage: The highest reading from the previous hour.
Hourly Minimum CR1000 Battery Voltage: The lowest reading from the previous hour.

Battery Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

- Hourly Sample CR1000 Battery Current: Measured at the top of the hour.

- Hourly Average CR1000 Battery Current: Average of the 60 one-minute readings for the previous hour.
- Hourly Maximum CR1000 Battery Current: The highest reading from the previous hour.
- Hourly Minimum CR1000 Battery Current: The lowest reading from the previous hour.

Load Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

Hourly Sample Load Current: Measured at the top of the hour.
Hourly Average Load Current: Average of the 60 one-minute readings for the previous hour.
Hourly Maximum Load Current: The highest reading from the previous hour.
Hourly Minimum CR1000 Battery Current: The lowest reading from the previous hour.

Solar Panel Voltage
Sensor: CH200
Output Units: V.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

Hourly Sample Solar Panel Voltage: Hourly reading at the top of the hour.
Hourly Average Solar Panel Voltage: Average of the 60 one-minute readings for the previous hour.
Hourly Maximum Solar Panel Voltage: The highest reading from the previous hour.
Hourly Minimum Solar Panel Voltage: The lowest reading from the previous hour.

Solar Panel Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

Hourly Sample Solar Panel Current: Hourly reading at the top of the hour.
Hourly Average Solar Panel Current: Average of the 60 one-minute readings for the previous hour.
Hourly Maximum Solar Panel Current: The highest reading from the previous hour.
Hourly Minimum Solar Panel Current: The lowest reading from the previous hour.

Datalogger (CR1000) Panel Temperature
Sensor: CR1000 Internal thermistor
Output Units: °C.

Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Average CR1000 Panel Temperature: Average of the 60 one-minute readings for the previous hour.

Voltage Regulator (CH200) Temperature
Sensor: CH200
Output Units: °C.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:
Hourly Average CR1000 Panel Temperature: Average of the 60 one-minute readings for the previous hour.

Battery Capacity
Sensor: CH200
Output Units: AHr.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:
Hourly Sample Previous Battery Capacity (NEWBATTCAP): Hourly reading at the top of the hour.
Hourly Sample Present Battery Capacity (BattCap): Hourly reading at the top of the hour.

Daily Cumulative Battery Current
Sensor: CH200
Output Units: AHr.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:
Hourly Sample Cumulative Battery Current In: Hourly reading at the top of the hour; cumulative to midnight.
Hourly Sample Cumulative Battery Current Out: Hourly reading at the top of the hour; cumulative to midnight.

Battery Charge Power
Sensor: CH200
Output Units: W.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Average Power to Charge Battery: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum Power to Charge Battery: Maximum of the 60 one-minute readings for the previous hour.

- Hourly Minimum Power to Charge Battery: Minimum of the 60 one-minute readings for the previous hour.

Load Power
Sensor: CH200
Output Units: W.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

Hourly Average Power Used by Load: Average of the 60 one-minute readings for the previous hour.
Hourly Maximum Power Used by Load: Maximum of the 60 one-minute readings for the previous hour.
Hourly Minimum Power Used by Load: Minimum of the 60 one-minute readings for the previous hour.

Charger State
Sensor: CH200
Output: -1 = regulator fault, 0 = no charge, 1 = current limited charging, 2 = cycle charging, 3 = float charging, 4 = battery test.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

Hourly Sample Charge State: Hourly reading at the top of the hour.

Resulting Final Storage Data Tables:
See Datalogger Output Files Excel Document

Notes
Definitions:
Scan interval = sampling duration = scan rate
Time of maximum or minimum values is not recorded
Sample reading = instantaneous reading
Beginning of the hour = top of the hour

Table B-5. This table is a condensed version of the Data Measurement and Recording groundwater with sap flow metadata standards shown above for FA-104 (Whiskers Slough) site ESMFA104-4.

		Data Files		Table
ESGFA104-4 Well Head with Sap Flow Station Data Standards				
Ground Water with Sap Flow		A	Station Diagnostics	HourlyDiag
Last Update:	7/27/2013	D	Data for the Current Conditions Page	HrlyClimate
Last Update By:	R Paetzold	P	15-min water table	QuarterHourlyWater
		H	Daily Raw Data	DailyRaw
Key Analysis and Demonstration Questions		M	Overall daily output	Daily
Determine the potential for generating hydroelectric power.		U	Hourly sample differential sap flowthermocouple measurements	TableTC
		V	Hourly average differential sap flow thermocouple measurements	TableDT
		W	Hourly sap flow	TableTDP
		Y	Hourly accumulated sap flow	TableHR
		Z	Daily sap flow	TableDY

CSI Data Station Collection Standards Summary Table

			Data Tables											
			Hourly Data				Fifteen-Minute Data				Daily Data			
Parameters	# Sensors	Units	Sample Point	Avg	Max	Min	Sample Point	Avg	Max	Min	Sample Point	Avg	Max	Min
Water Level														
- Water Ht (CS451)	1	cm, ft, psig	D				P	P	P	P		M	M	M
- Surface Water Temperature (CS451)	1	°C	D				P	P	P	P		M	M	M
Sap Flow - TDP30														
- TDP Type	22										H			
- Index Area	22										H			
- dTM1; Max Temperature Difference between sensor thermocouple	22	°C									H			
- SA1; Cross-sectional Area	22	cm^2									H			
- dTM2; Max Temperature Difference between sensor thermocouple	22	°C									H			
- SA2; Cross-sectional Area	22	cm^2									H			
- dTM3; Max Temperature Difference between sensor thermocouple	22	°C									H			
- SA3; Cross-sectional Area	22	cm^2									H			
- TC_dTC; Differential Thermocouple Temperature	22	°C		V										
- Day of Year	22		U,W,Y								Z			
- Time of Day; Hour, Minute	22		U,W,Y											
- TC_dTCa; Avg Differential Thermocouple Temperature	22	°C	U											
- TC_dTM; Max Differential Thermocouple Temperature	22	°C	U,Z											
- TC_Vel; Thermocouple Sap Velocity	22	cm/hr	U											
- TC_Flow; Thermocouple Sap Flow	22	g/hr	U,W											
- TC_FlowIx	22		W											
- TC_Status; Sensor Status	22		U,W											
- HtrV_ Saqp Flow Sensor Heater Voltage	4	V	U											
- Hr_Flow, Hourly Accumulated Sap Flow	22	g/hr	Y											
- DY_Flow; Accumulated Daily Sap Flow	1										Z			
Sap Flow - TDP50														
- TDP Type	10										H			
- Index Area	10										H			
- dTM1; Max Temperature Difference between sensor thermocouple	10	°C									H			
- SA1; Cross-sectional Area	10	cm^2									H			
- dTM2; Max Temperature Difference between sensor thermocouple	10	°C									H			
- SA2; Cross-sectional Area	10	cm^2									H			
- dTM3; Max Temperature Difference between sensor thermocouple	10	°C									H			
- SA3; Cross-sectional Area	10	cm^2									H			
- TC_dTC; Differential Thermocouple Temperature	10	°C		V										
- Day of Year	10		U,W,Y								Z			
- Time of Day; Hour, Minute	10		U,W,Y											
- TC_dTCa; Avg Differential Thermocouple Temperature	10	°C	U											
- TC_dTM; Max Differential Thermocouple Temperature	10	°C	U,Z											
- TC_Vel; Thermocouple Sap Velocity	10	cm/hr	U											
- TC_Flow; Thermocouple Sap Flow	10	g/hr	U,W											
- TC_FlowIx	10		W											
- TC_Status; Sensor Status	10		U,W											
- HtrV_ Saqp Flow Sensor Heater Voltage	4	V	U											
- Hr_Flow, Hourly Accumulated Sap Flow	10	g/hr	Y											
- DY_Flow; Accumulated Daily Sap Flow	1										Z			
Monitoring System Diagnostic Conditions														
- Station ID	na	number	A,D,U,V,W,Y				P				H,M,Z			
- Battery Voltage	1	V	A	A	A	A,U								
- Battery Current	1	A	A	A	A	A								
- Load Current	1	A	A	A	A	A								
- Solar Panel Voltage	1	V	A	A	A	A								
- Solar Panel Current	1	A	A	A	A	A								
- CR1000 Temperature	1	°C		A	U									
- CH200 Voltage RegulatorTemperature	1	°C		A										
- NEWBATTCAP, Previous Battery Capacity	1	Ahr	A											
- BattCap; Current Battery Capacity	1	AHr	A											
- Daily Cumulative Battery Current In	1	AHr	A											
- Daily Cumulative Battery Current Out	1	AHr	A											
- Charger Power; Avg Power to Charge Battery	1	W		A	A	A								
- Load Power, Avg Power used by Load	1	W		A	A	A								
- Charger State	1		A											

The following describes groundwater data measurement and recording standards for FA-104 (Whiskers Slough) station ESMFA104-10, representative of a groundwater CSI CR1000 type station with two temperature profile measurement sensors:

Susitna Hydrology Project
ESG104-10 Groundwater Station
Data Measurement and Recording Standards
Last Update: 01/12/2014
Last Update By: R Paetzold

Groundwater Station

Data-Collection Objectives: Meteorological data to evaluate the potential for hydro-electric power generation in the Susitna River region.
Time Recording Standard: **Always** Alaska Standard Time (UTC – 9).
Datalogger Scan Interval Standard: 3 seconds.
Time Measurement Standards:

Hourly readings are recorded at the end of the hour; therefore, the hourly average water temperature, for example, with a 60-second scan interval and a time stamp of 14:00 is measured from 13:01 to 14:00:00. For a 60-second scan interval, the hourly average would be the average of 60 min = 60 values.
Quarter-hourly readings are recorded every fifteen minutes starting at the top of the hour.
Instantaneous readings are taken at the time specified by the time stamp.
A day begins at midnight (00:00:00) and ends at midnight (23:59:55). All daily data are from the day prior to the date of the time stamp. For example, if the time stamp reads 09/09/2007 00:00 or 09/09/2007 12:00:00 AM, the data are from 09/08/2007.

Data Retrieval Interval: Data will be retrieved hourly.
Data Reporting Interval: Hourly

Images
Camera: Moultrie Game camera; not connected to data logger.
Memory Card: 16GB SD Flash Memory Card
Flash Card Capacity: ~20,000 Images or over 1 year
Images Taken: On camera's internal time interval.
Images Saved on Camera Memory Card: Half-hourly Lo-Resolution
Images Saved on Datalogger: Not connected to data logger.
Image Trigger Interval: 30-minutes
Data Retrieval: Manually, during station visits.

Water Height
Sensor: Two CS451 (Campbell Scientific, inc) pressure transducer, SDI-12 type sensors. Note INW PT-12s may be substituted for one or more of the CS451s.
Pressure Measurement Range: 0-7.25 psig
Output Units: cm, ft (water height above sensor), psig
Scan Interval: 60 seconds
Output to Tables:

- Fifteen-Minute Water Table:
  - Fifteen-Minute Sample Water Height: Fifteen minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour for each sensor.
  - Fifteen-Minute Average Water Height: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour for each sensor.
  - Fifteen-Minute Maximum Water Height: Fifteen minute maximum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour for each sensor.
  - Fifteen-Minute Minimum Water Height: Fifteen minute minimum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour for each sensor.
- Hourly Climate Table:
  - Hourly Sample Water Height: Sample at the top of each hour for each sensor.
- Daily Table:
  - Daily Average Water Height: Average of all readings for the previous day for each sensor.
  - Daily Maximum Water Height: Maximum water height for the previous day for each sensor.
  - Daily Minimum Water Height: Minimum water height for the previous day for each sensor.

Water Temperature

Sensor: Two CS451 (Campbell Scientific, inc) pressure transducer, SDI-12 type sensors. Note INW PT-12s may be substituted for one or more of the CS451s.

Operating Range: -10°C to 80°C

Output Units: °C

Scan Interval: 60 seconds

Output to Tables:

Fifteen-Minute Water Table:

Fifteen-Minute Average Water Temperature: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour for each sensor.

Fifteen-Minute Maximum Water Temperature: The highest reading taken during the previous fifteen minutes for each sensor.

Fifteen-Minute Minimum Water Temperature: The lowest reading taken during the previous fifteen minutes for each sensor.

Hourly Climate Table:

Hourly Sample Water Temperature: Sample at the top of each hour for each sensor.

Daily Table:

Daily Average Water Temperature: Average of all readings for the previous day for each sensor.

Daily Maximum Water Temperature: the highest reading taken during the previous day for each sensor.

Daily Minimum Water Temperature: the lowest reading taken during the previous day for each sensor.

Water Electrical Conductivity

Sensor: Two CS547A Probes.

Operating Range: 0°C to +50°C; 0.005 to 7.0 mS cm^{-1}.

Cell Constant: Individually calibrated. The cell constant (K_c) is found on a label near the termination of the cable.

Output Units: kΩ, mS cm^{-1}

Scan Interval: 60 minutes

Output to Tables:

- Fifteen-Minute Water Table:
  - Fifteen-Minute Sample Water Electrical Conductivity: Fifteen minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour for each sensor.
  - Fifteen-Minute Average Water Electrical Conductivity: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour for each sensor.
  - Fifteen-Minute Maximum Water Electrical Conductivity: Fifteen minute maximum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour for each sensor.
  - Fifteen-Minute Minimum Water Electrical Conductivity: Fifteen minute minimum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour for each sensor.
- Hourly Climate Table:
  - Hourly Sample Water Electrical Electrical Conductivity: Measured at the top of the hour for each sensor.
- Hourly Raw Table:
  - Hourly Sample Water Electrical Conductivity: Top of the hour measurement of water electrical conductivity each sensor, uncorrected for temperature.
  - Hourly Average Water Electrical Conductivity: Hourly average water electrical conductivity for each sensor, uncorrected for temperature.
- Daily Table:
  - Daily Average Water Electrical Conductivity: Average of all readings for the previous day for each sensor.
  - Daily Maximum Water Electrical Conductivity: Maximum of all readings for the previous day for each sensor.
  - Daily Minimum Water Electrical Conductivity: Minimum of all readings for the previous day for each sensor.

Water Temperature at Electrical Conductivity Sensors

Sensor: Two CS547A Probes with Betatherm 100K6A1 thermistors.

Operating Range: 0°C to +50°C

Output Units: °C.

Scan Interval: 60 minutes

Output to Tables:

Fifteen-Minute Water Table:

Fifteen-Minute Average Water Temperature: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour for each sensor.

  - <u>Fifteen-Minute Maximum Water Temperature:</u> The highest reading taken during the previous fifteen minutes for each sensor.
  - <u>Fifteen-Minute Minimum Water Temperature:</u> The lowest reading taken during the previous fifteen minutes for each sensor.
- <u>Hourly Climate Table:</u>
  - <u>Hourly Sample Water Temperature:</u> Measured at the top of the hour for each sensor.
- <u>Daily Table:</u>
  - <u>Daily Average Water Temperature:</u> Average of all readings for the previous day for each sensor.
  - <u>Daily Maximum Water Temperature:</u> Maximum of all readings for the previous day for each sensor.
  - <u>Daily Minimum Water Temperature:</u> Minimum of all readings for the previous day for each sensor.

Soil Temperature Profile

<u>Sensor:</u> Two GWS YSI Soil Profile Temperature Probes each with Twelve YSI Series 44033 thermistors.

<u>Installation:</u> Vertically in a drilled hole.

<u>Depths:</u> 0, 5, 10, 15, 20, 30, 40, 60, 80, 100, 120, 150 cm, 1-12 thermistors (based on actual depth of bored drill hole)

<u>Output Units</u>: kΩ, °C.

<u>Scan Interval:</u> 60 seconds

<u>Output to Tables:</u>

<u>Hourly Subsurface Table:</u>

> <u>Hourly Sample Soil Temperature:</u> Recorded at the top of each hour. (twelve values for each probe, one for each thermistor).
>
> <u>Hourly Average Soil Temperature:</u> Average of the 60 one-minute readings for the previous hour. (twelve values for each probe, one for each thermistor).

<u>Hourly Raw Table:</u>

> <u>Hourly Sample Sensor Resistance:</u> Recorded at the top of each hour. "Raw" data in kΩ. (twelve values for each probe, one for each thermistor)
>
> <u>Hourly Average Sensor Resistance:</u> Average of the 60 one-minute readings for the previous hour. "Raw" data in kΩ. (twelve values for each probe, one for each thermistor).

<u>Hourly Climate Table:</u>

> <u>Hourly Sample Soil Temperature:</u> Recorded at the top of each hour. (twelve values for each probe, one for each thermistor).

<u>Daily Table:</u>

> <u>Daily Average Soil Temperature:</u> Average of all temperature readings for the previous day ending at midnight AST. (twelve values for each probe, one for each thermistor).

Battery Voltage

<u>Sensor:</u> CH200

<u>Output Units</u>: V.

<u>Scan Interval:</u> 60 seconds

Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Sample CR1000 Battery Voltage: Measured at the top of the hour.
  - Hourly Average CR1000 Battery Voltage: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum CR1000 Battery Voltage: The highest reading from the previous hour.
  - Hourly Minimum CR1000 Battery Voltage: The lowest reading from the previous hour.

Battery Current

Sensor: CH200

Output Units: A.

Scan Interval: 60 seconds

Output to Tables:

Hourly Diagnostics Table:

Hourly Sample CR1000 Battery Current: Measured at the top of the hour.

Hourly Average CR1000 Battery Current: Average of the 60 one-minute readings for the previous hour.

Hourly Maximum CR1000 Battery Current: The highest reading from the previous hour.

Hourly Minimum CR1000 Battery Current: The lowest reading from the previous hour.

Load Current

Sensor: CH200

Output Units: A.

Scan Interval: 60 seconds

Output to Tables:

Hourly Diagnostics Table:

Hourly Sample Load Current: Measured at the top of the hour.

Hourly Average Load Current: Average of the 60 one-minute readings for the previous hour.

Hourly Maximum Load Current: The highest reading from the previous hour.

Hourly Minimum CR1000 Battery Current: The lowest reading from the previous hour.

Solar Panel Voltage

Sensor: CH200

Output Units: V.

Scan Interval: 60 seconds

Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Sample Solar Panel Voltage: Hourly reading at the top of the hour.
  - Hourly Average Solar Panel Voltage: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum Solar Panel Voltage: The highest reading from the previous hour.
  - Hourly Minimum Solar Panel Voltage: The lowest reading from the previous hour.

Solar Panel Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
    - Hourly Sample Solar Panel Current: Hourly reading at the top of the hour.
    - Hourly Average Solar Panel Current: Average of the 60 one-minute readings for the previous hour.
    - Hourly Maximum Solar Panel Current: The highest reading from the previous hour.
    - Hourly Minimum Solar Panel Current: The lowest reading from the previous hour.

Datalogger (CR1000) Panel Temperature
Sensor: CR1000 Internal thermistor
Output Units: °C.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

Hourly Average CR1000 Panel Temperature: Average of the 60 one-minute readings for the previous hour.

Voltage Regulator (CH200) Temperature
Sensor: CH200
Output Units: °C.
Scan Interval: 60 seconds
Output to Tables:
Hourly Diagnostics Table:

Hourly Average CR1000 Panel Temperature: Average of the 60 one-minute readings for the previous hour.

Resulting Final Storage Data Tables:
See Datalogger Output Files Excel Document

Notes
Definitions:
Scan interval = sampling duration = scan rate
Time of maximum or minimum values is not recorded
Sample reading = instantaneous reading
Beginning of the hour = top of the hour

Table B-6. This table is a condensed version of the Data Measurement and Recording groundwater metadata standards shown above for FA-104 (Whiskers Slough) site ESMFA104-10.

		Data Files		Table
Susitna ESGFA104-10 Groundwater Station Data Standards				
Surface Water		A	Station Diagnostics	HourlyDiag
Last Update:	1/12/2014	B	Hourly table for all measurements	Hourly
Last Update By:	R Paetzold	C	15-min met data	QuarterHrlyMet
		K	2-minute table for wind	TwoMinWd
Key Analysis and Demonstration Questions		P	15-min water table	QuarterHourlyWater
Determine the potential for generating hydroelectric power.		L	Hourly Raw Data (collected for field diagnostics)	HourlyRaw
		M	Overall daily output	Daily
		D	Data for the Current Conditions Page	HrlyClimate
		O	Hourly subsurface measurements	HourlySubs

CSI Data Station Collection Standards Summary Table

			Data Tables											
			Hourly Data				Fifteen-Minute Data				Daily Data			
Parameters	# Sensors	Units	Sample Point	Avg	Max	Min	Sample Point	Avg	Max	Min	Sample Point	Avg	Max	Min
- Water Ht (CS451 or INW PT12)	2	cm, ft, psig	D				P	P	P	P		M	M	M
- Water Temperature (CS451 or INW PT12)	2	°C	D					P	P	P		M	M	M
- Water Electrical Conductiviey (CS547A)	2	kΩ, mS cm^{-1}	D.L	L			P	P	P	P		M	M	M
- Water Temperature (CS547A)	2	°C	D					P	P	P		M	M	M
Soil Temperature Profile (12 GWS YSI Thermistor String)	2	°C	D,L,O	L,O								M		
Monitoring System Diagnostic Conditions														
- Station ID	na	number	A,D,L,O				P				M			
- Battery Voltage	1	V	A	A	A	A								
- Battery Current	1	A	A	A	A	A								
- Load Current	1	A	A	A	A	A								
- Solar Panel Voltage	1	V	A	A	A	A								
- Solar Panel Current	1	A	A	A	A	A								
- CR1000 Temperature	1	°C		A										
- CH200 Voltage RegulatorTemperature	1	°C		A										

Manually collected images from Motree Game Camera

Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Groundwater Study (7.5)

Part – A Appendix C
Groundwater Study Data-Collection Station Programs and Wiring Diagram Examples

Initial Study Report

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

Geo-Watersheds Scientific

June 2014

PART A - APPENDIX C: GROUNDWATER STUDY DATA-COLLECTION STATION PROGRAMS AND WIRING DIAGRAM EXAMPLES

The Groundwater Study data-collection station programs and wiring diagrams help ensure the collection of quality datasets. The examples within this appendix show the range of standard wiring diagrams and programs for various types of stations to meet study objectives. The primary station types include surface-water, groundwater, and meteorological stations. Station programs and wiring diagrams have been created for each station type.

Table C-1. This table lists representative station types with corresponding programs and wiring diagrams for each station type. Following the table, example programming and wiring diagrams for surface-water, groundwater, and meteorological stations are provided.

Focus Area	Primary Station Purpose (variation)	Representative Station
FA-128 (Slough 8A)	Surface-Water (CSI CR1000)	ESSFA128-1
FA-104 (Whiskers Slough)	Meteorological (CSI CR1000)	ESMFA104-2
FA-104 (Whiskers Slough)	Groundwater (CSI CR200X)	ESGFA104-3
FA-104 (Whiskers Slough)	Groundwater (CR1000, sap flow sensors)	ESGFA104-4
FA-104 (Whiskers Slough)	Groundwater (CSI CR1000, stream-bed profiles)	ESGFA104-10

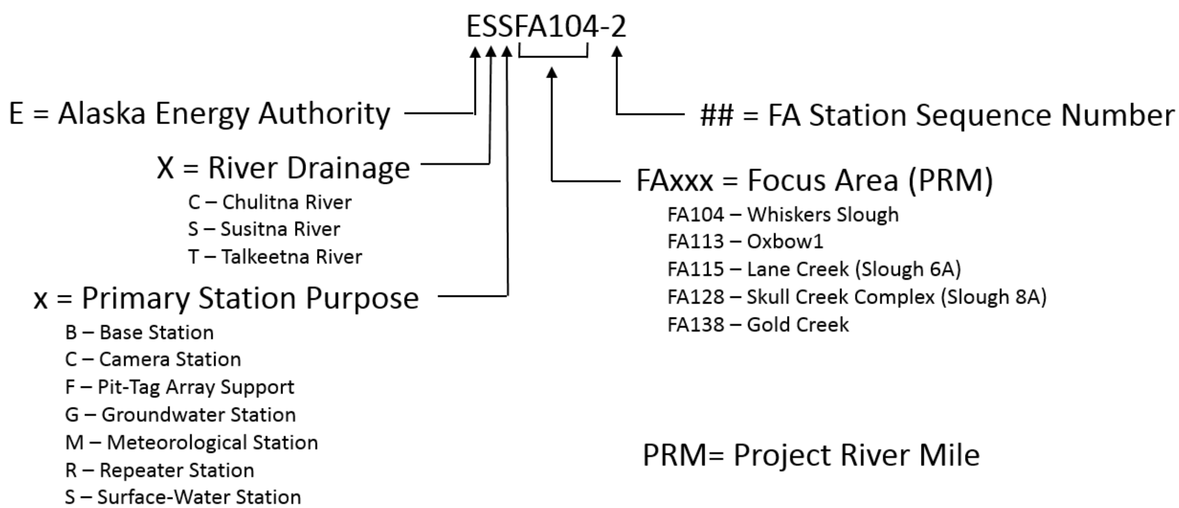

Figure C-1. Data collection station short name convention used for continuously monitored stations. Most stations collect data for multiple study objectives. This allows for improved efficiency of synoptic data collection and data collection standards.

The following program and wiring diagrams depict FA-128 (Slough 8A) station ESSFA128-1, representative of the surface-water (CSI CR1000) type station:

```
'CR1000 Series Datalogger

'Modification Of:  ESSFA104-1_20130719.cr1
'Modified by: AMcHugh
'Date Modified: 07/19/2013
'Modifications: Changed StationName

'Modification Of:  ESSFAW1_20130401.cr1
'Modified by: AMcHugh
'Date Modified: 07/19/2013
'Modifications: Added CH200 code.

'Modification Of:  ESSFA_20130121.cri
'Modified by: R Paetzold
'Date Modified: 04/01/2013
'Modifications: New station with two cameras, two pressure transducers, GWS YSI Air T sensor,
'               multiplexer, and soil profile temperature string.

'Program Name: ESSRA_20130121.cr1

'Modification Of:  ESS10_20121212.cr1
'Modified by: AMcHugh
'Date Modified:
'Modifications:

'Station Notes:
'      PakBus ID for Station: 520              'INSERT PakBus ID HERE <===========
'      Station ID:    520                      'INSERT Station ID HERE <==========
'      Time is set to AK Standard Time
''''''''''''''''''''''''''''''''''''''
'''' INDIVIDUAL STATION INPUTS ''''
''''''''''''''''''''''''''''''''''''''
'INSERT Station Name HERE:
StationName (ESSFA128-1)           'INSERT Station Name HERE
<==============================
'INSERT Station ID HERE:
Const ID = 520                  'INSERT Station ID HERE <=========================
'FIXED RESISTOR VALUES FOR GWS THERMISTOR CIRCUITS

'INSERT FIXED RESISTOR #1 (EX1 to SE1) MEASURED VALUE (kOHM) HERE:
*********************
Const Rf_1 = 1.000
```

```
'INSERT FIXED RESISTOR #2 (EX1 to SE2) MEASURED VALUE (kOHM) HERE:
*********************
Const Rf_2 = 1.000
'INSERT FIXED RESISTOR #3 (EX1 to SE3) MEASURED VALUE (kOHM) HERE:
*********************
Const Rf_3 = 1.000

'YSI thermistor conversion:
'kOHM to deg C
Const a = 0.0014654354
Const b = 0.0002386780
Const c = 0.0000001000

'CONTROL PORTS
' C1 CH200 - Charging Regulator
' C2 AM16/32B - Multiplexer, RES
' C3 AM16/32B - Multiplexer, CLK
' C4 CC5MPXWD Camera #1 Trigger
' C5 PT1 - CS450 Pressure Transducer
' C6 CC5MPXWD Camera #2 Trigger
' C7 PT2 - CS450 Pressure Transducer
' C8
' SW12V

'DECLARE PUBLIC VARIABLES
PreserveVariables ' variables are maintained over reboot.

Public MinIntoDay ' computed value from rTime

Public StationID ' Station ID number, USER INPUT
Public BattVolts_V
Public LoggerTemp_C

Public DlyBatCrtIn_AHr, DlyBatCrtOut_AHr
Public LoadPwr_W, ChargePwr_W

Public CH200_M0(9)  'Array to hold all data from CH200

Public CH200_MX(4)  ' Array to hold extended data from CH200
Alias CH200_MX(1) = BattTargV ' Battery charging target voltage
Alias CH200_MX(2) = DgtlPotSet ' Digital potentiometer setting
Alias CH200_MX(3) = BattCap ' Present battery capacity
Alias CH200_MX(4) = Qloss ' Battery charge deficit

' SDI-12 formatted battery capacity value
Public SDI12command As String
```

```
' Response from CH200. Retrns the address of the unit and "ok" if all went well
Public SDI12result As String
Public NEWBATTCAP ' the new battery capacticty if you need to change it.

Public CS450Data1(2)     'Water Level Sensor 1 - pressure, temperature
Public CS450Data2(2)     'Water Level Sensor 2 - pressure, temperature
Public WaterHt1_cm, WaterHt1_ft, WaterHt2_cm, WaterHt2_ft        ' Water level above the
probe
Public Therm_kOhm(15), TEMP_C(15)     'YSI thermistors - air temperature (1-3), soil
temperature (4-15)
Public WaterT_C(5)     'CSI 109 temperature sensor - water temperature

Public TAKEIMAGE
Public IMAGERATE_MIN ' Adjust this for the image rate.
Public STARTIMAGEMID ' time as Minutes Into Day to START taking images
Public STOPIMAGEMID  ' time as Minutes Into Day to STOP taking images.
Public CAMERAMANCONTROL As String * 2 'on or off
Public CAMERADEFROSTERMODE As String * 2 ' manual or auto
Public CAMERADEFROSTERMANCONTROL As String * 2 ' on or off
Public CAMERADEFROSTERONMID ' time as Minutes Into Day to turn Camera Heat On
Public CAMERADEFROSTEROFFMID ' time as Minutes Into Day to turn Camera Heat Off
Public TurnDefrosterOn As Boolean
Public TurnDefrosterVal As Long
Public SendVarResult As Long

Public TAKEIMAGE2
Public IMAGE2RATE_MIN ' adjust this for the image rate
Public STARTIMAGE2MID ' time as Minutes Into Day to START taking images
Public STOPIMAGE2MID  ' time as Minutes Into Day to STOP taking images.
Public CAMERA2MANCONTROL As String * 2 'on or off
Public CAMERA2DEFROSTERMODE As String * 2 ' manual or auto
Public CAMERA2DEFROSTERMANCONTROL As String * 2 ' on or off
Public CAMERA2DEFROSTERONMID ' time as Minutes Into Day to turn Camera Heat On
Public CAMERA2DEFROSTEROFFMID ' time as Minutes Into Day to turn Camera Heat Off
Public TurnDefroster2On As Boolean
Public TurnDefroster2Val As Long
Public SendVarResult2 As Long


Dim Initialized
Dim therm(15)
Dim i
Dim D(15)
Dim FixedRes(3)

Alias CS450Data1(1) = WaterHt1_psi
```

```
Alias CS450Data1(2) = WaterT1_C
Alias CS450Data2(1) = WaterHt2_psi
Alias CS450Data2(2) = WaterT2_C

Alias TEMP_C(1) = AirT_YSI1_C
Alias TEMP_C(2) = AirT_YSI2_C
Alias TEMP_C(3) = AirT_YSI3_C

Alias Temp_C(4) = SoilT_5cm_C
Alias Temp_C(5) = SoilT_10cm_C
Alias Temp_C(6) = SoilT_15cm_C
Alias Temp_C(7) = SoilT_20cm_C
Alias Temp_C(8) = SoilT_30cm_C
Alias Temp_C(9) = SoilT_40cm_C
Alias Temp_C(10) = SoilT_50cm_C
Alias Temp_C(11) = SoilT_60cm_C
Alias Temp_C(12) = SoilT_80cm_C
Alias Temp_C(13) = SoilT_100cm_C
Alias Temp_C(14) = SoilT_120cm_C
Alias Temp_C(15) = SoilT_150cm_C


Alias CH200_M0(1)=CH200BattVolts_V      'Battery voltage: VDC
Alias CH200_M0(2)=BattCrnt_A       'Current going into, or out of, the battery: Amps
Alias CH200_M0(3)=LoadCrnt_A       'Current going to the load: Amps
Alias CH200_M0(4)=SolarPanel_V     'Voltage coming into the charger: VDC
Alias CH200_M0(5)=SolarPanel_A     'Current coming into the charger: Amps
Alias CH200_M0(6)=Chgr_Tmp_C       'Charger temperature: Celsius
Alias CH200_M0(7)=Chgr_State       'Charging state: 2=Cycle, 3=Float, 1=Current Limited, or
0=None
Alias CH200_M0(8)=Chgr_Source      'Charging source: 0=None, 1=Solar, or 2=AC
Alias CH200_M0(9)=Ck_Batt          'Check battery error: 0=normal, 1=check battery

' Real time variable assigned
Public rTime(9)              'declare as public and dimension rTime to 9
Alias rTime(1) = Year        'assign the alias Year to rTime(1)
Alias rTime(2) = Month       'assign the alias Month to rTime(2)
Alias rTime(3) = DOM         'assign the alias Day to rTime(3)
Alias rTime(4) = Hour        'assign the alias Hour to rTime(4)
Alias rTime(5) = Minute      'assign the alias Minute to rTime(5)
Alias rTime(6) = Second      'assign the alias Second to rTime(6)
Alias rTime(7) = uSecond     'assign the alias uSecond to rTime(7)
Alias rTime(8) = WeekDay     'assign the alias WeekDay to rTime(8)
Alias rTime(9) = Day_of_Year  'assign the alias Day_of_Year to rTime(9)
```

```
' 15-minute Water Table
DataTable (QuarterHourlyWater,1,-1)
  DataInterval (0,15,Min,0)
  Sample (1,StationID,fp2)

  Sample (1,WaterHt1_cm,FP2)
  Average (1,WaterHt1_cm,FP2,False)
  Maximum (1,WaterHt1_cm,FP2,False,False)
  Minimum (1,WaterHt1_cm,FP2,False,False)

  Sample (1,WaterHt2_cm,FP2)
  Average (1,WaterHt2_cm,FP2,False)
  Maximum (1,WaterHt2_cm,FP2,False,False)
  Minimum (1,WaterHt2_cm,FP2,False,False)

  Sample (1,WaterHt1_ft,FP2)
  Average (1,WaterHt1_ft,FP2,False)
  Maximum (1,WaterHt1_ft,FP2,False,False)
  Minimum (1,WaterHt1_ft,FP2,False,False)

  Sample (1,WaterHt2_ft,FP2)
  Average (1,WaterHt2_ft,FP2,False)
  Maximum (1,WaterHt2_ft,FP2,False,False)
  Minimum (1,WaterHt2_ft,FP2,False,False)

  Average (1,WaterT1_C,FP2,False)
  Maximum (1,WaterT1_C,FP2,False,False)
  Minimum (1,WaterT1_C,FP2,False,False)

  Average (1,WaterT2_C,FP2,False)
  Maximum (1,WaterT2_C,FP2,False,False)
  Minimum (1,WaterT2_C,FP2,False,False)

  Sample (1,WaterHt1_psi,FP2)
  Average (1,WaterHt1_psi,FP2,False)
  Maximum (1,WaterHt1_psi,FP2,False,False)
  Minimum (1,WaterHt1_psi,FP2,False,False)

  Sample (1,WaterHt2_psi,FP2)
  Average (1,WaterHt2_psi,FP2,False)
  Maximum (1,WaterHt2_psi,FP2,False,False)
  Minimum (1,WaterHt2_psi,FP2,False,False)

  Average (5,WaterT_C,FP2,False)
  Maximum (5,WaterT_C,FP2,False,False)
  Minimum (5,WaterT_C,FP2,False,False)
```

```
EndTable

'Hourly Diagonostics Table
DataTable (HourlyDiag,1,-1)
  DataInterval (0,60,Min,0)
  Sample (1,StationID,fp2)

  'BATTERY VOLTS (V)
  Sample (1,BattVolts_V,FP2)
  Average (1,BattVolts_V,FP2,False)
  Maximum (1,BattVolts_V,FP2,False,False)
  Minimum (1,BattVolts_V,FP2,False,False)

  'BATTERY CURRENT (A)
  Sample (1,CH200_M0(2),FP2)
  Average (1,CH200_M0(2),FP2,False)
  Maximum (1,CH200_M0(2),FP2,False,False)
  Minimum (1,CH200_M0(2),FP2,False,False)

  'LOAD CURRENT (A)
  Sample (1,CH200_M0(3),FP2)
  Average (1,CH200_M0(3),FP2,False)
  Maximum (1,CH200_M0(3),FP2,False,False)
  Minimum (1,CH200_M0(3),FP2,False,False)

  'SOLAR PANEL VOLTS (V)
  Sample (1,CH200_M0(4),FP2)
  Average (1,CH200_M0(4),FP2,False)
  Maximum (1,CH200_M0(4),FP2,False,False)
  Minimum (1,CH200_M0(4),FP2,False,False)

  'SOLAR PANEL CURRENT (A)
  Sample (1,CH200_M0(5),FP2)
  Average (1,CH200_M0(5),FP2,False)
  Maximum (1,CH200_M0(5),FP2,False,False)
  Minimum (1,CH200_M0(5),FP2,False,False)

  'Logger Temperature (deg C)
  Average (1,LoggerTemp_C,FP2,False)

  'Charge Regulator Temperature (deg C)
  Average (1,CH200_M0(6),FP2,False)
EndTable

'Hourly Raw Measurements Table
DataTable (HourlyRaw,1,-1)
```

```
  DataInterval (0,60,Min,0)
  Sample (1,StationID,fp2)

  Sample (15,Therm_kOhm(),FP2)
  Average (15,Therm_kOhm(),FP2,False)
EndTable

'Hourly Meteorological Measurements Table
DataTable (Hourly,1,-1)
  DataInterval (0,60,Min,0)
  Sample (1,StationID,fp2)

  Sample (3,AirT_YSI1_C,FP2)
  Average (3,AirT_YSI1_C,FP2,False)
EndTable

'Hourly Subsurface Measurements Table
DataTable (HrlySubs,1,-1)
  DataInterval (0,60,Min,0)
  Sample (1,StationID,fp2)

  Sample (12,SoilT_5cm_C,FP2)
  Average (12,SoilT_5cm_C,FP2,False)
EndTable

'Hourly Climate Table (for Current Conditions Table on Web)
DataTable (HrlyClimate,1,96)
  DataInterval (0,60,Min,0)
  Sample (1,StationID,fp2)

  Sample (1,AirT_YSI1_C,FP2)
  Sample (1,WaterT1_C,FP2)
  Sample (1,WaterHt1_ft,FP2)
EndTable

'Daily Output Table
DataTable (Daily,1,-1)
  DataInterval(0,1440,Min,0)
  Sample (1,StationID,fp2)

  Average (3,AirT_YSI1_C,FP2,False)
  Maximum (3,AirT_YSI1_C,FP2,False,False)
  Minimum (3,AirT_YSI1_C,FP2,False,False)

  Average (1,WaterHt1_cm,FP2,False)
  Maximum (1,WaterHt1_cm,FP2,False,False)
```

```
  Minimum (1,WaterHt1_cm,FP2,False,False)

  Average (1,WaterHt2_cm,FP2,False)
  Maximum (1,WaterHt2_cm,FP2,False,False)
  Minimum (1,WaterHt2_cm,FP2,False,False)

  Average (1,WaterHt1_ft,FP2,False)
  Maximum (1,WaterHt1_ft,FP2,False,False)
  Minimum (1,WaterHt1_ft,FP2,False,False)

  Average (1,WaterHt2_ft,FP2,False)
  Maximum (1,WaterHt2_ft,FP2,False,False)
  Minimum (1,WaterHt2_ft,FP2,False,False)

  Average (1,WaterT1_C,FP2,False)
  Maximum (1,WaterT1_C,FP2,False,False)
  Minimum (1,WaterT1_C,FP2,False,False)

  Average (1,WaterT2_C,FP2,False)
  Maximum (1,WaterT2_C,FP2,False,False)
  Minimum (1,WaterT2_C,FP2,False,False)

  Average (1,WaterHt1_psi,FP2,False)
  Maximum (1,WaterHt1_psi,FP2,False,False)
  Minimum (1,WaterHt1_psi,FP2,False,False)

  Average (1,WaterHt2_psi,FP2,False)
  Maximum (1,WaterHt2_psi,FP2,False,False)
  Minimum (1,WaterHt2_psi,FP2,False,False)

  Average (5,WaterT_C,FP2,False)
  Maximum (5,WaterT_C,FP2,False,False)
  Minimum (5,WaterT_C,FP2,False,False)

  Average (12,SoilT_5cm_C,FP2,False)
EndTable

''''''''''''''''''''''
''' MAIN PROGRAM '''
''''''''''''''''''''''

'SCAN (EXECUTE) PROGRAM AT 60-SEC INTERVALS
BeginProg
  Scan (60,Sec,0,0)
    '''' Set Station ID ''''
    StationID = ID
```

```
  ' get the real time into variables
  RealTime (rTime)
  ' compute Minutes Into Day from hours and minutes into the hour.
  MinIntoDay = (Hour * 60) + Minute

  ' initialize the default (power up) conditions
  If Initialized = 0 Then
    NEWBATTCAP = 12 ' 100AHr is max capacity the CH200 will accept

    IMAGERATE_MIN = 60
    IMAGE2RATE_MIN = 60

    STARTIMAGEMID = 0 ' 0
    STOPIMAGEMID = 1439 ' 1439
    CAMERAMANCONTROL = "off"
    CAMERADEFROSTERMANCONTROL = "off"
    CAMERADEFROSTERMODE = "manual"
    CAMERADEFROSTERONMID = 710 ' 710  = 11:50
    CAMERADEFROSTEROFFMID = 720 ' 720 = noon

    STARTIMAGE2MID = 0 ' 0
    STOPIMAGE2MID = 1439 ' 1439
    CAMERA2MANCONTROL = "off"
    CAMERA2DEFROSTERMANCONTROL = "off"
    CAMERA2DEFROSTERMODE = "manual"
    CAMERA2DEFROSTERONMID = 710 ' 710  = 11:50
    CAMERA2DEFROSTEROFFMID = 720 ' 720 = noon

    Initialized = 1
  EndIf

  ''''''''''''''''''''''''''''''''''''''''''''''''
  '      CC5MPXWD Camera #1 Image Trigger       '
  ''''''''''''''''''''''''''''''''''''''''''''''''
  '   take an image every ImageRate_min between the Start and Stop times.
  If MinIntoDay > STARTIMAGEMID AND MinIntoDay < STOPIMAGEMID AND
IfTime(0,IMAGERATE_MIN,Min) Then
    PulsePort (4,20000) ' 20,000 uSec = 20mSec pulse to trigger
  EndIf
  ' OR take and image every time TakeImage is set to 1
  If TAKEIMAGE = 1 Then
    PulsePort (4,20000) ' 20,000 uSec = 20mSec pulse to trigger
    TAKEIMAGE = 0
  EndIf

  ''''''''''''''''''''''''''''''''''''''''''''''''
```

```
'      CC5MPXWD Camera #2  Image Trigger      '
''''''''''''''''''''''''''''''''''''''''''''''''''''
'    take an image every ImageRate_min between the Start and Stop times.
' The second image is taken 1 minute into the Image Rate period
If MinIntoDay > STARTIMAGEMID AND MinIntoDay < STOPIMAGEMID AND IfTime
(1,IMAGE2RATE_MIN,Min) Then
  PulsePort (6,20000) ' 20,000 uSec = 20mSec pulse to trigger
EndIf
' OR take and image every time TakeImage is set to 1
If TAKEIMAGE2 = 1 Then
  PulsePort (6,20000) ' 20,000 uSec = 20mSec pulse to trigger
  TAKEIMAGE2 = 0
EndIf

''''''''''''''''''''
'   Diagnostics   '
''''''''''''''''''''
'MEASURE DATALOGGER WIRING PANEL TEMPERATURE (deg C)
PanelTemp (LoggerTemp_C,250)
'''''''''''' MEASURE DATALOGGER BATTERY VOLTS (V)
Battery (BattVolts_V)

' Feature to enter specific battery capacity as a Public value and send to charger(s)
'Get additional values from CH200
SDI12Recorder (CH200_MX(),1,0,"M6!",1.0,0)
'If the present battery capacity isnot the  same as the new battery capacity, send the new one.
If BattCap <> NEWBATTCAP Then
  SDI12command = "XC" & FormatFloat (NEWBATTCAP, "%4.1f") & "!"
  SDI12Recorder (SDI12result,1,0,SDI12command,1.0,0)
EndIf

'CH200 CHARGE REGULATOR MEASUREMENTS
' Connected to Control Port 1
' We will use the defalut address of 0.
SDI12Recorder (CH200_M0(),1,0,"MC!",1.0,0)

' Compute running Power and daily running total AmpHours/Day values for each current
measurement.
LoadPwr_W = CH200BattVolts_V * LoadCrnt_A
ChargePwr_W = SolarPanel_V *SolarPanel_A
' Divide each 1 minute Amp sample by 1440 sample/day so that the total at the end of the day
is to get avg current for the day
' then muliply be 24 Hr/day to get AHr/Day. or divide by 60 because 24/1440 = 1/60
' Separate and sum each the positive and negative currents into and out of the battery to get the
total AHr in/out for the day.
' Sample hourly and daily, then zero at end of the day.
```

```
If BattCrnt_A > 0 Then DlyBatCrtIn_AHr = DlyBatCrtIn_AHr + BattCrnt_A/60
If BattCrnt_A < 0 Then DlyBatCrtOut_AHr = DlyBatCrtOut_AHr + BattCrnt_A/60

''''''''''''''''''''''''''''''''''''''''''''''''''''''
"     READ CSI SDI-12 CS450 water level/temp   "
''''''''''''''''''''''''''''''''''''''''''''''''''''''
' There are two CSI CS450 SDI-12 vented water level pressure transducers.
' Sensor 1 is connected to Control Port 5, Sensor 2 is connected to Control Port 7
' We will use the defalut address of 0.
SDI12Recorder (CS450Data1(),5,0,"C!",1.0,0)
SDI12Recorder (CS450Data2(),7,0,"C!",1.0,0)

' convert water heights in psi to cm (70.307 cm/psi)
WaterHt1_cm = WaterHt1_psi * 70.307
WaterHt2_cm = WaterHt2_psi * 70.307

'Convert Water Height in cm to ft. (0.0328 ft/cm)
WaterHt1_ft = WaterHt1_cm * 0.0328
WaterHt2_ft = WaterHt2_cm * 0.0328

''''''''''''''''''''''''''''''''''''''''''''''
'''    READ 109 Water Temp Probes    '''
''''''''''''''''''''''''''''''''''''''''''''''
Therm109 (WaterT_C(),5,12,Vx2,0,250,1.0,0)

''''''''''''''''''''''''''''''''''''''''''''
'''    READ Thermistors          '''
''''''''''''''''''''''''''''''''''''''''''''

'****************************************
"    READ AM16/32 #1 MULTIPLEXER     "
'****************************************

PortSet (2 ,1  )        'TURN ON AM16/32 #1 MULTIPLEXER, SET PORT 2 HIGH
i = 1                   'INITIALIZE INDEX INTERGER I TO ONE

SubScan (0,Sec,5)      'SCAN LOOP -- 5 ITERATIONS
  'ADVANCE AM16/32 #1 GROUP BY 1, PULSE PORT 2 (10 ms delay)
  PulsePort (3,10000)
  'MEASURE GWS THERMISTORS, (Voltage Ratio X = Rs/(Rs+Rf))
  BrHalf (therm(i),1,mV2500,1,Vx1,1,2500,True ,0,_60Hz,1.0,0)
  i = i + 1
  BrHalf (therm(i),1,mV2500,2,Vx1,1,2500,True ,0,_60Hz,1.0,0)
  i = i + 1
  BrHalf (therm(i),1,mV2500,3,Vx1,1,2500,True ,0,_60Hz,1.0,0)
```

```
  i = i + 1
 NextSubScan
 PortSet (2,0)        'TURN OFF AM16/32 #1 MULTIPLEXER, SET PORT 2 LOW

 'CONVERT MEASURED VOLTAGE RATIO TO RESISTANCE (kOHM) FOR 15 GWS
THERMISTORS
 For i=1 To 15
  Therm_kOhm(i) = Rf_1*therm(i)/(1-therm(i))
 Next i

 'CONVERT GWS THERMISTOR RESISTANCE TO deg C FOR 15 GWS THERMISTORS
 For i=1 To 15
  D(i) = LN (1000*Therm_kOhm(i))                   'ln resistance (ohm)
  TEMP_C(i) = (1/(a + b*D(i) + c*(D(i))^3)) - 273.15    'Steinhart & Hart Equation
 Next i

 ''''''''''''''''''''''''''''''''''''''''
 'Camera #1 control code:
 ''''''''''''''''''''''''''''''''''''''''
 ' The camera is turned Off at the top of the hour.
 If IfTime (0,60,Min) Then
  CAMERAMANCONTROL = "off"
  CAMERADEFROSTERMANCONTROL = "off"
  'Turn camera off
  PortSet (4,0)
 EndIf

 'Camera On control. Turning camera On will take photo.
 If CAMERAMANCONTROL = "on" Then
  PortSet (4,1 )
 EndIf
 'Turn camera Off if CameraManControl AND TurnDefrosterOn is false or off
 If CAMERAMANCONTROL = "off" AND TurnDefrosterOn = false Then
  PortSet (4 ,0 )
 EndIf

 '   Control CAMERA Defroster (aka Heat)
 'CameraDefrosterMode has two states, manual and auto.
 'If in manual, CameraDefrosterManControl turns the heat On.
 ' The camera's logic control turns the heat Off after 65 seconds unless turned back On.
 'Enter On or Off in CameraDefrosterManControl to turn heaters On or Off.
 'If in Auto, the heaters are turned on at CameraDefrosterOnMID and turned Off at
CameraDefrosterOffMID.
 ' MID stands for Minutes Into the Day.

 'The camera has its own heat control logic:
```

```
   ' If camera temp between 25 an 50C and CC5MPXDefroster value = not zero (usually 1), the
heat will be turned
   ' On, as one shot, for 65 seconds.  The camera turns the heater Off itself after 65 seconds.
   ' Because of this, the code below to turn the camera Off is not really used to turn the heat Off.
It is, however, used
   ' to TurnDefrosterOn to false therefore Not turning it On.
   ' Only when TurnDefroaterOn = true, is a value of 1 for TurnDefrosteVal sent to the camera to
turn On the camera and the heat.


   If CAMERADEFROSTERMODE = "manual" AND
CAMERADEFROSTERMANCONTROL = "off" Then
     TurnDefrosterOn = false
   EndIf

   If CAMERADEFROSTERMODE = "manual" AND
CAMERADEFROSTERMANCONTROL = "on" Then
     TurnDefrosterOn = true
   EndIf

   If CAMERADEFROSTERMODE = "auto" AND MinIntoDay >
CAMERADEFROSTERONMID AND MinIntoDay < CAMERADEFROSTEROFFMID Then
     TurnDefrosterOn = true
   EndIf

   If CAMERADEFROSTERMODE = "auto" AND MinIntoDay >
CAMERADEFROSTEROFFMID Then
     TurnDefrosterOn = false
   EndIf
   If CAMERADEFROSTERMODE = "auto" AND MinIntoDay <
CAMERADEFROSTERONMID Then
     TurnDefrosterOn = false
   EndIf

   'send string to turn On heat.  An image will be triggered.
   If TurnDefrosterOn = true Then
     'turn On camera
     PortSet (4,1 )
     'wait to let camera power up before sending string
     Delay (1,1200,mSec)
     TurnDefrosterVal = 1
     '      VVVVVVVVVVVVVVVVVVV Must have correct camera PakBus address here
VVVVVVVVVVVVVVVVVVVVVVVVV
     ' ComSDC8 is used to communicate through the MD485
     SendVariables
(SendVarResult,ComSDC8,0,521,0000,200,"Public","CC5MPXDefroster",TurnDefrosterVal,1)
```

```
   EndIf

   ''''''''''''''''''''''''''''''''''''
   'Camera #2 control code:
   '''''''''''''''''''''''''''''''''''''
   ' The camera is turned Off at the top of the hour.
   If IfTime (0,60,Min) Then
     CAMERA2MANCONTROL = "off"
     CAMERA2DEFROSTERMANCONTROL = "off"
     'Turn camera off
     PortSet (6,0)
   EndIf

   'Camera On control. Turning camera On will take photo.
   If CAMERA2MANCONTROL = "on" Then
     PortSet (6,1 )
   EndIf
   'Turn camera Off if CameraManControl AND TurnDefrosterOn is false or off
   If CAMERA2MANCONTROL = "off" AND TurnDefroster2On = false Then
     PortSet (6 ,0 )
   EndIf


   If CAMERA2DEFROSTERMODE = "manual" AND
CAMERA2DEFROSTERMANCONTROL = "off" Then
     TurnDefroster2On = false
   EndIf

   If CAMERA2DEFROSTERMODE = "manual" AND
CAMERA2DEFROSTERMANCONTROL = "on" Then
     TurnDefroster2On = true
   EndIf

   If CAMERA2DEFROSTERMODE = "auto" AND MinIntoDay >
CAMERA2DEFROSTERONMID AND MinIntoDay < CAMERA2DEFROSTEROFFMID
Then
     TurnDefroster2On = true
   EndIf

   If CAMERADEFROSTERMODE = "auto" AND MinIntoDay >
CAMERA2DEFROSTEROFFMID Then
     TurnDefroster2On = false
   EndIf
   If CAMERA2DEFROSTERMODE = "auto" AND MinIntoDay <
CAMERA2DEFROSTERONMID Then
     TurnDefroster2On = false
```

```
    EndIf

    'send string to turn On heat.  An image will be triggered.
    If TurnDefroster2On = true Then
      'turn On camera
      PortSet (6,1 )
      'wait to let camera power up before sending string
      Delay (1,1200,mSec)
      TurnDefroster2Val = 1
      '     VVVVVVVVVVVVVVVVVVVV Must have correct camera PakBus address here
VVVVVVVVVVVVVVVVVVVVVVVV
      ' ComSDC8 is used to communicate through the MD485
      SendVariables
(SendVarResult2,ComSDC8,0,522,0000,200,"Public","CC5MPXDefroster",TurnDefroster2Val,
1)
    EndIf

    CallTable QuarterHourlyWater
    CallTable HourlyDiag
    CallTable Hourly
    CallTable HrlySubs
    CallTable HrlyClimate
    CallTable HourlyRaw
    CallTable Daily

    If IfTime (0,1440,Min) Then
      DlyBatCrtIn_AHr = 0
      DlyBatCrtOut_AHr = 0
    EndIf

  NextScan
EndProg
```

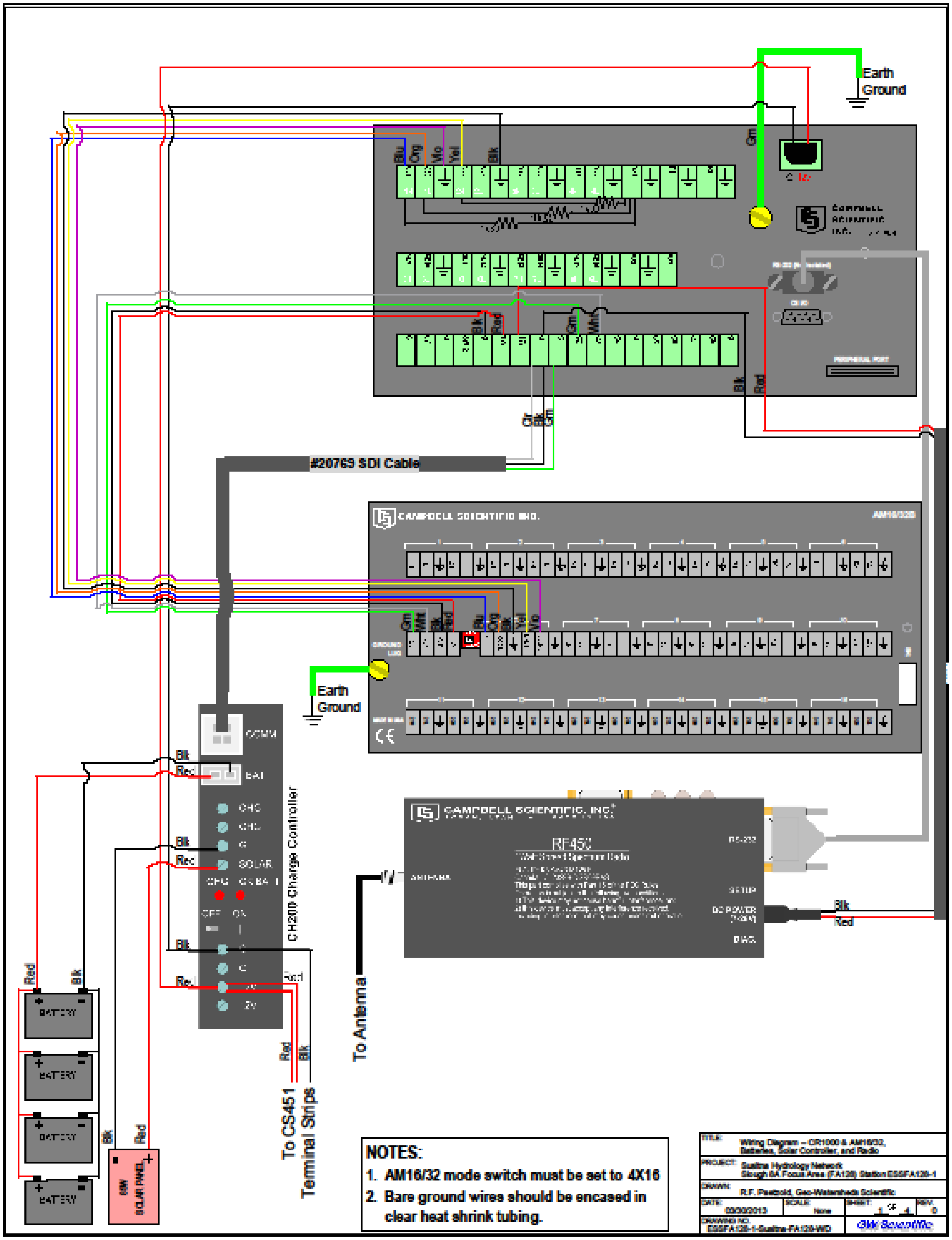

Figure C-2. ESSFA128-1 Sheet 1 (Data Logger, Power, Radio, Multiplexer).

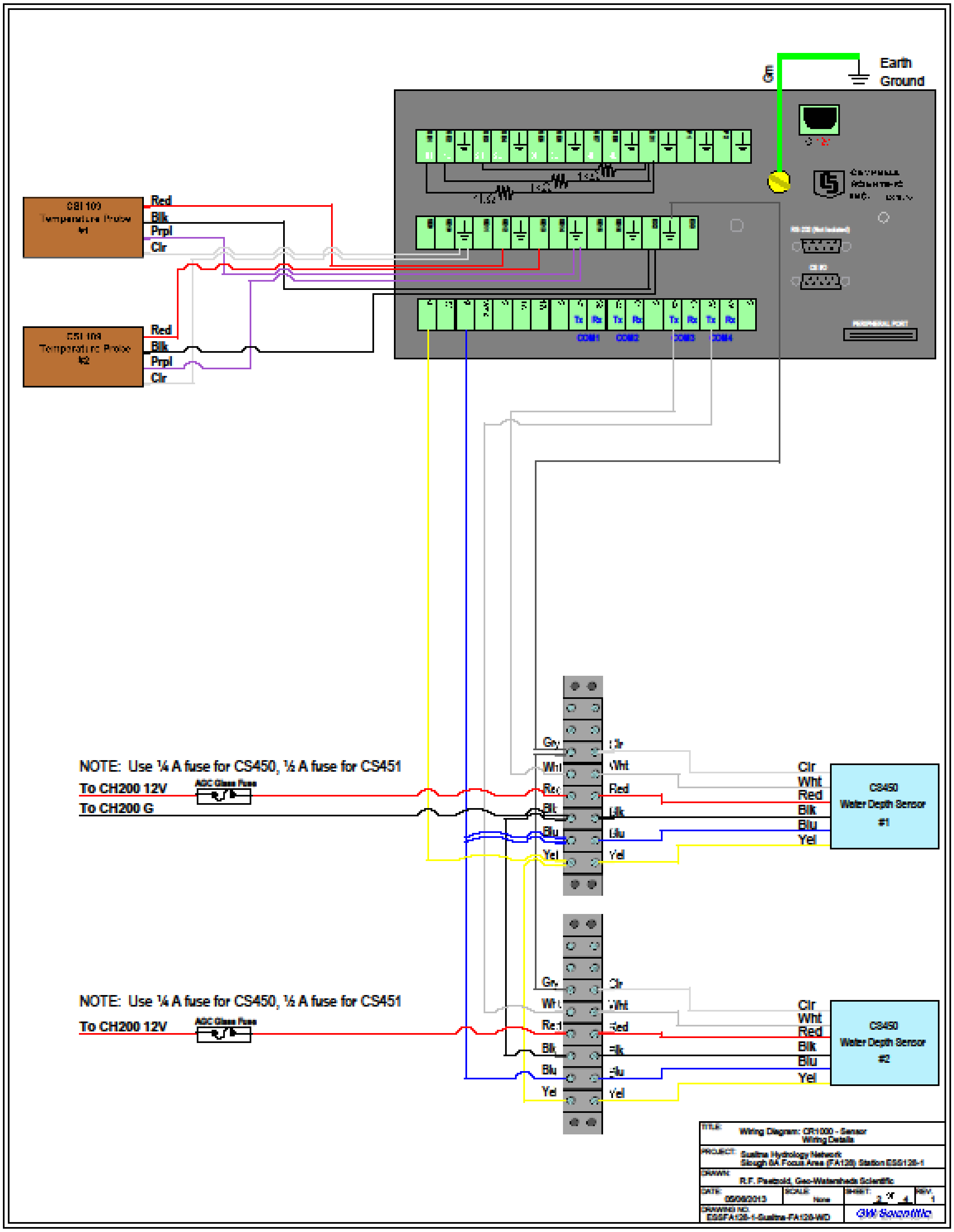

Figure C-3. ESSFA128-1 Sheet 2, rev. 1 (Data Logger, Sensors).

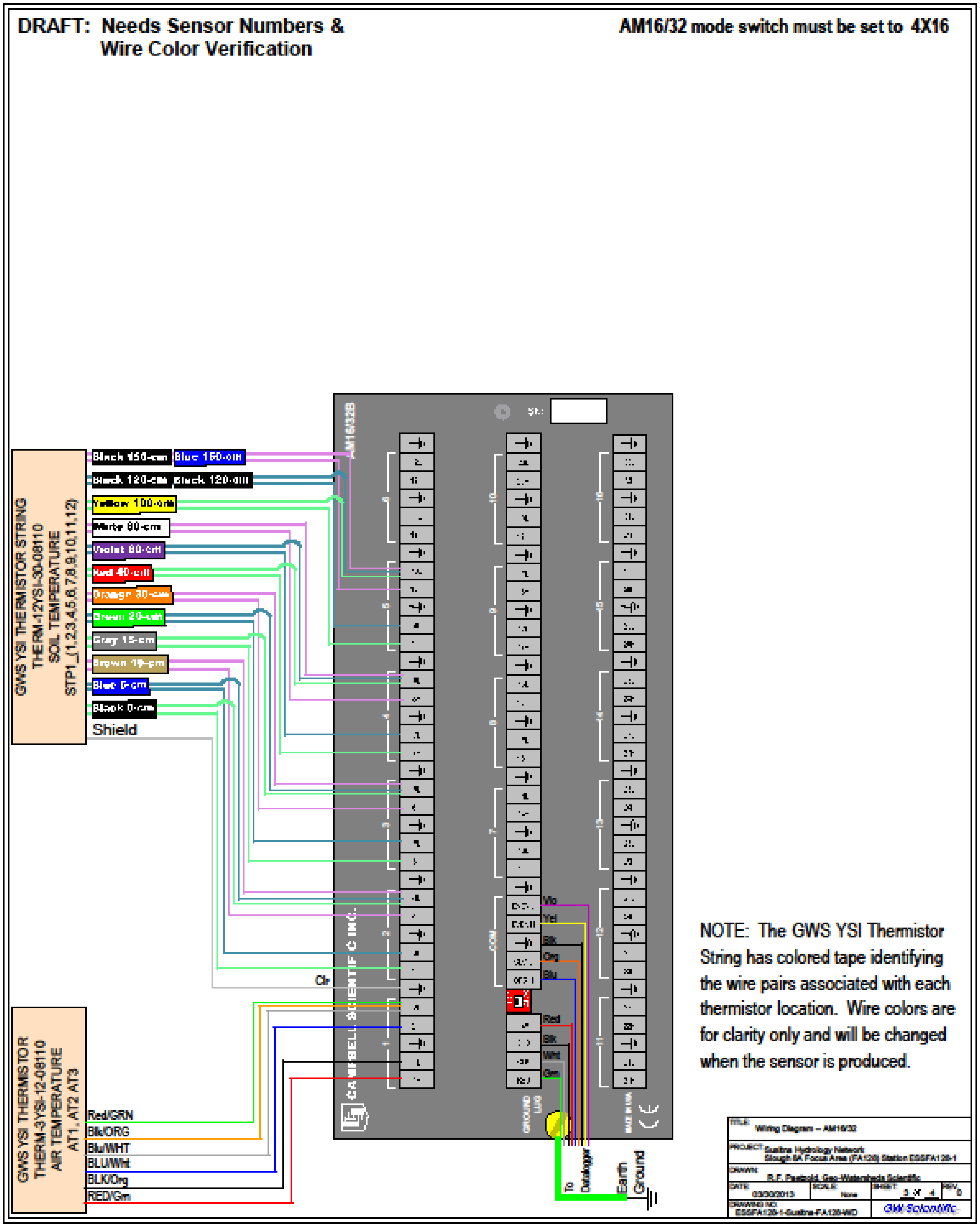

Figure C-4. ESSFA128-1 Sheet 3 (Multiplexer, Sensors).

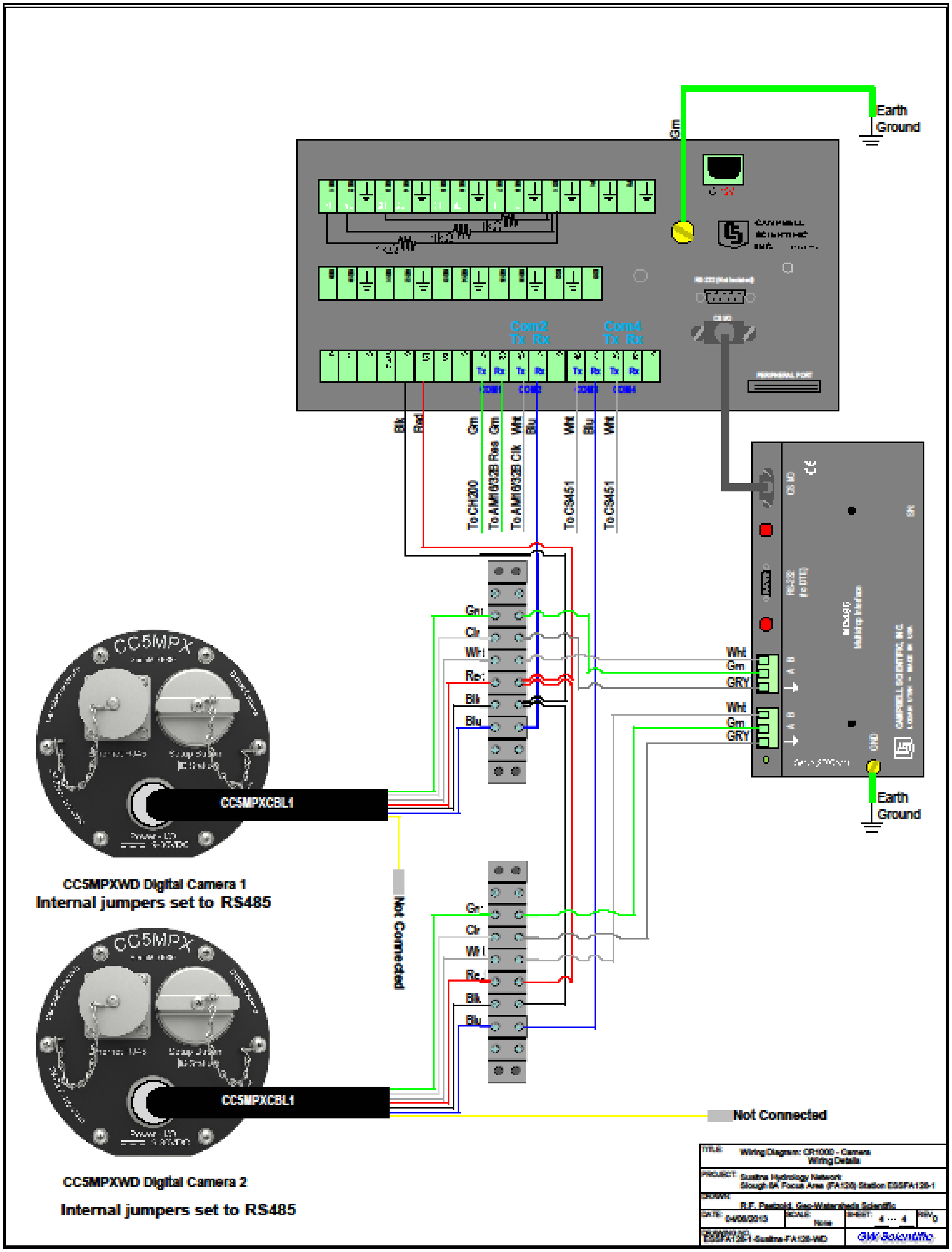

Figure C-5. ESSFA128-1 Sheet 4 (Data Logger, Cameras).

The following program and wiring diagrams depict FA-104 (Whiskers Slough) station ESMF104-2, representative of the meteorological (CSI CR1000) type station:

```
'CR1000 Series Datalogger

' Program name: ESMFA104-2_130904.cr1

'Modification Of: ESMFA104-2_130810.CR1
'Modified By: AMcHugh
'Date Modified: 08/10/13
'Modifications: Set WSpd2_ms = 0 if < 0.45

' Old mods:
'Modifications: Increase SM from 4 to 6. Changed temperature string depth names.
'Modifications: Fixed precip over count.

'Station Notes:
'	PakBus ID for Statino: 375		'INSERT PakBus ID HERE <==========
'	Station ID:	375		'INSERT Station ID HERE <==========
'	Time is set to AK Standard Time

''''''''''''''''''''''''''''''
'''' INDIVIDUAL STATION INPUTS ''''
''''''''''''''''''''''''''''''

'INSERT Station Name HERE:
StationName (ESMFA104-2)		'INSERT Station Name HERE
<=========================
'INSERT Station ID HERE:
Const ID = 375		'INSERT Station ID HERE
<=====================================
'NR Lite2 s/n 134704 sens 13.9 uV/W/m2  1000(mV/uV)/13.9(uV/W/m2) = 71.942 W/m2 / mV
Const NR = 71.942		'NR Lite2 calibration constant HERE
<=======================
' HFP01-15 s/n 8364 sens 61.15 uV/W/m2  1000/61.15 = 16.353
Const SHF = 16.353		' Hukseflux HFP calibration constant HERE
<===============

'FIXED RESISTOR VALUE FOR GWS THERMISTOR CIRCUITS
Const Rf = 1.0		'FIXED RESISTOR 1 (kOHM) HERE
'  For YSI thermistors -- conversion of kOHM to deg C
Const a = 0.0014654354
Const b = 0.0002386780
Const c = 0.0000001000
```

```
'DECLARE PUBLIC VARIABLES
PreserveVariables ' variables are maintained over reboot.

Public StationID ' Station ID number, USER INPUT
Public NR_CalCoef
Public SHF_CalCoef
Public BattVolts_V
Public LoggerTemp_C

Public DlyBatCrtIn_AHr, DlyBatCrtOut_AHr
Public LoadPwr_W, ChargePwr_W

Public CH200_M0(9)  'Array to hold all data from CH200

Public CH200_MX(4)  ' Array to hold extended data from CH200
Alias CH200_MX(1) = BattTargV ' Battery charging target voltage
Alias CH200_MX(2) = DgtlPotSet ' Digital potentiometer setting
Alias CH200_MX(3) = BattCap ' Present battery capacity
Alias CH200_MX(4) = Qloss ' Battery charge deficit

' SDI-12 formatted battery capacity value
Public SDI12command As String
' Response from CH200. Retrns the address of the unit and "ok" if all went well
Public SDI12result As String
Public NEWBATTCAP ' the new battery capacticty if you need to change it.

Public AirTemp_C, RH, DewPoint_C, AirTemp_F
Public PT1Data(2)     'Water Level Sensor 1 - pressure, temperature
Public WaterHt1_cm, WaterHt1_ft        ' Water level above the probe

Public SMAData(6),SMBData(6),SMCData(6),SMDData(6),SMEData(6),SMFData(6)
Public BaroPrNC_mB
Public Rain_mm
Public WSpd_ms, WDir, WSpd_mph
Public WSpd2_ms
Public WindChill_C, WindChill_F
Public VPdef_kPa, VPsat_kPa, VPact_kPa 'kPa

Public SolRad_W_m2
Public NetRad_mV, NetRad_W_m2, NetRadWindCorr_W_m2
Public SHF_W_m2, SHF_mV

Public Therm_kOhm(15), Temp_C(15)
Dim therm(15),D(15),i,j

Dim Initialized
```

```
Dim TwoMinWind

Alias SMAData(1) = SM_A_VV
Alias SMAData(2) = SM_A_EC_dS_m
Alias SMAData(3) = SM_A_T_C
Alias SMAData(4) = SM_A_Perm
Alias SMAData(5) = SM_A_Per_uS
Alias SMAData(6) = SM_A_VR

Alias SMBData(1) = SM_B_VV
Alias SMBData(2) = SM_B_EC_dS_m
Alias SMBData(3) = SM_B_T_C
Alias SMBData(4) = SM_B_Perm
Alias SMBData(5) = SM_B_Per_uS
Alias SMBData(6) = SM_B_VR

Alias SMCData(1) = SM_C_VV
Alias SMCData(2) = SM_C_EC_dS_m
Alias SMCData(3) = SM_C_T_C
Alias SMCData(4) = SM_C_Perm
Alias SMCData(5) = SM_C_Per_uS
Alias SMCData(6) = SM_C_VR

Alias SMDData(1) = SM_D_VV
Alias SMDData(2) = SM_D_EC_dS_m
Alias SMDData(3) = SM_D_T_C
Alias SMDData(4) = SM_D_Perm
Alias SMDData(5) = SM_D_Per_uS
Alias SMDData(6) = SM_D_VR

Alias SMEData(1) = SM_E_VV
Alias SMEData(2) = SM_E_EC_dS_m
Alias SMEData(3) = SM_E_T_C
Alias SMEData(4) = SM_E_Perm
Alias SMEData(5) = SM_E_Per_uS
Alias SMEData(6) = SM_E_VR

Alias SMFData(1) = SM_F_VV
Alias SMFData(2) = SM_F_EC_dS_m
Alias SMFData(3) = SM_F_T_C
Alias SMFData(4) = SM_F_Perm
Alias SMFData(5) = SM_F_Per_uS
Alias SMFData(6) = SM_F_VR

Alias PT1Data(1) = WaterHt1_psi
Alias PT1Data(2) = WaterT1_C
```

```
Alias CH200_M0(1)=CH200BattVolts_V       'Battery voltage: VDC
Alias CH200_M0(2)=BattCrnt_A       'Current going into, or out of, the battery: Amps
Alias CH200_M0(3)=LoadCrnt_A       'Current going to the load: Amps
Alias CH200_M0(4)=SolarPanel_V      'Voltage coming into the charger: VDC
Alias CH200_M0(5)=SolarPanel_A      'Current coming into the charger: Amps
Alias CH200_M0(6)=Chgr_Tmp_C        'Charger temperature: Celsius
Alias CH200_M0(7)=Chgr_State       'Charging state: 2=Cycle, 3=Float, 1=Current Limited, or
0=None
Alias CH200_M0(8)=Chgr_Source       'Charging source: 0=None, 1=Solar, or 2=AC
Alias CH200_M0(9)=Ck_Batt         'Check battery error: 0=normal, 1=check battery

Alias Temp_C(1) = AirT_YSI1_C
Alias Temp_C(2) = AirT_YSI2_C
Alias Temp_C(3) = AirT_YSI3_C

Alias Temp_C(4) = SoilT_5cm_C
Alias Temp_C(5) = SoilT_10cm_C
Alias Temp_C(6) = SoilT_15cm_C
Alias Temp_C(7) = SoilT_20cm_C
Alias Temp_C(8) = SoilT_30cm_C
Alias Temp_C(9) = SoilT_40cm_C
Alias Temp_C(10) = SoilT_50cm_C
Alias Temp_C(11) = SoilT_60cm_C
Alias Temp_C(12) = SoilT_80cm_C
Alias Temp_C(13) = SoilT_100cm_C
Alias Temp_C(14) = SoilT_120cm_C
Alias Temp_C(15) = SoilT_150cm_C

'Hourly Diagonostics Table
DataTable (HourlyDiag,1,-1)
  DataInterval (0,60,Min,0)
  Sample (1,StationID,fp2)

  'BATTERY VOLTS (V)
  Sample (1,BattVolts_V,FP2)
  Average (1,BattVolts_V,FP2,False)
  Maximum (1,BattVolts_V,FP2,False,False)
  Minimum (1,BattVolts_V,FP2,False,False)

  'BATTERY CURRENT (A)
  Sample (1,CH200_M0(2),FP2)
  Average (1,CH200_M0(2),FP2,False)
  Maximum (1,CH200_M0(2),FP2,False,False)
  Minimum (1,CH200_M0(2),FP2,False,False)
```

```
  'LOAD CURRENT (A)
  Sample (1,CH200_M0(3),FP2)
  Average (1,CH200_M0(3),FP2,False)
  Maximum (1,CH200_M0(3),FP2,False,False)
  Minimum (1,CH200_M0(3),FP2,False,False)

  'SOLAR PANEL VOLTS (V)
  Sample (1,CH200_M0(4),FP2)
  Average (1,CH200_M0(4),FP2,False)
  Maximum (1,CH200_M0(4),FP2,False,False)
  Minimum (1,CH200_M0(4),FP2,False,False)

  'SOLAR PANEL CURRENT (A)
  Sample (1,CH200_M0(5),FP2)
  Average (1,CH200_M0(5),FP2,False)
  Maximum (1,CH200_M0(5),FP2,False,False)
  Minimum (1,CH200_M0(5),FP2,False,False)

  Average (1,LoggerTemp_C,FP2,False)     'Logger Temperature (deg C)
  Average (1,CH200_M0(6),FP2,False)      'Charge Regulator Temperature (deg C)

  Sample (1,NEWBATTCAP,FP2)
  Sample (1,BattCap,FP2)

  Sample (1,DlyBatCrtIn_AHr,FP2)
  Sample (1,DlyBatCrtOut_AHr,FP2)

  Average (1,ChargePwr_W,FP2,False)
  Maximum (1,ChargePwr_W,FP2,False,False)
  Minimum (1,ChargePwr_W,FP2,False,False)

  Average (1,LoadPwr_W,FP2,False)
  Maximum (1,LoadPwr_W,FP2,False,False)
  Minimum (1,LoadPwr_W,FP2,False,False)

  ' Charger state
  Sample (1,CH200_M0(7),FP2)
EndTable

'Hourly Meteorological Measurements Table
DataTable (Hourly,1,-1)
  DataInterval (0,60,Min,0)
  Sample (1,StationID,fp2)

  Sample (3,AirT_YSI1_C,FP2)
  Average (3,AirT_YSI1_C,FP2,False)
```

```
Maximum (3,AirT_YSI1_C,FP2,False,False)
Minimum (3,AirT_YSI1_C,FP2,False,False)

Sample (1,AirTemp_C,FP2)
Average (1,AirTemp_C,FP2,False)
Maximum (1,AirTemp_C,FP2,False,False)
Minimum (1,AirTemp_C,FP2,False,False)

Sample (1,RH,FP2)
Average (1,RH,FP2,False)
Maximum (1,RH,FP2,False,False)
Minimum (1,RH,FP2,False,False)

Sample (1,DewPoint_C,FP2)
Average (1,DewPoint_C,FP2,False)
Maximum (1,DewPoint_C,FP2,False,False)
Minimum (1,DewPoint_C,FP2,False,False)

Sample (1,VPact_kPa,FP2)
Average (1,VPact_kPa,FP2,False)
Maximum (1,VPact_kPa,FP2,False,False)
Minimum (1,VPact_kPa,FP2,False,False)

Sample (1,VPsat_kPa,FP2)
Average (1,VPsat_kPa,FP2,False)
Maximum (1,VPsat_kPa,FP2,False,False)
Minimum (1,VPsat_kPa,FP2,False,False)

Sample (1,VPdef_kPa,FP2)
Average (1,VPdef_kPa,FP2,False)
Maximum (1,VPdef_kPa,FP2,False,False)
Minimum (1,VPdef_kPa,FP2,False,False)

Sample (1,WSpd_ms,FP2)
Sample (1,WDir,FP2)
WindVector (1,WSpd_ms,WDir,FP2,False,0,0,0)
Maximum (1,WSpd_ms,FP2,False,False)

Sample (1,WSpd2_ms,FP2)
Average (1,WSpd2_ms,FP2,False)
Maximum (1,WSpd2_ms,FP2,False,False)

Sample (1,WindChill_C,FP2)
Average (1,WindChill_C,FP2,False)
Maximum (1,WindChill_C,FP2,False,False)
Minimum (1,WindChill_C,FP2,False,False)
```

```
  Sample (1,SolRad_W_m2,FP2)
  Average (1,SolRad_W_m2,FP2,False)

  Sample (1,NetRad_W_m2,FP2)
  Average (1,NetRad_W_m2,FP2,False)

  Sample (1,NetRadWindCorr_W_m2,FP2)
  Average (1,NetRadWindCorr_W_m2,FP2,False)

  Totalize (1,Rain_mm,FP2,False)

  Sample (1,BaroPrNC_mB,FP2)
EndTable

'15-Min Meteorological Measurements Table
DataTable (QuarterHrlyMet,1,-1)
  DataInterval (0,15,Min,0)
  Sample (1,StationID,fp2)

  Sample (3,AirT_YSI1_C,FP2)
  Average (3,AirT_YSI1_C,FP2,False)
  Maximum (3,AirT_YSI1_C,FP2,False,False)
  Minimum (3,AirT_YSI1_C,FP2,False,False)

  Sample (1,AirTemp_C,FP2)
  Average (1,AirTemp_C,FP2,False)
  Maximum (1,AirTemp_C,FP2,False,False)
  Minimum (1,AirTemp_C,FP2,False,False)

  Sample (1,RH,FP2)
  Average (1,RH,FP2,False)
  Maximum (1,RH,FP2,False,False)
  Minimum (1,RH,FP2,False,False)

  Sample (1,DewPoint_C,FP2)
  Average (1,DewPoint_C,FP2,False)
  Maximum (1,DewPoint_C,FP2,False,False)
  Minimum (1,DewPoint_C,FP2,False,False)

  Sample (1,VPact_kPa,FP2)
  Average (1,VPact_kPa,FP2,False)
  Maximum (1,VPact_kPa,FP2,False,False)
  Minimum (1,VPact_kPa,FP2,False,False)

  Sample (1,VPsat_kPa,FP2)
```

```
  Average (1,VPsat_kPa,FP2,False)
  Maximum (1,VPsat_kPa,FP2,False,False)
  Minimum (1,VPsat_kPa,FP2,False,False)

  Sample (1,VPdef_kPa,FP2)
  Average (1,VPdef_kPa,FP2,False)
  Maximum (1,VPdef_kPa,FP2,False,False)
  Minimum (1,VPdef_kPa,FP2,False,False)

  Sample (1,WSpd_ms,FP2)
  Sample (1,WDir,FP2)
  WindVector (1,WSpd_ms,WDir,FP2,False,0,0,0)
  Maximum (1,WSpd_ms,FP2,False,False)

  Sample (1,WSpd2_ms,FP2)
  Average (1,WSpd2_ms,FP2,False)
  Maximum (1,WSpd2_ms,FP2,False,False)

  Sample (1,WindChill_C,FP2)
  Average (1,WindChill_C,FP2,False)
  Maximum (1,WindChill_C,FP2,False,False)
  Minimum (1,WindChill_C,FP2,False,False)

  Sample (1,SolRad_W_m2,FP2)
  Average (1,SolRad_W_m2,FP2,False)

  Sample (1,NetRad_W_m2,FP2)
  Average (1,NetRad_W_m2,FP2,False)

  Sample (1,NetRadWindCorr_W_m2,FP2)
  Average (1,NetRadWindCorr_W_m2,FP2,False)

  Totalize (1,Rain_mm,FP2,False)

  Sample (1,BaroPrNC_mB,FP2)
EndTable

'2-min Wind Table
DataTable (TwoMinWd,1,1440)
  DataInterval (0,2,Min,0)
  Sample (1,StationID,fp2)

  WindVector (1,WSpd_ms,WDir,FP2,False,0,0,0)
  Maximum (1,WSpd_ms,FP2,False,False)

  Average (1,WSpd2_ms,FP2,False)
```

```
  Maximum (1,WSpd2_ms,FP2,False,False)
EndTable

'15-minute Water Ttable
DataTable (QuarterHourlyWater,1,-1)
  DataInterval(0,15,Min,0)
  Sample (1,StationID,fp2)

  Sample (1,WaterHt1_cm,FP2)
  Average (1,WaterHt1_cm,FP2,False)
  Maximum (1,WaterHt1_cm,FP2,False,False)
  Minimum (1,WaterHt1_cm,FP2,False,False)

  Sample (1,WaterHt1_ft,FP2)
  Average (1,WaterHt1_ft,FP2,False)
  Maximum (1,WaterHt1_ft,FP2,False,False)
  Minimum (1,WaterHt1_ft,FP2,False,False)

  Sample (1,WaterT1_C,FP2)
  Average (1,WaterT1_C,FP2,False)
  Maximum (1,WaterT1_C,FP2,False,False)
  Minimum (1,WaterT1_C,FP2,False,False)

  Sample (1,WaterHt1_psi,FP2)
  Average (1,WaterHt1_psi,FP2,False)
  Maximum (1,WaterHt1_psi,FP2,False,False)
  Minimum (1,WaterHt1_psi,FP2,False,False)
EndTable

' Hourly Raw Table
DataTable (HourlyRaw,1,-1)
  DataInterval(0,60,Min,0)
  Sample (1,StationID,fp2)

  Sample (1,NR_CalCoef,FP2)
  Sample (1,SHF_CalCoef,FP2)

  Sample (15,Therm_kOhm(),FP2)
  Average (15,Therm_kOhm(),FP2,False)

  Sample (6,SM_A_Per_uS,FP2)
  Average (6,SM_A_Per_uS,FP2,False)

  Sample (1,SHF_mV,FP2)
  Average (1,SHF_mV,FP2,False)
EndTable
```

```
'Daily Output Table
DataTable (Daily,1,-1)
  DataInterval(0,1440,Min,0)
  Sample (1,StationID,fp2)

  Average (3,AirT_YSI1_C,FP2,False)
  Maximum (3,AirT_YSI1_C,FP2,False,False)
  Minimum (3,AirT_YSI1_C,FP2,False,False)

  Average (1,AirTemp_C,FP2,False)
  Maximum (1,AirTemp_C,FP2,False,False)
  Minimum (1,AirTemp_C,,FP2,False,False)

  Maximum (1,RH,FP2,False,False)
  Minimum (1,RH,FP2,False,False)

  Maximum (1,DewPoint_C,FP2,False,False)
  Minimum (1,DewPoint_C,,FP2,False,False)

  Maximum (1,VPact_kPa,FP2,False,False)
  Minimum (1,VPact_kPa,,FP2,False,False)

  Maximum (1,VPsat_kPa,FP2,False,False)
  Minimum (1,VPsat_kPa,,FP2,False,False)

  Maximum (1,VPdef_kPa,FP2,False,False)
  Minimum (1,VPdef_kPa,,FP2,False,False)

  WindVector (1,WSpd_ms,WDir,FP2,False,0,0,0)
  Maximum (1,WSpd_ms,FP2,False,False)

  Average (1,WSpd2_ms,FP2,False)
  Maximum (1,WSpd2_ms,FP2,False,False)

  Maximum (1,WindChill_C,FP2,False,False)
  Minimum (1,WindChill_C,,FP2,False,False)

  Average (1,SolRad_W_m2,FP2,False)

  Average (1,NetRad_W_m2,FP2,False)
  Average (1,NetRadWindCorr_W_m2,FP2,False)

  Totalize (1,Rain_mm,FP2,False)

  Average (1,SM_A_VV,FP2,False)
  Average (1,SM_B_VV,FP2,False)
```

```
  Average (1,SM_C_VV,FP2,False)
  Average (1,SM_D_VV,FP2,False)
  Average (1,SM_E_VV,FP2,False)
  Average (1,SM_F_VV,FP2,False)

  Average (1,SM_A_T_C,FP2,False)
  Average (1,SM_B_T_C,FP2,False)
  Average (1,SM_C_T_C,FP2,False)
  Average (1,SM_D_T_C,FP2,False)
  Average (1,SM_E_T_C,FP2,False)
  Average (1,SM_F_T_C,FP2,False)

  Average (1,SM_A_EC_dS_m,FP2,False)
  Average (1,SM_B_EC_dS_m,FP2,False)
  Average (1,SM_C_EC_dS_m,FP2,False)
  Average (1,SM_D_EC_dS_m,FP2,False)
  Average (1,SM_E_EC_dS_m,FP2,False)
  Average (1,SM_F_EC_dS_m,FP2,False)

  Average (12,SoilT_5cm_C,FP2,False)

  Average (1,SHF_W_m2,FP2,False)

  Average (1,WaterHt1_cm,FP2,False)
  Maximum (1,WaterHt1_cm,FP2,False,False)
  Minimum (1,WaterHt1_cm,FP2,False,False)

  Average (1,WaterHt1_ft,FP2,False)
  Maximum (1,WaterHt1_ft,FP2,False,False)
  Minimum (1,WaterHt1_ft,FP2,False,False)

  Average (1,WaterT1_C,FP2,False)
  Maximum (1,WaterT1_C,FP2,False,False)
  Minimum (1,WaterT1_C,FP2,False,False)

  Average (1,WaterHt1_psi,FP2,False)
  Maximum (1,WaterHt1_psi,FP2,False,False)
  Minimum (1,WaterHt1_psi,FP2,False,False)
EndTable


'Hourly Climate Table (for Current Conditions Table on Web)
' Size limited to 96 data values or 4 days worth.
DataTable (HrlyClimate,1,96)
  DataInterval (0,60,Min,0)
  Sample (1,StationID,fp2)
```

```
  Sample (3,AirT_YSI1_C,FP2)
  Sample (1,AirTemp_C,FP2)
  Sample (1,WaterHt1_cm,FP2)
  Sample (1,WaterHt1_ft,FP2)
  Sample (1,WaterT1_C,FP2)
  Sample (1,WaterHt1_psi,FP2)
  Sample (1,RH,FP2)
  Sample (1,DewPoint_C,FP2)
  Sample (1,WSpd_ms,FP2)
  Sample (1,WDir,FP2)
  Sample (1,WSpd2_ms,FP2)
  Sample (1,WindChill_C,FP2)
  Sample (1,SolRad_W_m2,FP2)
  Sample (1,NetRad_W_m2,FP2)
  Sample (1,NetRadWindCorr_W_m2,FP2)
  Totalize (1,Rain_mm,FP2,False)

  Sample (1,SM_A_VV,FP2)
  Sample (1,SM_B_VV,FP2)
  Sample (1,SM_C_VV,FP2)
  Sample (1,SM_D_VV,FP2)
  Sample (1,SM_E_VV,FP2)
  Sample (1,SM_F_VV,FP2)

  Sample (1,SM_A_T_C,FP2)
  Sample (1,SM_B_T_C,FP2)
  Sample (1,SM_C_T_C,FP2)
  Sample (1,SM_D_T_C,FP2)
  Sample (1,SM_E_T_C,FP2)
  Sample (1,SM_F_T_C,FP2)

  Sample (1,SM_A_EC_dS_m,FP2)
  Sample (1,SM_B_EC_dS_m,FP2)
  Sample (1,SM_C_EC_dS_m,FP2)
  Sample (1,SM_D_EC_dS_m,FP2)
  Sample (1,SM_E_EC_dS_m,FP2)
  Sample (1,SM_F_EC_dS_m,FP2)

  Sample (12,SoilT_5cm_C,FP2)

  Sample (1,SHF_W_m2,FP2)
  Sample (1,BaroPrNC_mB,FP2)
EndTable


'Hourly Sub Surface Table
```

```
DataTable (HourlySubs,1,-1)
  DataInterval (0,60,Min,0)
  Sample (1,StationID,fp2)

  Sample (1,SM_A_VV,FP2)
  Sample (1,SM_B_VV,FP2)
  Sample (1,SM_C_VV,FP2)
  Sample (1,SM_D_VV,FP2)
  Sample (1,SM_E_VV,FP2)
  Sample (1,SM_F_VV,FP2)

  Sample (1,SM_A_T_C,FP2)
  Sample (1,SM_B_T_C,FP2)
  Sample (1,SM_C_T_C,FP2)
  Sample (1,SM_D_T_C,FP2)
  Sample (1,SM_E_T_C,FP2)
  Sample (1,SM_F_T_C,FP2)

  Sample (1,SM_A_EC_dS_m,FP2)
  Sample (1,SM_B_EC_dS_m,FP2)
  Sample (1,SM_C_EC_dS_m,FP2)
  Sample (1,SM_D_EC_dS_m,FP2)
  Sample (1,SM_E_EC_dS_m,FP2)
  Sample (1,SM_F_EC_dS_m,FP2)

  Sample (12,SoilT_5cm_C,FP2)
  Average (12,SoilT_5cm_C,FP2,False)

  Sample (1,SHF_W_m2,FP2)
EndTable


''''''''''''''''''''''
"" MAIN PROGRAM ""
''''''''''''''''''''''

'SCAN (EXECUTE) PROGRAM AT 5-SEC INTERVALS
BeginProg
  'Three-second scan interval
  Scan (3,Sec,0,0)

    """ Set Station ID """
    StationID = ID
    NR_CalCoef = NR
    SHF_CalCoef = SHF
```

```
' initialize the default (power up) conditions
If Initialized = 0 Then
  Initialized = 1
  NEWBATTCAP = 12 ' 100AHr is max capacity the CH200 will accept
EndIf

''''  READ RM YOUNG 05106 WIND MONITOR  ''''
PulseCount (WSpd_ms,1,1,1,1,.098,0)                    'Wind Speed (m/s)
BrHalf(WDir,1,mV2500,8,Vx3,1,2500,true,200,250,355,0)       'Wind Direction (deg)

'''''' Read 014A Wind Speed sensor in m/s ''''''''
' M = 0.800 for m/s; O = 0.447
PulseCount (WSpd2_ms,1,2,2,1,0.800,0.447)

If WSpd2_ms < 0.45 Then
  WSpd2_ms =0
EndIf

''''''     Measure TE525MM Precip Gage  in mm to C4, Other lead to 5V.
PulseCount (Rain_mm,1,14,2,0,0.1,0)


'Begin 60-sec Loop
If IfTime (0,60,Sec) Then

  ''''''''''' MEASURE DATALOGGER WIRING PANEL TEMPERATURE (deg C)
  PanelTemp (LoggerTemp_C,250)

  ''''''''''' MEASURE DATALOGGER BATTERY VOLTS (V)
  Battery (BattVolts_V)

  ' Feature to enter specific battery capacity as a Public value and send to charger(s)
  'Get additional values from CH200
  SDI12Recorder (CH200_MX(),1,0,"M6!",1.0,0)
  'If the present battery capacity isnot the  same as the new battery capacity, send the new one.
  If BattCap <> NEWBATTCAP Then
    SDI12command = "XC" & FormatFloat (NEWBATTCAP, "%4.1f") & "!"
    SDI12Recorder (SDI12result,1,0,SDI12command,1.0,0)
  EndIf

  '''''''''''' CH200 CHARGE REGULATOR MEASUREMENTS
  SDI12Recorder (CH200_M0(),1,0,"MC!",1.0,0)

  ' Compute running Power and daily running total AmpHours/Day values for each current measurement.
  LoadPwr_W = CH200BattVolts_V * LoadCrnt_A
```

```
ChargePwr_W = SolarPanel_V *SolarPanel_A
' Divide each 1 minute Amp sample by 1440 sample/day so that the total at the end of the day is to get avg current for the day
' then muliply be 24 Hr/day to get AHr/Day. or divide by 60 because 24/1440 = 1/60
' Separate and sum each the positive and negative currents into and out of the battery to get the total AHr in/out for the day.
' Sample hourly and daily, then zero at end of the day.

If BattCrnt_A > 0 Then DlyBatCrtIn_AHr = DlyBatCrtIn_AHr + BattCrnt_A/60
If BattCrnt_A < 0 Then DlyBatCrtOut_AHr = DlyBatCrtOut_AHr + BattCrnt_A/60

''''''''    READ INW or CSI SDI-12 Pressure Transducer
SDI12Recorder (PT1Data(),5,1,"M!",1.0,0)
' convert water heights in psi to cm (70.307 cm/psi)
WaterHt1_cm = WaterHt1_psi * 70.307
'Convert Water Height in cm to ft. (0.0328 ft/cm)
WaterHt1_ft = WaterHt1_cm * 0.0328

'''''''' Read 4 CS650 Soil Moisuture probes.
SDI12Recorder (SMAData(),5,"A","M3!",1.0,0)
SDI12Recorder (SMBData(),5,"B","M3!",1.0,0)
SDI12Recorder (SMCData(),5,"C","M3!",1.0,0)
SDI12Recorder (SMDData(),5,"D","M3!",1.0,0)
SDI12Recorder (SMEData(),5,"E","M3!",1.0,0)
SDI12Recorder (SMFData(),5,"F","M3!",1.0,0)

''''''''''    Measure Net Radiation  NR Lite in W/m2
VoltDiff(NetRad_mV,1,mv25,5,True,0,_60Hz,1,0)
NetRad_W_m2 = NetRad_mV * NR_CalCoef
' Correct for wind if more than 5 m/s
If WSpd_ms >=5 Then
  NetRadWindCorr_W_m2 = NetRad_W_m2 *(1+0.021286*(WSpd_ms-5))
Else
  NetRadWindCorr_W_m2 = NetRad_W_m2
EndIf

'''''''''' Measure Hukseflux Heat Flux Plate
VoltDiff (SHF_mV,1,mV7_5,6,True ,0,_60Hz,1.0,0)
SHF_W_m2 = SHF_mV * SHF_CalCoef

''''''  READ HC2S3 AIR TEMPERATURE/RELATIVE HUMIDITY SENSOR
' HC2S3 Air T/RH sensor ON always to 12V.
'Read Air Temperature Sensor; Single-End Measurement
VoltSe (AirTemp_C,1,mV2500,4,0,0,_60Hz,0.1,-40)
'Read Relative Humidity Sensor; Single-End Measurement
VoltSe (RH,1,mV2500,7,0,0,_60Hz,0.1,0)
```

```
    'Correction for sensor inaccuracy when RH near 100%
    If RH>100 AND RH<103 Then RH=100
    'Calculate Dew Point from Measured Air Temperature and Relative Humidity
    DewPoint (DewPoint_C,AirTemp_C,RH)

    '''''''  Calculate Wind Chill  '''''''
    'From page 180 of the 2006 Alaska Safety Handbook (BP Exploration (Alaska) Inc.,
ConocoPhillips Alaska)
    'Wind Chill (°F) = 35.74 + 0.6215T - 35.75 (V^0.16 ) + 0.4275T(V^0.16 )
    '    Where, T=Air Temperature (°F)   V=Wind Speed (mph)
    'Air temperaute is measured every execution interval wind chill is computed every exection
interval with the current wind speed and previous
    ' the equation only applies if ws is >= 3 mph and air temp is <= 50 F then apply the equation,
other wise WindChill temp remains Air Temp.

    AirTemp_F = AirTemp_C * (9/5) + 32
    WSpd_mph = WSpd_ms * 2.2369363
    ' set wind chill temp to air temp
    WindChill_F = AirTemp_F
    WindChill_F = 35.74 + 0.6215 * AirTemp_F - 35.75 * (WSpd_mph^0.16) + 0.4275 *
AirTemp_F * (WSpd_mph^0.16)
    WindChill_C = (WindChill_F - 32) * 5/9   'Added 05/08/08 RFP

    If WSpd_mph < 3 OR AirTemp_F > 50 Then WindChill_F = AirTemp_F
    If WSpd_mph < 3 OR AirTemp_F > 50 Then WindChill_C = AirTemp_C

    ''''''' Read Solar Radiation - LI200X Pyranometer; Output units are W/m2
    VoltDiff (SolRad_W_m2,1,mV7_5,3,True ,0,_60Hz,200,0)

    '''''''''' Compute Saturated, Actual and Deficit Vapor Pressure
    SatVP (VPsat_kPa,AirTemp_C)
    VaporPressure (VPact_kPa,AirTemp_C,RH)
    VPdef_kPa = VPsat_kPa - VPact_kPa

'***********************************************************************
    ''    READ AM16/32 #1 MULTIPLEXER      Every 1 minute      ''

'***********************************************************************

    PortSet (2,1 )         'TURN ON AM16/32 #1 MULTIPLEXER, SET PORT 2 HIGH
    i = 1                  'INITIALIZE INDEX INTERGER I TO ONE
    'READ 36 GWS THERMISTORS
    SubScan (0,Sec,5)      'SCAN LOOP -- 5 ITERATIONS
      PulsePort (3,10000)    'ADVANCE AM16/32 #1 GROUP BY 1, PULSE PORT 3
      'MEASURE GWS THERMISTORS, (Voltage Ratio X = Rs/(Rs+Rf))
      BrHalf (therm(i),1,mV2500,1,Vx1,1,2500,True ,0,_60Hz,1.0,0)
```

```
      i = i + 1
      BrHalf (therm(i),1,mV2500,2,Vx1,1,2500,True ,0,_60Hz,1.0,0)
      i = i + 1
      BrHalf (therm(i),1,mV2500,3,Vx1,1,2500,True ,0,_60Hz,1.0,0)
      i = i + 1
    NextSubScan
    PortSet (2,0)        'TURN OFF AM16/32 #1 MULTIPLEXER, SET PORT 2 LOW

    'CONVERT MEASURED VOLTAGE RATIO TO RESISTANCE (kOHM) FOR 36 GWS
THERMISTORS
    For i=1 To 15
      Therm_kOhm(i) = Rf*therm(i)/(1-therm(i))
    Next i

    'CONVERT GWS THERMISTOR RESISTANCE TO deg C FOR 36 GWS
THERMISTORS
    For i=1 To 15
      D(i) = LN (1000*Therm_kOhm(i))                      'ln resistance (ohm)
      Temp_C(i) = (1/(a + b*D(i) + c*(D(i))^3)) - 273.15     'Steinhart & Hart Equation
    Next i

    '''''''' CS100 barometric pressure sensor wired ON with a jumper on the sensor between
Supply and
    '''''''' Read CS100 Barometric Pressure Sensor; Output in mb Uncorrected for elevation
    '' range 600 to 1100mb = 0 to 1 vdc; M = 0.2, 0 = 600mbar
    VoltSe (BaroPrNC_mB,1,mV2500,16,1,0,_60Hz,0.2,600)

  EndIf  'End of 60-seccond scan loop

  CallTable HourlyDiag
  CallTable Hourly
  CallTable QuarterHrlyMet
  CallTable TwoMinWd
  CallTable QuarterHourlyWater
  CallTable HourlyRaw
  CallTable Daily
  CallTable HrlyClimate
  CallTable HourlySubs

  If IfTime (0,1440,Min) Then
    DlyBatCrtIn_AHr = 0
    DlyBatCrtOut_AHr = 0
  EndIf

 NextScan
EndProg
```

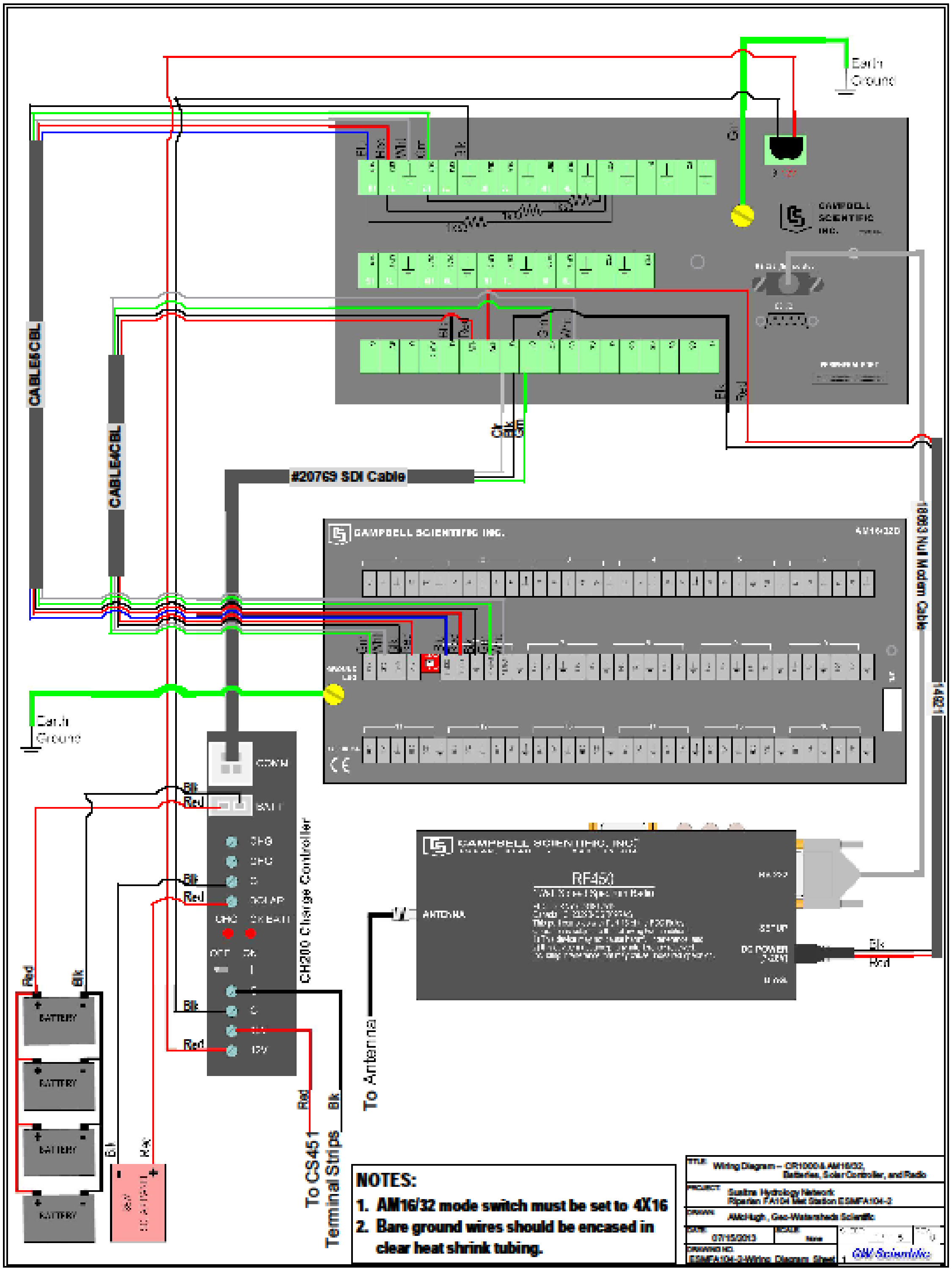

Figure C-6. ESMFA104-2 Sheet 1 (Data Logger, Power, Radio, Multiplexer).

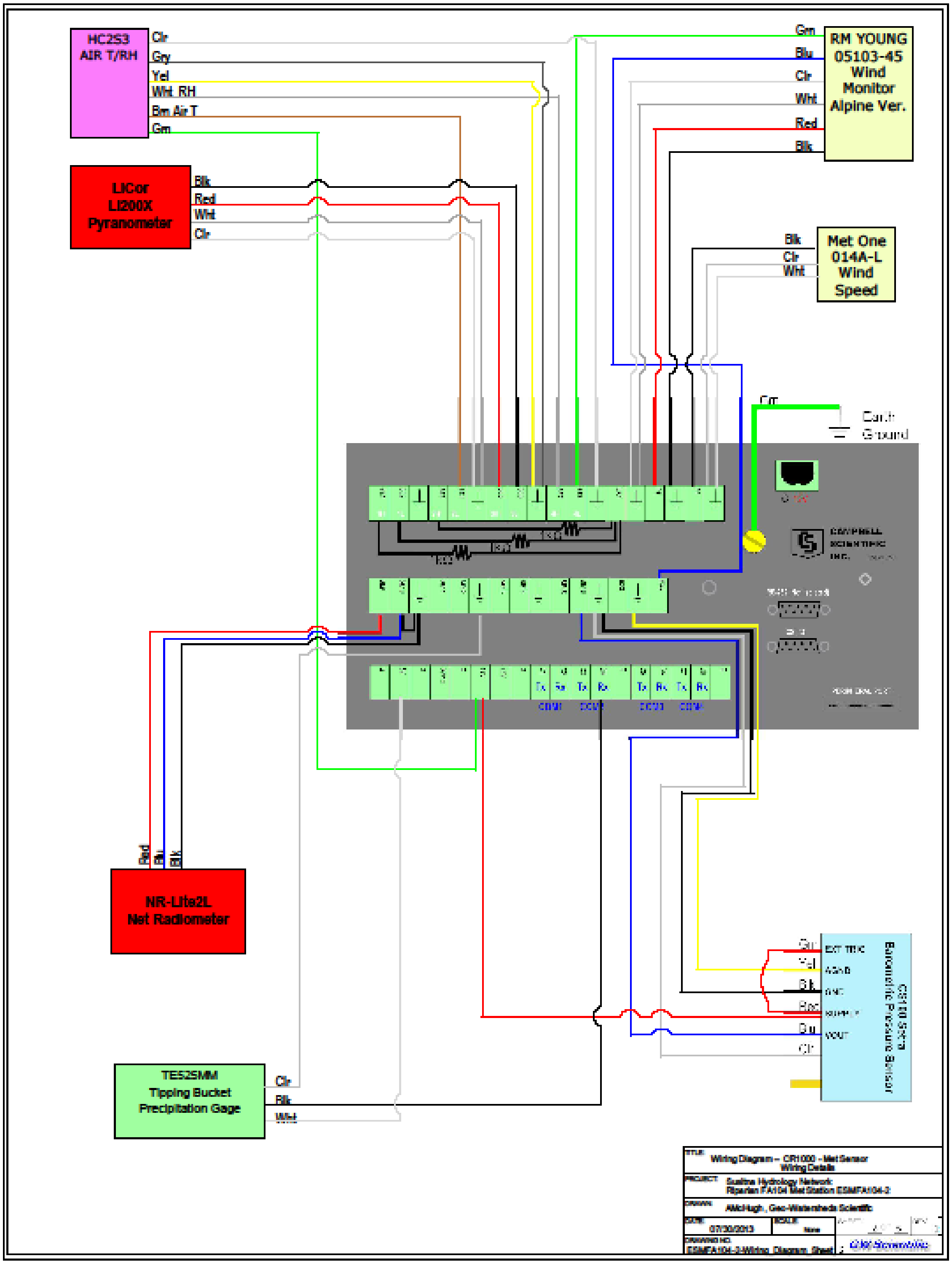

Figure C-7. ESMFA104-2 Sheet 2 (Data Logger, Met Sensors).

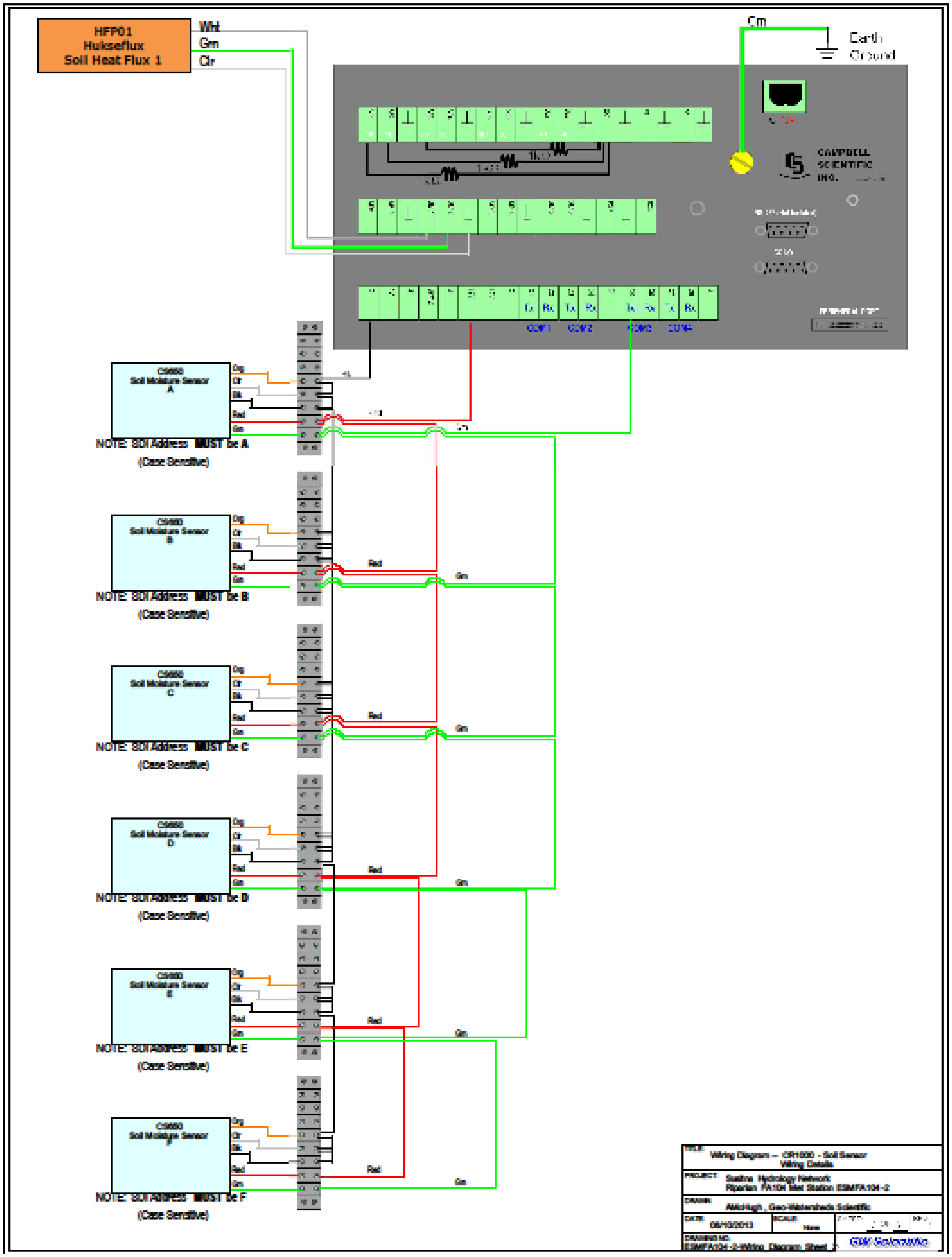

Figure C-8. ESMFA104-2 Sheet 3 (Soil Sensors).

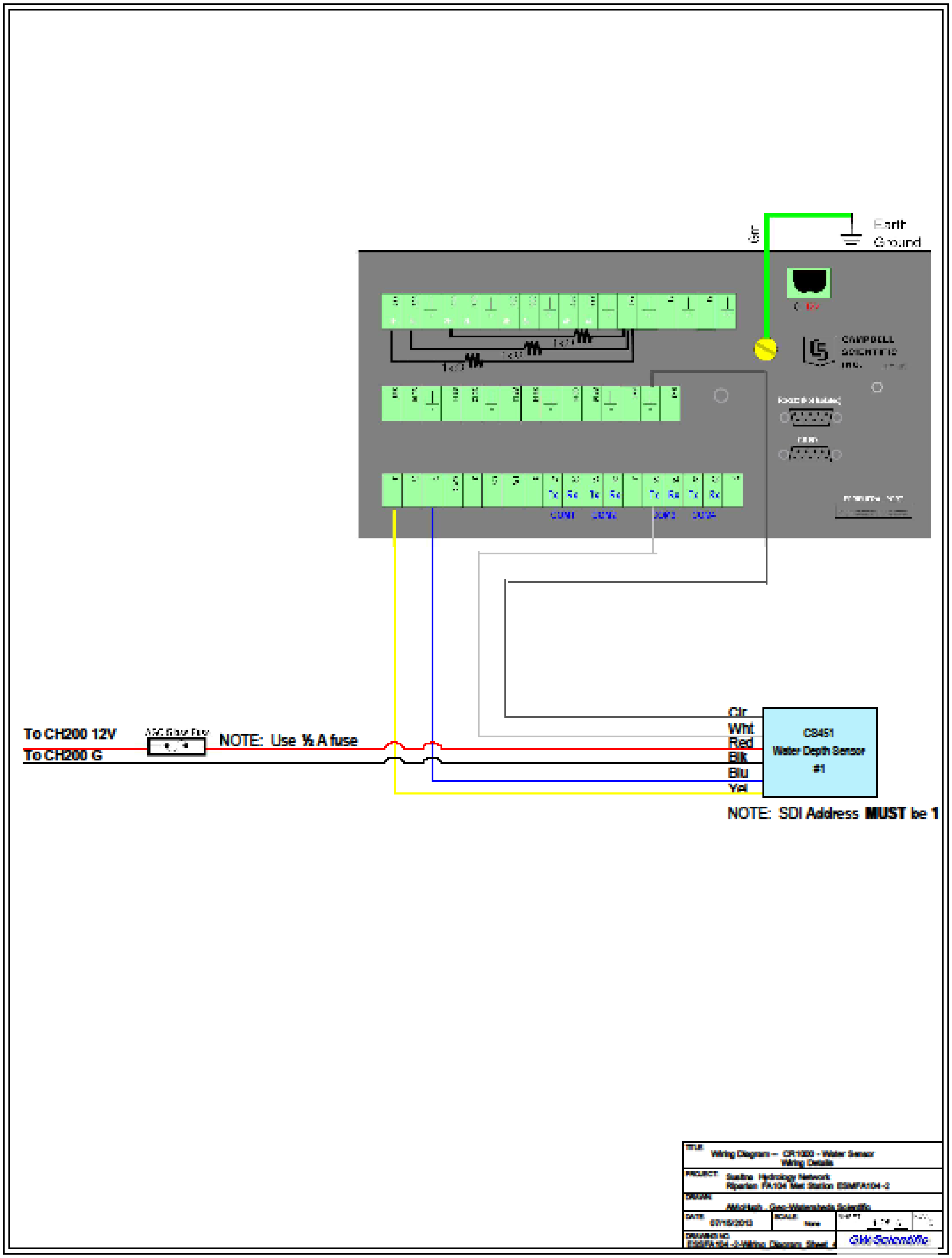

Figure C-9. ESMFA104-2 Sheet 4 (CS Water Sensors).

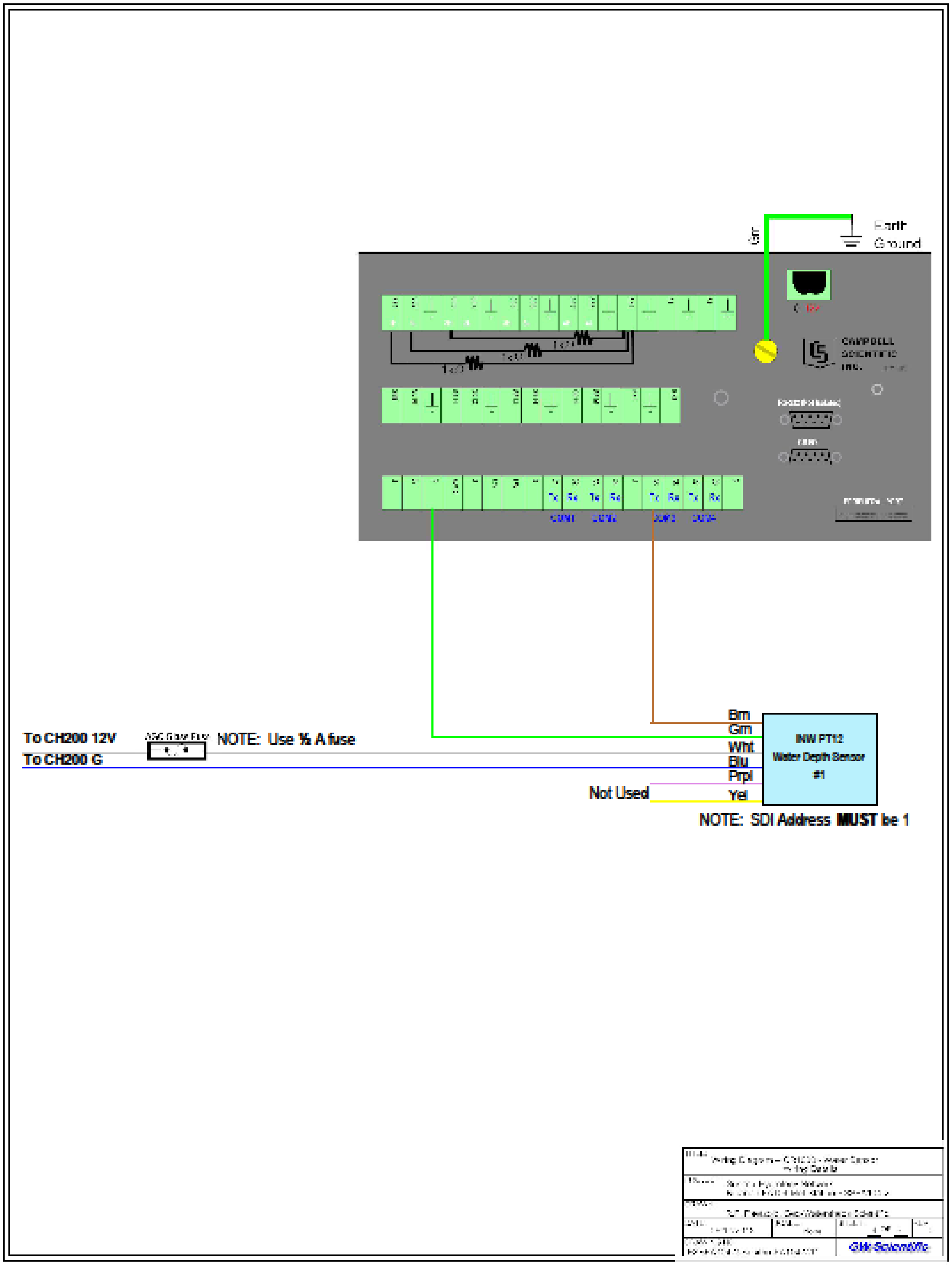

Figure C-10. ESMFA104-2 Sheet 4alt (INW Water Sensors).

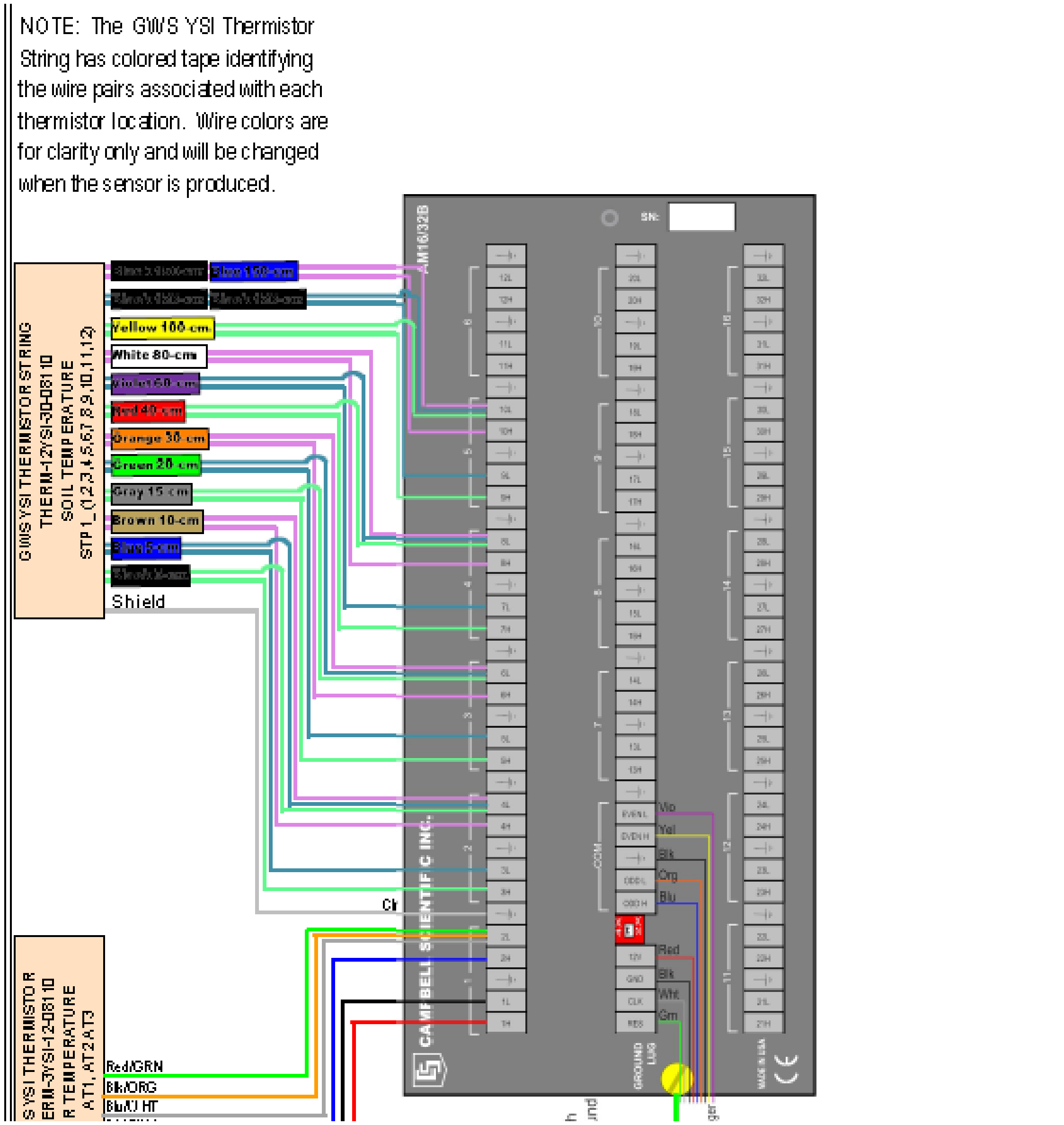

Figure C-11. ESMFA104-2 Sheet 5 (Multiplexer, Sensors).

The following program and wiring diagrams depict FA-104 (Whiskers Slough) station ESMFA104-3, representative of the groundwater (CSI CR200X) type station:

```
'CR200 Series Datalogger

'Modification Of:
'Modified by:
'Date Modified:
'Modifications:

'	PakBus ID for Station: 395		'INSERT PakBus ID HERE <===========
'	Station ID:	395		'INSERT Station ID HERE <==========
'	Time is set to AK Standard Time
''''''''''''''''''''''''''''''''''
'''' INDIVIDUAL STATION INPUTS ''''
''''''''''''''''''''''''''''''''''
'INSERT Station ID HERE:
Const ID = 395			'INSERT Station ID HERE <===========================

'CONTROL PORTS
' C1 SDI-12 Buss: CH200 - Charging Regulator; PTs
' C2

Public StationID ' Station ID number, USER INPUT
Public BattVolts_V

Public DlyBatCrtIn_AHr, DlyBatCrtOut_AHr
Public LoadPwr_W, ChargePwr_W

Public CS450Data1(2)	'Water Level Sensor 1 - pressure, temperature
Public CS450Data2(2)	'Water Level Sensor 2 - pressure, temperature
Public CS450Data3(2)	'Water Level Sensor 3 - pressure, temperature

Public WaterHt1_cm, WaterHt1_ft, WaterHt2_cm, WaterHt2_ft, WaterHt3_cm, WaterHt3_ft
' Water level above the probe

Public CH200_MX(4)  ' Array to hold extended data from CH200
Alias CH200_MX(1) = BattTargV ' Battery charging target voltage
Alias CH200_MX(2) = DgtlPotSet ' Digital potentiometer setting
Alias CH200_MX(3) = BattCap ' Present battery capacity
Alias CH200_MX(4) = Qloss ' Battery charge deficit
```

```
Public CH200_M0(9)  'Array to hold all data from CH200 charge controller

Alias CS450Data1(1) = WaterHt1_psi
Alias CS450Data1(2) = WaterT1_C
Alias CS450Data2(1) = WaterHt2_psi
Alias CS450Data2(2) = WaterT2_C
Alias CS450Data3(1) = WaterHt3_psi
Alias CS450Data3(2) = WaterT3_C

Alias CH200_M0(1)=CH200BattVolts_V       'Battery voltage: VDC
Alias CH200_M0(2)=BattCrnt_A        'Current going into, or out of, the battery: Amps
Alias CH200_M0(3)=LoadCrnt_A        'Current going to the load: Amps
Alias CH200_M0(4)=SolarPanel_V      'Voltage coming into the charger: VDC
Alias CH200_M0(5)=SolarPanel_A      'Current coming into the charger: Amps
Alias CH200_M0(6)=Chgr_Tmp_C        'Charger temperature: Celsius
Alias CH200_M0(7)=Chgr_State        'Charging state: 2=Cycle, 3=Float, 1=Current Limited, or
0=None
Alias CH200_M0(8)=Chgr_Source       'Charging source: 0=None, 1=Solar, or 2=AC
Alias CH200_M0(9)=Ck_Batt           'Check battery error: 0=normal, 1=check battery

Dim Initialized

DataTable (QuarterHrWater,1,-1)
  DataInterval (0,15,min)
  Sample (1,StationID)

  Sample (1,WaterHt1_ft)
  Average (1,WaterHt1_ft,False)

  Sample (1,WaterHt2_ft)
  Average (1,WaterHt2_ft,False)

  Sample (1,WaterHt3_ft)
  Average (1,WaterHt3_ft,False)

  Sample (1,WaterT1_C)
  Sample (1,WaterT2_C)
  Sample (1,WaterT3_C)

  Sample (1,WaterHt1_psi)
```

```
  Average (1,WaterHt1_psi,False)

  Sample (1,WaterHt2_psi)
  Average (1,WaterHt2_psi,False)

  Sample (1,WaterHt3_psi)
  Average (1,WaterHt3_psi,False)
EndTable

'Hourly Diagonostics Table
DataTable (HourlyDiag,1,-1)
  DataInterval (0,60,Min)
  Sample (1,StationID)

  'BATTERY VOLTS (V)
  Sample (1,BattVolts_V)
  Average (1,BattVolts_V,False)

  'BATTERY CURRENT (A)
  Sample (1,CH200_M0(2))
  Average (1,CH200_M0(2),False)

  'LOAD CURRENT (A)
  Sample (1,CH200_M0(3))
  Average (1,CH200_M0(3),False)

  'SOLAR PANEL VOLTS (V)
  Sample (1,CH200_M0(4))
  Average (1,CH200_M0(4),False)

  'SOLAR PANEL CURRENT (A)
  Sample (1,CH200_M0(5))
  Average (1,CH200_M0(5),False)

  'Charge Regulator Temperature (deg C)
  Average (1,CH200_M0(6),False)

  Sample (1,BattCap)

  Average (1,ChargePwr_W,False)
```

```
EndTable

'Hourly Climate Table (for Current Conditions Table on Web)
DataTable (HrlyClimate,1,96)
  DataInterval (0,60,Min)
  Sample (1,StationID)

  Sample (1,WaterT1_C)
  Sample (1,WaterHt1_ft)
  Sample (1,WaterT2_C)
  Sample (1,WaterHt2_ft)
  Sample (1,WaterT3_C)
  Sample (1,WaterHt3_ft)

EndTable

'Daily Output Table
DataTable (Daily,1,-1)
  DataInterval(0,1440,Min)
  Sample (1,StationID)

  Maximum (1,WaterHt1_ft,False,0)
  Minimum (1,WaterHt1_ft,False,0)

  Maximum (1,WaterHt2_ft,False,0)
  Minimum (1,WaterHt2_ft,False,0)

  Maximum (1,WaterHt3_ft,False,0)
  Minimum (1,WaterHt3_ft,False,0)

  Maximum (1,WaterT1_C,False,0)
  Minimum (1,WaterT1_C,False,0)

  Maximum (1,WaterT2_C,False,0)
  Minimum (1,WaterT2_C,False,0)

  Maximum (1,WaterT3_C,False,0)
  Minimum (1,WaterT3_C,False,0)

EndTable
```

```
'Main Program
BeginProg
  Scan (60,Sec)

    '''' Set Station ID ''''
    StationID = ID

    ' Meassure Battery Voltage (V)
    Battery (BattVolts_V)

    'CH200 CHARGE REGULATOR MEASUREMENTS
    ' Connected to Control Port 1
    ' We will use the defalut address of 0.
    SDI12Recorder (CH200_M0(),"0M!",1.0,0)
    'Get additional values from CH200
    SDI12Recorder (CH200_MX(),"M6!",1.0,0)

    ' Compute running Power and daily running total AmpHours/Day values for each current measurement.
    LoadPwr_W = CH200BattVolts_V * LoadCrnt_A
    ChargePwr_W = SolarPanel_V *SolarPanel_A
    ' Divide each 1 minute Amp sample by 1440 sample/day so that the total at the end of the day is to get avg current for the day
    ' then muliply be 24 Hr/day to get AHr/Day. or divide by 60 because 24/1440 = 1/60
    ' Separate and sum each the positive and negative currents into and out of the battery to get the total AHr in/out for the day.
    ' Sample hourly and daily, then zero at end of the day.

    If BattCrnt_A > 0 Then DlyBatCrtIn_AHr = DlyBatCrtIn_AHr + BattCrnt_A/60
    If BattCrnt_A < 0 Then DlyBatCrtOut_AHr = DlyBatCrtOut_AHr + BattCrnt_A/60

    ''''''''''''''''''''''''''''''''''''''''''''''
    ''     READ CSI SDI-12 CS450 water level/temp   ''
    ''''''''''''''''''''''''''''''''''''''''''''''
    ' There are up to three CSI CS451 or INW PT12 SDI-12 vented water level pressure transducers.
    ' Each sensor is connected to Control Port 1
    ' Each sensor has a unique SDI-12 address 1,2 and 3.
```

```
    SDI12Recorder (CS450Data1(),"1M!",1.0,0)
    SDI12Recorder (CS450Data2(),"2M!",1.0,0)
    SDI12Recorder (CS450Data3(),"3M!",1.0,0)

    ' convert water heights in psi to cm (70.307 cm/psi)
    WaterHt1_cm = WaterHt1_psi * 70.307
    WaterHt2_cm = WaterHt2_psi * 70.307
    WaterHt3_cm = WaterHt3_psi * 70.307

    'Convert Water Height in cm to ft. (0.0328 ft/cm)
    WaterHt1_ft = WaterHt1_cm * 0.0328
    WaterHt2_ft = WaterHt2_cm * 0.0328
    WaterHt3_ft = WaterHt3_cm * 0.0328

    CallTable QuarterHrWater
    CallTable HourlyDiag
    CallTable HrlyClimate
    CallTable Daily

    If IfTime (0,1440,Min) Then
      DlyBatCrtIn_AHr = 0
      DlyBatCrtOut_AHr = 0
    EndIf

  NextScan
EndProg
```

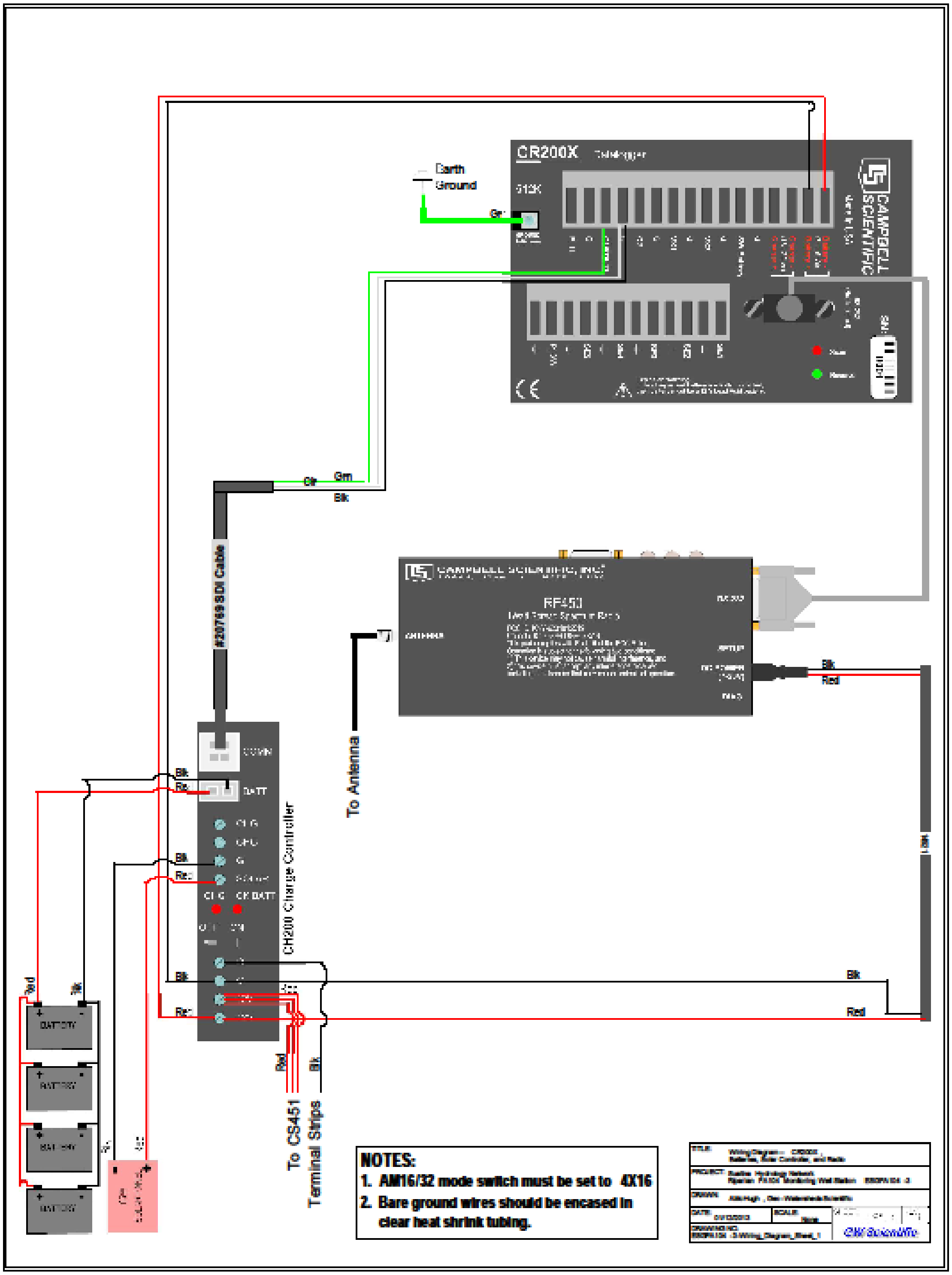

Figure C-12. ESGFA104-3 Sheet 1 (Data Logger, Power, Radio).

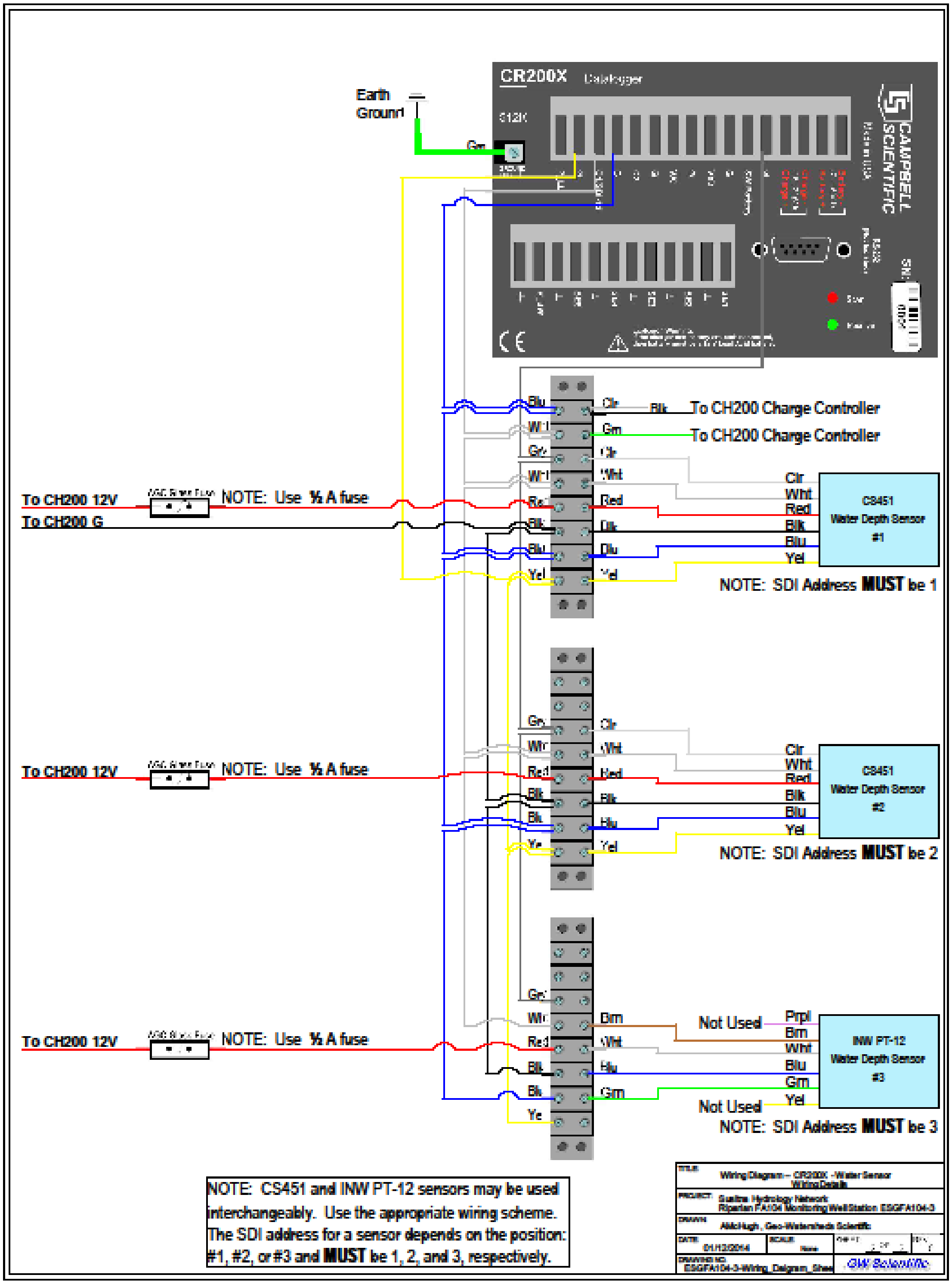

Figure C-13. ESGFA104-3 Sheet 2 Mix (Data Logger, INW/CSI Sensors).

The following program and wiring diagrams depict FA-104 (Whiskers Slough) station ESGFA104-4, representative of the groundwater (CR1000, sap flow sensors) data type station:

```
'CR1000 Series Datalogger

' Well Monitoring with Sap Flow
' Sensor count (22) TDP30s / (10) TDP50s

' Program Name ESGFA104-4_20131108.cr1

'Modification Of: ESGFA104-4_130725.cr1
'Modified By: R Paetzold
'Date Modified: 8Nov2013
'Modifications: Added Sap Flow Heater control commands to turn power ON/OFF
'           The heater is initially ON; To turn OFF, find SapHtrControlMode
'             and add to a Numeric Display, right click, select View/Modify Value and change ON
to OFF.
'           To turn heater ON, find SapHtrControlMode & add to a Numeric Display, right click,
'             select View/Modify Value and change OFF to ON.
'           Default mode is heater ON.


'Modification Of: ESGFA104-4.CR1
'Modified By: AMcHugh
'Date Modified: 16July2013
'Modifications: Added CH200 code

'Modification Of: 'FLGS-TDP.CR1          Release Program Version 2.1
'Modified By: AMcHugh
'Date Modified: 30June2013
'Modifications: Added PT stuff from ESGFA115-5_130627.cr1, changed to GWS Public
' variable names if needed.

'Dynamax Inc
'10808 Fallstone Rd, Ste 350, Houston, TX 77099
'Phone: 281-564-5100
'Fax: 281-564-5200
'www.Dynamax.com

'Program: FLGS - TDP using CR1000
'Program author: Sai Gonuguntla, Dynamax, Inc


'/////////////////////////// CONSTANTS //////////////////////////////////////
```

```
'INSERT Station Name HERE:
StationName (ESGFA104-4)          'INSERT Station Name HERE
<=========================
'INSERT Station ID HERE:
Const ID = 396              'INSERT Station ID HERE
<==================================

'//////////////////////////////////////////////////////////////////////////
'          BEGIN:  User constants
'          User can change the following constants only
'//////////////////////////////////////////////////////////////////////////

Const INT_SCAN = 60                   ' Scan every seconds
Const INT_AVG = 60          ' Average every minutes average and LOG interval are same
Const NUM_TDP = 32                    ' Number of TDP sensors
Const NUM_TC = 32           ' Number of Thermocouples/ measurement points among all the
TDP sensors
' A TDP10/30/50 each has 1, a TDP80 sensor has 2 & a TDP100 sensor has 3 thermocouples/
measurement points
' So total number of Thermocouples(NUM_TC) must be determined depending on the number
and type of sensors in use
' For example a system with 4 TDP30 sensors and 2 TDP80 sensors and 2 TDP100 sensors
' will have in all 14 thermocuples/ measurement points    ' i.e. NUM_TC = 14
Const DTMIN = 0.2              ' Minimum differential below which the measurement from sensor
is ignored
Const WARMUP_MIN = 60             ' Warmup time in min before the measurements are
considered valid

Const FIELDINDEX = 1.0    ' This is the index value either Area INdex/ LAI used to scale plant
sapflow to field
Const FLAG_INDEX_EN=0            ' Enable scaling of sapflow to the field
Const FLAG_VOTE_EN=0             ' Enable voting algorithm

Const PS_ENABLE   = 0                         ' Enable power save at night ' Note power save is
not performed on a day when auto zero is done
Const PS_START=1260         ' Power save start (Heater off) min-since mid night
' time at which to start the power save, 1260 corresponds to 21:00 hours or 9:00 PM
Const PS_STOP=300                     ' Power save end (Heater on) hour-since mid night
'          time at which to stop power save mode and turn heaters ON, 300 corresponds to 5AM

Const ZERO_ENABLE=1                          ' Enable auto calibration/ auto sero
Const ZERO_STARTHOUR=1        '          Top of the Hour at which to start auto zero
algorithm, must 1:00 am or more
Const ZERO_STOPHOUR=3                        ' Top of the Hour at which to stop performing auto
zero and compute new zero (dTM) value.
```

```
Const ZERO_DAYINT=1                    ' Number of days between successive auto-zero

'///////////////////////////////////////////////////////////////////////////////
'       END User modified constants
'///////////////////////////////////////////////////////////////////////////////

Const TIMER_START=0                                   '   0   Start
Const TIMER_STOP=1                                    '   1   Stop
Const TIMER_RSTnSTART=2                           '   2   Reset and start
Const TIMER_STOPnRST=3                            '   3   Stop and reset
Const TIMER_READONLY=4                            '   4   Read only

' FLGS TC-Status
Const TCSTAT_OFF        =   0
Const TCSTAT_OKV            =   1
Const TCSTAT_OKN            =   2           ' This status is not applicable but
used for consistensy with numbers
Const TCSTAT_WARM           =   3
Const TCSTAT_FAULT      =   4
Const TCSTAT_MERR           =   5
Const TCSTAT_ZERO           =   6
Const TCSTAT_MAX            =   7
Const TCSTAT_REV        =   8

' FLGS TDP-Status
Const TDPSTAT_OFF           =   0
Const TDPSTAT_OKV           =   1
Const TDPSTAT_OKN           =   2
Const TDPSTAT_WARM      =   3
Const TDPSTAT_FAULT     =   4
Const TDPSTAT_MERR      =   5
Const TDPSTAT_ZERO      =   6
Const TDPSTAT_MAX           =   7
Const TDPSTAT_NALL          =   8
Const TDPSTAT_ERRCH         =   9

'IDs for sensor 5and sensor TCs
Const TDP10  = 10.0
Const TDP30  = 30.0
Const TDP50  = 50.0
Const TDP80  = 80.0
Const TDP80A        = 80.0
Const TDP80B        = 80.1
Const TDP100= 100.0
Const TDP100A       = 100.0
Const TDP100B       = 100.1
```

```
Const TDP100C        = 100.2

'Declare Variables and Units
' System constants
Const MAX_TDP = 32                  ' maximum num of thermocouple channels
Const MAX_TC = 32           ' maximum num of thermocouple channels
' Heater constants
Const TIMERNO_WARMUP=1
Const NUM_HTR=4             'Number of heater voltages
Const HTROFF_VOLT=0.5                                       'Heater voltage less than this
is OFF
' Calculation constants
Const MV_TO_DT_MULT=25.0               'Multiplier mV to dT conversion
Const MV_TO_DT_OFFSET=0.0                       'Offset mV to dT conversion

' Public Variables
PreserveVariables ' variables are maintained over reboot.

Public StationID ' Station ID number, USER INPUT
Public BattVolts_V
Public LoggerTemp_C

Public SapHtrControlMode As String * 2 'ON' or 'OFF'
Public SapHtrControlStatus

Public DlyBatCrtIn_AHr, DlyBatCrtOut_AHr
Public LoadPwr_W, ChargePwr_W

Public CH200_M0(9)  'Array to hold all data from CH200

Public CH200_MX(4)  ' Array to hold extended data from CH200
Alias CH200_MX(1) = BattTargV ' Battery charging target voltage
Alias CH200_MX(2) = DgtlPotSet ' Digital potentiometer setting
Alias CH200_MX(3) = BattCap ' Present battery capacity
Alias CH200_MX(4) = Qloss ' Battery charge deficit

' SDI-12 formatted battery capacity value
Public SDI12command As String
' Response from CH200. Retrns the address of the unit and "ok" if all went well
Public SDI12result As String
Public NEWBATTCAP ' the new battery capacticty if you need to change it.

Public PT1Data(2)     'Water Level Sensor 1 - pressure, temperature
Public WaterHt1_cm, WaterHt1_ft        ' Water level above the probe

Alias PT1Data(1) = WaterHt1_psi
```

```
Alias PT1Data(2) = WaterT1_C

Alias CH200_M0(1)=CH200BattVolts_V      'Battery voltage: VDC
Alias CH200_M0(2)=BattCrnt_A      'Current going into, or out of, the battery: Amps
Alias CH200_M0(3)=LoadCrnt_A      'Current going to the load: Amps
Alias CH200_M0(4)=SolarPanel_V     'Voltage coming into the charger: VDC
Alias CH200_M0(5)=SolarPanel_A     'Current coming into the charger: Amps
Alias CH200_M0(6)=Chgr_Tmp_C       'Charger temperature: Celsius
Alias CH200_M0(7)=Chgr_State      'Charging state: 2=Cycle, 3=Float, 1=Current Limited, or
0=None
Alias CH200_M0(8)=Chgr_Source      'Charging source: 0=None, 1=Solar, or 2=AC
Alias CH200_M0(9)=Ck_Batt

'////////////////////////////////////////////////////////////////////
Public InputTDP001 As String * 200
Public InputTDP002 As String * 200
Public InputTDP003 As String * 200
Public InputTDP004 As String * 200
Public InputTDP005 As String * 200
Public InputTDP006 As String * 200
Public InputTDP007 As String * 200
Public InputTDP008 As String * 200
Public InputTDP009 As String * 200
Public InputTDP010 As String * 200
Public InputTDP011 As String * 200
Public InputTDP012 As String * 200
Public InputTDP013 As String * 200
Public InputTDP014 As String * 200
Public InputTDP015 As String * 200
Public InputTDP016 As String * 200
Public InputTDP017 As String * 200
Public InputTDP018 As String * 200
Public InputTDP019 As String * 200
Public InputTDP020 As String * 200
Public InputTDP021 As String * 200
Public InputTDP022 As String * 200
Public InputTDP023 As String * 200
Public InputTDP024 As String * 200
Public InputTDP025 As String * 200
Public InputTDP026 As String * 200
Public InputTDP027 As String * 200
Public InputTDP028 As String * 200
Public InputTDP029 As String * 200
Public InputTDP030 As String * 200
Public InputTDP031 As String * 200
Public InputTDP032 As String * 200
```

```
Public readstring As String * 200

Public ArrayTemp(10)
'/////////////////////////////////////////////////////////////////////
Public RealTimeArray(9)
Public RealTimeSec
Public RealTimeMin
Public RealTimeHour
Public Count_Day
Public JDAY
Public JHM

Public HtrV(4)
Public Htr_ON_Time
Public  Flag_HtrOff

'New set of variables
Public iTC   ', NUM_TC
Public TC_Sno(32)
Public TC_Stype(32)
Public TC_dTC(32)
Public TC_dTCa(32)
Public TC_dTM(32)
Public TC_SArea(32)
Public TC_Flow(32)
Public TC_Vel(32)                        ' Velocity in cm/h , MVB- 11-18-08
Public TC_Status(32)

Public iTDP    'NUM_TDP,
Public TDP_SType(32)
Public TDP_nCH(32)
Public TDP_IArea(32)
Public TDP_Flow(32)
Public TDP_Status(32)
Public TDP_FlowIx(32)

Public Flow_AvgIx
Public Count_OKV
Public nVoteout
Public Count_OKN
Public MaxDiff(32)
Public MaxDiffAll
Public Flow_Int
Public Hr_Flow
Public DY_Flow
```

```
Public ZRun_Count
Public ZRun_dT0(32)
Public ZRun_dT1(32)
Public ZRun_dT2(32)
Public ZRun_dTAvg(32)
Public ZRun_dTMax(32)

Public Flag_ZeroDay
Public ZDay_Count
Public ZDay_dT0(32)
Public ZDay_dT1(32)
Public ZDay_dT2(32)
Public ZDay_dTAvg(32)
Public ZDay_dTDiff(32)
Public ZDay_dTNew(32)

'Declare internal varaibles
Dim KPar
Dim StartCh
Dim Initialized

' Define units for variables used in the program
Units BattVolts_V=Volts
Units LoggerTemp_C=Deg C
Units TC_dTC=Deg C

'/////////////////////////// BEGIN TABLE DECLARATIONS/////////////////////
'Define Data Tables

'Hourly Diagonostics Table
DataTable (HourlyDiag,1,-1)
  DataInterval (0,60,Min,0)
  Sample (1,StationID,fp2)

  'BATTERY VOLTS (V)
  Sample (1,BattVolts_V,FP2)
  Average (1,BattVolts_V,FP2,False)
  Maximum (1,BattVolts_V,FP2,False,False)
  Minimum (1,BattVolts_V,FP2,False,False)

  'BATTERY CURRENT (A)
  Sample (1,CH200_M0(2),FP2)
  Average (1,CH200_M0(2),FP2,False)
  Maximum (1,CH200_M0(2),FP2,False,False)
  Minimum (1,CH200_M0(2),FP2,False,False)
```

```
 'LOAD CURRENT (A)
 Sample (1,CH200_M0(3),FP2)
 Average (1,CH200_M0(3),FP2,False)
 Maximum (1,CH200_M0(3),FP2,False,False)
 Minimum (1,CH200_M0(3),FP2,False,False)

 'SOLAR PANEL VOLTS (V)
 Sample (1,CH200_M0(4),FP2)
 Average (1,CH200_M0(4),FP2,False)
 Maximum (1,CH200_M0(4),FP2,False,False)
 Minimum (1,CH200_M0(4),FP2,False,False)

 'SOLAR PANEL CURRENT (A)
 Sample (1,CH200_M0(5),FP2)
 Average (1,CH200_M0(5),FP2,False)
 Maximum (1,CH200_M0(5),FP2,False,False)
 Minimum (1,CH200_M0(5),FP2,False,False)

 Average (1,LoggerTemp_C,FP2,False)     'Logger Temperature (deg C)
 Average (1,CH200_M0(6),FP2,False)      'Charge Regulator Temperature (deg C)

 Sample (1,NEWBATTCAP,FP2)
 Sample (1,BattCap,FP2)

 Sample (1,DlyBatCrtIn_AHr,FP2)
 Sample (1,DlyBatCrtOut_AHr,FP2)

 Average (1,ChargePwr_W,FP2,False)
 Maximum (1,ChargePwr_W,FP2,False,False)
 Minimum (1,ChargePwr_W,FP2,False,False)

 Average (1,LoadPwr_W,FP2,False)
 Maximum (1,LoadPwr_W,FP2,False,False)
 Minimum (1,LoadPwr_W,FP2,False,False)

 ' Charger state
 Sample (1,CH200_M0(7),FP2)
EndTable

'15-minute Water Ttable
DataTable (QuarterHourlyWater,1,-1)
 DataInterval(0,15,Min,0)
 Sample (1,StationID,fp2)

 Sample (1,WaterHt1_cm,FP2)
 Average (1,WaterHt1_cm,FP2,False)
```

```
  Maximum (1,WaterHt1_cm,FP2,False,False)
  Minimum (1,WaterHt1_cm,FP2,False,False)

  Sample (1,WaterHt1_ft,FP2)
  Average (1,WaterHt1_ft,FP2,False)
  Maximum (1,WaterHt1_ft,FP2,False,False)
  Minimum (1,WaterHt1_ft,FP2,False,False)

  Sample (1,WaterT1_C,FP2)
  Average (1,WaterT1_C,FP2,False)
  Maximum (1,WaterT1_C,FP2,False,False)
  Minimum (1,WaterT1_C,FP2,False,False)

  Sample (1,WaterHt1_psi,FP2)
  Average (1,WaterHt1_psi,FP2,False)
  Maximum (1,WaterHt1_psi,FP2,False,False)
  Minimum (1,WaterHt1_psi,FP2,False,False)
EndTable

'Daily Output Table
DataTable (Daily,1,-1)
  DataInterval(0,1440,Min,0)
  Sample (1,StationID,fp2)

  Average (1,WaterHt1_cm,FP2,False)
  Maximum (1,WaterHt1_cm,FP2,False,False)
  Minimum (1,WaterHt1_cm,FP2,False,False)

  Average (1,WaterHt1_ft,FP2,False)
  Maximum (1,WaterHt1_ft,FP2,False,False)
  Minimum (1,WaterHt1_ft,FP2,False,False)

  Average (1,WaterT1_C,FP2,False)
  Maximum (1,WaterT1_C,FP2,False,False)
  Minimum (1,WaterT1_C,FP2,False,False)

  Average (1,WaterHt1_psi,FP2,False)
  Maximum (1,WaterHt1_psi,FP2,False,False)
  Minimum (1,WaterHt1_psi,FP2,False,False)
EndTable

'Hourly Climate Table (for Current Conditions Table on Web)
' Size limited to 96 data values or 4 days worth.
DataTable (HrlyClimate,1,96)
  DataInterval (0,60,Min,0)
  Sample (1,StationID,fp2)
```

```
  Sample (1,WaterHt1_cm,FP2)
  Sample (1,WaterHt1_ft,FP2)
  Sample (1,WaterT1_C,FP2)
  Sample (1,WaterHt1_psi,FP2)
EndTable

' Hourly Raw Table
DataTable (DailyRaw,1,-1)
  DataInterval(0,1440,Min,0)
  Sample (1,StationID,fp2)

  Sample (1,InputTDP001,String) ' Sample TDP sensor settings strings
  Sample (1,InputTDP002,String)
  Sample (1,InputTDP003,String)
  Sample (1,InputTDP004,String)
  Sample (1,InputTDP005,String)
  Sample (1,InputTDP006,String)
  Sample (1,InputTDP007,String)
  Sample (1,InputTDP008,String)
  Sample (1,InputTDP009,String)
  Sample (1,InputTDP010,String)
  Sample (1,InputTDP011,String)
  Sample (1,InputTDP012,String)
  Sample (1,InputTDP013,String)
  Sample (1,InputTDP014,String)
  Sample (1,InputTDP015,String)
  Sample (1,InputTDP016,String)
  Sample (1,InputTDP017,String)
  Sample (1,InputTDP018,String)
  Sample (1,InputTDP019,String)
  Sample (1,InputTDP020,String)
  Sample (1,InputTDP021,String)
  Sample (1,InputTDP022,String)
  Sample (1,InputTDP023,String)
  Sample (1,InputTDP024,String)
  Sample (1,InputTDP025,String)
  Sample (1,InputTDP026,String)
  Sample (1,InputTDP027,String)
  Sample (1,InputTDP028,String)
  Sample (1,InputTDP029,String)
  Sample (1,InputTDP030,String)
  Sample (1,InputTDP031,String)
  Sample (1,InputTDP032,String)
EndTable
```

```
'Intermediate table for dTC/ Internal table for calculating average of dTC only
DataTable(TableDT, True, 1)
  DataInterval(0,INT_AVG,Min,10)
  Average(NUM_TC,TC_dTC(),FP2,False)
EndTable

' Main table for TC(thermocouple) variables
DataTable(TableTC,True,-1)
  DataInterval(0,INT_AVG,Min,10)

  Sample (1,JDAY,FP2)
  Sample (1,JHM,FP2)
  Sample (NUM_TC,TC_dTCa(1),FP2)
  Sample (NUM_TC,TC_dTM(1),FP2)
  Sample (NUM_TC,TC_Vel(1),FP2)
  Sample (NUM_TC,TC_Flow(1),FP2)
  Sample (NUM_TC,TC_Status(1),FP2)
  Average(4,HtrV(),FP2,False)
  '
  Minimum(1,BattVolts_V,FP2,False,0)
  Maximum(1,LoggerTemp_C,FP2,False,0)
  Sample (1,SapHtrControlMode,String)
  Sample (1,SapHtrControlStatus,FP2)
EndTable

'Table of SF calculations on each sensor along with indexed values and status codes
DataTable(TableTDP, True, -1)
  DataInterval(0,INT_AVG,Min,10)
  '
  Sample (1,JDAY,FP2)
  Sample (1,JHM,FP2)
  Sample (NUM_TDP,TDP_Flow(1),FP2)
  Sample (NUM_TDP,TDP_FlowIx(1),FP2)
  Sample (NUM_TDP,TDP_Status(1),FP2)
EndTable

' Hourly Table
DataTable(TableHR, True, -1)
  DataInterval(0,60,Min,10)

  Sample (1,JDAY,FP2)
  Sample (1,JHM,FP2)
  Sample (1,Hr_Flow,FP2)
EndTable

' Daily Table
```

```
DataTable(TableDY, True, -1)
  DataInterval(0,1440,Min,10)

  Sample (1,JDAY,FP2)
  Sample (1,DY_Flow,FP2)
  Sample (NUM_TC,TC_dTM(1),FP2)
EndTable

' Test Table to test the autozero rundata and algorithm ** Removed 11-18-08
'DataTable(TableZRu,True,-1)
'        DataInterval(0,INT_AVG,Min,10)

'        Sample (1,JDAY,FP2)
'        Sample (1,JHM,FP2)
'        Sample (1,ZRun_Count,FP2)
'        Sample (NUM_TC,ZRun_dT0(1),FP2)
'        Sample (NUM_TC,ZRun_dT1(1),FP2)
'        Sample (NUM_TC,ZRun_dT2(1),FP2)
'        Sample (NUM_TC,ZRun_dTAvg(1),FP2)
'        Sample (NUM_TC,ZRun_dTMax(1),FP2)

'        Average(4,HtrV(),FP2,False)
'        Minimum(1,BattVolts_V,FP2,False,0)
'        Maximum(1,LoggerTemp_C,FP2,False,0)
'EndTable


' Test Table to test the autozero rundata and algorithm ** Removed 11-18-08
'DataTable(TableZDa,True,-1)
'        DataInterval(0,INT_AVG,Min,10)

'        Sample (1,JDAY,FP2)
'        Sample (1,JHM,FP2)
'        Sample (1,ZDay_Count,FP2)
'        Sample (NUM_TC,ZDay_dT0(1),FP2)
'        Sample (NUM_TC,ZDay_dT1(1),FP2)
'        Sample (NUM_TC,ZDay_dT2(1),FP2)
'        Sample (NUM_TC,ZDay_dTAvg(1),FP2)
'        Sample (NUM_TC,ZDay_dTDiff(1),FP2)
'        Sample (NUM_TC,ZDay_dTNew(1),FP2)

'        Average(4,HtrV(),FP2,False)
'        Minimum(1,BattVolts_V,FP2,False,0)
'        Maximum(1,LoggerTemp_C,FP2,False,0)
'EndTable
```

```
'/////////////////////////// END TABLE DECLARATIONS//////////////////////

'////////////////Begin Subroutines//////////////////////////////
' Function for: Vote out one sensor
Sub VoteOut1
  Count_OKV=0
  Flow_AvgIx=0
  For iTDP = 1 To NUM_TDP Step 1
    If (TDP_Status(iTDP)=TDPSTAT_OKV) Then
      Flow_AvgIx=Flow_AvgIx+TDP_FlowIx(iTDP)
      Count_OKV=Count_OKV+1
    EndIf
  Next iTDP
  Flow_AvgIx = Flow_AvgIx/Count_OKV

  For iTDP = 1 To NUM_TDP Step 1
    If (TDP_Status(iTDP) = TDPSTAT_OKV) Then
      MaxDiff(iTDP) = ABS (TDP_FlowIx(iTDP)-Flow_AvgIx)
    EndIf
  Next iTDP

  MaxDiffAll = 0
  For iTDP = 1 To NUM_TDP Step 1
    If (MaxDiff(iTDP) > MaxDiffAll AND TDP_Status(iTDP) = TDPSTAT_OKV) Then
      MaxDiffAll=MaxDiff(iTDP)
      nVoteout=iTDP
    EndIf
  Next iTDP
  TDP_Status(nVoteout)=TDPSTAT_OKN
  Count_OKN=Count_OKN+1
EndSub

' Function for: Running average of dT values
Sub AutoZeroRun
  ' All conditions for autozero are successful so perform running average
  ZRun_Count = ZRun_Count + 1

  For iTC = 1 To 32 Step 1
    If (ZRun_Count = 0) Then
      'do nothhing ' the control will never come here

    ElseIf (ZRun_Count = 1) Then
      ZRun_dT0(iTC) = TC_dTCa(iTC)
      ZRun_dTMax(iTC) = ZRun_dT0(iTC)                    'Added 4-20-08 MVB , Make sure
dTMax Initialized
```

```
    ElseIf (ZRun_Count = 2) Then
      ZRun_dT1(iTC) = ZRun_dT0(iTC)
      ZRun_dT0(iTC) = TC_dTCa(iTC)

      If (ZRun_dT1(iTC)  > ZRun_dT0(iTC)) Then              'Added 4-20-08 MVB
        ZRun_dTMax(iTC) = (ZRun_dT1(iTC)+ZRun_dT0(iTC))/2  ' In case only 2 readings taken
      Else
        ZRun_dTMax(iTC) = ZRun_dT0(iTC)
      EndIf
    Else ' for all >=3
      ZRun_dT2(iTC) = ZRun_dT1(iTC)
      ZRun_dT1(iTC) = ZRun_dT0(iTC)
      ZRun_dT0(iTC) = TC_dTCa(iTC)

      ZRun_dTAvg(iTC) = (ZRun_dT2(iTC) + ZRun_dT1(iTC) + ZRun_dT0(iTC))/3

      'If (ZRun_Count = 3)
      'ZRun_dTMax(iTC) = ZRun_dTAvg(iTC)
      If (ZRun_dTAvg(iTC)  > ZRun_dTMax(iTC))
        ZRun_dTMax(iTC) = ZRun_dTAvg(iTC)
        ' No Else here, using the previous dTmax
      EndIf
    EndIf
  Next i
EndSub

'Function for: Perform autozero day
Sub AutoZeroDay
  ' All conditions for autozero are successful so perform running average
  ZDay_Count = ZDay_Count + 1

  For iTC = 1 To 32 Step 1

    If (ZDay_Count <= 0) Then
      'do nothhing ' the control will never come here

    ElseIf (ZDay_Count = 1) Then
      ZDay_dT2(iTC) = 0
      ZDay_dT1(iTC) = TC_dTM(iTC)
      ZDay_dT0(iTC) = ZRun_dTMax(iTC)

      ZDay_dTAvg(iTC)          = (ZDay_dT1(iTC) + ZDay_dT0(iTC))/2
      ZDay_dTDiff(iTC) = ABS((ZDay_dT0(iTC) - ZDay_dTAvg(iTC)) *
100/ZDay_dTAvg(iTC))

      If ZDay_dTDiff(iTC) >= 10 Then
```

```
      ZDay_dTNew(iTC) = ZDay_dTAvg(iTC)
    Else
      ZDay_dTNew(iTC) = ZDay_dT0(iTC)
    EndIf
    'dTM value is changed after the calibration or autozero during current day
    TC_dTM(iTC) = ZDay_dTNew(iTC)

   ElseIf (ZDay_Count >= 2) Then
    ZDay_dT2(iTC) = ZDay_dT1(iTC)
    ZDay_dT1(iTC) = ZDay_dT0(iTC)
    ZDay_dT0(iTC) = ZRun_dTMax(iTC)

    ZDay_dTAvg(iTC)         = (ZDay_dT1(iTC) + ZDay_dT1(iTC) + ZDay_dT0(iTC))/3
    ZDay_dTDiff(iTC) = ABS((ZDay_dT0(iTC) - ZDay_dTAvg(iTC)) *
100/ZDay_dTAvg(iTC))

    If ZDay_dTDiff(iTC) >= 10 Then
      ZDay_dTNew(iTC) = ZDay_dTAvg(iTC)
    Else
      ZDay_dTNew(iTC) = ZDay_dT0(iTC)
    EndIf
    'dTM value is changed after the calibration or autozero during current day
    TC_dTM(iTC) = ZDay_dTNew(iTC)
   EndIf
  Next iTC
EndSub
'////////////////End Subroutines////////////////////////////////

'Main Program
BeginProg
  ' Syntax for TDP sensors
  '       InputTDP# = "TDP Type, Index Area, dTM1, SA1, dTM2, SA2, dTM3, SA3"
  ' Default all sensors are TDP30 with DTM=8.0 degC, SA = 1.0 sq.cm, and index area = 1.0
  InputTDP001 = "30.0,1.00,9.50,1.00,8.00,1.00,8.00,1.00"
  InputTDP002 = "30.0,1.00,9.05,1.00,8.00,1.00,8.00,1.00"
  InputTDP003 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
  InputTDP004 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
  InputTDP005 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
  InputTDP006 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
  InputTDP007 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
  InputTDP008 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
  InputTDP009 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
  InputTDP010 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
  InputTDP011 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
  InputTDP012 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
  InputTDP013 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
```

```
InputTDP014 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP015 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP016 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP017 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP018 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP019 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP020 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP021 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP022 = "30.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP023 = "50.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP024 = "50.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP025 = "50.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP026 = "50.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP027 = "50.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP028 = "50.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP029 = "50.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP030 = "50.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP031 = "50.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"
InputTDP032 = "50.0,1.00,8.00,1.00,8.00,1.00,8.00,1.00"

iTC=1
StartCh = 1
For iTDP=1 To NUM_TDP Step 1
  Select Case iTDP
  Case 0
    ' do none
  Case 1
    readstring = InputTDP001
  Case 2
    readstring = InputTDP002
  Case 3
    readstring = InputTDP003
  Case 4
    readstring = InputTDP004
  Case 5
    readstring = InputTDP005
  Case 6
    readstring = InputTDP006
  Case 7
    readstring = InputTDP007
  Case 8
    readstring = InputTDP008
  Case 9
    readstring = InputTDP009
  Case 10
    readstring = InputTDP010
```

```
Case 11
  readstring = InputTDP011
Case 12
  readstring = InputTDP012
Case 13
  readstring = InputTDP013
Case 14
  readstring = InputTDP014
Case 15
  readstring = InputTDP015
Case 16
  readstring = InputTDP016
Case 17
  readstring = InputTDP017
Case 18
  readstring = InputTDP018
Case 19
  readstring = InputTDP019
Case 20
  readstring = InputTDP020
Case 21
  readstring = InputTDP021
Case 22
  readstring = InputTDP022
Case 23
  readstring = InputTDP023
Case 24
  readstring = InputTDP024
Case 25
  readstring = InputTDP025
Case 26
  readstring = InputTDP026
Case 27
  readstring = InputTDP027
Case 28
  readstring = InputTDP028
Case 29
  readstring = InputTDP029
Case 30
  readstring = InputTDP030
Case 31
  readstring = InputTDP031
Case 32
  readstring = InputTDP032
EndSelect
```

```
  ' Read string values to an array
  SplitStr (ArrayTemp(),readstring,",",8,0)
  ' Assign temporary array values to sensor array
  'SensorTDP(i) = ArrayTemp() 'This will not work as crbasic doesnot support 2 dimensional
arrays

  ' Assign senosr array values to TC arrray for faster calculations
  Select Case ArrayTemp(1)                'switch based on sensor type
  Case 10.0, 30.0, 50.0             ' Is the sensor TDP10 or TDP30 or TDP50?
    TC_Sno(iTC) = iTDP
    TC_Stype(iTC) = ArrayTemp(1)
    TC_dTM(iTC) = ArrayTemp(3)
    TC_SArea(iTC) = ArrayTemp(4)
    iTC=iTC+1

    TDP_SType(iTDP) = ArrayTemp(1)
    TDP_IArea(iTDP) = ArrayTemp(2)
    TDP_nCH(iTDP) = StartCh
    StartCh=StartCh+1

  Case 80.0                               ' Is the sensor TDP80?
    TC_Sno(iTC) = iTDP
    TC_Stype(iTC) = ArrayTemp(1) ' 113.0
    TC_dTM(iTC) = ArrayTemp(3)
    TC_SArea(iTC) = ArrayTemp(4)
    iTC=iTC+1
    TC_Sno(iTC) = iTDP
    TC_Stype(iTC) = 113.1                 ' TDP80 channel B
    TC_dTM(iTC) = ArrayTemp(5)
    TC_SArea(iTC) = ArrayTemp(6)
    iTC=iTC+1

    TDP_SType(iTDP) = ArrayTemp(1)
    TDP_IArea(iTDP) = ArrayTemp(2)
    TDP_nCH(iTDP) = StartCh
    StartCh=StartCh+2

  Case 100.0                        ' Is the sensor TDP100?
    TC_Sno(iTC) = iTDP
    TC_Stype(iTC) = ArrayTemp(1) ' 113.0
    TC_dTM(iTC) = ArrayTemp(3)
    TC_SArea(iTC) = ArrayTemp(4)
    iTC=iTC+1
    TC_Sno(iTC) = iTDP
    TC_Stype(iTC) = 114.1                 ' TDP100 channel B
    TC_dTM(iTC) = ArrayTemp(5)
```

```
    TC_SArea(iTC) = ArrayTemp(6)
    iTC=iTC+1
    TC_Sno(iTC) = iTDP
    TC_Stype(iTC) = 114.2                    ' TDP100 channel C
    TC_dTM(iTC) = ArrayTemp(7)
    TC_SArea(iTC) = ArrayTemp(8)
    iTC=iTC+1

    TDP_SType(iTDP) = ArrayTemp(1)
    TDP_IArea(iTDP) = ArrayTemp(2)
    TDP_nCH(iTDP) = StartCh
    StartCh=StartCh+3

  Case 0.00
    Exit For     ' End of required channels

  Case Else
    'Error in decodin gthe sesnsor array elements
  EndSelect
Next i

' NUM_TC = iTC - 1                    ' Total number of thermocouples in use

'//////////End parsing string to arrays or variables


'////////////////////////////////////////////////
'Write setup to TABLE_SETUP
'////////////////////////////////////////////////

'Initialize timer TIMERNO_WARMUP
Timer(TIMERNO_WARMUP,min,TIMER_RSTnSTART)

Count_Day=0
Flag_ZeroDay = True
ZDay_Count = 0
ZRun_Count = 0
' clear temporary variables
For iTC=1 To 32 Step 1
  ZRun_dT0(iTC)=0
  ZRun_dT1(iTC)=0
  ZRun_dT2(iTC)=0
  ZRun_dTAvg(iTC)=0
  ZRun_dTMax(iTC)=0

  ZDay_dT0(iTC)=0
```

```
   ZDay_dT1(iTC)=0
   ZDay_dT2(iTC)=0
   ZDay_dTAvg(iTC)=0
   ZDay_dTDiff(iTC)=0
   ZDay_dTNew(iTC)=0
  Next i

  'Initially set port4 for AVR control signal OFF; now in Initialized statements below
'  PortSet(4,0)

  Scan(INT_SCAN,Sec,1,0)

   RealTime(RealTimeArray)
   'Check for top of the hour

   ' initialize the default (power up) conditions
   If Initialized = 0 Then
    Initialized = 1
    NEWBATTCAP = 12 ' 100AHr is max capacity the CH200 will accept
    SapHtrControlMode = "ON"  'Default mode is Sap Flow Sensor Heater ON
    PortSet(4,1)
   EndIf

   '''''Sap Flow Heater Control'''''

   If SapHtrControlMode = "OFF" Then
     SapHtrControlStatus = 0
     PortSet(4,0)
   EndIf

   If SapHtrControlMode = "ON" Then
     SapHtrControlStatus = 1
     PortSet(4,1)
   EndIf

   'Condition If top of the hour
   If (TimeIntoInterval (0,60,Min)) Then ' Do this only on the first pass after the top of the hour
    ' Store hourly data in table and reset accumulators, *** Update 11-19-08 MVB
    JDAY = RealTimeArray(9)
    JHM =  RealTimeArray(4)*100 + RealTimeArray(5)
    CallTable(TableHR)
         'Temporary Removal******* Added Back MVB*****
    Hr_Flow=0

    'Check for top of the day
```

```
   If (TimeIntoInterval (0,24,hr)) Then        '*** Update 11-19-08 MVB
    ' If top of the day, Store daily data in table and reset accumulators
    '   Top of the day need to store daily table
    JDAY = RealTimeArray(9)
    CallTable(TableDY)                                        ' Temporary
Removal*******Added Back MVB *******
    DY_Flow = 0

    '   Update day counter, this counter may be used as a public variable for other algorithms
    Count_Day = Count_Day + 1


    'Check for auto zero in this day and enable the flags
    ' number of seconds since ZERO_STARTHOUR is less than INT_SCAN*2 i.e. before the
second pass
    'at the top of every hour check if it is ZERO_STARTHOUR, if so enable flags for auto zero
(run and day)
    '  Removed - MVB '  RealTimeSec =
RealTimeArray(4)*60*60+RealTimeArray(5)*60+RealTimeArray(6)
    If ((ZERO_ENABLE) AND (ZERO_DAYINT <> 0)) Then
     '  Remove '  If (RealTimeSec <= (ZERO_STARTHOUR*60*60 + INT_SCAN)) Then
             ' Will only execute 1 x top of the day...

     ' Check and enable auto zero for today if necessary
     If ((Count_Day <= 2) OR ((Count_Day MOD ZERO_DAYINT)=0 AND  Count_Day >=
ZERO_DAYINT)) Then
      'Perform auto zero on day0, day1, day2 and every day following day2 at an interval
ZERO_DAYINT
      Flag_ZeroDay = True
      ZRun_Count = 0
      ' clear temporary variables
      For iTC=1 To 32 Step 1
       ZRun_dT0(iTC)=0
       ZRun_dT1(iTC)=0
       ZRun_dT2(iTC)=0
       ZRun_dTAvg(iTC)=0
       ZRun_dTMax(iTC)=0
      Next iTC
     Else
      Flag_ZeroDay = False
     EndIf            ' End Count Day Check
     '   Removed Hour Start Check ' EndIf                          ' End Time Zero Start
Hour Check
    Else
     Flag_ZeroDay = False
    EndIf                                                     ' End zero_enable Check
```

```
    EndIf                                                   ' After Top of the day Check
   EndIf              'Condition EndIf top of the hour


  If SapHtrControlStatus = 1 Then
   '      If powersave option is enabled check times and perform powersave
    If  (PS_ENABLE=True) Then
      RealTime(RealTimeArray)
      RealTimeMin = RealTimeArray(4)*60+RealTimeArray(5)
      If (RealTimeMin < PS_STOP) Then      PortSet(4, 0)      ' Shutdown AVR
      If (RealTimeMin >= PS_STOP) Then      PortSet(4, 1)      ' AVR ON
      If (RealTimeMin >= PS_START) Then      PortSet(4, 0)     ' Shutdown AVR
    Else
      PortSet(4, 1)           ' If power save option is not enabled AVR ON always
    EndIf
  EndIf
 If SapHtrControlStatus = 0 Then PortSet(4,0)

   ' Measure battery voltage
   Battery (BattVolts_V)
   'Wiring Panel Temperature measurement LoggerTemp_C:
   PanelTemp(LoggerTemp_C,_60Hz)
   'read heater voltages
   VoltSe(HtrV(1),2,mV5000,14,1,0,_60Hz,0.004,0)
   ' A 15K and 4.99K voltage divider is inline that reduces the voltage seen by the logger to 1/4th
of its actual value
   ' Hence a multiplier of 0.004 is applied
   '               VoltDiff(HtrV(1),4,mV5000,5,True,0,_60Hz,0.001,0.0)

   'Begin 60-sec Loop
   If IfTime (0,60,Sec) Then

    ' Start GWS code VVVVVVVVVVVVVVVVVVVVVVVVV
    """ Set Station ID """
    StationID = ID

    """"""""""" CH200 CHARGE REGULATOR MEASUREMENTS
    ' Feature to enter specific battery capacity as a Public value and send to charger(s)
    'Get additional values from CH200
    SDI12Recorder (CH200_MX(),1,0,"M6!",1.0,0)
    'If the present battery capacity isnot the  same as the new battery capacity, send the new one.
    If BattCap <> NEWBATTCAP Then
      SDI12command = "XC" & FormatFloat (NEWBATTCAP, "%4.1f") & "!"
      SDI12Recorder (SDI12result,1,0,SDI12command,1.0,0)
    EndIf
```

```
    """""""""" CH200 CHARGE REGULATOR MEASUREMENTS
    SDI12Recorder (CH200_M0(),1,0,"MC!",1.0,0)

    ' Compute running Power and daily running total AmpHours/Day values for each current
measurement.
    LoadPwr_W = CH200BattVolts_V * LoadCrnt_A
    ChargePwr_W = SolarPanel_V *SolarPanel_A
    ' Divide each 1 minute Amp sample by 1440 sample/day so that the total at the end of the day
is to get avg current for the day
    ' then muliply be 24 Hr/day to get AHr/Day. or divide by 60 because 24/1440 = 1/60
    ' Separate and sum each the positive and negative currents into and out of the battery to get
the total AHr in/out for the day.
    ' Sample hourly and daily, then zero at end of the day.

    If BattCrnt_A > 0 Then DlyBatCrtIn_AHr = DlyBatCrtIn_AHr + BattCrnt_A/60
    If BattCrnt_A < 0 Then DlyBatCrtOut_AHr = DlyBatCrtOut_AHr + BattCrnt_A/60


    """"""""    READ INW or CSI SDI-12 Pressure Transducer
    SDI12Recorder (PT1Data(),5,1,"M!",1.0,0)
    ' convert water heights in psi to cm (70.307 cm/psi)
    WaterHt1_cm = WaterHt1_psi * 70.307
    'Convert Water Height in cm to ft. (0.0328 ft/cm)
    WaterHt1_ft = WaterHt1_cm * 0.0328
  EndIf  'End of 60-seccond scan loop
  ' End GWS code ^^^^^^^^^^^^^^^^^^^^^^^^

  'Calculate warmup time condition; all the warmup statuses are based on Heater voltage Vin1
  'TIMERNO_WARMUP
  If (HtrV(1) < HTROFF_VOLT)
    Timer(TIMERNO_WARMUP,min,TIMER_STOPnRST)                              'Stop
and reset timer TIMERNO_WARMUP if haeter voltage HtrV(1) < 0.5V
    Flag_HtrOff = TRUE
                                      'HeaterOff flag True
  Else
    If (Flag_HtrOff = TRUE)
      Timer(TIMERNO_WARMUP,min,TIMER_RSTnSTART)                 'Reset and start timer
TIMERNO_WARMUP if haeter voltage HtrV(1) >= 0.5V and just started
    EndIf
    Flag_HtrOff = FALSE
                                      'HeaterOff flag True
  EndIf

  'Turn AM16/32 Multiplexer On
  PortSet(2,1)
  Delay(0,150,mSec)
```

```
  iTC=1

  SubScan(100000,uSec,NUM_TC)                                   'Added delays MVB
4-20-2008
    'Switch to next AM16/32 Multiplexer channel
    PulsePort(3,35000)                               'Maximum Delay Added also
    'Generic Differential Voltage measurements dTC on the AM16/32 Multiplexer:
    VoltDiff(TC_dTC(iTC),1,mV2_5C,1,1,0,_60Hz,25.0,0.0)                          ' reads
mV from the sensor and calculate dT = mV *25.0
    iTC=iTC+1
  NextSubScan
  'Turn AM16/32 Multiplexer Off
  PortSet(2,0)
  Delay(0,150,mSec)
  'Store average of dT values in TableDT - internal program / temporary table
  CallTable(TableDT)

  'Average the dT values at the average interval (INT_AVG) and compute sapflow
  If TimeIntoInterval(0,INT_AVG,min)  Then

    ' Call subroutine to calculate sapflow on each thermocouple
    For iTC = 1 To NUM_TC Step 1
      TC_dTCa(iTC) = TableDT.TC_dTC_AVG(iTC,1)
                                   ' read average of dTC from TableDT

      ' Initialize variables
      TC_Status(iTC) = TCSTAT_OKV
      TC_Vel(iTC)=0
      TC_Flow(iTC)=0

      Do ' this is used to obtain a way for CONTINUE statement in C
        ' Start TC-SapFlow computations
        If ((HtrV(1)<HTROFF_VOLT OR TC_dTCa(iTC) = NAN) AND
TC_Status(iTC)=TCSTAT_OKV) Then
          TC_Status(iTC) = TCSTAT_OFF
          ExitDo
        EndIf

        If ( (TC_dTCa(iTC) > 62  OR TC_dTCa(iTC) < -62)  AND
TC_Status(iTC)=TCSTAT_OKV) Then
          TC_Status(iTC) = TCSTAT_FAULT
          ExitDo
        EndIf

        If (TC_dTCa(iTC) = 0  AND TC_Status(iTC)=TCSTAT_OKV) Then
          TC_Status(iTC) = TCSTAT_MERR
```

```
      ExitDo
     EndIf
     If (TC_dTCa(iTC) < 0  AND TC_Status(iTC)=TCSTAT_OKV) Then
      TC_Status(iTC) = TCSTAT_REV
      ExitDo
     EndIf

     If (TC_dTM(iTC) < TC_dTCa(iTC)  AND TC_Status(iTC)=TCSTAT_OKV) Then
      TC_Status(iTC) = TCSTAT_ZERO
      ExitDo
     Else If (TC_Status(iTC)=TCSTAT_OKV)
      KPar = ((TC_dTM(iTC) - TC_dTCa(iTC))/ TC_dTCa(iTC))
      '          constant no units
      If  KPar < 0 Then        ' only double checking not necessary
       TC_Status(iTC) = TCSTAT_ZERO
       ExitDo
      Else
       '                 Updated Vel to cm/h, not sec. because FP2 format would not show values,
nor is it standard!!
       TC_Vel(iTC) = 0.0119 * (KPar ^ 1.231)*3600                                  '
Velocity in cm/h , MVB- 11-18-08
       TC_Flow(iTC) = TC_SArea(iTC) * TC_Vel(iTC)                                  '
SapFlow in g/hr
      EndIf
     EndIf

     ' check for maxflow
     If ( (TC_dTCa(iTC) <= DTMIN OR TC_Vel(iTC) > 200) AND
TC_Status(iTC)=TCSTAT_OKV) Then
      TC_Status(iTC) = TCSTAT_MAX
      ExitDo
     EndIf
     ExitDo
    Loop
    ' check for warmup time
    Htr_ON_Time = Timer(TIMERNO_WARMUP,min,TIMER_READONLY)
    If (Htr_ON_Time < WARMUP_MIN ) Then
     TC_Status(iTC) = TCSTAT_WARM
    EndIf

    If (TC_Status(iTC) <> TCSTAT_OKV) Then
     'Make all the storing variables to zero//// If necessary

    EndIf
   Next iTC
```

```
    'Call Data Tables and Store Data
    RealTime(RealTimeArray)
    JDAY = RealTimeArray(9)
    JHM =  RealTimeArray(4)*100+RealTimeArray(5)
    CallTable(TableTC)
                              'This was temporarily removed MVB put back 4-21


    'Convert thermocouple sapflow to TDP sensor sapflow
    ' Not implemented ' currently the code works for TDP10/30/50 sensors
    For iTDP = 1 To NUM_TDP Step 1

      StartCh = TDP_nCH(iTDP)
      If (StartCh > NUM_TC)
        ExitFor
      EndIf

      If ((TDP_SType(iTDP) = TDP10) OR (TDP_SType(iTDP) = TDP30) OR
(TDP_SType(iTDP) = TDP50)) Then
        TDP_Flow(iTDP) = TC_Flow(StartCh)
        TDP_Status(iTDP) = TC_Status(StartCh)

      ElseIf (TDP_SType(iTDP) = TDP80)
        If ((TC_Status(StartCh)=TC_Status(StartCh+1)) AND
(TC_Status(StartCh)=TCSTAT_OKV)) Then
          TDP_Flow(iTDP) = TC_Flow(StartCh) + TC_Flow(StartCh+1)
          TDP_Status(iTDP) = TC_Status(StartCh)
        ElseIf ((TC_Status(iTC)= TC_Status(iTC+1))) Then
          TDP_Flow(iTDP) = 0
          TDP_Status(iTDP) = TC_Status(StartCh)
        Else
          TDP_Flow(iTDP) = 0
          TDP_Status(iTDP) = TDPSTAT_NALL
        EndIf

      ElseIf (TDP_SType(iTDP) = TDP100)
        If ((TC_Status(StartCh)= TC_Status(StartCh+1)) AND
(TC_Status(StartCh)=TC_Status(StartCh+2)) AND (TC_Status(StartCh)=TCSTAT_OKV))
Then
          TDP_Flow(iTDP) = TC_Flow(StartCh) + TC_Flow(StartCh+1) + TC_Flow(StartCh+2)
          TDP_Status(iTDP) = TC_Status(StartCh)
        ElseIf ((TC_Status(StartCh)= TC_Status(StartCh+1)) AND
(TC_Status(StartCh)=TC_Status(StartCh+2))) Then
          TDP_Flow(iTDP) = 0
          TDP_Status(iTDP) = TC_Status(StartCh)
        Else
```

```
      TDP_Flow(iTDP) = 0
      TDP_Status(iTDP) = TDPSTAT_NALL
    EndIf
  Else
    ' Problem in assigning TC to TDP
    TDP_Flow(iTDP) = 0
    TDP_Status(iTDP) = TDPSTAT_ERRCH
  EndIf
Next iTDP

'Calculate indexes for each sensor not thermocouple
For iTDP = 1 To NUM_TDP Step 1
  'Index sapflow to field
  TDP_FlowIx(iTDP) = TDP_Flow(iTDP) / TDP_IArea(iTDP) * FIELDINDEX
Next iTDP

'Perform Voting on Indexed sapflows
' vote out 2 sensors if number of sensors with OKV >6
'or vote out 1 sensor if number of sensors with OKV >2 and <=6
'or vote out none if number of sensors with OKV <=2
'Count the number of sensors currently voting
'//////////////////Vote out first one if necessary
Count_OKV = 0
Count_OKN=0
For iTDP = 1 To NUM_TDP Step 1
  If (TDP_Status(iTDP) = TDPSTAT_OKV) Then
    Count_OKV = Count_OKV +1
  EndIf
Next iTDP
'//////////////Vote out first one
If (Count_OKV > 6) Then
  Call VoteOut1
EndIf
'//////////////////Vote out second one if necessary
'Count the number of sensors currently voting
Count_OKV = 0
For iTDP = 1 To NUM_TDP Step 1
  If (TDP_Status(iTDP) = TDPSTAT_OKV) Then
    Count_OKV = Count_OKV +1
  EndIf
Next iTDP

If (Count_OKV > 2) Then
  Call VoteOut1
EndIf
'//////////////////////////////////////////////////////////
```

```
    RealTime(RealTimeArray)
    JDAY = RealTimeArray(9)
    JHM =  RealTimeArray(4)*100+RealTimeArray(5)
    CallTable(TableTDP)                                                'Temporary
removal*******added back MVB***************

    'Calculate average indexed sapflow of the voting sensors
    Flow_AvgIx = 0
    Count_OKV = 0
    For iTDP = 1 To NUM_TDP Step 1
      If (TDP_Status(iTDP)=TDPSTAT_OKV) Then
        Flow_AvgIx = Flow_AvgIx + TDP_FlowIx(iTDP)
        Count_OKV = Count_OKV +1
      EndIf
    Next iTDP
    Flow_AvgIx = Flow_AvgIx/Count_OKV
    If Flow_AvgIx < 0 Then
      Flow_AvgIx = 0
    EndIf
    Flow_Int = Flow_AvgIx * INT_AVG / 60                    ' Hourly component of the
Instantaneous flow rate
    Hr_Flow = Hr_Flow + Flow_Int                                       '        Update
hourly accumulator
    DY_Flow = DY_Flow + Hr_Flow                                                 '
Update daily accumulator

    ' Peform auto zero - running
    'add the conditions for autozero enabled and interval here
    ' Check is autozero is enabled
    RealTime(RealTimeArray)
    RealTimeMin = RealTimeArray(4)*60+RealTimeArray(5)
    If (( Flag_ZeroDay = True) AND (RealTimeMin >= ZERO_STARTHOUR*60) AND
(RealTimeMin <= ZERO_STOPHOUR*60)) Then
      ' Call Subroutine for compuring dT running averages
      Call AutoZeroRun
      '                                   CallTable(TableZRu)
        *****************  Not needed after 11-18-08
    EndIf                         ' End Autozero running

    'Perform autozero day
    RealTime(RealTimeArray)
    RealTimeMin = RealTimeArray(4)*60+RealTimeArray(5)
    If ((Flag_ZeroDay = True) AND (RealTimeMin = ZERO_STOPHOUR*60)) Then
      ' Call subroutine for computing new dTM
      Call AutoZeroDay
```

```
      Flag_ZeroDay = False            'Disable autozero until midnight or logger power is reset
      '                                       CallTable(TableZDa)           *****************
Not needed after 11-18-08
     EndIf                            ' End Autozero day

   EndIf                          'End of If TimeIntoInterval - INT_AVG


   ' GWS Tables VVVVVVVVVVVVVVVVVVVV
   CallTable HourlyDiag
   CallTable QuarterHourlyWater
   CallTable Daily
   CallTable HrlyClimate
   CallTable DailyRaw
   ' End GWS Tables ^^^^^^^^^^^^^^

   If IfTime (0,1440,Min) Then
     DlyBatCrtIn_AHr = 0
     DlyBatCrtOut_AHr = 0
   EndIf

  NextScan
EndProg
```

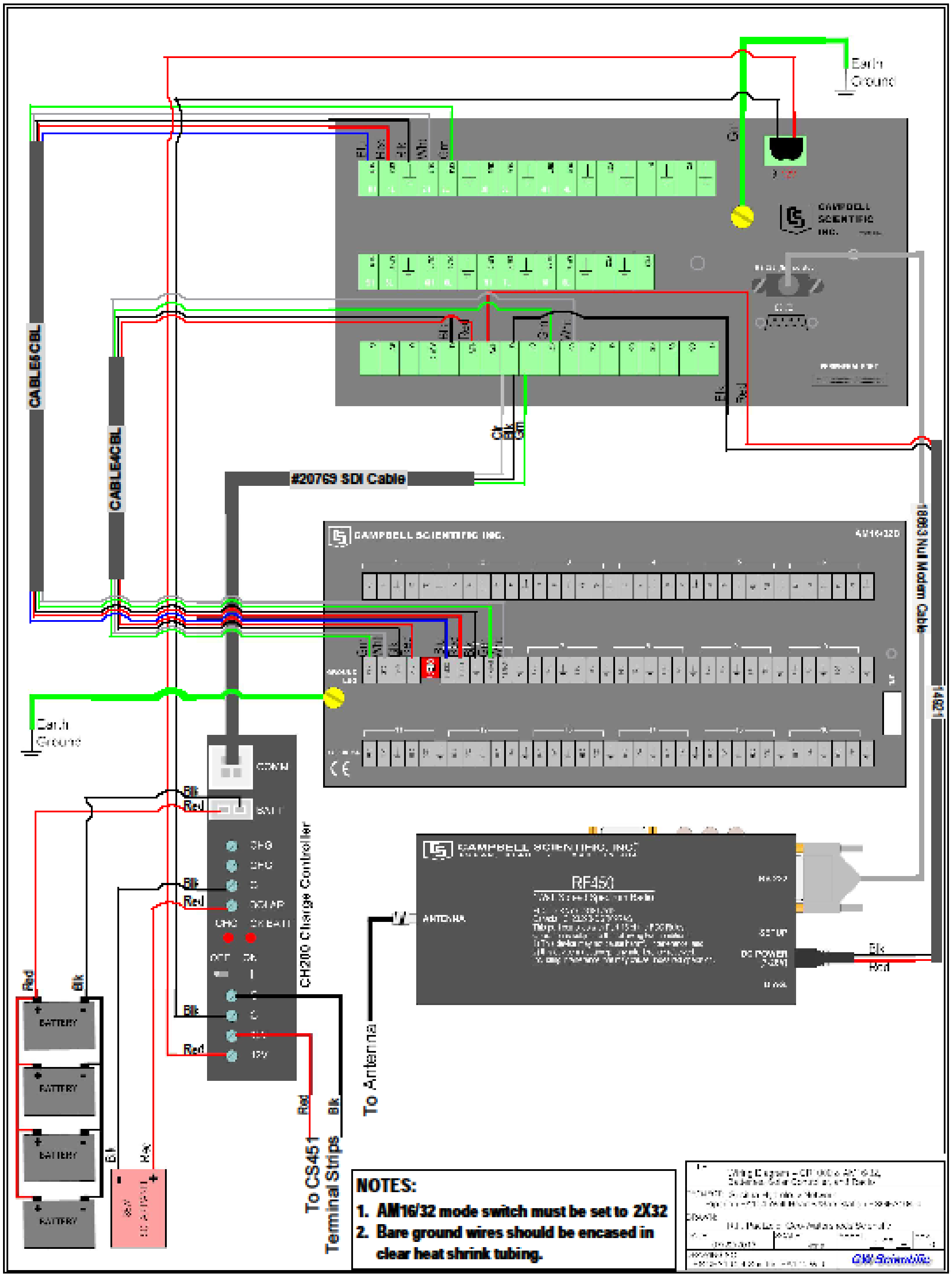

Figure C-14. ESGFA104-4 Sheet 1 (Data Logger, Power, Radio, Multiplexer).

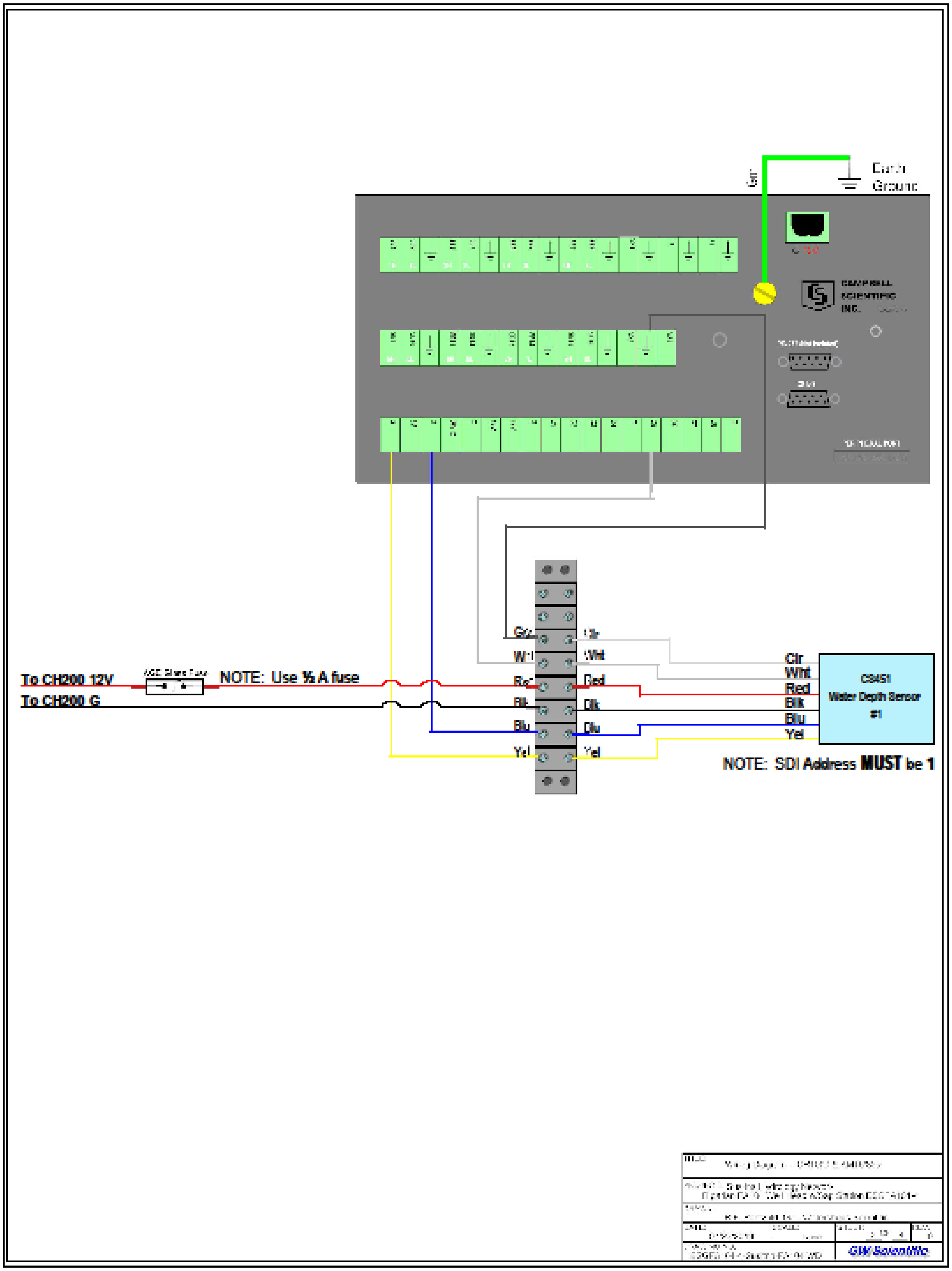

Figure C-15. ESGFA104-4 Sheet 2 (Data Logger, CS Sensors).

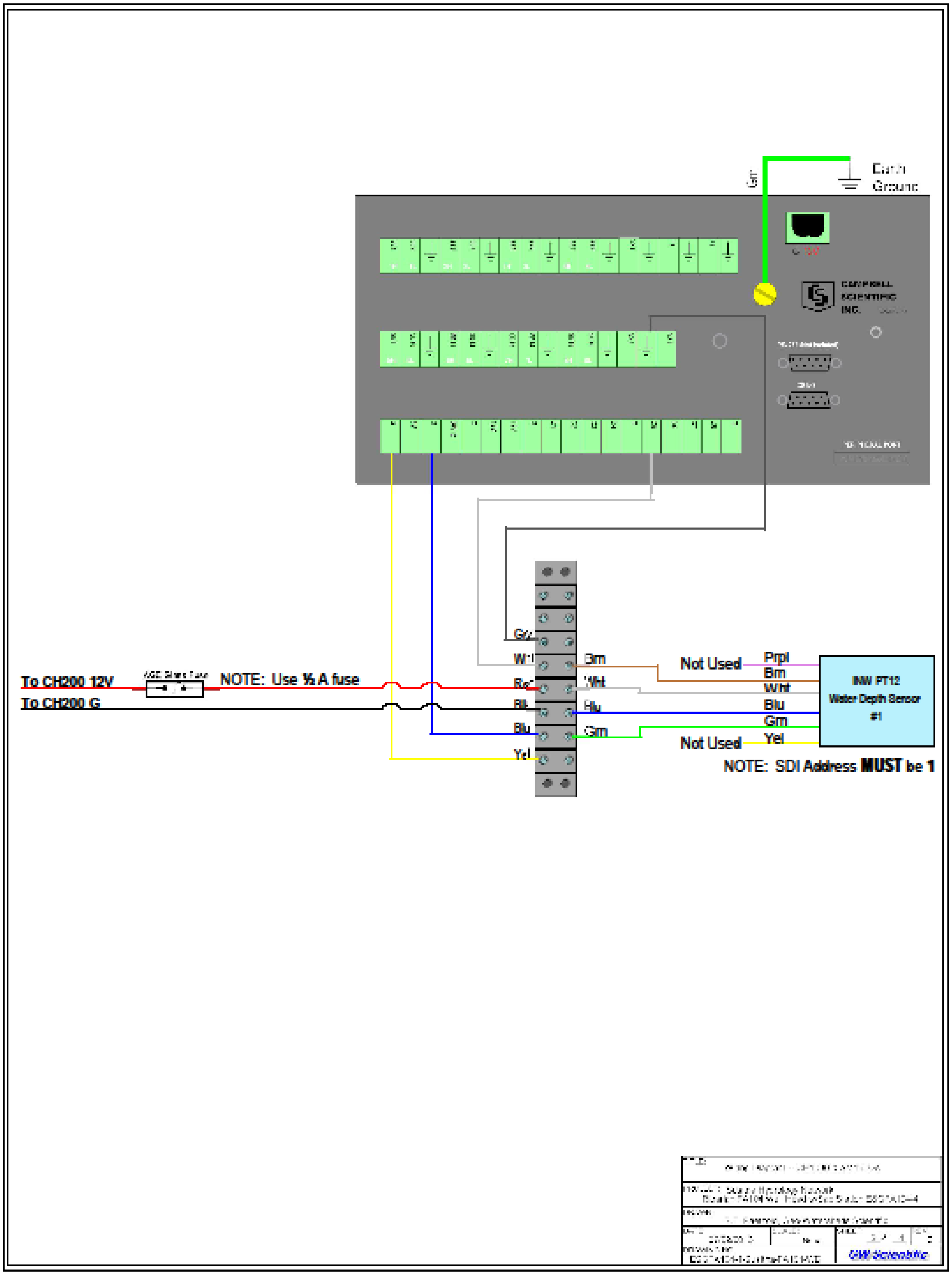

Figure C-16. ESGFA104-4 Sheet 2alt (Data Logger, INW Sensors).

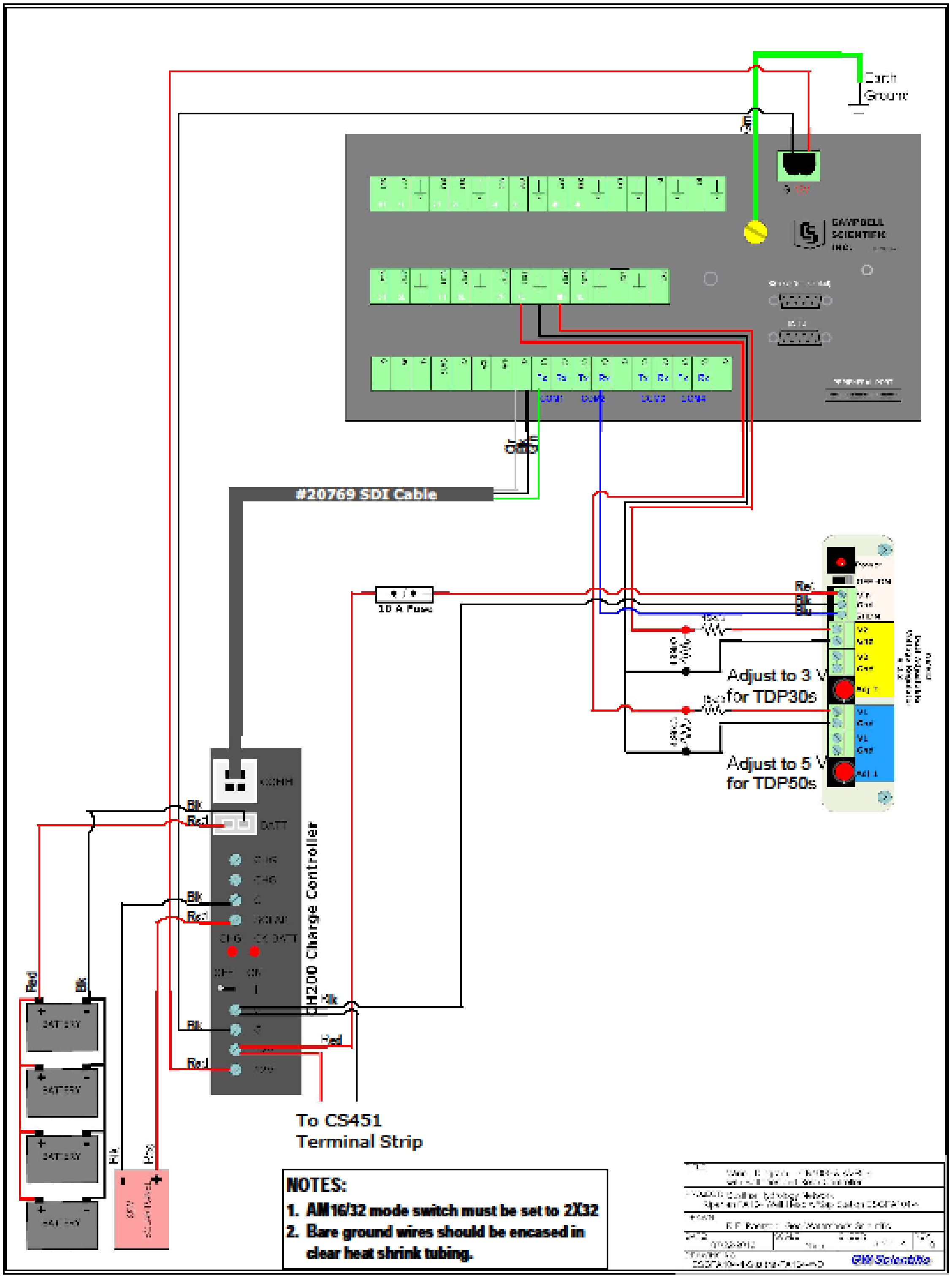

Figure C-17. ESGFA104-4 Sheet 3 (Multiplexer, ADVR).

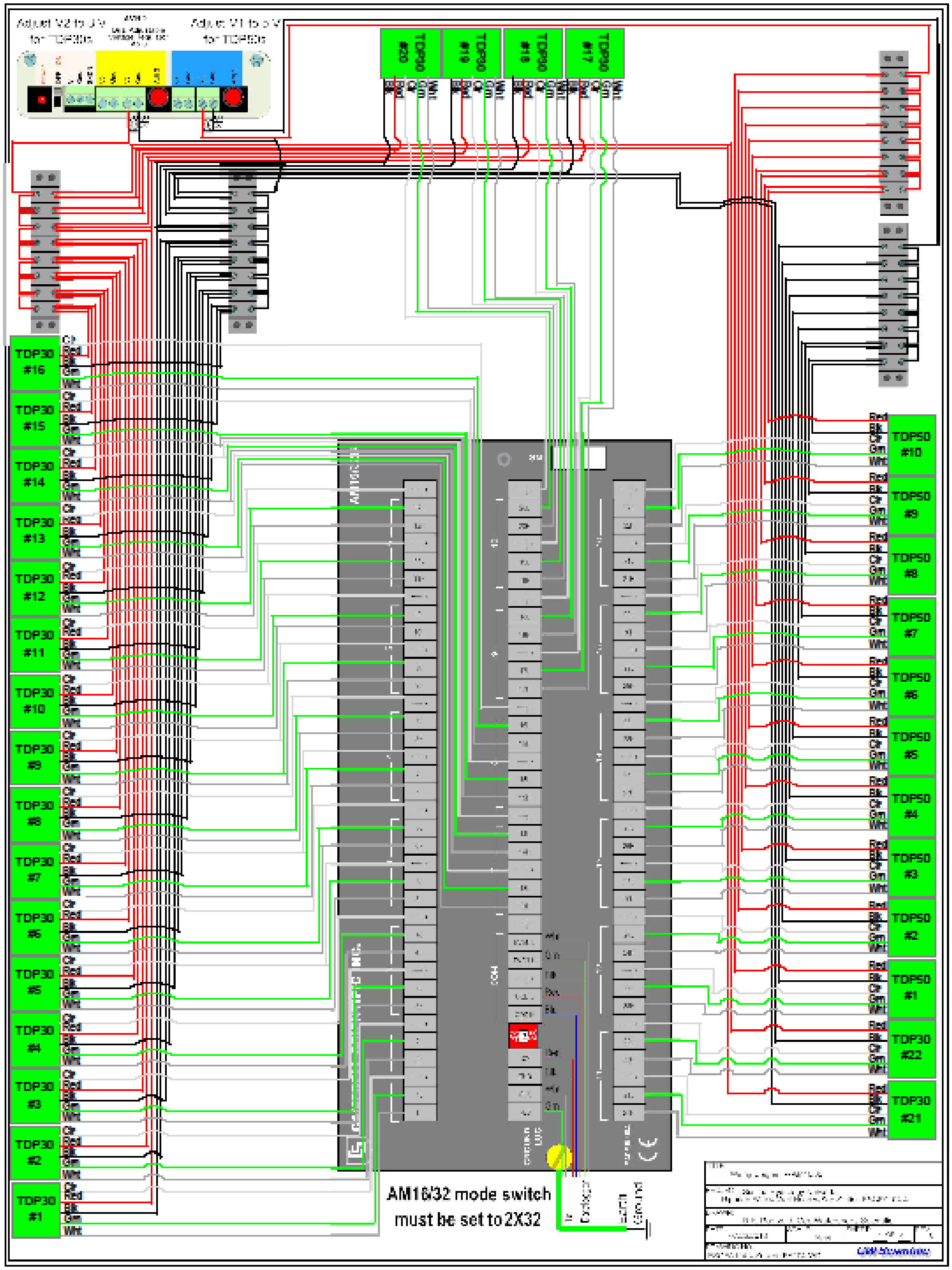

Figure C-18. ESGFA104-4 Sheet 4 (Multiplexer, Sap Flow Sensors).

The following program and wiring diagrams depict FA-104 (Whiskers Slough) station ESGFA104-10, representative of the groundwater (CSI CR1000, stream-bed profiles) data type station:

```
'CR1000 Series Datalogger
'Program name: ESGFA104-10_130926.cr1

'Modification Of: ESG104-10_130810.CR1
'Modified By: AMcHugh
'Date Modified:
'Modifications: Fixed Daily table to process all PTs. Updated NEWBATTCAP to 100.

'Old Modifications:
' Changed temperature string depth names
' Added CH200 code

'Station Notes:
'	PakBus ID for Statino: 365		'INSERT PakBus ID HERE <==========
'	Station ID:	365		'INSERT Station ID HERE <==========
'	Time is set to AK Standard Time


''''''''''''''''''''''''''''''''''''
'''' INDIVIDUAL STATION INPUTS ''''
''''''''''''''''''''''''''''''''''''

'INSERT Station Name HERE:
StationName (ESGFA104-10)		'INSERT Station Name HERE
<=========================
'INSERT Station ID HERE:
Const ID = 365			'INSERT Station ID HERE
<==================================

' CS547A s/n 6373 cal 1.387
' we are doing 0% temperature correction.
Const CS547A1CalFactor = 1.387 ' <<<<<<<<<<<<<<<< MUST ENTER SENSOR-SPECIFIC
CAL FACTOR HERE>
Const CS547A1cable = 100  ' <<<<<<<<<<<<<<<< MUST ENTER SENSOR-SPECIFIC
CABLE LENGTH HERE>

' CS547A s/n 6372 cal 1.476
' we are doing 0% temperature correction.
Const CS547A2CalFactor = 1.476 ' <<<<<<<<<<<<<<<< MUST ENTER SENSOR-SPECIFIC
CAL FACTOR HERE>
```

```
Const CS547A2cable = 100   ' <<<<<<<<<<<<<<<< MUST ENTER SENSOR-SPECIFIC
CABLE LENGTH HERE>

'FIXED RESISTOR VALUE FOR GWS THERMISTOR CIRCUITS
Const Rf = 1.0            'FIXED RESISTOR 1 (kOHM) HERE
'  For YSI thermistors -- conversion of kOHM to deg C
Const a = 0.0014654354
Const b = 0.0002386780
Const c = 0.0000001000

'DECLARE PUBLIC VARIABLES
PreserveVariables ' variables are maintained over reboot.

Public StationID ' Station ID number, USER INPUT
Public BattVolts_V
Public LoggerTemp_C

Public DlyBatCrtIn_AHr, DlyBatCrtOut_AHr
Public LoadPwr_W, ChargePwr_W

Public CH200_M0(9)  'Array to hold all data from CH200

Public CH200_MX(4)  ' Array to hold extended data from CH200
Alias CH200_MX(1) = BattTargV ' Battery charging target voltage
Alias CH200_MX(2) = DgtlPotSet ' Digital potentiometer setting
Alias CH200_MX(3) = BattCap ' Present battery capacity
Alias CH200_MX(4) = Qloss ' Battery charge deficit

' SDI-12 formatted battery capacity value
Public SDI12command As String
' Response from CH200. Retrns the address of the unit and "ok" if all went well
Public SDI12result As String
Public NEWBATTCAP ' the new battery capacticty if you need to change it.

Public PT1Data(2)    'Water Level Sensor 1 - pressure, temperature
Public PT2Data(2)    'Water Level Sensor 2 - pressure, temperature
Public PT3Data(2)    'Water Level Sensor 3 - pressure, temperature
Public PT4Data(2)    'Water Level Sensor 4 - pressure, temperature

Public WaterHt1_cm, WaterHt1_ft      ' Water level above the probe
Public WaterHt2_cm, WaterHt2_ft      ' Water level above the probe
Public WaterHt3_cm, WaterHt3_ft      ' Water level above the probe
Public WaterHt4_cm, WaterHt4_ft      ' Water level above the probe

Public Cond1_mS_cm, Cond1_uS_cm
Public Cond1TC_mS_cm, Cond1TC_uS_cm
```

```
Public Cond1T_C
Public Cond2_mS_cm, Cond2_uS_cm
Public Cond2TC_mS_cm, Cond2TC_uS_cm
Public Cond2T_C

Public Therm_kOhm(24), Temp_C(24) ' two GWS soil temp strings

Dim Initialized
Dim Rs1,Rs2
Dim therm(24),D(24),i,j

Alias PT1Data(1) = WaterHt1_psi
Alias PT1Data(2) = WaterT1_C
Alias PT2Data(1) = WaterHt2_psi
Alias PT2Data(2) = WaterT2_C
Alias PT3Data(1) = WaterHt3_psi
Alias PT3Data(2) = WaterT3_C
Alias PT4Data(1) = WaterHt4_psi
Alias PT4Data(2) = WaterT4_C

Alias CH200_M0(1)=CH200BattVolts_V      'Battery voltage: VDC
Alias CH200_M0(2)=BattCrnt_A      'Current going into, or out of, the battery: Amps
Alias CH200_M0(3)=LoadCrnt_A      'Current going to the load: Amps
Alias CH200_M0(4)=SolarPanel_V      'Voltage coming into the charger: VDC
Alias CH200_M0(5)=SolarPanel_A      'Current coming into the charger: Amps
Alias CH200_M0(6)=Chgr_Tmp_C      'Charger temperature: Celsius
Alias CH200_M0(7)=Chgr_State      'Charging state: 2=Cycle, 3=Float, 1=Current Limited, or
0=None
Alias CH200_M0(8)=Chgr_Source      'Charging source: 0=None, 1=Solar, or 2=AC
Alias CH200_M0(9)=Ck_Batt      'Check battery error: 0=normal, 1=check battery


Alias Temp_C(1) = SoilT_5cm_C
Alias Temp_C(2) = SoilT_10cm_C
Alias Temp_C(3) = SoilT_15cm_C
Alias Temp_C(4) = SoilT_20cm_C
Alias Temp_C(5) = SoilT_30cm_C
Alias Temp_C(6) = SoilT_40cm_C
Alias Temp_C(7) = SoilT_50cm_C
Alias Temp_C(8) = SoilT_60cm_C
Alias Temp_C(9) = SoilT_80cm_C
Alias Temp_C(10) = SoilT_100cm_C
Alias Temp_C(11) = SoilT_120cm_C
Alias Temp_C(12) = SoilT_150cm_C

Alias Temp_C(13) = SoilT2_5cm_C
```

```
Alias Temp_C(14) = SoilT2_10cm_C
Alias Temp_C(15) = SoilT2_15cm_C
Alias Temp_C(16) = SoilT2_20cm_C
Alias Temp_C(17) = SoilT2_30cm_C
Alias Temp_C(18) = SoilT2_40cm_C
Alias Temp_C(19) = SoilT2_50cm_C
Alias Temp_C(20) = SoilT2_60cm_C
Alias Temp_C(21) = SoilT2_80cm_C
Alias Temp_C(22) = SoilT2_100cm_C
Alias Temp_C(23) = SoilT2_120cm_C
Alias Temp_C(24) = SoilT2_150cm_C


'Hourly Diagonostics Table
DataTable (HourlyDiag,1,-1)
  DataInterval (0,60,Min,0)
  Sample (1,StationID,fp2)

  'BATTERY VOLTS (V)
  Sample (1,BattVolts_V,FP2)
  Average (1,BattVolts_V,FP2,False)
  Maximum (1,BattVolts_V,FP2,False,False)
  Minimum (1,BattVolts_V,FP2,False,False)

  'BATTERY CURRENT (A)
  Sample (1,CH200_M0(2),FP2)
  Average (1,CH200_M0(2),FP2,False)
  Maximum (1,CH200_M0(2),FP2,False,False)
  Minimum (1,CH200_M0(2),FP2,False,False)

  'LOAD CURRENT (A)
  Sample (1,CH200_M0(3),FP2)
  Average (1,CH200_M0(3),FP2,False)
  Maximum (1,CH200_M0(3),FP2,False,False)
  Minimum (1,CH200_M0(3),FP2,False,False)

  'SOLAR PANEL VOLTS (V)
  Sample (1,CH200_M0(4),FP2)
  Average (1,CH200_M0(4),FP2,False)
  Maximum (1,CH200_M0(4),FP2,False,False)
  Minimum (1,CH200_M0(4),FP2,False,False)

  'SOLAR PANEL CURRENT (A)
  Sample (1,CH200_M0(5),FP2)
  Average (1,CH200_M0(5),FP2,False)
  Maximum (1,CH200_M0(5),FP2,False,False)
```

```
  Minimum (1,CH200_M0(5),FP2,False,False)

  Average (1,LoggerTemp_C,FP2,False)     'Logger Temperature (deg C)
  Average (1,CH200_M0(6),FP2,False)      'Charge Regulator Temperature (deg C)

  Sample (1,NEWBATTCAP,FP2)
  Sample (1,BattCap,FP2)

  Sample (1,DlyBatCrtIn_AHr,FP2)
  Sample (1,DlyBatCrtOut_AHr,FP2)

  Average (1,ChargePwr_W,FP2,False)
  Maximum (1,ChargePwr_W,FP2,False,False)
  Minimum (1,ChargePwr_W,FP2,False,False)

  Average (1,LoadPwr_W,FP2,False)
  Maximum (1,LoadPwr_W,FP2,False,False)
  Minimum (1,LoadPwr_W,FP2,False,False)

  ' Charger state
  Sample (1,CH200_M0(7),FP2)

EndTable


'15-minute Water Ttable
DataTable (QuarterHourlyWater,1,-1)
  DataInterval(0,15,Min,0)
  Sample (1,StationID,fp2)

  Sample (1,WaterHt1_cm,FP2)
  Average (1,WaterHt1_cm,FP2,False)
  Maximum (1,WaterHt1_cm,FP2,False,False)
  Minimum (1,WaterHt1_cm,FP2,False,False)

  Sample (1,WaterHt2_cm,FP2)
  Average (1,WaterHt2_cm,FP2,False)
  Maximum (1,WaterHt2_cm,FP2,False,False)
  Minimum (1,WaterHt2_cm,FP2,False,False)

  Sample (1,WaterHt3_cm,FP2)
  Average (1,WaterHt3_cm,FP2,False)
  Maximum (1,WaterHt3_cm,FP2,False,False)
  Minimum (1,WaterHt3_cm,FP2,False,False)

  Sample (1,WaterHt4_cm,FP2)
```

```
Average (1,WaterHt4_cm,FP2,False)
Maximum (1,WaterHt4_cm,FP2,False,False)
Minimum (1,WaterHt4_cm,FP2,False,False)

Sample (1,WaterHt1_ft,FP2)
Average (1,WaterHt1_ft,FP2,False)
Maximum (1,WaterHt1_ft,FP2,False,False)
Minimum (1,WaterHt1_ft,FP2,False,False)

Sample (1,WaterHt2_ft,FP2)
Average (1,WaterHt2_ft,FP2,False)
Maximum (1,WaterHt2_ft,FP2,False,False)
Minimum (1,WaterHt2_ft,FP2,False,False)

Sample (1,WaterHt3_ft,FP2)
Average (1,WaterHt3_ft,FP2,False)
Maximum (1,WaterHt3_ft,FP2,False,False)
Minimum (1,WaterHt3_ft,FP2,False,False)

Sample (1,WaterHt4_ft,FP2)
Average (1,WaterHt4_ft,FP2,False)
Maximum (1,WaterHt4_ft,FP2,False,False)
Minimum (1,WaterHt4_ft,FP2,False,False)

Sample (1,WaterT1_C,FP2)
Average (1,WaterT1_C,FP2,False)
Maximum (1,WaterT1_C,FP2,False,False)
Minimum (1,WaterT1_C,FP2,False,False)

Sample (1,WaterT2_C,FP2)
Average (1,WaterT2_C,FP2,False)
Maximum (1,WaterT2_C,FP2,False,False)
Minimum (1,WaterT2_C,FP2,False,False)

Sample (1,WaterT3_C,FP2)
Average (1,WaterT3_C,FP2,False)
Maximum (1,WaterT3_C,FP2,False,False)
Minimum (1,WaterT3_C,FP2,False,False)

Sample (1,WaterT4_C,FP2)
Average (1,WaterT4_C,FP2,False)
Maximum (1,WaterT4_C,FP2,False,False)
Minimum (1,WaterT4_C,FP2,False,False)

Sample (1,WaterHt1_psi,FP2)
Average (1,WaterHt1_psi,FP2,False)
```

```
  Maximum (1,WaterHt1_psi,FP2,False,False)
  Minimum (1,WaterHt1_psi,FP2,False,False)

  Sample (1,WaterHt2_psi,FP2)
  Average (1,WaterHt2_psi,FP2,False)
  Maximum (1,WaterHt2_psi,FP2,False,False)
  Minimum (1,WaterHt2_psi,FP2,False,False)

  Sample (1,WaterHt3_psi,FP2)
  Average (1,WaterHt3_psi,FP2,False)
  Maximum (1,WaterHt3_psi,FP2,False,False)
  Minimum (1,WaterHt3_psi,FP2,False,False)

  Sample (1,WaterHt4_psi,FP2)
  Average (1,WaterHt4_psi,FP2,False)
  Maximum (1,WaterHt4_psi,FP2,False,False)
  Minimum (1,WaterHt4_psi,FP2,False,False)


  Sample (1,Cond1TC_mS_cm,FP2)
  Average (1,Cond1TC_mS_cm,FP2,False)
  Maximum (1,Cond1TC_mS_cm,FP2,False,False)
  Minimum (1,Cond1TC_mS_cm,FP2,False,False)

  Sample (1,Cond2TC_mS_cm,FP2)
  Average (1,Cond2TC_mS_cm,FP2,False)
  Maximum (1,Cond2TC_mS_cm,FP2,False,False)
  Minimum (1,Cond2TC_mS_cm,FP2,False,False)

  Average (1,Cond1T_C,FP2,False)
  Maximum (1,Cond1T_C,FP2,False,False)
  Minimum (1,Cond1T_C,FP2,False,False)

  Average (1,Cond2T_C,FP2,False)
  Maximum (1,Cond2T_C,FP2,False,False)
  Minimum (1,Cond2T_C,FP2,False,False)
EndTable

' Hourly Raw Table
DataTable (HourlyRaw,1,-1)
  DataInterval(0,60,Min,0)
  Sample (1,StationID,fp2)

  Sample (1,Rs1,FP2)
  Average (1,Rs1,FP2,False)
```

```
  Sample (1,Rs2,FP2)
  Average (1,Rs2,FP2,False)

  Sample (24, Therm_kOhm(),FP2)
  Average (24,Therm_kOhm(),FP2,False)
EndTable


'Daily Output Table
DataTable (Daily,1,-1)
  DataInterval(0,1440,Min,0)
  Sample (1,StationID,fp2)

  Average (1,WaterHt1_cm,FP2,False)
  Maximum (1,WaterHt1_cm,FP2,False,False)
  Minimum (1,WaterHt1_cm,FP2,False,False)

  Average (1,WaterHt2_cm,FP2,False)
  Maximum (1,WaterHt2_cm,FP2,False,False)
  Minimum (1,WaterHt2_cm,FP2,False,False)

  Average (1,WaterHt3_cm,FP2,False)
  Maximum (1,WaterHt3_cm,FP2,False,False)
  Minimum (1,WaterHt3_cm,FP2,False,False)

  Average (1,WaterHt4_cm,FP2,False)
  Maximum (1,WaterHt4_cm,FP2,False,False)
  Minimum (1,WaterHt4_cm,FP2,False,False)


  Average (1,WaterHt1_ft,FP2,False)
  Maximum (1,WaterHt1_ft,FP2,False,False)
  Minimum (1,WaterHt1_ft,FP2,False,False)

  Average (1,WaterHt2_ft,FP2,False)
  Maximum (1,WaterHt2_ft,FP2,False,False)
  Minimum (1,WaterHt2_ft,FP2,False,False)

  Average (1,WaterHt3_ft,FP2,False)
  Maximum (1,WaterHt3_ft,FP2,False,False)
  Minimum (1,WaterHt3_ft,FP2,False,False)

  Average (1,WaterHt4_ft,FP2,False)
  Maximum (1,WaterHt4_ft,FP2,False,False)
  Minimum (1,WaterHt4_ft,FP2,False,False)
```

```
Average (1,WaterT1_C,FP2,False)
Maximum (1,WaterT1_C,FP2,False,False)
Minimum (1,WaterT1_C,FP2,False,False)

Average (1,WaterT2_C,FP2,False)
Maximum (1,WaterT2_C,FP2,False,False)
Minimum (1,WaterT2_C,FP2,False,False)

Average (1,WaterT3_C,FP2,False)
Maximum (1,WaterT3_C,FP2,False,False)
Minimum (1,WaterT3_C,FP2,False,False)

Average (1,WaterT4_C,FP2,False)
Maximum (1,WaterT4_C,FP2,False,False)
Minimum (1,WaterT4_C,FP2,False,False)


Average (1,WaterHt1_psi,FP2,False)
Maximum (1,WaterHt1_psi,FP2,False,False)
Minimum (1,WaterHt1_psi,FP2,False,False)

Average (1,WaterHt2_psi,FP2,False)
Maximum (1,WaterHt2_psi,FP2,False,False)
Minimum (1,WaterHt2_psi,FP2,False,False)

Average (1,WaterHt3_psi,FP2,False)
Maximum (1,WaterHt3_psi,FP2,False,False)
Minimum (1,WaterHt3_psi,FP2,False,False)

Average (1,WaterHt4_psi,FP2,False)
Maximum (1,WaterHt4_psi,FP2,False,False)
Minimum (1,WaterHt4_psi,FP2,False,False)

Average (1,Cond1TC_mS_cm,FP2,False)
Maximum (1,Cond1TC_mS_cm,FP2,False,False)
Minimum (1,Cond1TC_mS_cm,FP2,False,False)

Average (1,Cond2TC_mS_cm,FP2,False)
Maximum (1,Cond2TC_mS_cm,FP2,False,False)
Minimum (1,Cond2TC_mS_cm,FP2,False,False)

Average (1,Cond1T_C,FP2,False)
Maximum (1,Cond1T_C,FP2,False,False)
Minimum (1,Cond1T_C,FP2,False,False)
```

```
  Average (1,Cond2T_C,FP2,False)
  Maximum (1,Cond2T_C,FP2,False,False)
  Minimum (1,Cond2T_C,FP2,False,False)

  Average (12,SoilT_5cm_C,FP2,False)
  Average (12,SoilT2_5cm_C,FP2,False)
EndTable


'Hourly Climate Table (for Current Conditions Table on Web)
' Size limited to 96 data values or 4 days worth.
DataTable (HrlyClimate,1,96)
  DataInterval (0,60,Min,0)
  Sample (1,StationID,fp2)

  Sample (1,WaterHt1_cm,FP2)
  Sample (1,WaterHt1_ft,FP2)
  Sample (1,WaterHt1_psi,FP2)
  Sample (1,WaterT1_C,FP2)

  Sample (1,WaterHt2_cm,FP2)
  Sample (1,WaterHt2_ft,FP2)
  Sample (1,WaterHt2_psi,FP2)
  Sample (1,WaterT2_C,FP2)

  Sample (1,WaterHt3_cm,FP2)
  Sample (1,WaterHt3_ft,FP2)
  Sample (1,WaterHt3_psi,FP2)
  Sample (1,WaterT3_C,FP2)

  Sample (1,WaterHt4_cm,FP2)
  Sample (1,WaterHt4_ft,FP2)
  Sample (1,WaterHt4_psi,FP2)
  Sample (1,WaterT4_C,FP2)

  Sample (1,Cond1TC_mS_cm,FP2)
  Sample (1,Cond2TC_mS_cm,FP2)

  Sample (1,Cond1T_C,FP2)
  Sample (1,Cond2T_C,FP2)

EndTable

'Hourly Climate Table (for Current Conditions Table on Web)
DataTable (HourlySubs,1,-1)
  DataInterval (0,60,Min,0)
```

```
  Sample (1,StationID,fp2)

  Sample (12,SoilT_5cm_C,FP2)
  Average (12,SoilT_5cm_C,FP2,False)

  Sample (12,SoilT2_5cm_C,FP2)
  Average (12,SoilT2_5cm_C,FP2,False)
EndTable

''''''''''''''''''''
'''' MAIN PROGRAM ''''
''''''''''''''''''''

'SCAN (EXECUTE) PROGRAM AT 5-SEC INTERVALS
BeginProg
  'Three-second scan interval
  Scan (3,Sec,0,0)
    '''''' Set Station ID ''''''
    StationID = ID

    ' initialize the default (power up) conditions
    If Initialized = 0 Then
      Initialized = 1
      NEWBATTCAP = 100 ' 100AHr is max capacity the CH200 will accept
    EndIf

    'CS547A1 Conductivity and Temperature Probe #1 measurements Cond1_mS_cm,
Cond1TC_mS_cm, and Cond1T_C
    'Make preliminary voltage measurement
    BrFull(Rs1,1,mV2500,5,2,1,2500,True,True,0,250,-0.001,1)
    'Convert voltage measurement to resistance
    Rs1=Rs1/(1-Rs1)
    'Make refined voltage measurement based on preliminary measurement
    Select Case Rs1
    Case Is <1.8
      BrHalf(Rs1,1,mV2500,10,2,1,2500,True,0,250,1,0)
    Case Is <9.25
      BrFull(Rs1,1,mV2500,5,2,1,2500,True,True,0,250,-0.001,1)
    Case Is <280
      BrFull(Rs1,1,mV250,5,2,1,2500,True,True,0,250,-0.001,1)
    EndSelect
    'Convert voltage measurement to resistance
    Rs1=Rs1/(1-Rs1)
    'Subtract resistance errors from cable length
    Rs1=Rs1-(CS547A1cable*0.000032+0.005)
    'Calculate EC
```

```
Cond1_mS_cm=(1/Rs1)*CS547A1CalFactor
'Correct EC for ionization errors
If Cond1_mS_cm<0.474 Then
  Cond1_mS_cm=Cond1_mS_cm*0.95031-0.00378
Else
  Cond1_mS_cm=-0.02889+(0.98614*Cond1_mS_cm)+(0.02846*Cond1_mS_cm^2)
EndIf
'Make temperature measurement (Deg C)
Therm107(Cond1T_C,1,11,1,0,250,1,0)
'Correct EC for temperature errors
Cond1TC_mS_cm=(Cond1_mS_cm*100)/((Cond1T_C-25)*0+100)
'Trap measurements below 0.005 mS/cm threshold
If Cond1TC_mS_cm<0.005 Then Cond1TC_mS_cm=0.005

Cond1_uS_cm = Cond1_mS_cm * 1000
Cond1TC_uS_cm = Cond1TC_mS_cm * 1000

'CS547A2 Conductivity and Temperature Probe #2 measurements Cond_mS_cm,
CondTC_mS_cm, and CondT_C
'Make preliminary voltage measurement
BrFull(Rs2,1,mV2500,3,3,1,2500,True,True,0,250,-0.001,1)
'Convert voltage measurement to resistance
Rs2=Rs2/(1-Rs2)
'Make refined voltage measurement based on preliminary measurement
Select Case Rs2
Case Is <1.8
  BrHalf(Rs2,1,mV2500,6,3,1,2500,True,0,250,1,0)
Case Is <9.25
  BrFull(Rs2,1,mV2500,3,3,1,2500,True,True,0,250,-0.001,1)
Case Is <280
  BrFull(Rs2,1,mV250,3,3,1,2500,True,True,0,250,-0.001,1)
EndSelect
'Convert voltage measurement to resistance
Rs2=Rs2/(1-Rs2)
'Subtract resistance errors from cable length
Rs2=Rs2-(CS547A2cable*0.000032+0.005)
'Calculate EC
Cond2_mS_cm=(1/Rs2)*CS547A2CalFactor
'Correct EC for ionization errors
If Cond2_mS_cm<0.474 Then
  Cond2_mS_cm=Cond2_mS_cm*0.95031-0.00378
Else
  Cond2_mS_cm=-0.02889+(0.98614*Cond2_mS_cm)+(0.02846*Cond2_mS_cm^2)
EndIf
'Make temperature measurement (Deg C)
Therm107(Cond2T_C,1,7,1,0,250,1,0)
```

```
'Correct EC for temperature errors
Cond2TC_mS_cm=(Cond2_mS_cm*100)/((Cond2T_C-25)*0+100)
'Trap measurements below 0.005 mS/cm threshold
If Cond2TC_mS_cm<0.005 Then Cond2TC_mS_cm=0.005

Cond2_uS_cm = Cond2_mS_cm * 1000
Cond2TC_uS_cm = Cond2TC_mS_cm * 1000

'Begin 60-sec Loop
If IfTime (0,60,Sec) Then

  '''''''''' MEASURE DATALOGGER WIRING PANEL TEMPERATURE (deg C)
  PanelTemp (LoggerTemp_C,250)

  '''''''''' MEASURE DATALOGGER BATTERY VOLTS (V)
  Battery (BattVolts_V)

  ' Feature to enter specific battery capacity as a Public value and send to charger(s)
  'Get additional values from CH200
  SDI12Recorder (CH200_MX(),1,0,"M6!",1.0,0)
  'If the present battery capacity isnot the  same as the new battery capacity, send the new one.
  If BattCap <> NEWBATTCAP Then
    SDI12command = "XC" & FormatFloat (NEWBATTCAP, "%4.1f") & "!"
    SDI12Recorder (SDI12result,1,0,SDI12command,1.0,0)
  EndIf

  '''''''''''' CH200 CHARGE REGULATOR MEASUREMENTS
  SDI12Recorder (CH200_M0(),1,0,"MC!",1.0,0)

  ' Compute running Power and daily running total AmpHours/Day values for each current measurement.
  LoadPwr_W = CH200BattVolts_V * LoadCrnt_A
  ChargePwr_W = SolarPanel_V *SolarPanel_A
  ' Divide each 1 minute Amp sample by 1440 sample/day so that the total at the end of the day is to get avg current for the day
  ' then muliply be 24 Hr/day to get AHr/Day. or divide by 60 because 24/1440 = 1/60
  ' Separate and sum each the positive and negative currents into and out of the battery to get the total AHr in/out for the day.
  ' Sample hourly and daily, then zero at end of the day.

  If BattCrnt_A > 0 Then DlyBatCrtIn_AHr = DlyBatCrtIn_AHr + BattCrnt_A/60
  If BattCrnt_A < 0 Then DlyBatCrtOut_AHr = DlyBatCrtOut_AHr + BattCrnt_A/60


  ''''''''''    READ INW or CSI SDI-12 Pressure Transducer
  SDI12Recorder (PT1Data(),5,1,"M!",1.0,0)
```

```
    SDI12Recorder (PT2Data(),5,2,"M!",1.0,0
    SDI12Recorder (PT3Data(),5,3,"M!",1.0,0
    SDI12Recorder (PT4Data(),5,4,"M!",1.0,0
    ' convert water heights in psi to cm (70.307 cm/psi)
    WaterHt1_cm = WaterHt1_psi * 70.307
    'Convert Water Height in cm to ft. (0.0328 ft/cm)
    WaterHt1_ft = WaterHt1_cm * 0.0328

    WaterHt2_cm = WaterHt2_psi * 70.307
    WaterHt2_ft = WaterHt2_cm * 0.0328
    WaterHt3_cm = WaterHt3_psi * 70.307
    WaterHt3_ft = WaterHt3_cm * 0.0328
    WaterHt4_cm = WaterHt4_psi * 70.307
    WaterHt4_ft = WaterHt4_cm * 0.0328


'***************************************************************************
    "    READ AM16/32 #1 MULTIPLEXER      Every 1 minute      "

'***************************************************************************
    PortSet (2,1 )         'TURN ON AM16/32 #1 MULTIPLEXER, SET PORT 2 HIGH
    i = 1                  'INITIALIZE INDEX INTERGER I TO ONE
    'READ 36 GWS THERMISTORS
    SubScan (0,Sec,4)      'SCAN LOOP -- 5 ITERATIONS
      PulsePort (3,10000)    'ADVANCE AM16/32 #1 GROUP BY 1, PULSE PORT 2
      'MEASURE GWS THERMISTORS, (Voltage Ratio X = Rs/(Rs+Rf))
      BrHalf (therm(i),1,mV2500,1,Vx1,1,2500,True ,0,_60Hz,1.0,0)
      i = i + 1
      BrHalf (therm(i),1,mV2500,2,Vx1,1,2500,True ,0,_60Hz,1.0,0)
      i = i + 1
      BrHalf (therm(i),1,mV2500,3,Vx1,1,2500,True ,0,_60Hz,1.0,0)
      i = i + 1
    NextSubScan
    PortSet (2,0)          'TURN OFF AM16/32 #1 MULTIPLEXER, SET PORT 1 LOW

    'CONVERT MEASURED VOLTAGE RATIO TO RESISTANCE (kOHM) FOR 36 GWS
THERMISTORS
    For i=1 To 12
      Therm_kOhm(i) = Rf*therm(i)/(1-therm(i))
    Next i
    'CONVERT GWS THERMISTOR RESISTANCE TO deg C FOR 36 GWS
THERMISTORS
    For i=1 To 12
      D(i) = LN (1000*Therm_kOhm(i))                        'ln resistance (ohm)
      Temp_C(i) = (1/(a + b*D(i) + c*(D(i))^3)) - 273.15     'Steinhart & Hart Equation
    Next i
```

```
    EndIf  'End of 60-seccond scan loop

    CallTable HourlyDiag
    CallTable QuarterHourlyWater
    CallTable HourlyRaw
    CallTable Daily
    CallTable HrlyClimate
    CallTable HourlySubs

    If IfTime (0,1440,Min) Then
      DlyBatCrtIn_AHr = 0
      DlyBatCrtOut_AHr = 0
    EndIf

  NextScan
EndProg
```

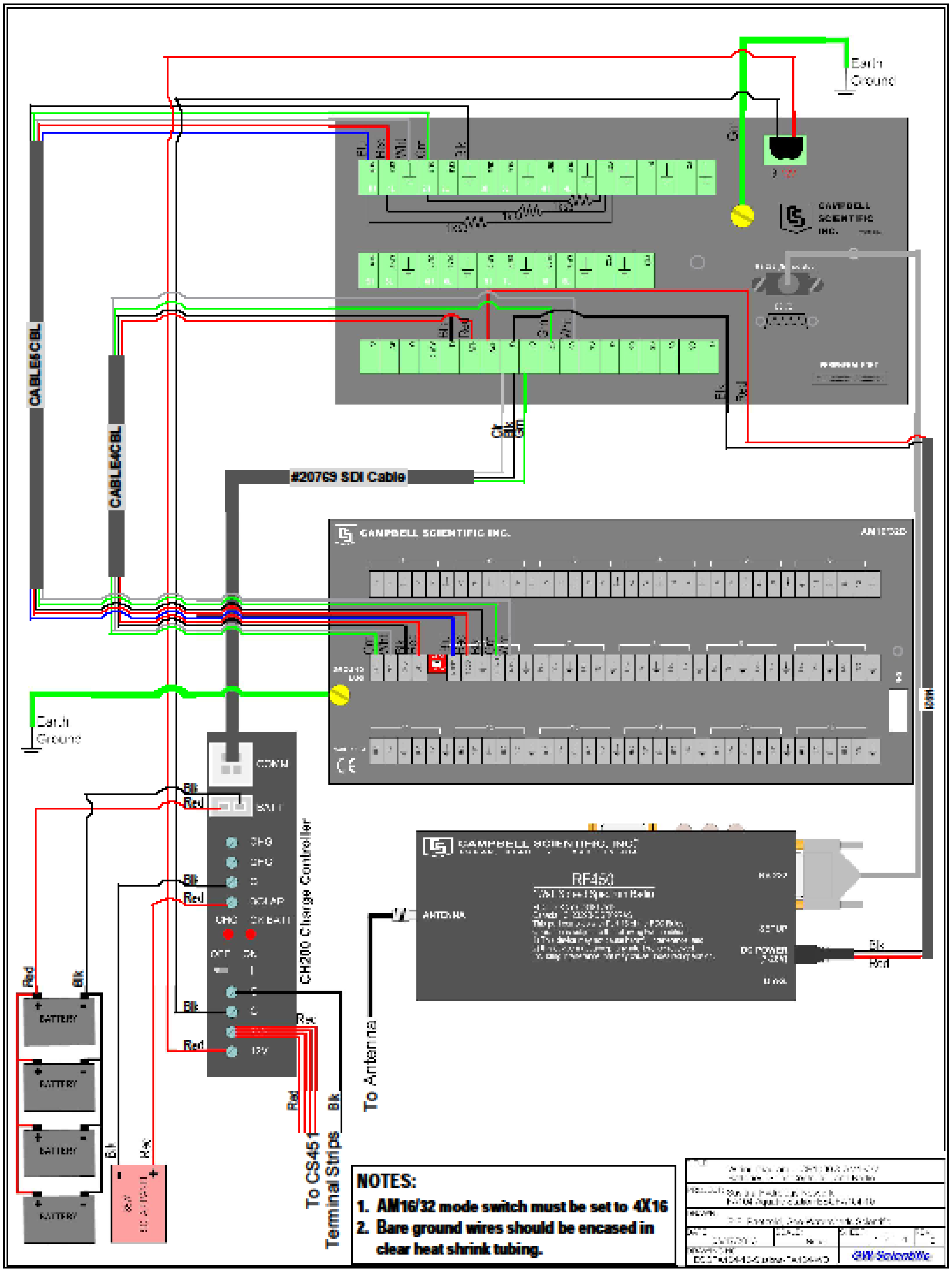

Figure C-19. ESGFA104-10 Sheet 1 (Data Logger, Power, Radio, Multiplexer).

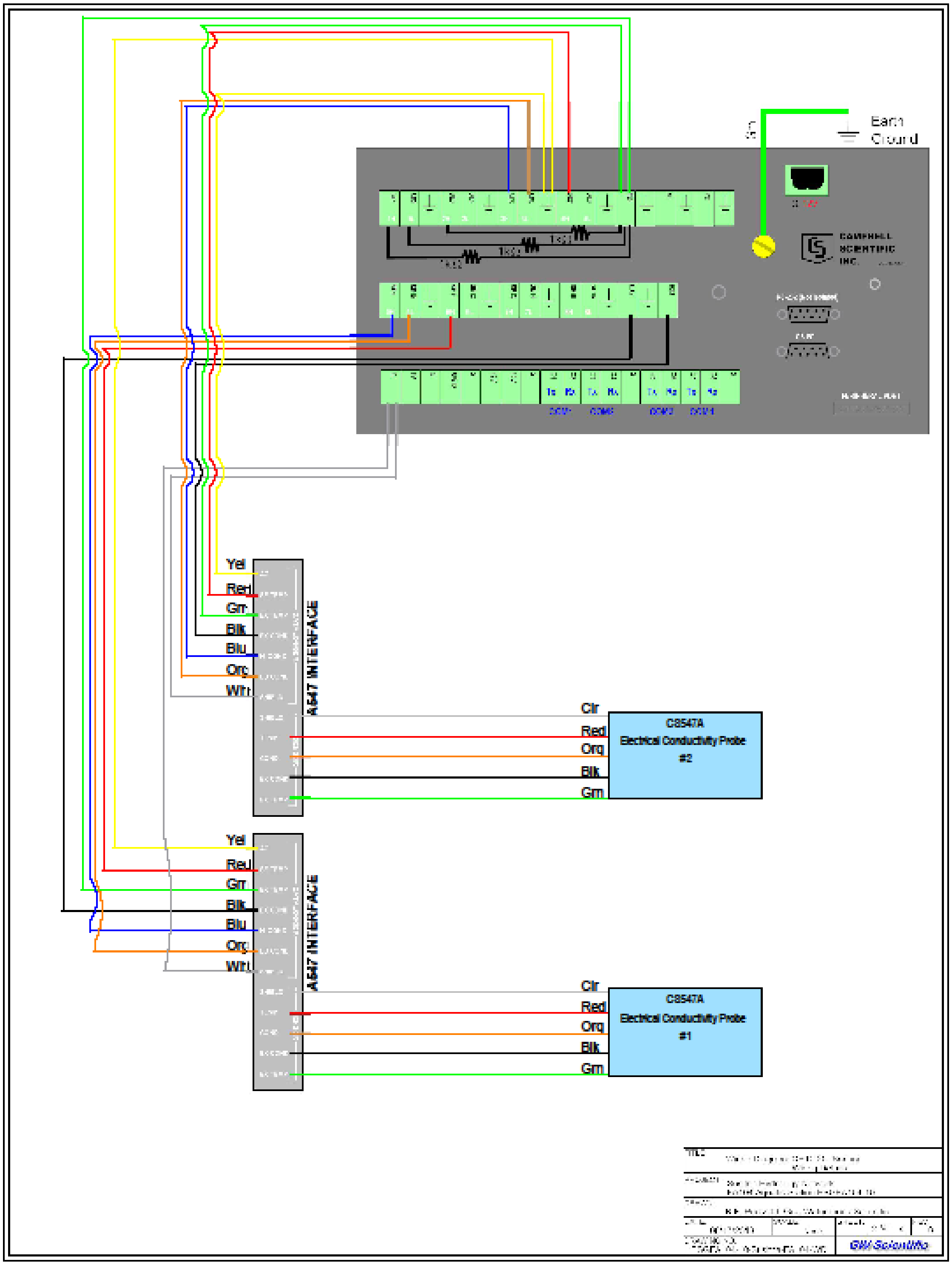

Figure C-20. ESGFA104-10 Sheet 2 (Data Logger, Conductivity Sensors).

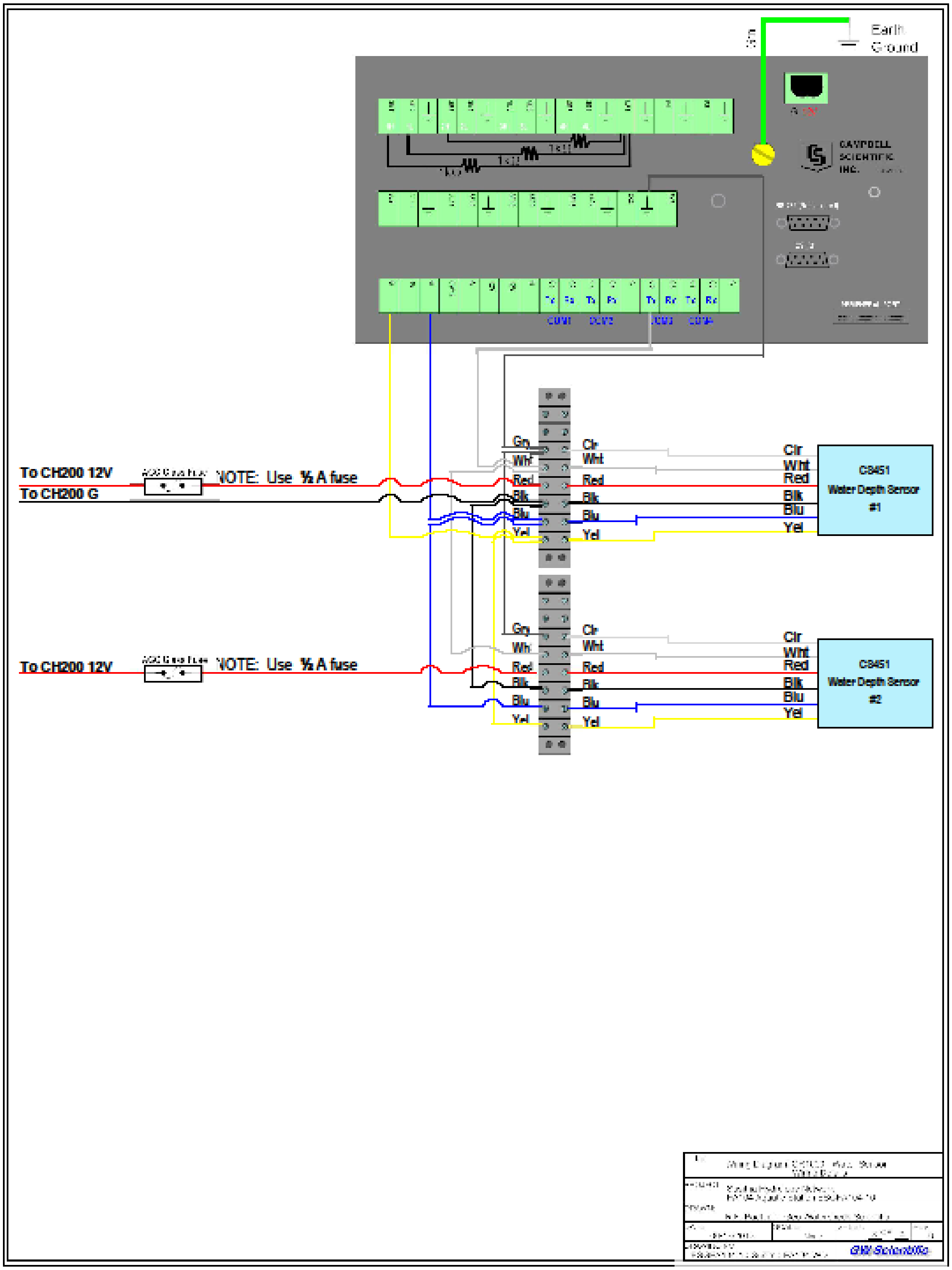

Figure C-21. ESGFA104-10 Sheet 3 (Data Logger, CS451 WaterSensors).

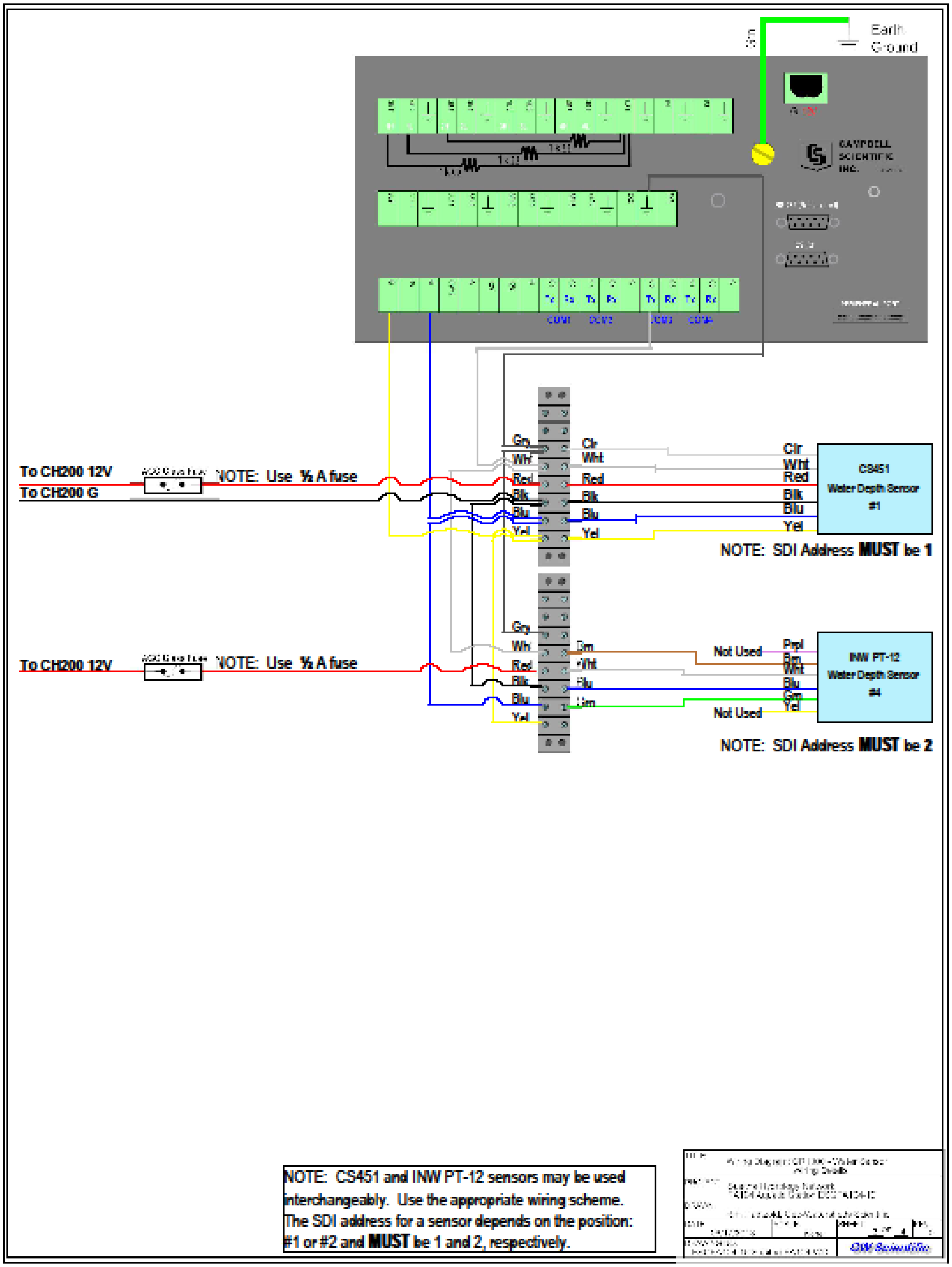

Figure C-22. ESGFA104-10 Sheet 3Alt (Data Logger, Mix CS451 & INW PT-12 WaterSensors).

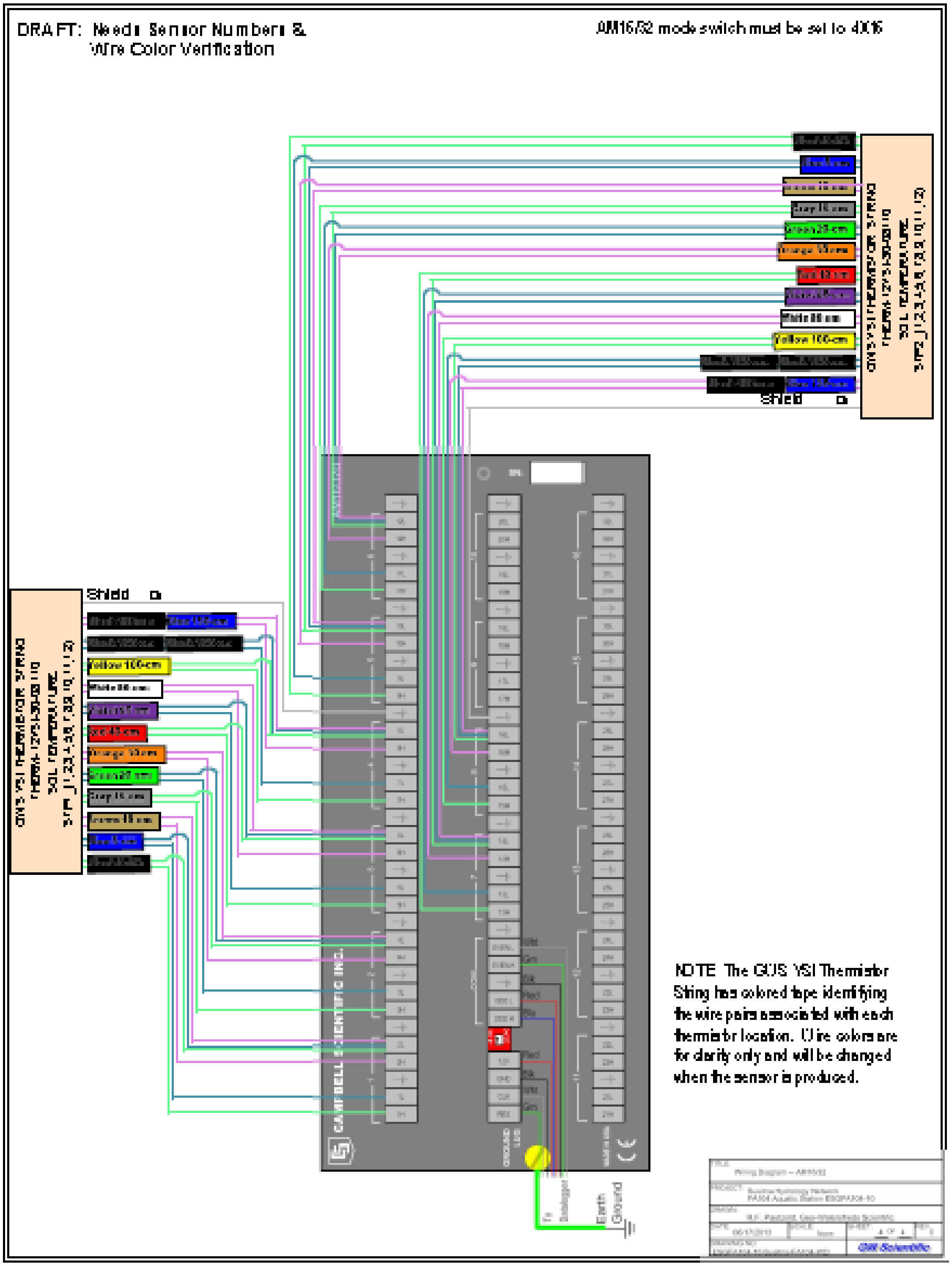

Figure C-23. ESGFA104-10 Sheet 4 (Multiplexer, Sensors).

Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Groundwater Study (7.5)

Part A - Appendix D
Selected Focus Area Time-Lapse Photo Examples

Initial Study Report

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

Geo-Watersheds Scientific

June 2014

PART A - APPENDIX D: SELECTED FOCUS AREA TIME-LAPSE PHOTO EXAMPLES

The selected images in this appendix are intended to show a range of applications for each camera station. The primary purpose of each camera station may vary, but all cameras were in positions to help gain the most information for a variety of study objectives. Cameras with a view of water bodies are applicable for the groundwater/surface-water interactions and for use with other forms of empirical data being collected. All cameras also help capture important riparian vegetation changes in a wide assortment of vegetation units. For example, riparian evapo-transpiration porometer protocol requires specific atmospheric (cloudy or full sun) and dry leaf conditions for conducting leaf porometer measurements. Near-real-time photos allow scheduling of field trips during appropriate atmospheric conditions, therefore facilitating cost-effective field operation. Cameras have also captured ice / floodplain vegetation interactions, informing the floodplain vegetation ice processes study design.

Images from all but two cameras are manually downloaded when field crews are working in a Focus Area, so each set of available images may vary in number of available images and date ranges. The other two cameras are part of the Campbell Scientific CR1000 data acquisition system reporting over the radio telemetry network and provide images in near-real-time. Because poor images may still provide some useful information, only images with no clear view are deleted during quality control checks. Examples of these conditions include camera lens covered in frost or snow, tree limbs completely blocking the camera view, or general camera malfunctions.

Table D-1. This table lists example QC3 Focus Area time-lapse station images. Following the table, example images are provided below in downstream Focus Area order.

Stations Equipped with Time-Lapse Images	Site	Camera Installation Date	Last Image Download Date	Number of Images Currently Available
FA-138 (Gold Creek)	ESCFA138-8[2]	2013-11-06	2013-11-06	1
	ESCFA138-9	2013-11-06	2013-11-17	445
	ESCFA138-10	2013-11-06	2013-11-17	723
	ESCFA138-11[2]	2013-11-06	2013-11-06	1
FA-128 (Slough 8A)	ESSFA128-1[1]	2013-05-13	2014-01-14	8393
	ESCFA128-29	2013-11-06	2013-11-22	2449
	ESCFA128-30	2013-10-04	2013-11-22	1038
	ESCFA128-31	2013-10-25	2013-11-09	1457
	ESCFA128-32[2]	2013-10-25	2013-10-25	1
	ESCFA128-34[2]	2013-11-03	2013-11-03	1
	ESCFA128-35	2013-11-06	2013-11-21	1396
	ESCFA128-36[3]	2013-11-03	not available	0
FA-115 (Slough 6A)	ESCFA115-11[2]	2013-11-03	2013-11-03	1
	ESCFA115-12[2]	2013-11-03	2013-11-03	1
	ESCFA115-13[2]	2013-11-03	2013-11-03	1
FA-113 (Oxbow 1)	ESCFA113-2[2]	2013-11-02	2013-11-02	1
	ESCFA113-3[2]	2013-10-31	2013-10-31	1
	ESCFA113-4[2]	2013-10-31	2013-10-31	1
FA-104 (Whiskers Slough)	ESSFA104-1	2013-04-20	2014-01-14	2436
	ESCFA104-16	2013-10-31	2013-12-04	1424
	ESCFA104-17	2013-10-31	2013-12-09	2155
	ESCFA104-18[2]	2013-10-31	2013-10-31	1
	ESCFA104-19	2013-10-31	2013-11-13	1232
	ESCFA104-20	2013-10-31	2013-11-15	1429
	ESCFA104-21[3]	2013-10-31	not available	0
	ESCFA104-22	2013-10-31	2013-12-09	2590

[1] Campbell Scientific 5MPX near-real-time reporting camera
[2] The single image provided is the first image taken upon installation of this camera. Additional images will be retrieved during the next site visit.
[3] Images will be retrieved during the next site visit.

Figure D-1. This FA-138 (Gold Creek) image from ESCFA138-8 displays a view of early-winter river side channel and Slough 11 conditions on November 06, 2013. Station camera records images (empirical data) for the Slough 11 outlet conditions, leaf-out and leaf-off timing, and winter ice and snow cover conditions.

Figure D-2. This FA-138 (Gold Creek) image from ESCFA138-9 displays a view of early winter Slough 11 conditions on November 06, 2013. Station camera records images (empirical data) for the Slough 11 aquatic transect, Slough 11 hydrology conditions, leaf-out and leaf-off timing, and winter ice and snow cover conditions.

Figure D-3. This FA-138 (Gold Creek) image from ESCFA138-10 displays an early winter view of Upper Side Channel 11, with the main channel in the background on November 06, 2013. Station camera records images (empirical data) for the Upper Side Channel 11 aquatic transect, outlet hydrology conditions, main channel in the background, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions.

Figure D-4. This FA-138 (Gold Creek) image from ESCFA138-11 displays a view of early winter main channel river conditions on November 06, 2013. The station image is looking upstream. Station camera records images (empirical data) for the FA-138 riparian transect, main channel hydrology, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions.

Figure D-5. These FA-128 (Slough 8A) images from ESSFA128-1 display spring snowmelt flooding through Slough 8A and side channel on May 29, 2013 (top) and summer water-quality differences between Slough 8A and inflow from the side channel on June 04, 2013 (bottom). Station camera records images (empirical data) for the side channel, slough, leaf-out and leaf-off timing, riparian vegetation / ice interactions, winter ice and snow cover conditions. This camera is part of the Campbell Scientific CR1000 data acquisition system reporting over the radio telemetry network and provides images in near-real-time

Figure D-6. These FA-128 (Slough 8A) images from ESCFA128-29 displays a side channel on the left hand side of the image view and a junction at the top of the side channel leading down to Slough 8a on the right. The top image was taken in early winter on November 06, 2013. The bottom picture was taken during winter conditions on November 22, 2013. Station camera records images (empirical data) for the inlet and outlet, side channel, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions.

Figure D-7. These FA-128 (Slough 8A) images from ESCFA128-30 display the upstream end of Slough 8A in late fall conditions on October 04, 2013 (top) and early winter conditions on November 09, 2013 (bottom). Station camera records images (empirical data) for the slough, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions. The image direction is looking upstream.

Figure D-8. These FA-128 (Slough 8A) images from ESCFA128-31 display the location of the Slough 8A upper aquatic transect near ESGFA128-7 in late fall on October 25, 2013 (top) and early winter conditions on November 09, 2013 (bottom). Station camera records images (empirical data) for the aquatic transect, slough and stream, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions. The image direction is looking upstream.

Figure D-9. This FA-128 (Slough 8A) image from ESCFA128-32 displays the upper riparian transect and station ESCFA128-5 with trees instrumented with sap flow sensors in late fall conditions on October 10, 2013. Station camera records images (empirical data) for the riparian transect and leaf-out and leaf-off timing.

Figure D-10. This FA-128 (Slough 8A) image from ESCFA128-34 displays a side channel with an inlet to an additional side channel on the right side of the picture on November 03, 2013. Station camera records images (empirical data) for the riparian transect, inlet and outlet, main channel, side channel, riparian vegetation / ice interactions, and leaf-out and leaf-off timing.

Figure D-11. This FA-128 (Slough 8A) image from ESCFA128-36 displays a view looking at a side channel downstream of the outlet of Slough 8A on November 03, 2013. Station camera records images (empirical data) for the outlet, side channel, stream, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions.

Figure D-12. This FA-115 (Slough 6A) image from ESCFA115-11 displays an unnamed stream recharged by groundwater near ESGFA115-2 in early winter on November 03, 2013. Station camera records images (empirical data) for the riparian transect, stream, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions.

Figure D-13. This FA-115 (Slough 6A) image from ESCFA115-12 displays a view of a side channel, looking downstream on November 03, 2013. Station camera records images (empirical data) for the riparian transect, side channel, leaf-out and leaf-off timing, and winter ice and snow cover conditions.

Figure D-14. This FA-115 (Slough 6A) image from ESCFA115-13 displays Slough 6A and the outlet of the unnamed stream flowing into the slough on November 02, 2013. Station camera records images (empirical data) for the slough and stream, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions.

Figure D-15. This FA-113 (Oxbow 1) image from ESCFA113-2 displays the inlet to the Oxbow 1 side channel, looking across the mainstem channel on November 02, 2013. Station camera records images (empirical data) for the inlet, main channel, side channel, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions.

Figure D-16. This FA-113 (Oxbow 1) image from ESCFA113-3 displays the outlet of the Oxbow 1 side channel with the mainstem channel in the background, looking downstream on October 31, 2013. Station camera records images (empirical data) for the outlet, main channel, side channel, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions.

Figure D-17. This FA-113 (Oxbow 1) image from ESCFA113-4 displays a view looking at the Oxbow 1 side channel and unnamed stream flowing into the major bend in the side channel at the ESGFA113-1 station location on October 31, 2013. Station camera records images (empirical data) for the aquatic transect, side channel, slough and stream, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions.

Figure D-18. These FA-104 (Whiskers Creek) images from ESSFA104-1 display vegetation development and the confluence of Whiskers Slough and Whiskers Creek, looking upstream during leaf-out on June 05, 2013 (top) and on June 10, 2013 (bottom). Station camera records images (empirical data) for the inlet and outlet, slough, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions. This camera is part of the Campbell Scientific CR1000 data acquisition system reporting over the radio telemetry network and provides images in near-real-time.

Figure D-19. These FA-104 (Whiskers Slough) images from ESCFA104-16 display the outlet of Whiskers Slough and side channel in the background, looking downstream in early winter on October 31, 2013 (top) and during early winter ice jamming on November 22, 2013 (bottom). Station camera records images (empirical data) for the outlet, slough and stream, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions.

Figure D-20. These FA-104 (Whiskers Slough) images from ESCFA104-17 displays Whiskers Creek, just above the confluence with Whiskers Slough, looking downstream in late fall conditions on October 31, 2013 (top) and after initial early winter ice jamming on the mainstem on December 04, 2013 (bottom). Station camera records images (empirical data) for the slough and stream, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions.

Figure D-21. This FA-104 (Whiskers Slough) image from ESCFA104-18 displays Whiskers Creek, looking downstream during late fall conditions on October 31, 2013. Station camera records images (empirical data) for the stream, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions.

Figure D-22. These FA-104 (Whiskers Slough) images from ESCFA104-19 display an outlet/inlet of Whiskers Slough and Whiskers Side Channel, looking across and upstream at the mainstem channel in late fall on October 31, 2013 (top) and in early winter before mainstem ice jamming on November 12, 2013 (bottom). Station camera records images (empirical data) for the inlet/outlet, side channel, slough and stream, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions.

Figure D-23. These FA-104 (Whiskers Slough) images from ESCFA104-20 display the Whiskers Side Channel, looking downstream, at the upper outlet to Whiskers Slough, in the Slough 3A reach, in late fall on October 31, 2013 (top) and in early winter on November 15, 2013 (bottom). The mainstem has not yet developed early winter ice jams. Station camera records images (empirical data) for the side channel, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions.

Figure D-24. These FA-104 (Whiskers Slough) images from ESCFA104-21 display a view looking upstream at the upstream end of Whiskers Side Channel at the ESGFA104-10 station location during late fall on October 31, 2013 (top). The bottom image shows early winter conditions on November 15, 2013. The mainstem has not yet developed early winter ice jams. Station camera records images (empirical data) for the aquatic transect, main channel, side channel, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions.

Figure D-25. These FA-104 (Whiskers Slough) images from ESCFA104-22 display a view looking across the inlet/outlet of Whiskers Slough, in the Slough 3B reach, and across the Whiskers Side Channel on October 31, 2013 (top). The bottom image shows early winter conditions on November 4, 2013. The mainstem has not yet developed early winter ice jams. Station camera records images (empirical data) for the inlet/outlet, side channel, slough, leaf-out and leaf-off timing, riparian vegetation / ice interactions, and winter ice and snow cover conditions.

Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Groundwater Study (7.5)

Part A - Appendix E
Level-Loop Survey and Survey Control Points Examples

Initial Study Report

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

Geo-Watersheds Scientific

June 2014

APPENDIX E: LEVEL-LOOP SURVEY AND SURVEY CONTROL POINTS EXAMPLES

The establishment and maintenance of survey control for hydrologic stations is important when conducting hydrology studies. Multi-year studies require elevations control networks that are accessible in summer and winter and maintain continuity of data accuracy over the multi-year study period. This becomes more critical when groundwater/surface-water (GW/SW) interaction studies are being conducted. Horizontal and vertical GW/SW gradients may frequently reverse direction (transient interactions), resulting in periods with very flat gradients. As hydrologic gradients become more flat, survey error can significantly change interpretations of the direction and rate of groundwater flow, and exchanges with surface-water systems.

For this reason, horizontal and vertical survey control points were established using the methods described in the Instream Flow Study (Section 8.5.4.1.1). The selected level-loop vertical elevation surveys in this appendix provide an example of standardized QA/QC protocol for measuring elevations with level-loop survey methods established for the Groundwater Study. Level-loop surveys are conducted to measure water surface elevation and track water level changes over time and to establish survey control. Examples of the F-001 Elevation Survey Form have been provided, showing forms that have reached the status of quality control level 3 (QC3), the QC level at which data are reviewed by a Project team senior professional, checking for logic, soundness, and adding qualifiers to results if warranted. A photo image of a survey underway during a well installation to measure water levels to Project datum and accuracy standards is also included.

Images of temporary benchmark (TBM) control points are displayed following the provided examples of level-loop vertical elevation survey forms. Typically, three to four benchmarks are used for an elevation control network at a groundwater or surface-water station. These benchmarks ensure consistency and accuracy when level-loop surveys are conducted. This is a more accurate method than using RTK surveying methods each year. The primary benefit of the RTK surveying is the efficient initial establishment of Project datum at a local site in reference to area-wide control networks. An excerpt of example control point coordinate data is included in the last figure. The combination of these survey techniques provides a defensible approach to surveying hydrology stations and features in arctic environments.

Figure E-1. This image taken at FA104 (Whiskers Slough) depicts a survey underway during a well installation to measure water levels to Project datum and accuracy standards on August 27, 2013.

Susitna-Watana Hydroelectric Project: Groundwater Study
Form F-001: Elevation Survey Form

Project ID: **GW Task6 Riparian** Focus Area - Station ID Location: ESGFA138-7 / (Gold Creek)
Survey Purpose: **Water Level Elevations** Date: 20130904 Time: 13:30

Location:	ESGFA138-7 (Gold Creek). Station location on left side of Upper Side Channel 11, near Susitna River at PRM 138.							
Survey objective:	Determine Water-Surface (WS) Elevation.					Weather Observations:		
Instrument Type:	Leica NA720		Instrument ID:	5650888 (GWS owned)		partly sunny		
Rod Type:	Fiberglass		Rod ID:	Crane Fiber Glass				
Bench Mark Information:						Survey Team Names		
Name	Agency Responsible	Elevation (ft)	Latitude (dd-mmmmm)	Longitude (dd-mmmmm)		Carl Ruffino, Ryan Willis, James Shinas		
TBM1	GWS	695.788	62.7678	-149.7072				

Station	BS (ft)	HI (ft)	FS (ft)	Elevation (fasl)	Distance (ft)	Horizontal Angle	Vertical Angle	Remarks
TBM1	3.73	699.52		695.79				Geovera bench mark rebar
WS-SU			11.35	688.17				water-surface elevation On Susitna adjacent to al cap
TBM4			1.82	697.70				Bolt in 0.5 ft. diam birch, N of monitoring well
WS-BP			6.93	692.59				water-surface elevation at self logging PT
Turn on WS								
WS-BP	7.180	699.77		692.59				
TBM4			2.07	697.70				close to 0.00'
WS-SU			11.60	688.17				close to 0.00'
TBM1			3.98	695.79				close to 0.00'
		Final Water elevation (Susitna River) is average elevation = 688.17 ft. Final water elevation (Beaver Pond) is average elevation = 692.59 ft.						

Abbreviations: backsight, BS; degrees, dd; feet, ft; feet above mean sea level, famsl; foresight, FS; height of instrument, HI; minutes, mm; seconds, ss; water surface, ws; ice surface, is.

Left and right bank referenced to looking downstream.

Elevations are adjusted when the difference falls outside the ±0.01 tolerance.

FAMSL is referenced to the North American Vertical Datum of 1988

Horizonal data is referenced to WGS84

Notes:

QC1: 20130904 CRuffino QC2: 20131113 CRuffino QC3: 20131217 R C-Willis

Figure E-2. This figure depicts an example F-001 Elevation Survey Form for GW Task 6 Riparian for FA-138 (Gold Creek) station ESGFA138-7 conducted on September 04, 2013. This survey was conducted to measure a water surface elevation. This example displays a form that has reached quality control level 3 (QC3), the level at which data are reviewed by a Project team senior professional, checking for logic, soundness, and adding qualifiers to results if warranted.

Susitna-Watana Hydroelectric Project: Groundwater Study

Form F-001: Elevation Survey Form

Project ID: **GW Task6 Riperian** Focus Area - Station ID Location: ESGFA128-2/ (Slough 8A)

Survey Purpose: **Water Level Elevations** Date: 20130926 Time: 13:50

Location:	ESGFA128-2 is located upstream on upper riparian transect, near PRM 130.				
Survey objective:	Determine water-surface (WS) elevation.			Weather Observations:	
Instrument Type:	Leica NA720	Instrument ID:	5650888 (GWS owned)	n/a	
Rod Type:	Fiberglass	Rod ID:	Crane Fiber Glass		
Bench Mark Information:				Survey Team Names	
Name	Agency Responsible	Elevation (ft)	Latitude (dd-mmmmm)	Longitude (dd-mmmmm)	Carl Ruffino, James Shinas
TBM1	GWS	587.48	62.67213	149.89402	

Station	BS (ft)	HI (ft)	FS (ft)	Elevation (feet)	Distance (ft)	Horizontal Angle	Vertical Angle	Remarks
TBM1	4.75	592.23		587.48				al cap
WS			13.87	578.36				water surface
TBM2			3.36	588.86				bolt in tree
Turn on TBM2								
TBM2	3.439	592.30		588.86				
WS			13.94	578.36				close to 0.00'
TBM1			4.824	587.48				close to 0.00'
		Final water-surface elevation = 678.38 ft.						

s: backsight,

Left and right bank referenced to looking downstream.

Elevations are adjusted when the difference falls outside the ±0.01 tolerance.

FAMSL is referenced to the North American Vertical Datum of 1988

Horizonal data is referenced to WGS84

Notes:

QC1: 20130926 CRuffino QC2: 20131114 CRuffino QC3:21031221 R C-Wills

Figure E-3. This figure depicts an example F-001 Elevation Survey Form for GW Task 6 Riparian for FA-128 (Slough 8A) station ESGFA128-2 conducted on September 26, 2013. This survey was conducted to measure water surface elevation. This example displays a form that has reached quality control level 3 (QC3), the level at which data are reviewed by a Project team senior professional, checking for logic, soundness, and adding qualifiers to results if warranted.

Susitna-Watana Hydroelectric Project: Groundwater Study
Form F-001: Elevation Survey Form

Project ID: **GW Task6 Riparian** Focus Area - Station ID Location: FA 104 (Whiskers Slough) - ESGFA104-8
Survey Purpose: **Water Level Elevations** Date: 20130708 Time: n/a

Location:	ESGFA104-8 at Whiskers Slough. Station location is on right side of river, PRM 104.				
Survey objective:	Establish survey control.			Weather Observations:	
Instrument Type:	Leica NA720	Instrument ID:	5650888 (GWS owned)	Sunny. Temperature in mid 70Fs	
Rod Type:	Fiberglass	Rod ID:	Crane Fiber Glass		
Bench Mark Information:				Survey Team Names	
Name	Agency Responsible	Elevation (ft)	Latitude (dd-mmmmm)	Longitude (dd-mmmmm)	Demi Mixon, James Lilly, Lisle Doria
TBM3	GWS	381.79	62.37687	-150.16567	

Station	BS (ft)	HI (ft)	FS (ft)	Elevation (fasl)	Distance (ft)	Horizontal Angle	Vertical Angle	Remarks
TBM3	0.73	382.52		381.79				Bolt in 3 ft. diam spruce, T-48 sap flow, NW of monitoring well
TBM1		382.52	1.69	380.84				Bolt in 0.8 ft diam. spruce tree, T-43 sap flow, E of enclosure
TBM2		382.52	0.67	381.85				Bolt in 1.5 ft. white birch with enclosure, T-44 sap flow
Turn on TBM3								
TBM2	1.01	382.86		381.85				
TBM1		382.86	2.02	380.84				close to 0.00'
TBM3		382.86	1.07	381.79				close to 0.00'

Abbreviations: backsight, BS; degrees, dd; feet, ft; feet above mean sea level, famsl; foresight, FS; height of instrument, HI; minutes, mm; seconds, ss; water surface, ws; ice surface, is.

Left and right bank referenced to looking downstream.

Elevations are adjusted when the difference falls outside the ±0.01 tolerance.

FAMSL is referenced to the North American Vertical Datum of 1988

Horizonal data is referenced to WGS84

Notes: Transcribed from Mixon Field Book 1, pg. 79.

QC1: 20130710 D Mixon QC2: 20130718 D Mixon QC3: 20131230 CRuffino

Figure E-4. This figure depicts an example F-001 Elevation Survey Form for GW Task 6 Riparian for FA-104 (Whiskers Slough) station ESGFA104-8 conducted on July 09, 2013. This survey was conducted to establish an elevation survey control network at ESGFA104-8. This example displays a form that has reached quality control level 3 (QC3), the level at which data are reviewed by a Project team senior professional, checking for logic, soundness, and adding qualifiers to results if warranted.

Figure E-5. This figure depicts example survey control points established at FA-128 (Slough 8A) for conducting level-loop vertical elevation surveys. The top images illustrate elevation survey temporary benchmarks (TBM) located on trees. The top right image displays TBM 2 at ESGFA128-13. The bottom image displays an aluminum cap (Alcap) on rebar (TBM1) at ESGFA128-20. It is common for rebar TBMs to frost heave in winter, so it is beneficial to use 3 to 4 points in trees or other solid features. TBMs also have to be found in the winter, which becomes difficult when there is 3 to 6 feet of snow on the ground.

Groundwater Study						
Control Point Coordinates RTK						
Date of Survey: August 2013						
Lead Technical Contact:	Steve Smith, Geovera, scsmith@gci.net, 907-399-4345					
Last Update:	8/19/13					
Last Update By:	Steve Smith					
The following data is Final DRAFT						
Horizontal data is WGS84/AKSP Zone 4 U.S. Survey Feet, Vertical data is NAVD88/Geoid09 (Feet)						
Focus Area 104						
Groundwater Study Control Points						
Point No.	**Latitude**	**Longitude**	**Northing**	**Easting**	**Elevation**	**Descriptor**
30418	62.3744469920	150.1683474340	3059916.9590	1611834.7670	376.97	WS-10 TBM 10
30419	62.3744480610	150.1683481590	3059917.3500	1611834.6450	376.88	WS-10 MW1 OG
30420	62.3761950050	150.1696798130	3060556.6530	1611610.2340	377.73	ESGFA104-9 MW4 OG
30421	62.3762172670	150.1699588940	3060564.9170	1611562.8760	373.96	ESGFA104-9 W3 OG
30422	62.3762850540	150.1705566030	3060589.9680	1611461.4690	373.04	ESGFA104-9 W2 OG
30423	62.3762860130	150.1709339520	3060590.4880	1611397.4080	380.10	ESGFA104-9 W1 OG
30424	62.3762572150	150.1709094430	3060579.9480	1611401.5410	381.17	ESGFA104-9 SITE OG
30425	62.3761894270	150.1707793630	3060555.1050	1611423.5590	380.03	ESGFA104-9 TBM1
30427	62.3768392480	150.1696435520	3060792.1830	1611617.0080	378.69	ESGFA104-1 TBM10
30428	62.3767573610	150.1693425750	3060762.1100	1611668.0250	377.12	ESGFA104-1 SITE OG
30429	62.3768034340	150.1697220640	3060779.1240	1611603.6450	377.46	ESGFA104-1 TOP BANK
30431	62.3769993660	150.1701461570	3060850.9490	1611531.8370	374.82	WS-30 OG
30432	62.3768812060	150.1713599770	3060808.2920	1611325.6590	375.57	WC 10 TBM10
30433	62.3768417120	150.1714261430	3060793.8820	1611314.3880	374.81	WC 10 OG
30435	62.3781707000	150.1701921040	3061279.2290	1611525.1640	377.08	ESGFA104-5 TBM4
30436	62.3780994890	150.1703813870	3061253.2780	1611492.9630	377.27	ESGFA104-5 MW1 OG
30437	62.3781003030	150.1702863570	3061253.5330	1611509.0960	378.87	ESGFA104-5 SITE OG
30438	62.3780629040	150.1701647780	3061239.8050	1611529.6990	375.61	ESGFA104-5 TOP BANK 1
30439	62.3781660290	150.1705874170	3061277.6980	1611458.0520	374.20	ESGFA104-5 TOP BANK 2
30440	62.3782369420	150.1709999130	3061303.8100	1611388.0960	376.81	ESGFA104-13 TBM10
30441	62.3786350080	150.1718091300	3061449.7140	1611251.1120	379.86	ESMFA104-2 TBM10
30442	62.3786267210	150.1719039900	3061446.7270	1611235.0010	379.57	ESMFA104-2 SITE OG
30443	62.3787823630	150.1721401330	3061503.7390	1611195.0660	379.45	ESMFA104-2 MW1 OG

Figure E-6. An example of RTK control point coordinates compiled and updated in August 2013.