Application Manual

AquaMonitor

Version 1.1

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1.0 Introduction and Hardware Prototype

AquaMonitor is a mobile application built for both iOS and Android that allows users to monitor water quality parameters in real-time. The application sends push notifications when measurements deviate from ranges set by the user. This is particularly useful because the user can take immediate action and visually see the water quality parameter change. As an example, if an ammonia measurement reaches a level of 0.27 ppm and the user's specified maximum is 0.25 ppm, the user will get an ammonia warning notification. As the user begins a water change to fix this issue, the reading in the application will update in real-time. Therefore, the user can get the ammonia level to return to a desired level instead of estimating.

The AquaMonitor system can measure any water quality parameter for which there is a sensor for. I have constructed a hardware prototype that has been fully programmed and works with the application. It consists of an ESP32 microcontroller, which has built-in WiFi and Bluetooth for $3.70 USD in bulk ($10.11 USD off of Amazon), and a Gikfun DS18B20 waterproof temperature sensor for $4.06 USD off of Amazon. The prototype can be seen in Figure 1.1 below.
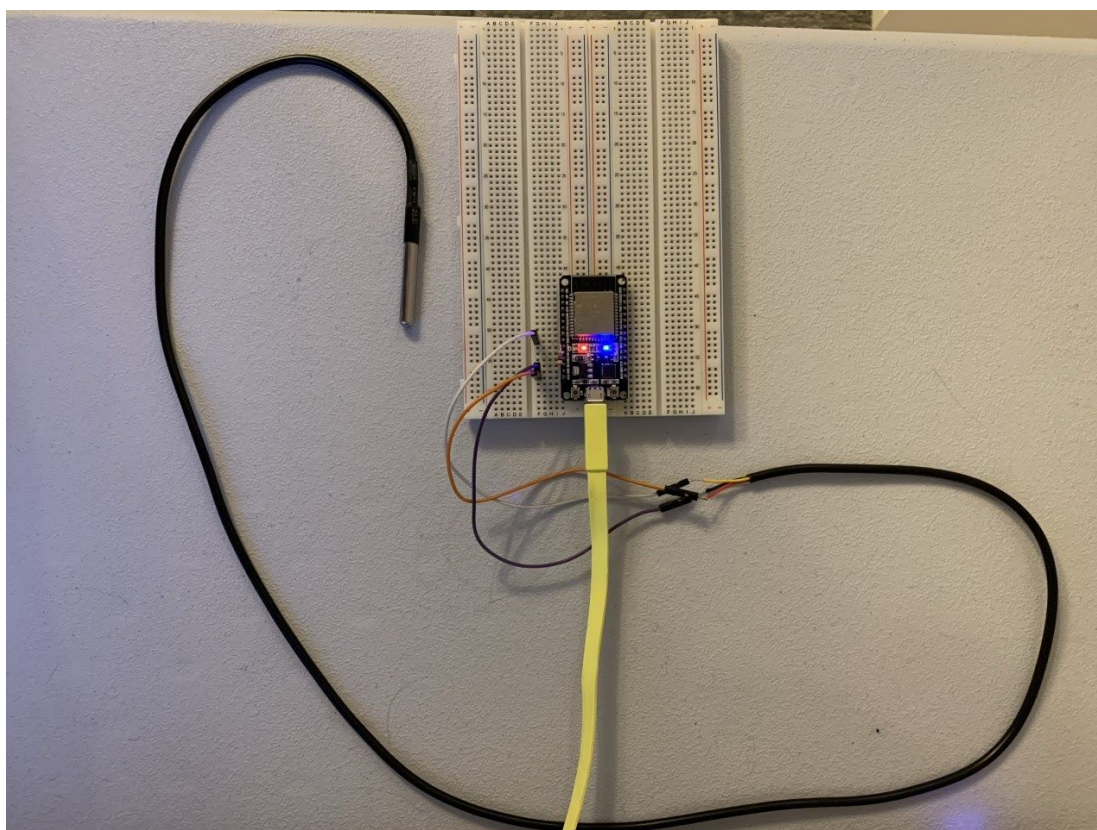

Figure 1.1: Hardware Prototype (Black Probe - Gikfun DS18B20 Waterproof Temperature Sensor, Yellow Cord - Standard Micro USB Cable for Power, Microcontroller on Breadboard - ESP32)

The microcontroller has more than enough GPIO ports to support all the water quality parameters needed. The proposed parameters that are supported in this version of AquaMonitor are temperature, pH, ammonia, nitrate, nitrite, alkalinity, general hardness, dissolved oxygen, and salinity. Sensors for these parameters can be agreed upon and programmed onto the microcontroller. Additionally, the microcontroller has been programmed to send sensor measurements to the server every 30 seconds. However, this can easily be changed for subsequent versions. The rest of this document will go over version 1.1 of the AquaMonitor software. Color schemes and logos can be easily customized for an individual company.
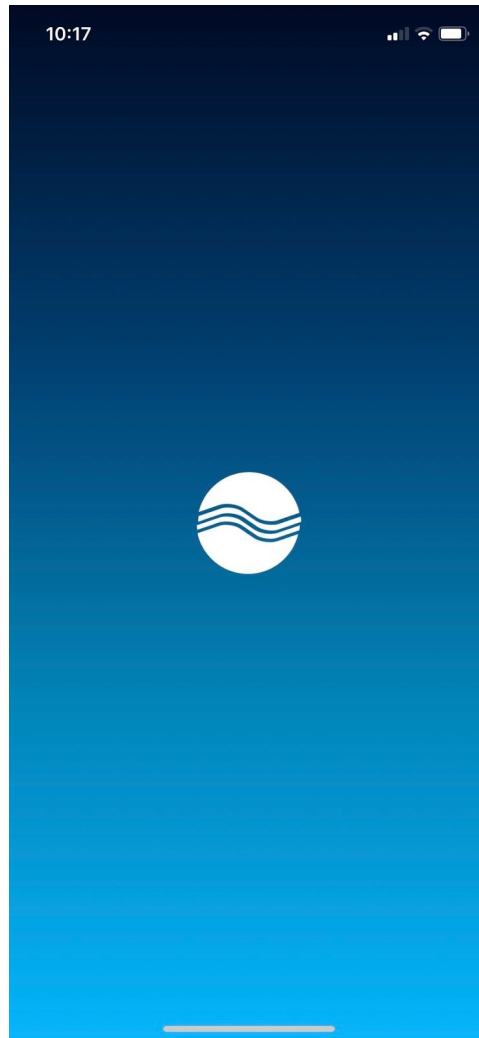

Figure 1.2: Application Introductory Screen

2.0 Home

The home screen is where the current readings for each of the water quality parameters are displayed. The last recorded reading is displayed inside of a progress circle with the respective unit. The unit can be changed in the settings based on user preference (e.g. °F instead of °C for the temperature parameter) and the reading will be converted accordingly on the home screen without a subsequent fetch from the database. The progress circle is a visual component to illustrate the current reading with respect to the user's desired minimum and maximum values. If the wheel is completely filled, the reading would be greater than or equal to the user's maximum. If the wheel was completely empty, the reading would be less than or equal to the user's minimum. When the wheel is partially filled with the parameter's color, this indicates that the reading exists somewhere in the user's desired range.
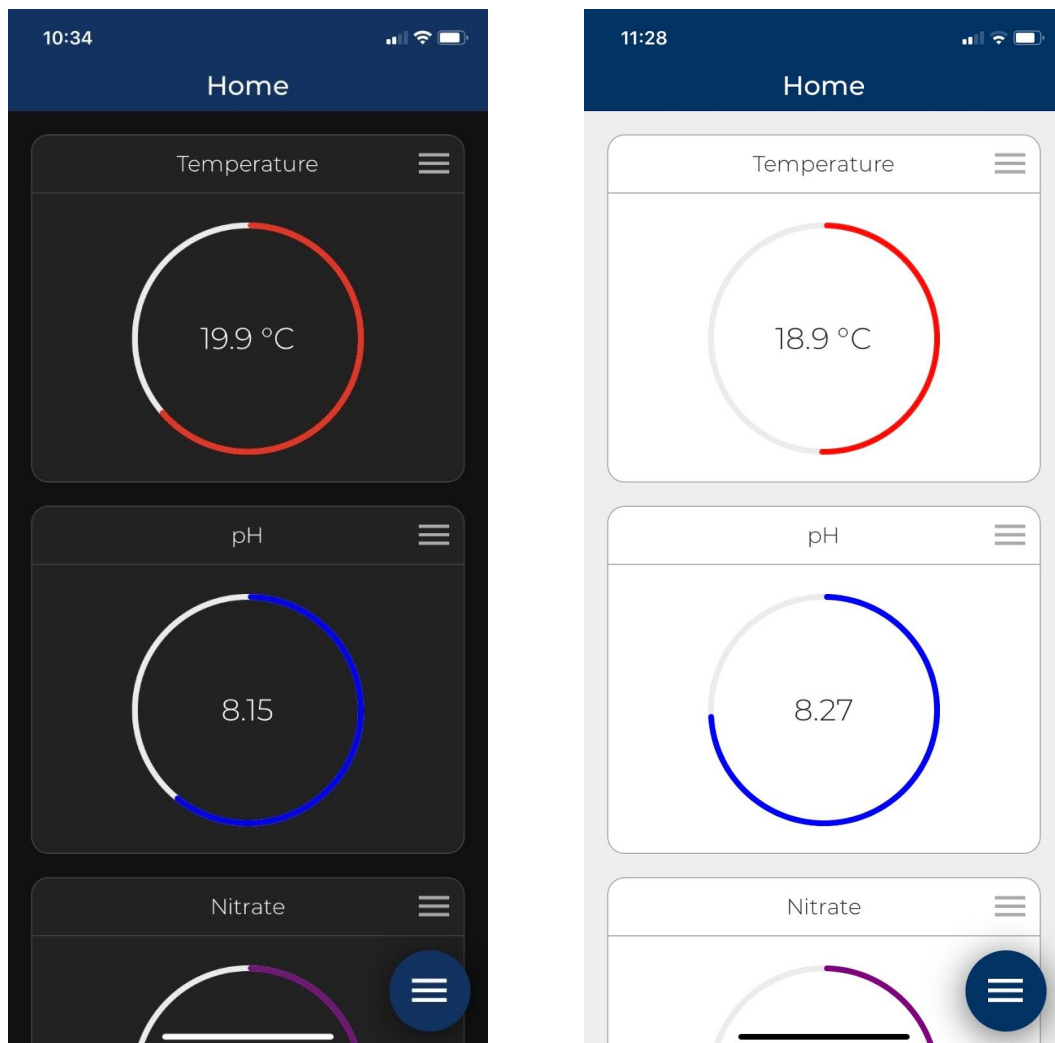

Figure 2.1: The Home Screen. (Left: Dark Mode, Right: Light Mode)

The user is able rearrange the ordering of the parameters from the default on the home screen if desired. (e.g. Perhaps nitrate levels are the most important to the user, and thus should be the first parameter in the list) The default ordering, from top to bottom, of the parameters is: temperature, pH, ammonia, nitrate, nitrite, alkalinity, general hardness, dissolved oxygen, salinity. In order to change the order of a parameter, the user must press and hold on the symbol in the top right corner of the parameter component (3 horizontal lines) until the opacity of the component changes (see Figure 2.2), and then drag and release the component where it is desired. Haptics are used to indicate to the user when the component is ready to be dragged. The change will be saved locally so that the application remembers the ordering for subsequent logins.
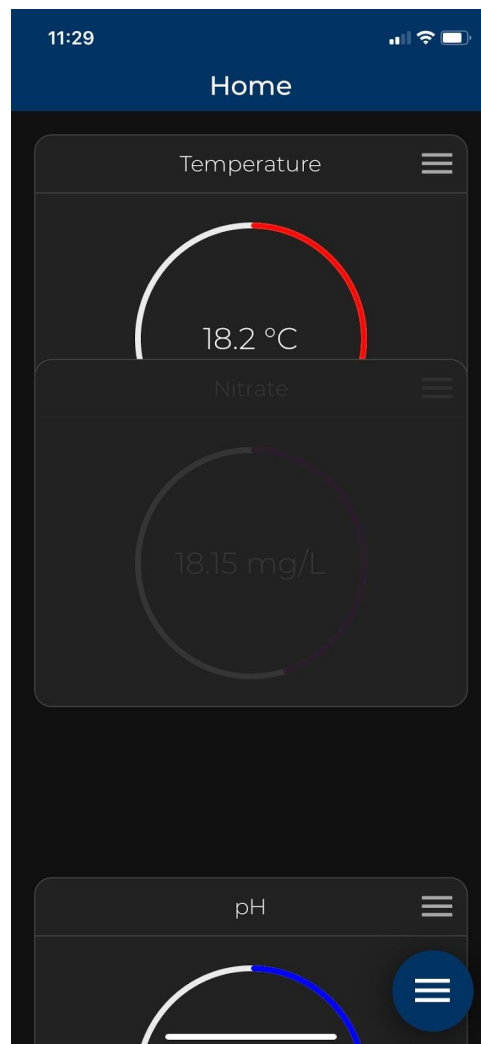
Figure 2.2: Nitrate component being dragged to the top

2.1 Parameter Details

In order to view the details screen for a specific water quality parameter, the user just needs to press on the area that contains the progress circle for the respective parameter from the home screen. Figure 2.3 shows the details screen for the temperature parameter. On the details screen, there are 12-hour statistics that have been recorded for the parameter. A graph shows how the collected readings fluctuate over the past 12 hours, with temperature values on the y-axis and time of recording the x-axis. The average, minimum, and maximum values recorded are displayed below the graph. In order to return to the home screen from the details screen, press the back arrow located in the top left corner of the screen.
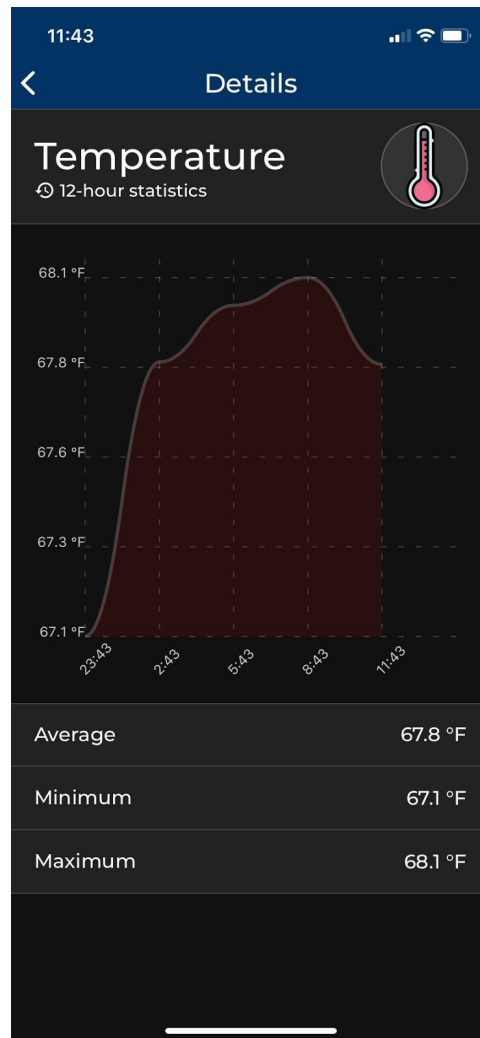
Figure 2.3: Temperature Details Screen

3.0 Devices

 Initially, the user will not have any devices associated with their account, as seen in Figure 3.1 below. On the home screen there will be a link to the devices screen, where the user can add or select a device. Pressing this link, or using the navigation, will bring the user to the devices screen where there is a button to add a device.
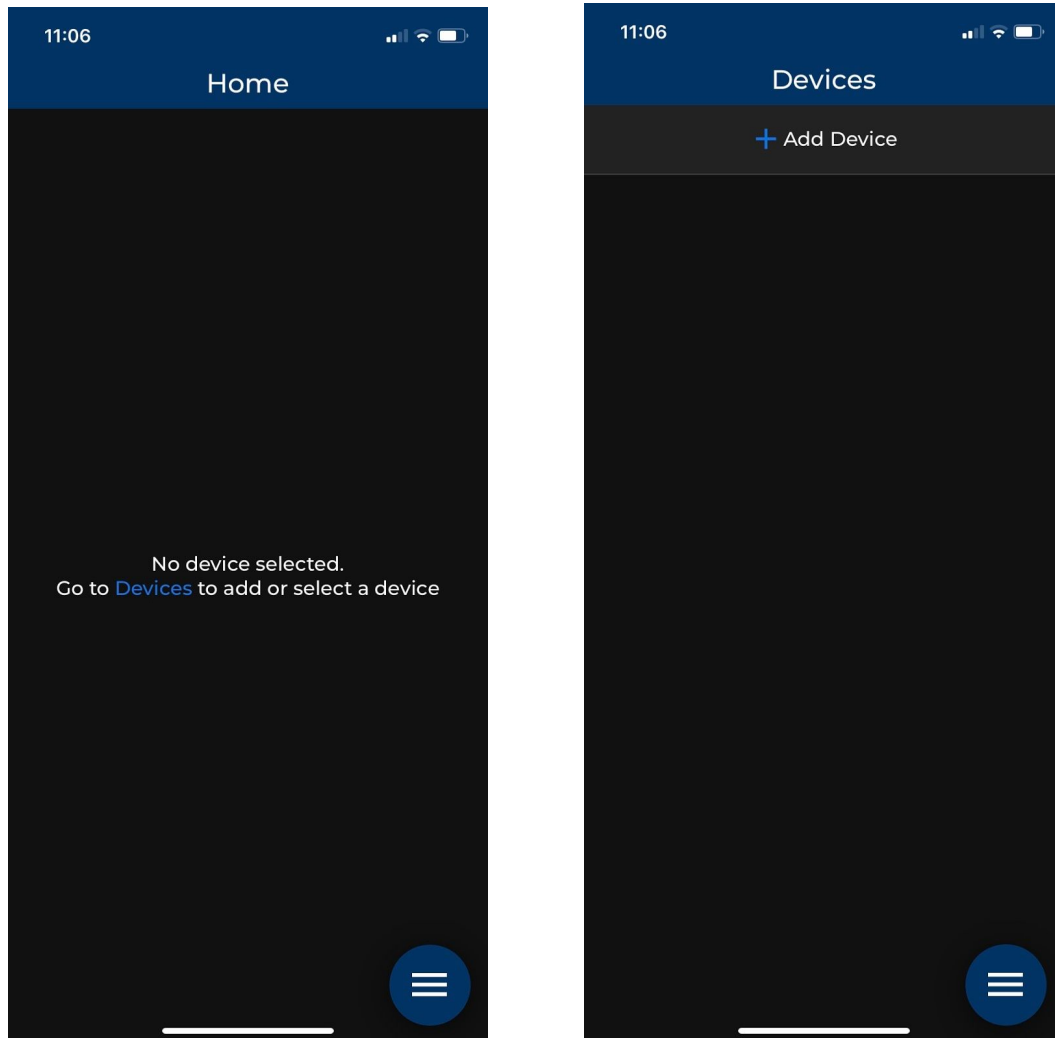

Figure 3.1: Application without a connected device (Left: Home Screen, Right: Devices Screen)

Upon pressing the button to add a device, a prompt will appear that will ask the user to provide the device identification on the device as seen in Figure 3.2. If the user enters a valid ID, they will then name the device in a subsequent prompt.
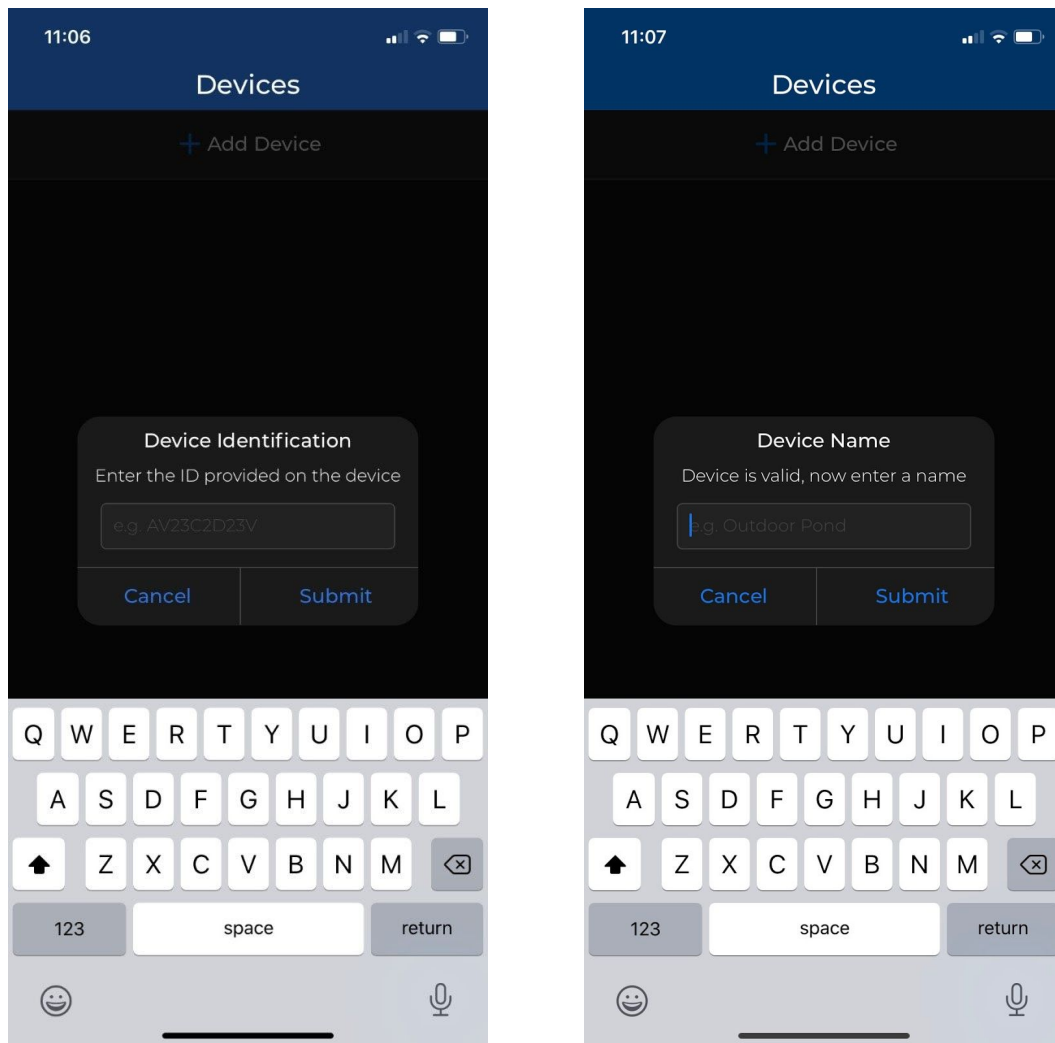

Figure 3.2: Adding a new device. (Left: Device identification prompt, Right: Device name prompt)

If the user submits an invalid device ID or a device linked to another account, a corresponding alert will appear stating why the provided ID was invalid as seen in Figure 3.3. Lastly, if the user enters an ID for a device already linked to their account, the prompt input will simply clear and the phone will trigger a haptic error vibration.
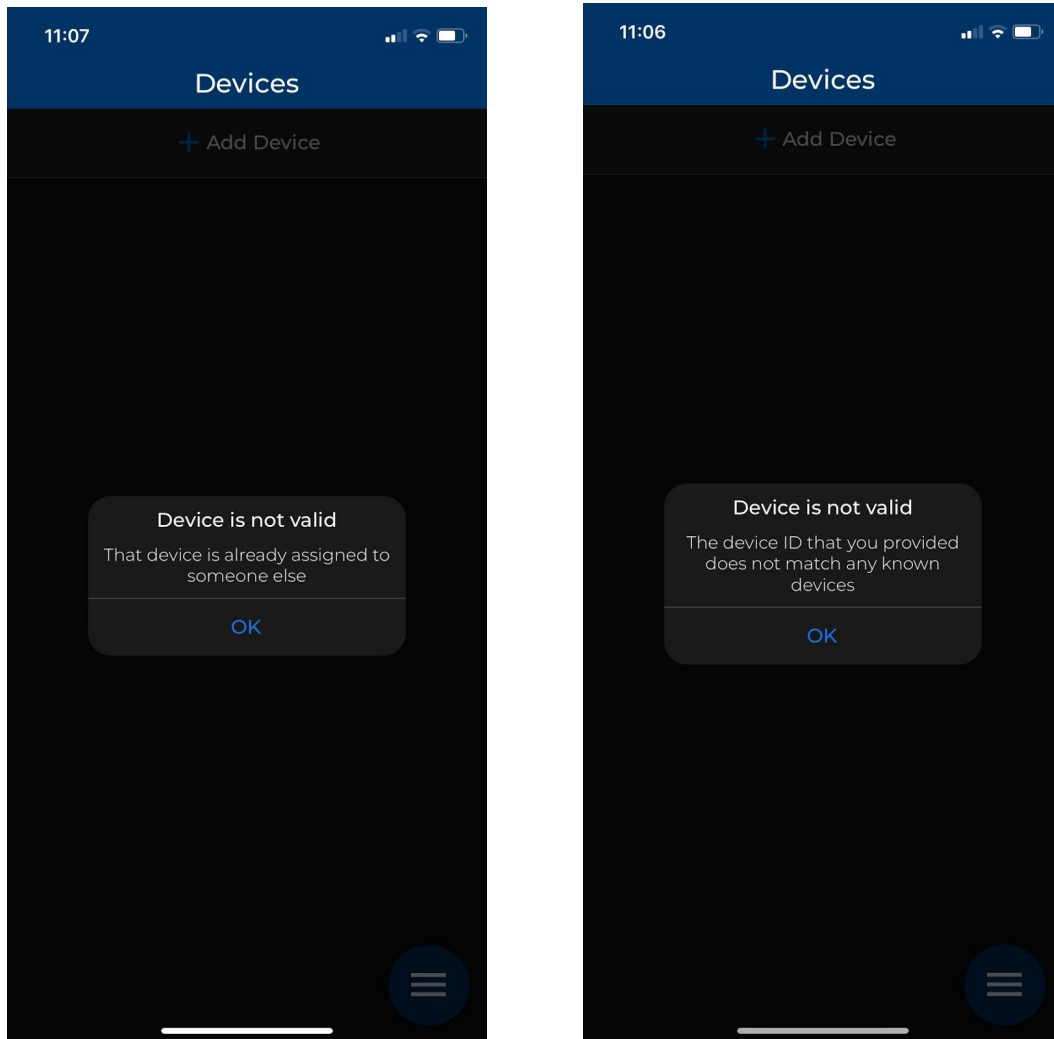

Figure 3.3: Errors while adding a new device. (Left: Device already assigned to someone else, Right: Invalid ID)

After devices are added, water quality parameters are created in the database with default values, some of which can be changed later by the user under settings. These include the parameter's unit, minimum, maximum, and color. Table 3.1 details the default values. The color column is for the progress circles displayed on the home screen.

Table 3.1: Water Quality Parameter Defaults

Parameter	Unit	Min	Max	Absolute Min(*)	Absolute Max(*)	Color	Sensor Precision(*)
Temperature	°C	12.0	24.0	-40.0	40.0	red	0.1
pH	N/A	7.5	8.5	1.0	14.0	blue	0.1
Ammonia	ppm	0.00	0.25	0.00	0.80	green	0.01
Nitrate	ppm	0.0	40.0	0.0	200.0	purple	0.1
Nitrite	ppm	0.00	0.25	0.00	0.80	yellow	0.01
Alkalinity	ppm	50	200	0	1000	#7c3f00	1
General Hardness	ppm	200	530	0	1000	#f7138e	1
Dissolved Oxygen	ppm	7.0	9.0	0.0	20.0	#6bcae2	0.1
Salinity	ppt	3.0	7.0	0.0	20.0	gray	0.1

* These columns are subject to change when choices for sensors are confirmed. This is because the range and precision for a particular sensor is capable of measuring will most likely differ from another sensor.

The device will then show up under the devices screen as seen in Figure 3.4. The user can select the device by simply pressing on the device, which then brings the user to the home screen to show the water quality parameters associated with that device. A user will know which device is selected by going to the devices screen and seeing the text highlighted in blue with a checkmark on the right side.
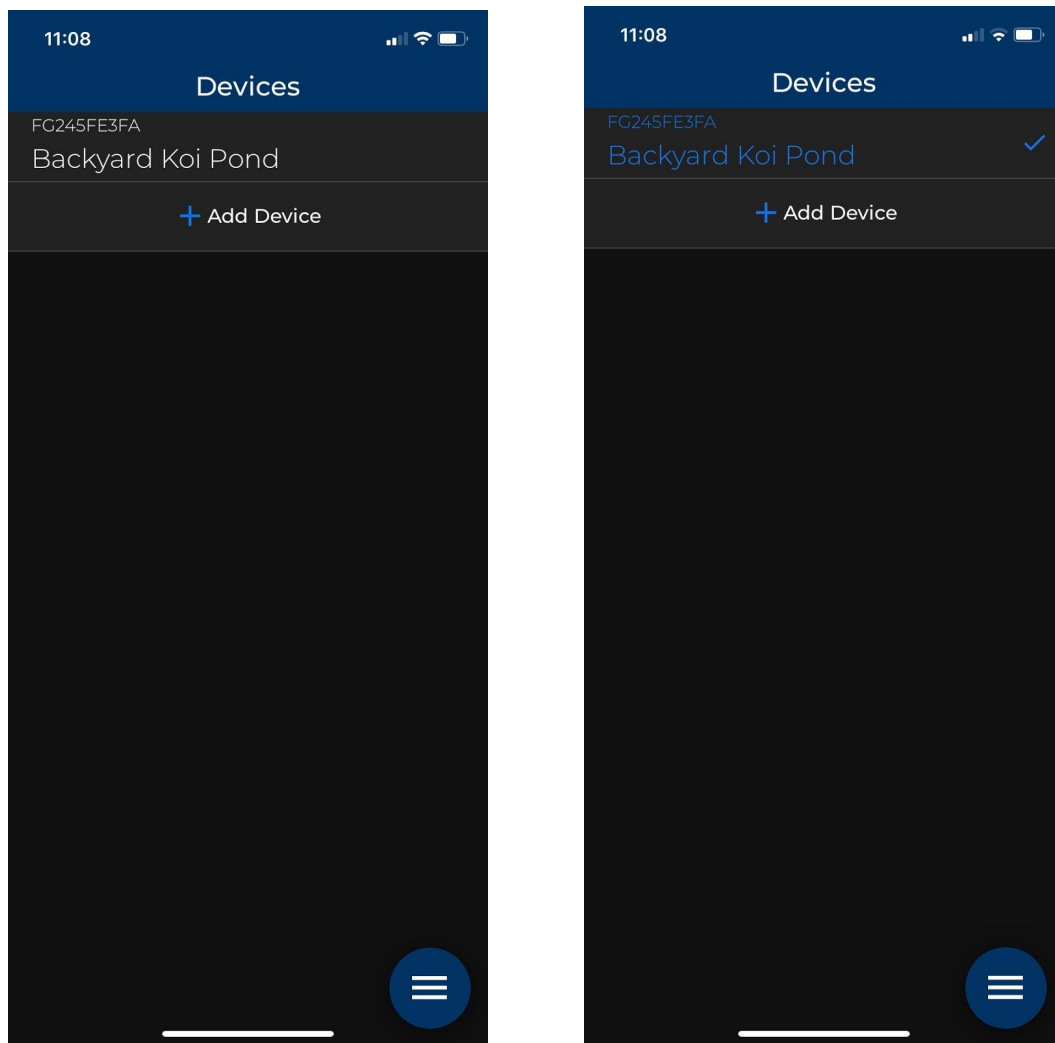

Figure 3.4: Newly Added Device (Left: Unselected, Right: Selected)

In order to edit the name of a device or delete the device from the user's account, the user will swipe left on the device. This will cause a swipeout menu to appear as shown in Figure 3.5.
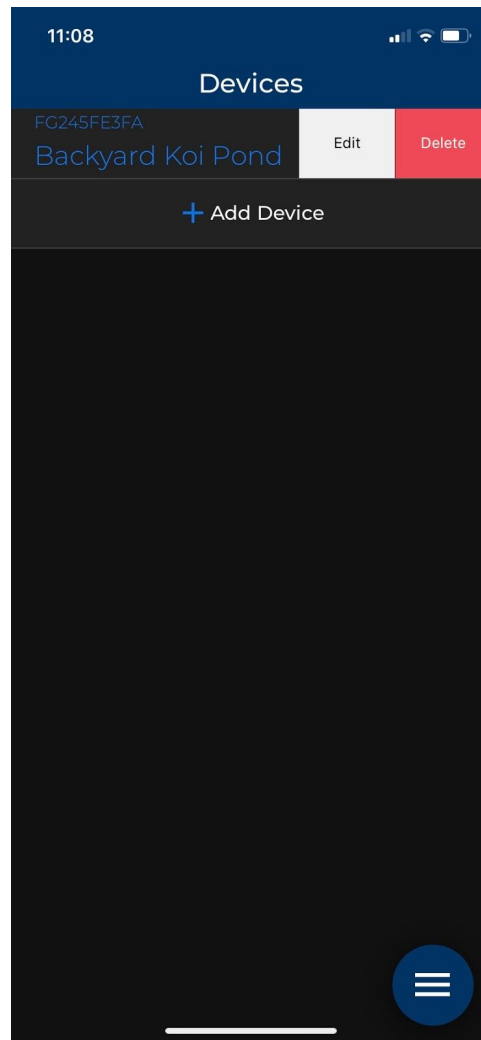

Figure 3.5: Device Swipeout Menu

Figure 3.6 shows the swipeout menu options in more detail. Pressing the edit button will cause a prompt to appear where the user can enter a new name for the device. Pressing the delete button will cause an alert to appear as confirmation for deleting the device from their account.
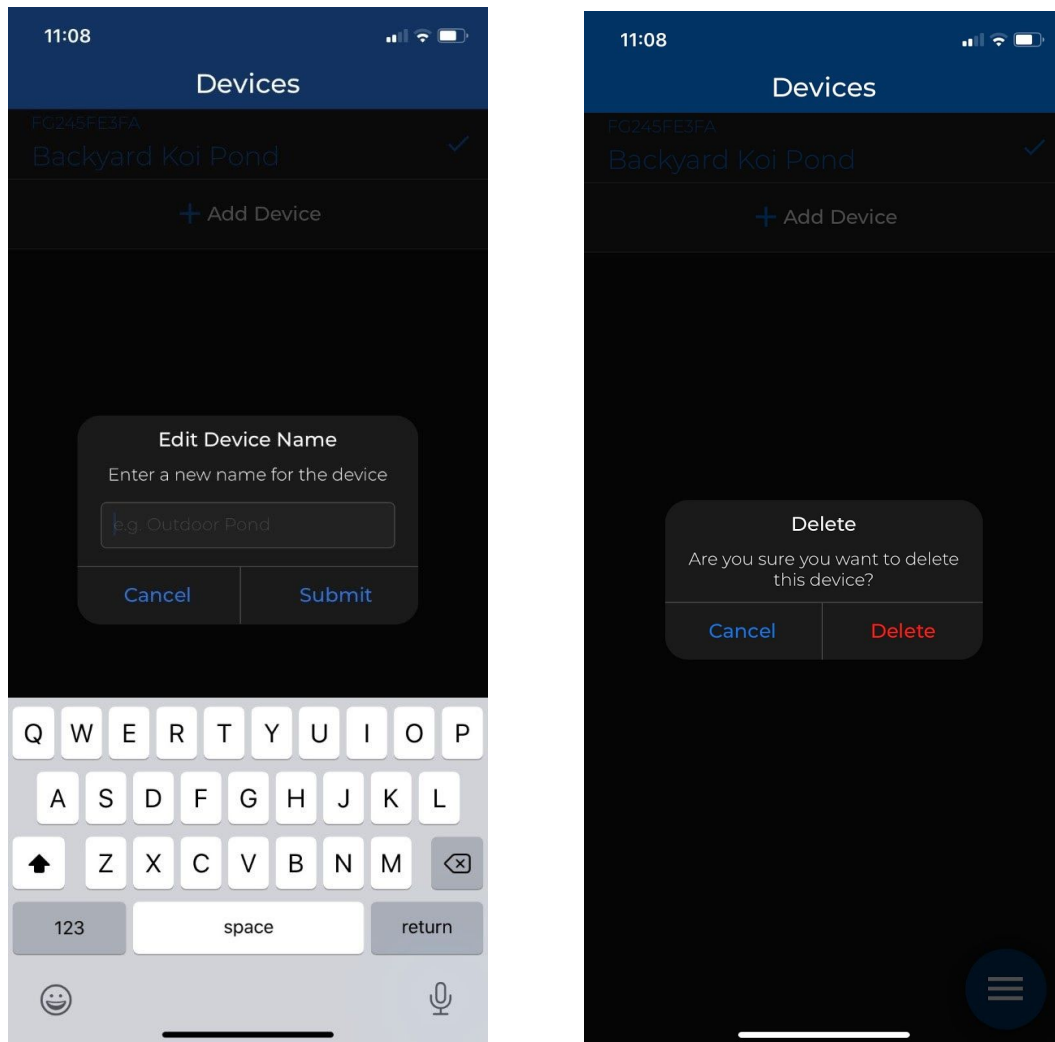

Figure 3.6: Device Swipeout Options (Left: Edit, Right: Delete)

4.0 Settings

The settings screen contains user preferences for the application along with settings for water quality parameters. All changes in settings take effect immediately.

4.1 Dark Mode

The first setting is a toggle for dark mode. When the setting is not toggled the application will be in light mode and when toggled the application will be in dark mode. Upon logging in to the application for the first time, the application will detect whether dark mode is enabled on the iPhone or Android device and toggle dark mode automatically if it is enabled. If the user has no preference or is in light mode, the application will default to light mode.
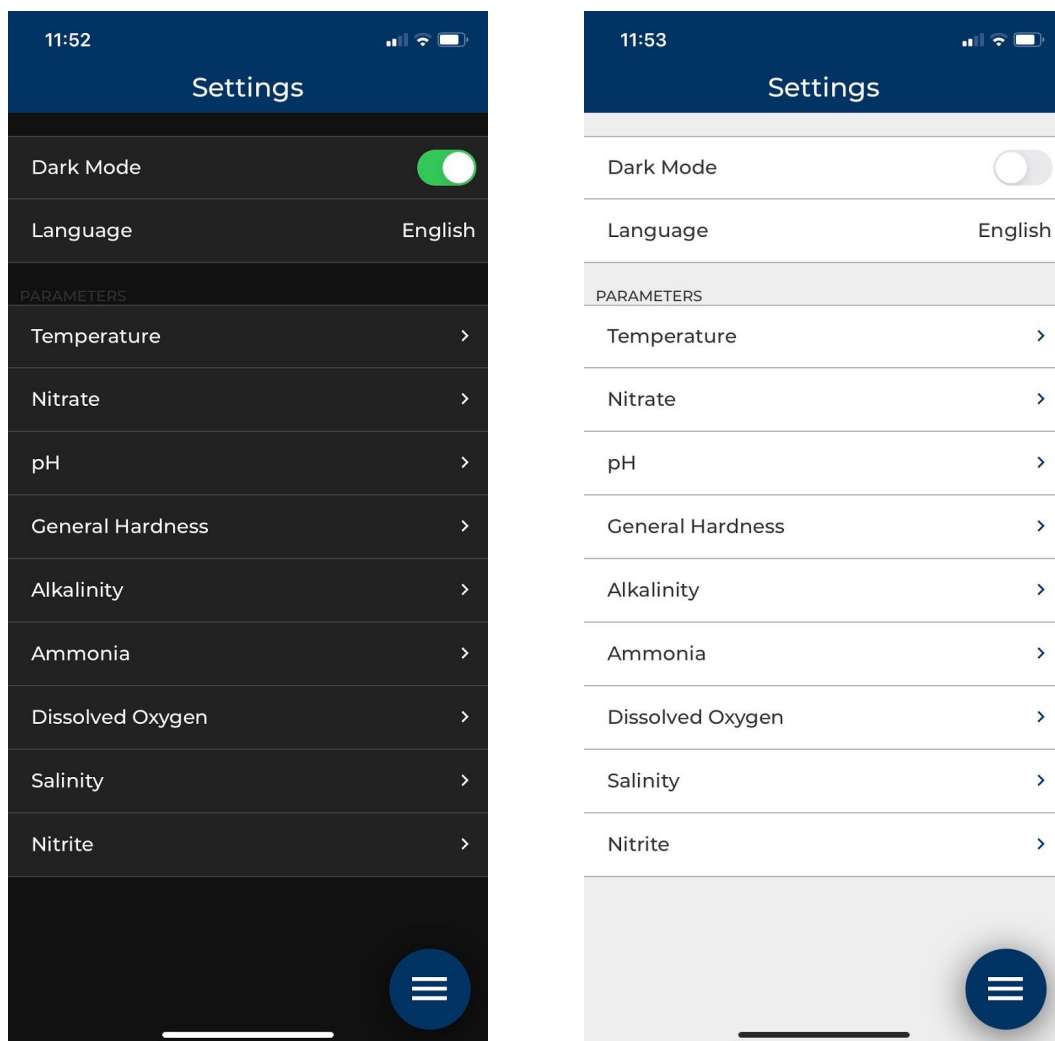

Figure 4.1: The Settings Screen. (Left: Dark Mode, Right: Light Mode)

4.2 Language

The second setting allows the user to select a language for use in the application. Pressing on the setting brings up a wheel picker as shown on the left in Figure 4.2. The picker allows the user to scroll through the languages available on the application. In version 1.1, English, Japanese, and Spanish are supported. Adding other languages is simple and can be done by request. If the user does not wish to proceed, pressing anywhere in the shaded region above the picker will cancel the operation. When a choice is found, simply pressing the "Set Language" button will confirm the selection. The right side of Figure 4.2 shows the settings screen after switching to Japanese. Upon logging in for the first time, the application will detect the language being used on the iPhone or Android device and set the language automatically if it is supported. If the language is not supported, the application will default to English.

Figure 4.2: Changing the application language. (Left: Language picker, Right: Settings screen after selecting Japanese)

4.3 Parameter Settings

Following on the settings screen are the parameter settings. Pressing one of the parameters brings the user to a screen to change the settings for that respective parameter. (e.g. Temperature in Figure 4.3) Here the user is able to adjust the unit, minimum, maximum, and color if it applies to the specific parameter. (e.g. pH doesn't have a unit, ammonia doesn't have a minimum as it is always ideally 0 ppm, salinity is only measured in ppt)
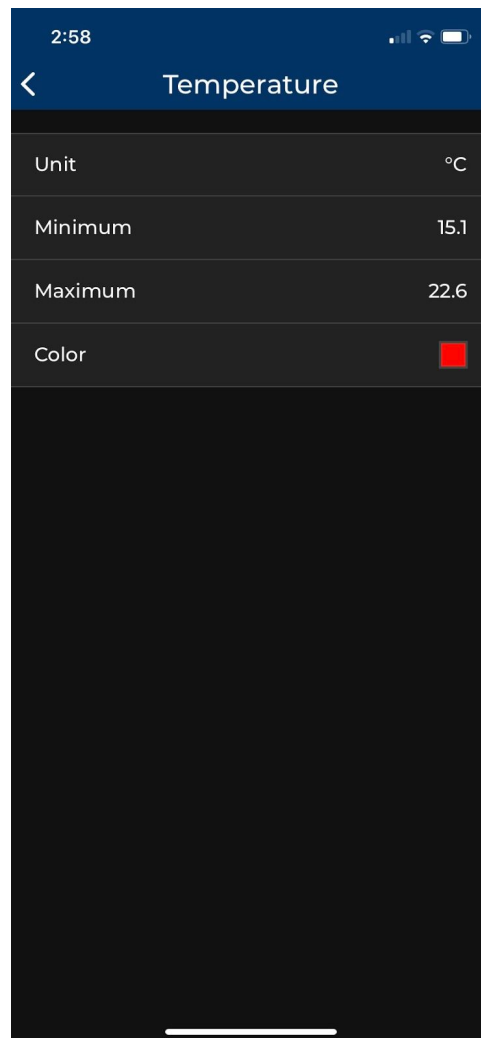
Figure 4.3: Temperature Settings

Pressing one of the first three settings brings up a picker as shown in Figure 4.4. Acting the same as the picker used for selecting a language, pressing the shaded area cancels the operation and there is a button to confirm the operation. The picker was chosen over numerical keyboard input to eliminate error checking and provide the user with the discrete values that the sensor is able to record. Note, as the minimum cannot be greater than the maximum, the minimum values will stop before the maximum. (e.g. For temperature, if the maximum is 22.6, the possible minimum values will go up to 22.5) To have a greater minimum than the current maximum, the maximum will need to be increased first. The vice versa logic applies for the maximum values.
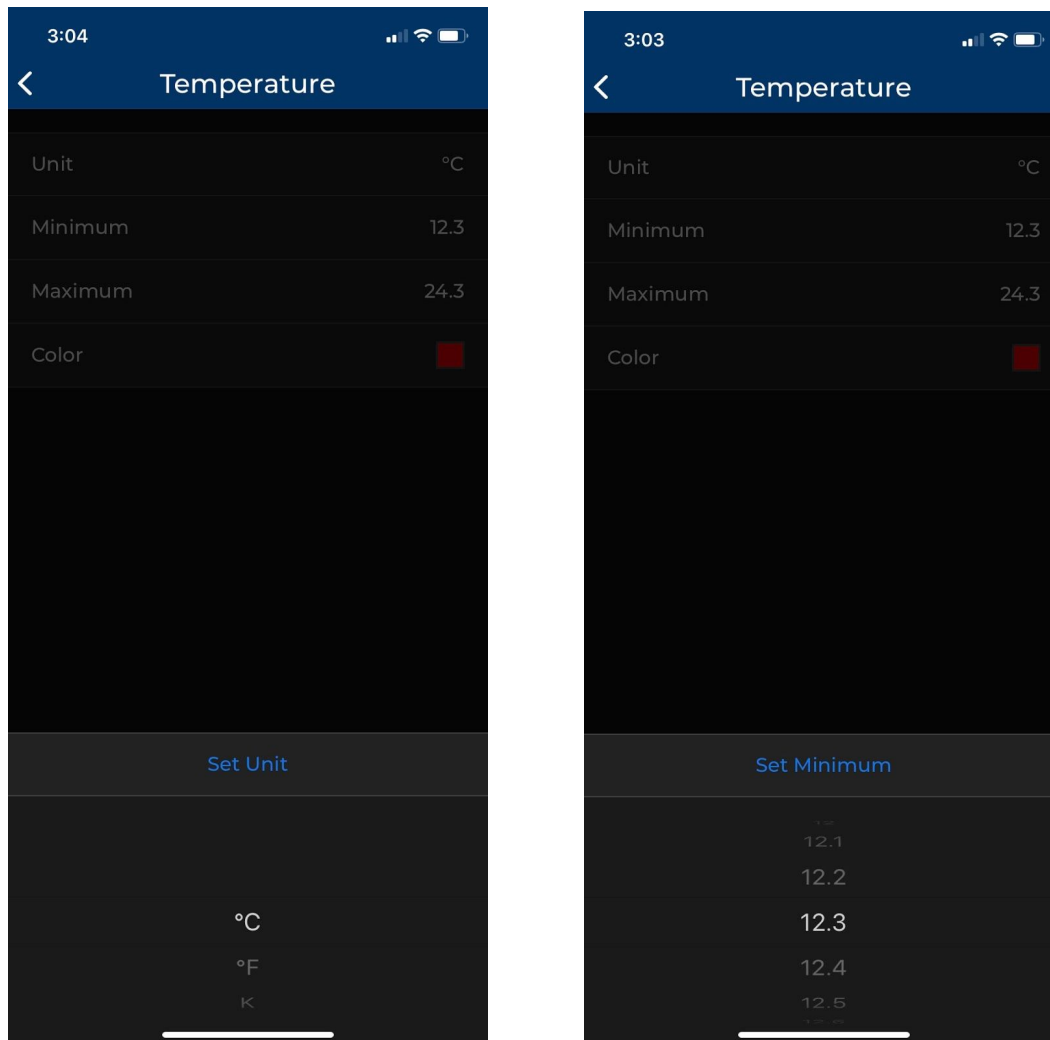

Figure 4.4: Changing the temperature settings. (Left: Unit picker, Right: Minimum Picker)

Pressing the fourth setting brings up an interactive color picker as shown in Figure 4.5. In this picker, the user is able to drag the dial around the outer circle in order to find a color they prefer to be associated with the water quality parameter. Below the picker are two sliders that can be used to further customize the color. The first slider changes the color's saturation, while the second slider changes the color's lightness value. Once the user has selected a color that they desire, simply pressing the set color button will save the new setting. The operation can be canceled by pressing the shaded area above the picker.
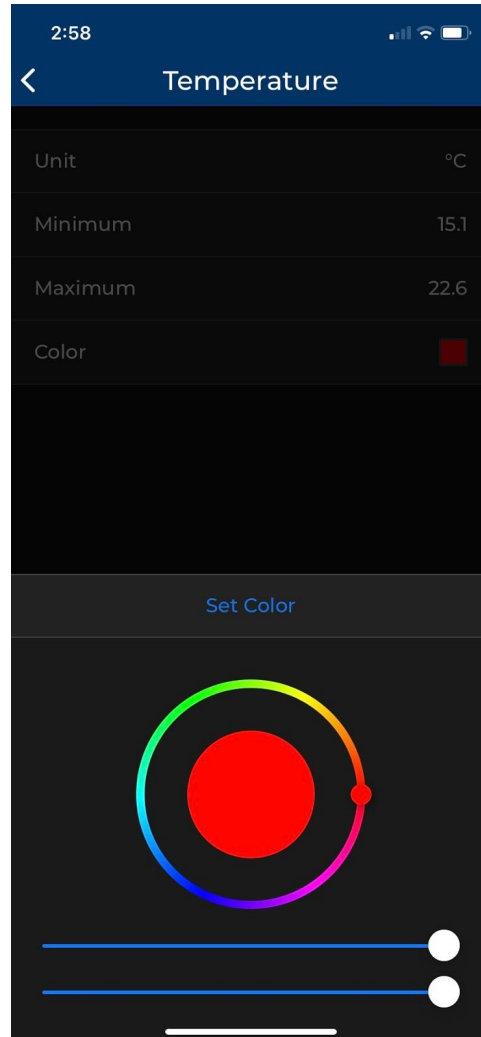

Figure 4.5: Setting the color for the temperature setting.

5.0 Navigation

The navigation screen shown in Figure 5.1 is triggered by pressing the navigation button located in the bottom right corner of top layer screens. This means that any screen without a back button will have the navigation button present. The navigation screen provides buttons for each of the routes in the application: Home, Devices, Settings, and Sign Out. To navigate to a specific screen, the user will press the image associated with the route. To cancel the operation and return to the screen the user was on previously, as denoted in the header (e.g. Settings in Figure 5.1) simply press the navigation button again which has now become an cross instead of the three horizontal bars.
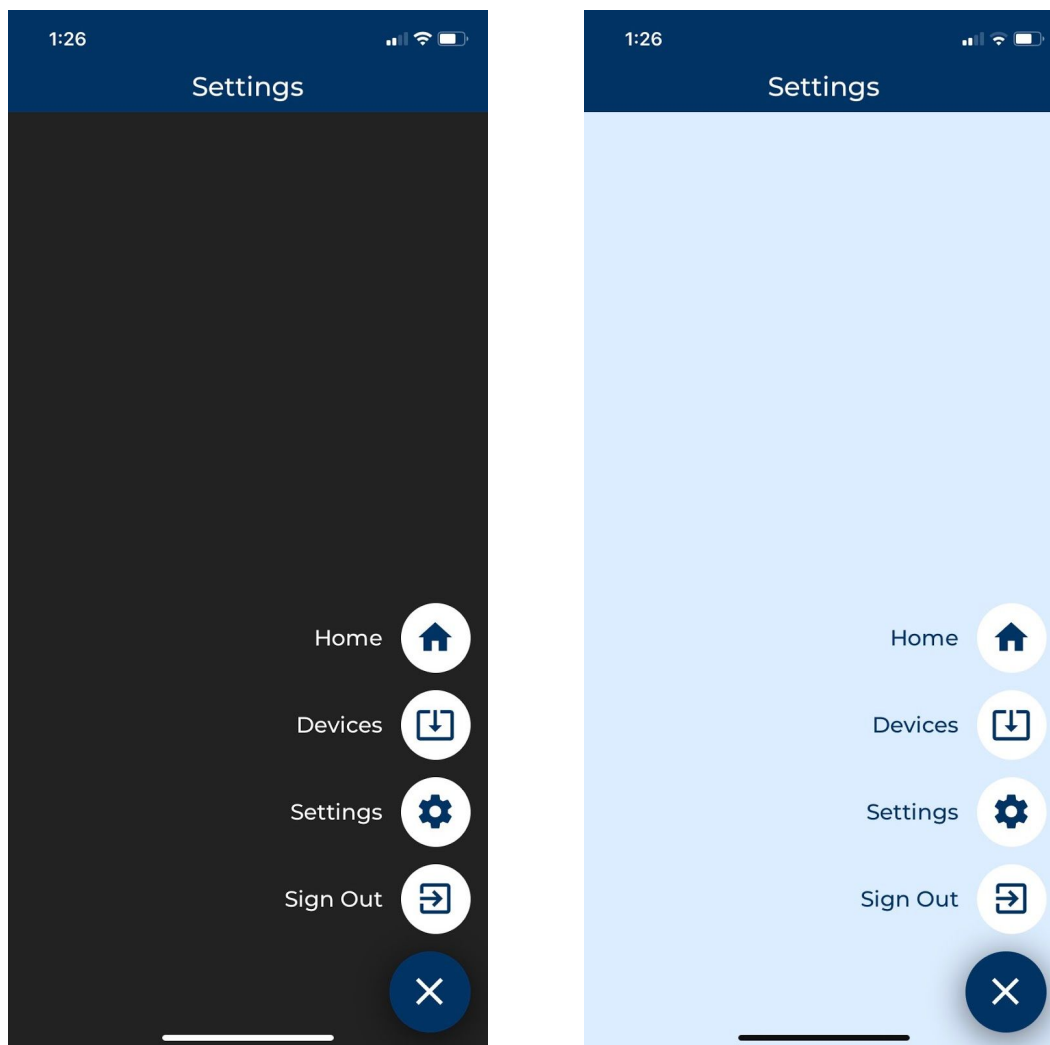

Figure 5.1: The Navigation Screen. (Left: Dark Mode, Right: Light Mode)

6.0 Push Notifications

Perhaps the most important feature of this application, push notifications were implemented to notify the user of unsafe water quality parameters. When a reading is created by the device that is not in the user's desired range, a push notification will appear to alert the user of the situation. Examples can be seen in Figure 6.1 below. Note that the logo and name in the notification will change when the application is deployed.
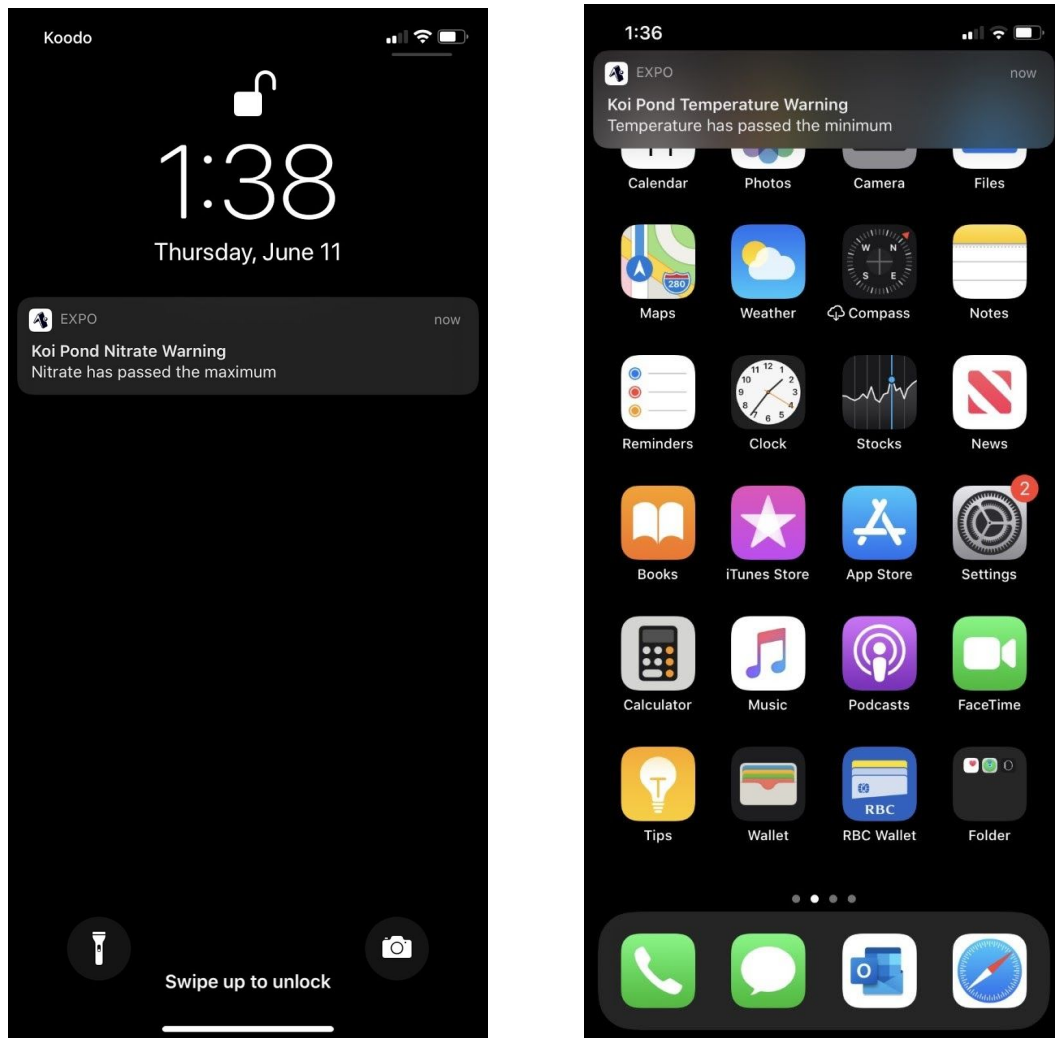

Figure 6.1: Push Notifications. (Left: Nitrate Warning on Lock Screen, Right: Temperature Warning on an Unlocked iPhone)

Push notifications will be sent to all of the devices that the user is signed into at a given time. If the user signs out of their account on a given device however, they will no longer receive notifications. This means explicitly logging out in the application under

the navigation such that automatic logins do not occur. If they login again, notifications will resume. The user will receive notifications even if the app is closed. Given that the device measures water quality parameters every 30 seconds, a notification for a water quality parameter is limited to be sent every 30 minutes while the warning persists. This is so that the user is not absolutely bombarded with notifications. Note that this time lock is easily adjustable.

Upon installing the application for the first time, the user will be prompted to allow the application to send push notifications, as seen in Figure 6.2. Again, the name will be changed when the application is deployed. The App Store and Google Play require an explanation for notifications, and given the context of this application, (alerts for unsafe water quality parameters), this should not be a problem.
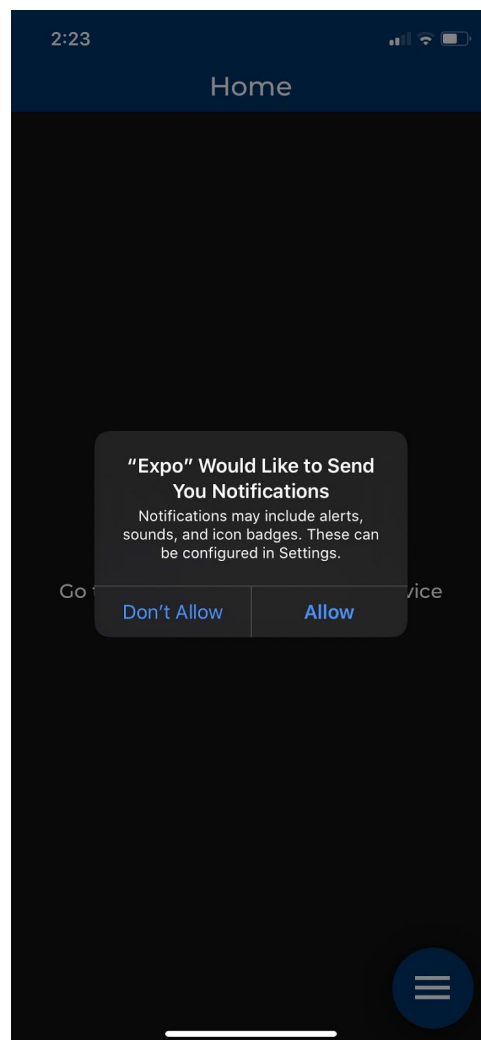

Figure 6.2: Requesting to Allow Push Notifications

7.0 Authentication

Upon opening the application for the first time, the user will encounter the login screen. Once the user has logged in, the application will bypass the login screen and automatically login the user in subsequent sessions by saving their credentials in a local encrypted secure storage. This saves the user the hassle and time of manually typing in their credentials every single time they want to use the application. If the user wants to login to a different account or just sign out from application, they can do so with the signout navigation route highlighted in section 5.0.
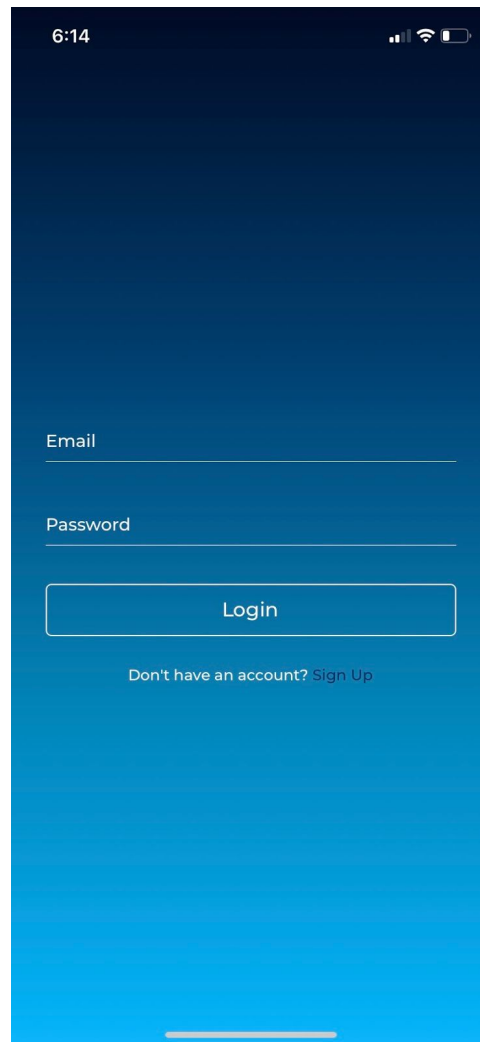

Figure 7.1: Login Screen

If the user does not yet have an account, they can press the sign up link below the login button. This will bring the user to the sign up screen which is shown in Figure 7.2. The signup screen requires that the user re-enter their proposed password to

ensure they did not make a typo in the first field. After signing up, the application will bring the user to the login screen to login for the first time. There is also a back arrow located in the top left corner of the screen to bring the user back to the login screen if needed.
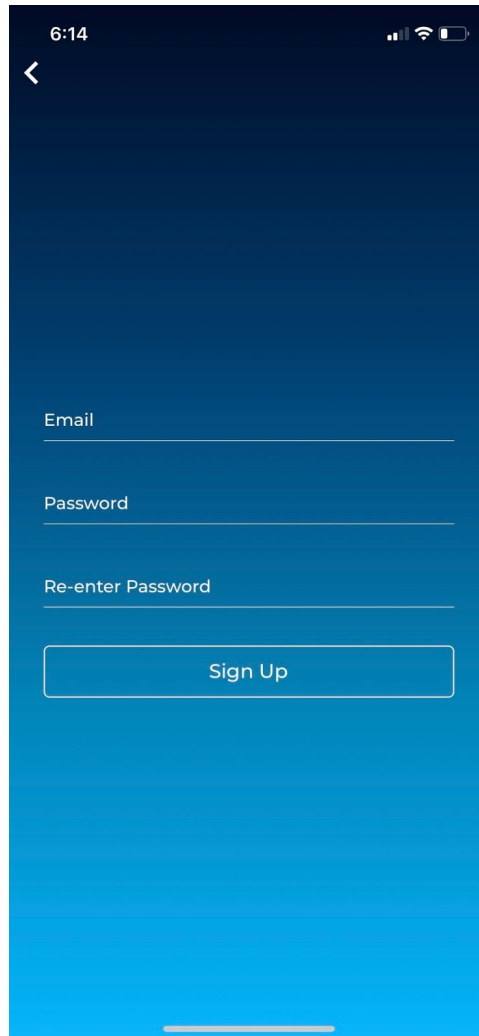

Figure 7.2: Sign Up Screen

Application security is accomplished using JSON web tokens. Protected API routes can only be accessed if the request contains a token specific to a user. Upon logging in, the user receives a token from the server and stores it in the local secure storage. The token contains metadata to identify the user sending the request. This makes it impossible for someone to get a token from their login and try to delete another user's device for example. A user can only access or modify their data on the server.

8.0 Subsequent Versions

1. A questionnaire when first logging into the app could be used to help determine the defaults for water quality parameters. For example:
   - What type of fish are in your aquarium or pond?
   - How many gallons is your aquarium? Larger volumes of water tend to have much more stable quality parameters.
   - Do you keep your fish outdoors during the winter?
2. Another navigation component that allows users to create regular reminders for their pond/aquarium. The application will send push notifications at the desired day of week and time. This could include regular water changes, filter cleaning, pump cleaning, etc. The user could mark these as complete, and a visual component like a calendar could be used to visualize the reminders and if they were completed or not. Additionally, the user would be able to delete reminders at any time or edit existing reminders.