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CS4390 and CS4391 Senior Capstone Project

TerraTek User Manual

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Spring 2025

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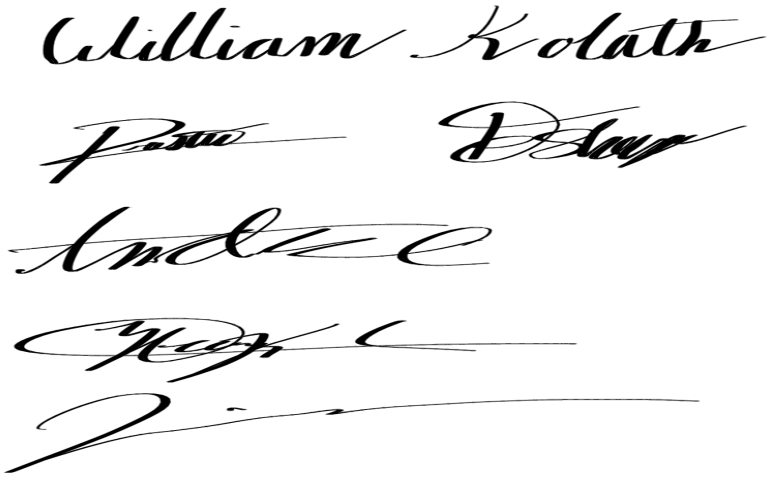


Contents

Chapter 1

Using the Dashboard

To access the dashboard, navigate to `https://terratekrwh.com` on any browser with internet connection.

1.1 Homepage

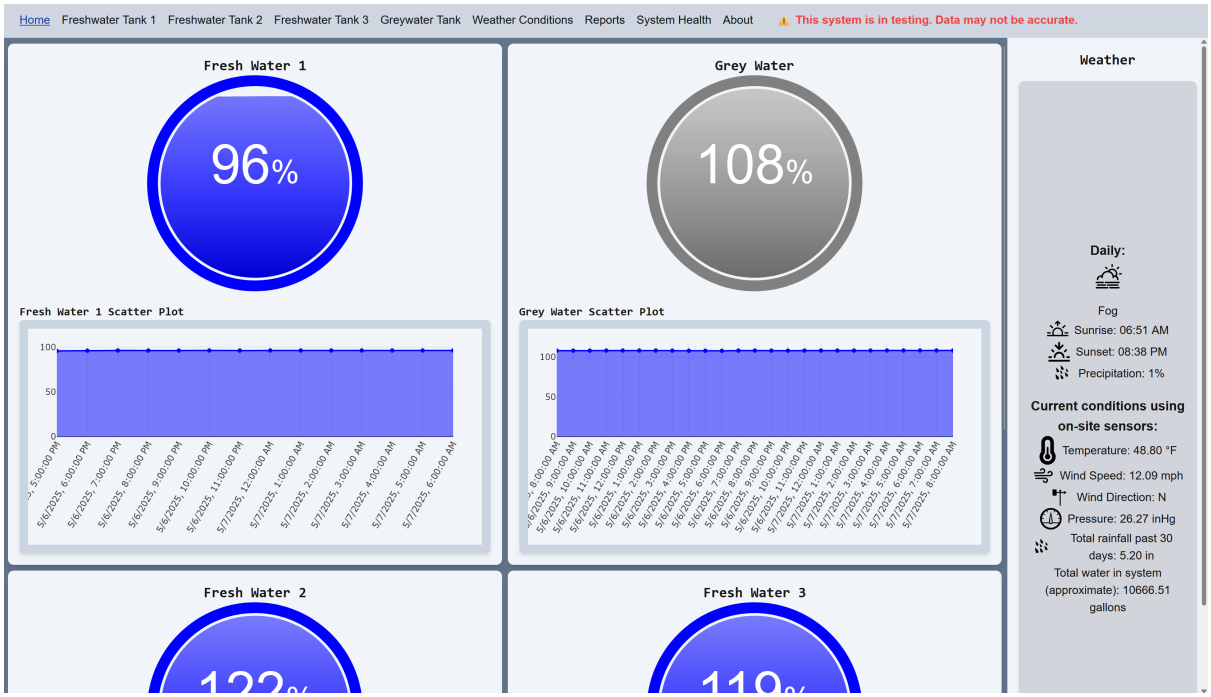


Figure 1.1: Home Page

The home page allows the user to quickly view the levels of all four tanks. The page is broken up into 2 sections, water level and weather conditions. In the water level section, you are able

to view the current level of the tank and a graph showing the past 30 days of what the water level has been. In the weather section, you are given the forecast of the days participation percentage and the sunrise/sunset. Below that, you are given the current readings from the weather station that has been deployed. This includes temperature, Wind speed and direction, pressure, and the sum of rain that has been recorded in the past 30 days.

1.2 Tank Pages

Figure 1.2: Tank Page

The Tank pages are split by type. These being "Freshwater Tank 1, 2, and 3" and then "Greywater Tank". The pages provide detailed insight into the current and historical status of the systems. The layout is divided into two main sections: real-time tank readings and historical data visualizations. In the real-time section, users can monitor key metrics such as water level, pH, electrical conductivity (EC), and temperature through dynamic gauges. The 4 metrics are only used in the Freshwater 1 Tank and Greywater Tank. The other two tanks only have water level and temperature. On the right, historical trends over the past 3 months are plotted for each metric, offering context for recent changes or anomalies. For example, sudden drops in pH or spikes in EC are made visually apparent through these time-series graphs. This page ensures that irregularities can be caught and addressed promptly.

1.3 Weather Page

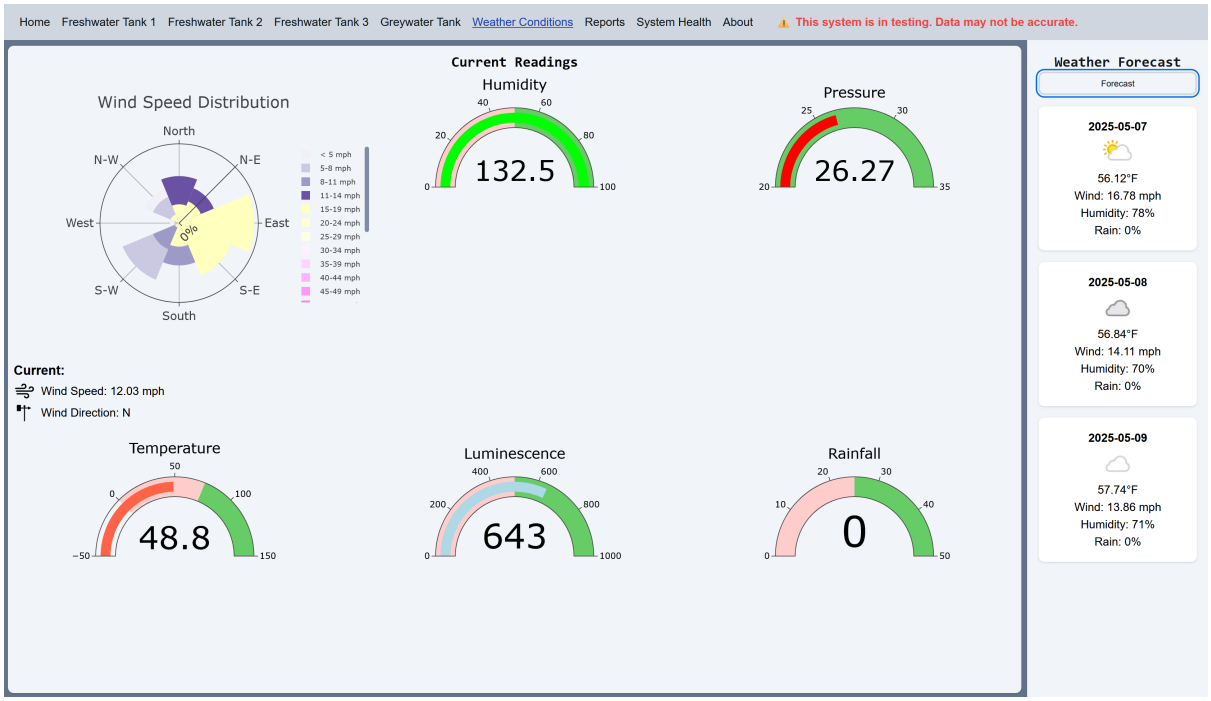


Figure 1.3: Weather Page

The Weather Page give environmental context to the changes within the Rain Water Harvesting System being monitored. This information can be further extrapolated to understand how a certain amount of rainfall can change the levels in the freshwater tanks. Additionally the Weather Page includes some basic forecasting, provided by an outside source, to allow users to see what weather patterns are approaching the systems location. The Weather forecast includes a drop down selection to allow users to choose between 3-day and hourly forecasting.

1.4 Reports Page

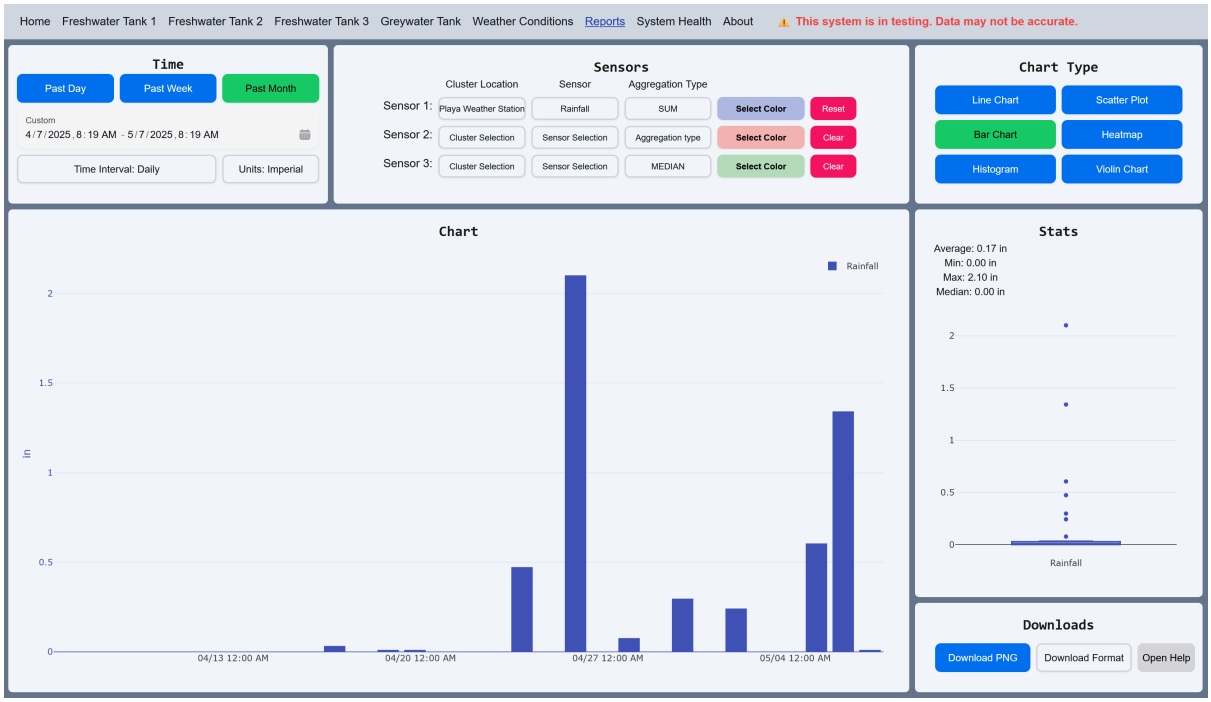


Figure 1.4: Reports Page

The reports page allows users to generate custom reports to assist in the analysis of collected data. The page allows the user to compare data from up to 3 sensors. The page is broken up into 6 sections, Time, Sensors, Chart Type, Stats, Downloads, and the chart. Each section will be discussed bellow.

1.4.1 Time

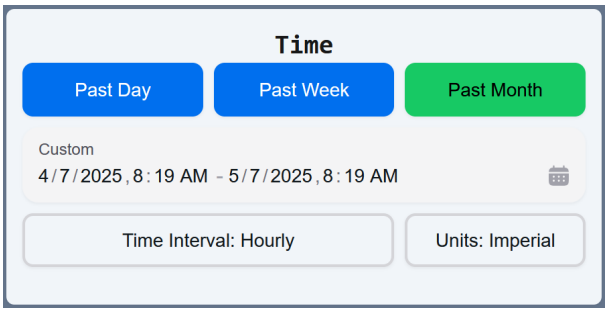


Figure 1.5: Time Section

Within the time section the user is able to select the time range for the chart as well as Time interval and units. There are three ways to select the time range for the chart. The easiest way is by utilizing the quick time range buttons. Utilizing these buttons the user can see the past

day, past week, or the past month. The user can also change the range in the custom time field directly bellow the buttons. Additionally users can utilize the calender functionality by clicking on the calendar icon on the right side of the custom time field.

Below the time controls are two drop-downs the one on the left allows users to select the frequency of the data-points. There are three options; Daily, Hourly, and No Aggregation. For example, selecting Daily will display one point of data on the chart for each day, and No Aggregation will display every point of data collected. The drop down on the right allows the user to select which units are displayed, by default everything is displayed in imperial units, however metric can also be selected.

1.4.2 Sensors

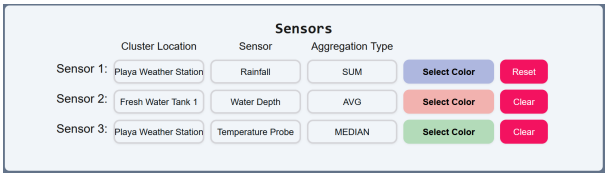


Figure 1.6: Sensor Section

The sensor section is where the user selects each sensor to be displayed as part of the chart. There are two items that are required to uniquely identify a sensor, The sensor name and its location. For example Playa Weather Station - Rainfall or Fresh Water Tank 2 - Water Depth. Once both of these items are chosen the graph will display data from that sensor if the sensor exists in the system. Once the sensor is selected the user may chose the aggregation type. If the time interval is in either Hourly or Daily then the data points are combined to produce fewer points on the chart. The default is average, however the options are average, median, minimum, maximum, and sum. For example, if the user would like to see the daily temperature highs they would select daily for the time interval and maximum for the aggregation type, this will allow the user to see the highest temperature for each day. When viewing the rainfall is highly recommended to select sum, this will allow users to see the total rainfall for each time interval.

The user may also chose to select a different color for the sensor data points and the sensor selections can be cleared using the clear button.

1.4.3 Chart Type

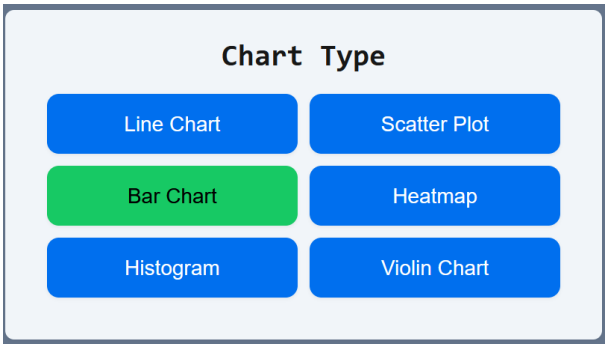


Figure 1.7: Chart Type

In this section the user may select the type of visualization that they wish to view.

1.4.4 Stats

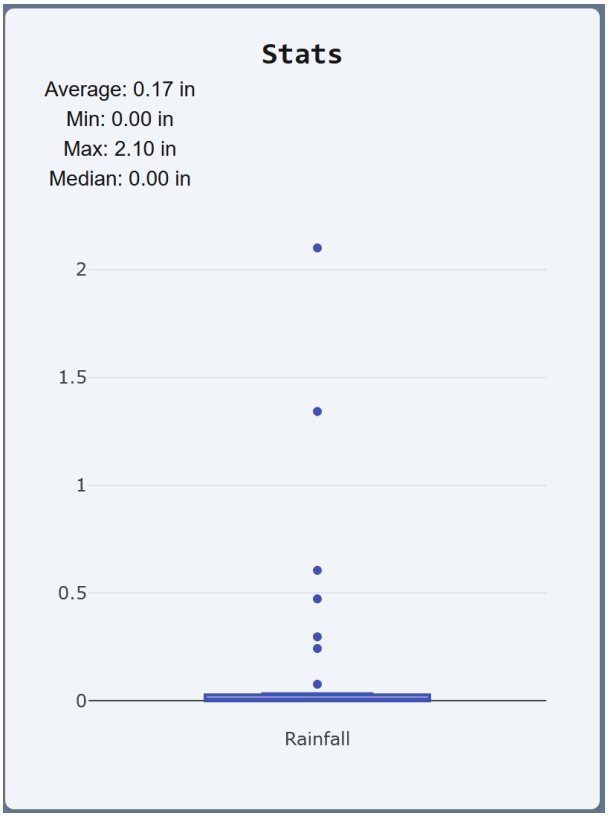


Figure 1.8: Stats Section

The stats sections displays some useful information about the data being displayed as well as a box plot for the data.

1.4.5 Downloads

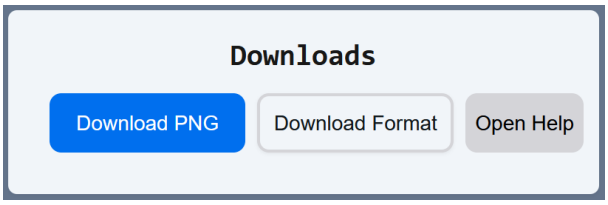


Figure 1.9: Downloads Section

The downloads section allows users to download data either in the form of a chart or raw data either in a csv or json format. the center drop down is used to select the download type and the button on the left will initiate a download. There is also a quick help accessible by clicking on the help button on the right.

1.4.6 Chart

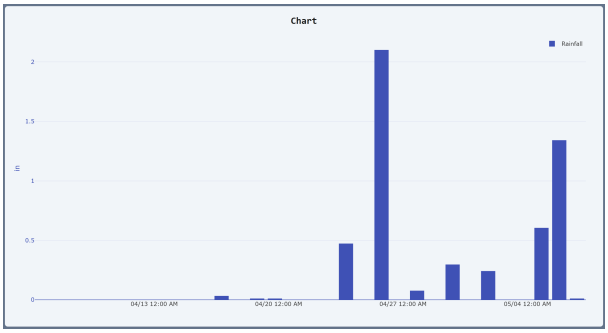


Figure 1.10: Chart

The chart section will display the user generated chart.

1.5 System Health Page

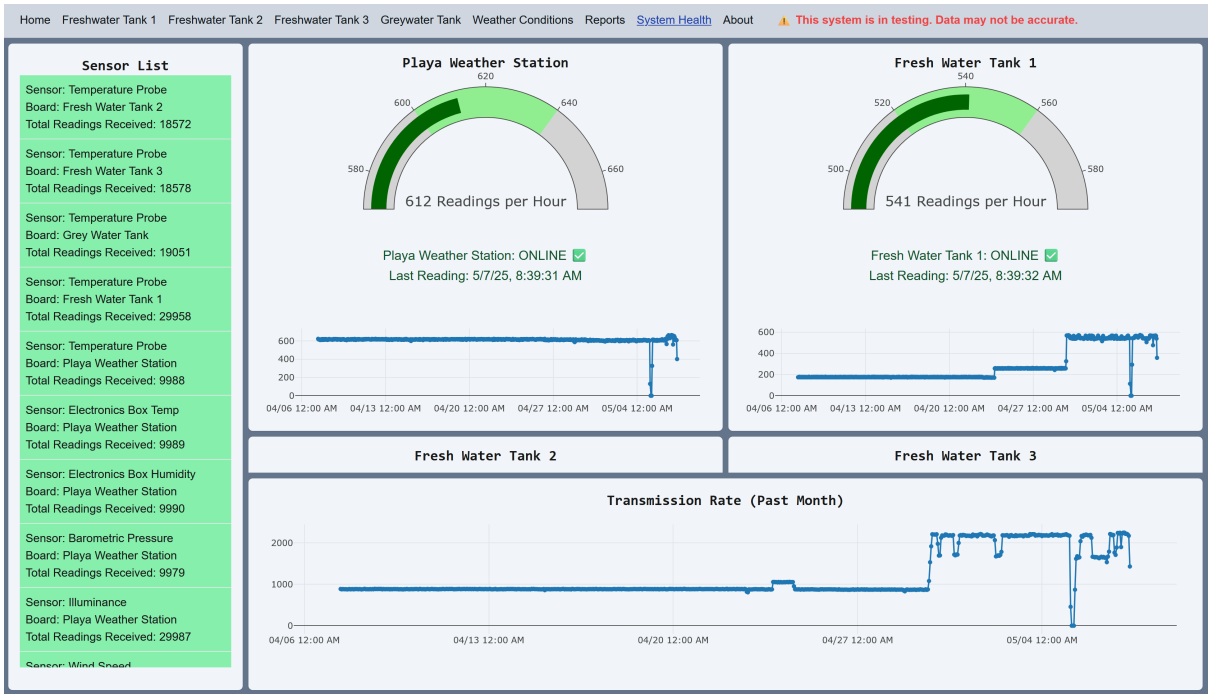


Figure 1.11: System Health Page

The system health page allows users to see the transmission rates and histories for each node. In the center section of the page details about each node are displayed, including current transmission rate, historical transmission rate, online/offline status, and time of last message received. The bottom part of the page displays the transmission history for the entire system for the past month. On the left is a list of all sensors that are part of the system. The sensor list displays any sensor outages along with the number of readings revived from each sensor over the past month.

Green sensors indicate that there is no issues detected with the sensor. Yellow indicates that there are intermittent errors being received from a sensor. And red indicated that either no data is being received from the sensor or that only errors have been received for the past 12 hours. Please note that yellow sensors are not necessarily indicating an issue with the system. For example, if the lid is off of a tank the expected behavior is to receive error messages from the depth sensors. Please see Chapter 4, Troubleshooting LoRaWAN Connection for additional details about network issues.

1.6 TerraTek API

The primary function that will be used when you will call the API is customcall. If you would like to change the file it resides in Senior-Project/Website/pages/api/fetchdata. Customcall will generate an SQL query based on the variables given to it.

customcall will take the following variables:

- timeframe (int): timeframe will fetch data X hours from the most current datapoint
- sensor (int): this will dictate the sensor that you are fetching data from. If no board is given it will fetch from all available boards. This will only support a singular sensor, if you want to collect multiple sensors they will require their own queries.
- board (string): this will dictate the board that you are fetching from. If no sensor is given it will fetch from all available sensors on the given board. This will only support a singular board, if you want to collect multiple boards they will require their own queries.
- start (string): sets the start date with yyyy-mm-dd formatting
- end (string): sets the end date with yyyy-mm-dd formatting. If no end date is given the current date is used.
- calc (string): Dictates the calculation method. The following are the only valid entries.
  - AVG
  - MIN
  - MAX
  - SUM
  - MEDIAN
- timeinterval (string): Dictates the data aggregation method. The following are the only valid entries.
  - All
  - Hourly
  - Daily

- unit_conversion (bool): Dictates if the data is in imperial(0) or metric(1). Defaults to imperial if no variable is given.

A sample query may look like the following:

`http://terratekrwh.com/api/fetchdata/sensor-data?board=[board_weatherstation]&sensor=[sensor_Wind]&calc=[aggregation]&timeframe=[X]`

there needs to be a ? after fetchdata and & in between each variable in order for the api to properly fetch this query.

Chapter 2

System Maintenance

2.1 Calibrating PH

To calibrate the Atlas Scientific pH transmitter and Industrial Sensor, follow these steps using the on-board push-button interface:

Preparation:

- Power on the transmitter.
- Have calibration solutions ready (4, 7, 10)
- Ensure the sensor is connected and fully submerged in calibration solution during the calibration process.

Calibration Steps:

- 1-Point Calibration (Required for accurate readings):
  - Place the probe in pH 7.00 buffer.
  - Press and hold the middle/orange button for 1.5 seconds. The LED Screen will display "CAL 7.0".
  - After a few seconds the screen will flash "donE" and the calibration is complete.
- 2 or 3 Point Calibration (Optional – Improves accuracy):
  - Must Complete 1-Point Calibration

  - After 1-point calibration, rinse the probe and place it in pH 4.00 or pH 10.00 buffer solution.
  - Press and hold the left/red button for 4.0 calibration or the right/blue button for 10.0 calibration.
  - The LED Screen will display "CAL 4.0" or The LED Screen will display "CAL 10.0" respectively.
  - When calibration is complete the LED Screen will display "donE".

- Resetting Calibration:
  - Hold the middle/orange and right/blue buttons for 3 seconds, the screen will flash "rESEt".
  - Hold the middle/orange and right/blue buttons again to confirm.
  - Press the red button to cancel.

- Additional information and more thorough instructions can be found in the Atlas Scientific pH_Transmitter Datasheet
  - https://files.atlas-scientific.com/pH_transmitter.pdf

2.2 Calibrating EC

To calibrate the Atlas Scientific EC transmitter and Industrial K 0.1 Sensor, follow these steps using the on-board push-button interface:

Preparation:

- Power on the transmitter.
- Have calibration solutions ready (84μs, 1413μs)
- Ensure the sensor is connected and fully submerged in calibration solution during the calibration process.

Selection Probe Type:

- Press and hold the left/DRY and right/HIGH buttons for 1.5 seconds

- This will open the setup Menu
- Press the LOW and HIGH buttons to navigate to the correct probe type "0.1L"
- Press the DRY button to save the selection.

Calibration Steps:

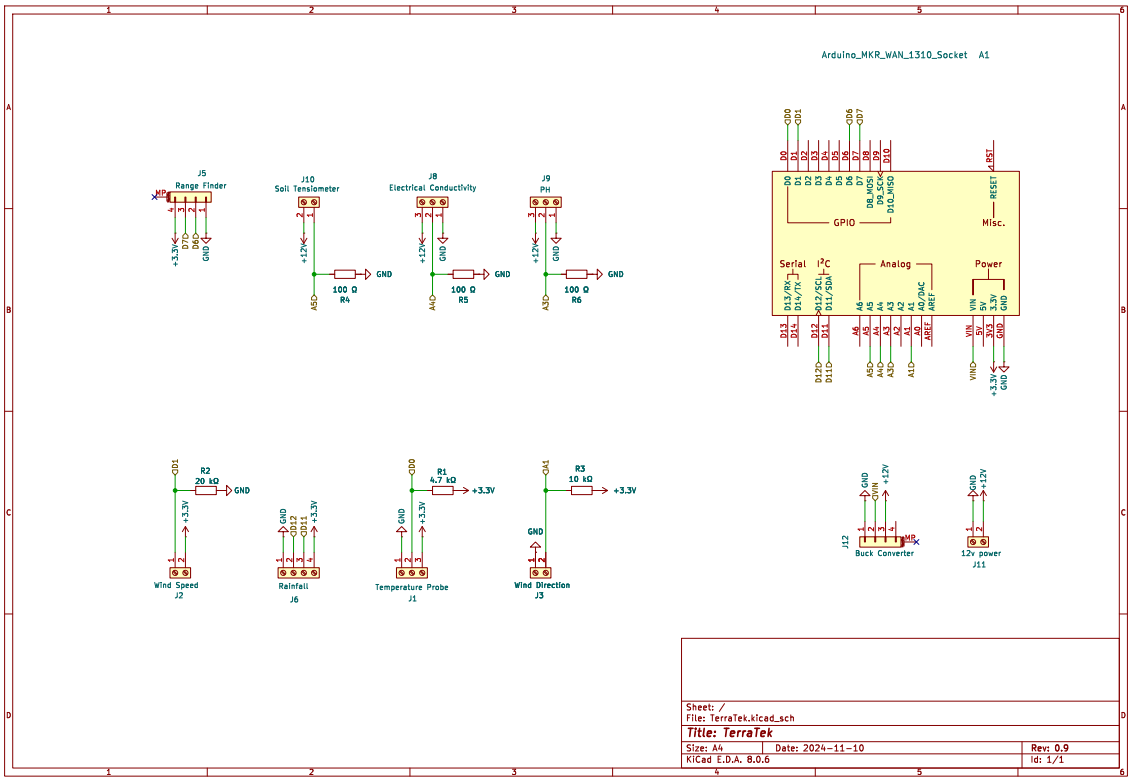
- Dry Calibration:
  - Ensure the probe is completely dry — no water or solution on the sensor.
  - Press and hold the DRY calibration button (left button) for 1.5 seconds.
  - After a few seconds the screen will flash "drY", then "dONE" and the calibration is complete.
- Low and High point Calibration:
  - Must Complete Dry Calibration
  - Submerge the sensor in the low 84μs calibration solution.
  - Press and hold the LOW calibration button (Middle button) for 1.5 seconds.
  - After a few seconds the screen will flash "Lo", then "dONE" and the calibration is complete.
  - Rinse the sensor and gently pat dry.
  - Submerge the sensor in the high 1413μs calibration solution.
  - Press and hold the High calibration button (Right button) for 1.5 seconds.
  - After a few seconds the screen will flash "HI9H", then "dONE" and the calibration is complete.
- Resetting Calibration:
  - Hold the middle/LOW and right/HIGH buttons for 3 seconds, the screen will flash "rESEt".
  - Hold the middle/LOW and right/HIGH buttons again to confirm.
  - Press the Left/DRY button to cancel.

- Additional information and more thorough instructions can be found in the Atlas Scientific EC_Transmitter Datasheet
  - https://files.atlas-scientific.com/EC_transmitter.pdf

Chapter 3

Hardware Troubleshooting and Repair

3.1 Sensor Wiring



3.2 Common Repair Tasks

3.2.1 Replacing an Ultrasonic Sensor

To replace the Ultrasonic Sensor the user must unscrew the sensor that requires replacement and screw the new sensor in its place. Wire the new sensor using the above schematic. If the sensor is not working correctly try swapping the data lines as it is easy to mix them up when installing. Red is power, black is ground, RX on pin 7, TX on pin 6. The link to purchase a replacement can be found bellow.

3.2.2 Troubleshooting/Replacing an Arduino

If the Arduino for a sensor cluster stops working, first press the little white button on the top of the Arduino to restart the board. If that does not turn on turn on the board then secondly, un-power the board from the battery to completely shut it down, then remove the Arduino from the pcb and place it back into the black terminals where it came from. If both of those steps do not power on the board, please visit the link below for the MKR WAN 1310 and purchase one. Once the board arrives, there is some some code that needs to be run on the board to get its ID. For this, go to our GitHub and run the code marked, `First_Run.ino`, and that will get the boards id. Next step in to flash the code on to the Arduino, visit the out GitHub and open the file called Arduino, "Station you're replacing".ino, now run the .ino file in the Arduino IDE to fash it onto the board. The final step is to reattach all the sensors associated with the cluster and re-attach it to the battery.

3.2.3 Replacing a PCB

In the event of hardware failure or damage, the system includes procedures for replacing a printed circuit board (PCB) within the sensor module. This process involves safely disconnecting power from the system, removing the damaged PCB, and installing a new board. Care must be taken to ensure correct alignment of pin headers and proper connection of all peripheral components such as sensors and power lines. The wiring to each of the sensors are shown in section 3.1 of this user manual called 'Sensor Wiring'. Once installed, the system is powered back on and tested for functionality, ensuring that all sensor readings are correctly transmitted and received. This modular hardware approach allows for quick recovery and minimizes system downtime in the field.

3.2.4 Repairing Faulty Connection

If you're not getting accurate readings from a sensor, first ensure that all wires are properly connected and in their correct positions. During our testing, we found that some sensors can accidentally be connected in reverse without damaging the board. To resolve this, power off the board, adjust any connections you suspect are incorrect, and then power the board back on. This should resolve most connection-related issues. If problems persist, refer to the links provided for troubleshooting the specific sensor.

3.3 Sensor Documentation

3.4 Where To Buy/Documentation

1. Wind Speed and Direction: https://www.sparkfun.com/products/15901
2. Environmental Shield: https://store.arduino.cc/products/arduino-mkr-env-shield-rev2
3. Rainfall: https://www.dfrobot.com/product-2689.html?srsltid=AfmBOor5jU0KnStHxVt5dgBNrSwvk cZshJ_vf-2xTV
4. Ultrasonic: https://www.dfrobot.com/product-1934.html
5. EC Senor: https://atlas-scientific.com/kits/industrial-conductivity-kit-k-0-1/
6. Ph Senor: https://atlas-scientific.com/kits/industrial-ph-kit/
7. Soil Senor (Possible future addition): https://www.irrometer.com/pdf/117.pdf
8. Temperature Probe https://www.adafruit.com/product/381
9. LoRaWAN Arduino MKR WAN 1310 https://store.arduino.cc/products/arduino-mkr-wan-1310? srsltid=AfmBOoq8LOOJXNw8yMe8T3jsnT9s8qzkI_csg-QpgLkzuHMnJaNT5ntK
10. LoRaWAN Gateway https://www.elecrow.com/lr1302-868m-915m-lorawan-hat-for-rpi-sx1302-l html?r=cmVsYXRl

Chapter 4

Software Troubleshooting

For most software related tasks the user should contact support@terratekrwh.com for assistance. However, bellow are some common software troubleshooting tasks.

4.1 Troubleshooting LoRaWAN Connection

The first step in trouble shooting network issues it to determine if the issue is with the gateway or with an end node. If the issue is affecting all transmissions please see "Gateway Troubleshooting". If the issue is with a single node first check that the Arduino is powered on, if there are no lights on the Arduino see "Troubleshooting/Replacing an Arduino". If the Arduino is powered on please restart the device by hitting the small button on the top of the board. If these steps do not solve the issue contact support@terratekrwh.com for assistance. Please note that anytime a new node is added or an Arduino is replaced the user must contact support@terratekrwh.com to properly configure the network and database to accept the new board.

4.2 Updating Arduino Firmware

To ensure compatibility with updated sensors, communication protocols, or logic improvements, the Arduino firmware can be updated through the Arduino IDE using the firmware updater found in **Tools - Firmware Updater**. This process involves connecting the Arduino board to a computer via USB, selecting the correct board in the IDE, and uploading the latest version of the firmware sketch. After a successful upload, the system should be tested to confirm that all sensors are responsive and that data is being accurately collected and transmitted. Regular

firmware updates help maintain system reliability and allow for future scalability of the project.

4.3 Expanding with Additional Sensors

To integrate a new sensor into the Arduino system, begin by identifying the sensor's communication protocol (e.g., I2C, SPI, analog, digital) and supply voltage requirements. Connect the sensor to the appropriate pins on the Arduino and verify electrical compatibility. In the firmware, include any required libraries (often provided by the manufacturer or open source), and initialize the sensor in the setup() function. In the loop() function, add code to read data from the sensor at regular intervals and process or format the output as needed. Finally, modify the data transmission logic to include the new sensor's readings in the output stream (e.g., via serial, LoRa, or Wi-Fi). After implementation, test the sensor independently and within the full system to ensure proper integration without introducing latency or data conflicts. Document the sensor's configuration and update the repository with the new code under version control. Contact support@terratekrwh.com for any help with adding sensors to the network.

4.4 Gateway Troubleshooting

To troubleshoot the gateway the first thing that must be done is to power the Raspberry Pi off then back on again. If that does not solve the issue after waiting about 5 minutes the next step is to check the network connection. Ensue that the Ethernet connection is working and the network is up. If these steps do not solve the issue please contact support@terratekrwh.com to troubleshoot the issue.

4.5 Connecting to the Server Over SSH

For any connections that need to be made please contact support@terratekrwh.com for assistance.

4.6 Server Troubleshooting

In order to troubleshoot the server, the first step is to restart the server with the following command:

```
sudo reboot
```

If the problem persists, roll-back any recent file changes made on the server until web functionality returns. If functionality has not returned please contact support@terratekrwh.com for further assistance

4.7 Database Troubleshooting

If the database has run into issues, ensure that data inserted into the server follows the following conventions and that values within a table's primary keys do not repeat. The current primary keys are as follows:

- Dates: TIMESTAMP - Timestamp that will be generated by the sensor
- Boards: Board_ID - ID to identify the board, stored as a hex value
- Sensors: Sensor_ID - ID to identify sensors, stored as an integer
- Errors: Error_ID - identifies errors, stored as either a 1 or 0
- Reading: Reading_ID - identifies the current reading, stored as an integer

if the data does not follow these conventions, perform a pass on code that will interface with the database such as code for sensors as well as deleting any offending entries. If the problem continues to persist contact support@terratekrwh.com for assistance.

In order to check the database you have the option to directly connect to MySQL on the server or run a local instance of the website as the API can also perform these queries.

4.7.1 logging into MySQL

When you are on the server navigate to the Database which is located in /Senior-Project/Database. Then run the following command:

```
mysql -u [SQL USERNAME] -p
```

This will prompt MySQL to ask for the password to access the database where you are able to wite your queries to search and delete any offending entries.

4.7.2 logging through the API

When you are on the server navigate to the website located in /Senior-Project/Website and run the following command:

```
npm run dev
```

this will run a local instance of the website where you can access the API. The API does not support the removal of entries, but has functionality to query the database.

```
http://[localhost id]/api/sensors
http://[localhost id]/api/boards
http://[localhost id]/api/readings
```

these perform the following respective queries:

```
SELECT * FROM Sensors
SELECT * FROM Boards
SELECT * FROM Readings
```

Appendix A

Additional references

- Arduino: https://docs.arduino.cc/hardware/mkr-wan-1310/
- Ubuntu: https://ubuntu.com/tutorials/install-ubuntu-server#1-overview
- MySQL: https://dev.mysql.com/doc/refman/8.4/en/language-structure.html
- GitHub Repo: https://github.com/DeskColor/TerraTek
- ChirpStack: https://www.chirpstack.io/docs/getting-started/raspberry-pi.html
- Weather Kit: https://github.com/sparkfun/SparkFun_Weather_Meter_Kit_Arduino_Library/blob/main/documents/Weather_Meter_Kit_Datasheet.pdf
- Next.js: https://nextjs.org/docs