PUMPLOGIC

User Guide

Automated Relay Controller

Temperature-triggered | Schedule-based | Voltage-protected

Web-based control panel accessible via WiFi Access Point at 192.168.4.1

Version 1.0

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Automated Relay Controller Version 2.3

Introduction

PumpLogic is an automated pump controller designed for solar-powered, battery-powered, or constant-power installations where a pump must run on a schedule with flexible control options.

PumpLogic uses a modular control system where features can be independently enabled or disabled to match your installation:

Feature	Enable/Disable	What It Does
Temperature	Always active	Activates the pump when temperature crosses the trigger threshold. Supports **Trigger High** (cooling — pump ON when hot) and **Trigger Low** (freeze protection — pump ON when cold) with configurable temperature buffer to prevent rapid cycling.
Schedule	Always active	Restricts pump operation to configured time windows (separate weekday/weekend schedules).
On/Off Timer Mode	Configurable	When enabled, the pump cycles between ON and OFF durations. When disabled, the pump runs continuously as long as conditions are met.
Voltage Monitoring	Configurable	When enabled, blocks the pump if battery voltage drops below the cutoff and manages charge recovery. When disabled, voltage is ignored (for constant-power installations).
Vacuum Sensor	Configurable	When enabled, adds vacuum-triggered pump override — the pump starts immediately when vacuum drops below the trigger (in inHg).

Temperature and **Schedule** are always active. On/Off Timer Mode, Voltage Monitoring, and the Vacuum Sensor can each be independently enabled or disabled, giving you full control over how PumpLogic operates.

Key capabilities:

- **Flexible temperature control** — Trigger High (cooling) or Trigger Low (freeze protection) with configurable buffer (minimum 3°F) to prevent rapid cycling
- **On/Off Timer Mode** — enable for timed cycling or disable for continuous pump operation driven by conditions

• **Voltage monitoring** — enable for battery-powered installations or disable for constant-power setups

• Separate weekday and weekend operating schedules with midnight wrapping support

• Optional quiet hours window to block pump operation during specific hours

• Optional vacuum sensor (displayed in inHg) with vacuum-triggered pump override, on-screen Zero Vacuum calibration, and a 24-hour vacuum graph

• Low voltage lockout with accumulated charge recovery (pause/resume)

• Stale sensor data fail-safe — blocks pump if temperature, voltage, or vacuum data stops updating

• Automatic temperature sensor recovery if disconnected

• Daily min/max temperature, voltage, and vacuum (inHg) tracking

• Daily and lifetime pump runtime counters

• Battery percentage estimation for Lead-Acid and LiFePO4 batteries

• **Battery health tracking** — cumulative cycle count, deepest daily depth-of-discharge with date, and 30-day rolling average DoD; reset together when the battery is replaced

• 24-hour graphs for battery charge/discharge, temperature, and vacuum with 15-minute intervals

• Voltage trend indicator (rising, falling, stable)

• Event log with up to 100 entries and automatic pruning of entries older than 7 days

• Serial Monitor Log — view internal system messages wirelessly with export capability; boot logs (first 10 minutes) are preserved separately and never overwritten

• **Battery-backed real-time clock** — keeps accurate time across power loss and extended shutdowns, so the pump schedule runs immediately on boot without waiting for a browser to connect

• **Configurable timezone** — choose from 6 US zones (Eastern, Central, Mountain, Pacific, Alaska, Hawaii) with a Daylight Saving toggle

• **RTC status indicator** on the Network card with a color-coded health badge (green "RTC OK", amber "RTC Lost Power", red "No RTC")

• **Set Time** — manually enter date, time, and timezone when no WiFi-capable device is available; values are written to the RTC so they survive reboots

• **Automatic drift correction** — browser time syncs only when device clock drifts more than 60 seconds; the RTC is re-read every hour to keep the system clock accurate

• Boot/reboot event tracking with 48-hour history on the Detailed Cumulative Report

• Time sync warning banner when device clock is not yet synced

• Automatic reboot protection for unattended reliability

• Web-based control panel accessible from any device with a browser

• **Settings management** — save/restore defaults, export/import settings files, automatic hourly backups

• **Settings change tracking** — configuration changes logged to the event log with category details

• **WiFi credential safety** — 180-second auto-revert on SSID/password changes, plus a physical reset button for WiFi recovery

PumpLogic hosts its own WiFi network and serves a complete control panel from the device itself — no internet connection or external server required.

Getting Started

Connecting to WiFi

1. On your phone, tablet, or computer, open **WiFi settings**

2. Look for the network named **PumpLogic-XXXX** where XXXX is the last 4 hex characters of the device's MAC address (this is the default; the name may differ if changed in settings)

3. Connect to the network (no password by default)

4. Open a web browser and navigate to:

• **http://192.168.4.1** (always works), or

• **http://pumplogic.local** (works on iPhones, Macs, and most computers)

The PumpLogic control panel will load in your browser.

Important Notes

• PumpLogic creates its **own WiFi network**. It does not join your home or office WiFi.

• Only devices connected to PumpLogic's WiFi network can access the control panel.

• **You will not have internet access** while connected to PumpLogic's network. On most modern devices the control panel opens automatically — see below.

• The IP address is always **192.168.4.1**.

• **Shortcut URL:** iPhones, iPads, Macs, Windows, and most Linux computers support **http://pumplogic.local** as an easy-to-remember alternative to the IP address. Android devices may not support this — use the IP address instead.

• **Range:** PumpLogic's WiFi typically covers 10–30 meters (30–100 feet) indoors. Move closer if you have trouble connecting.

WiFi "No Internet" Warning

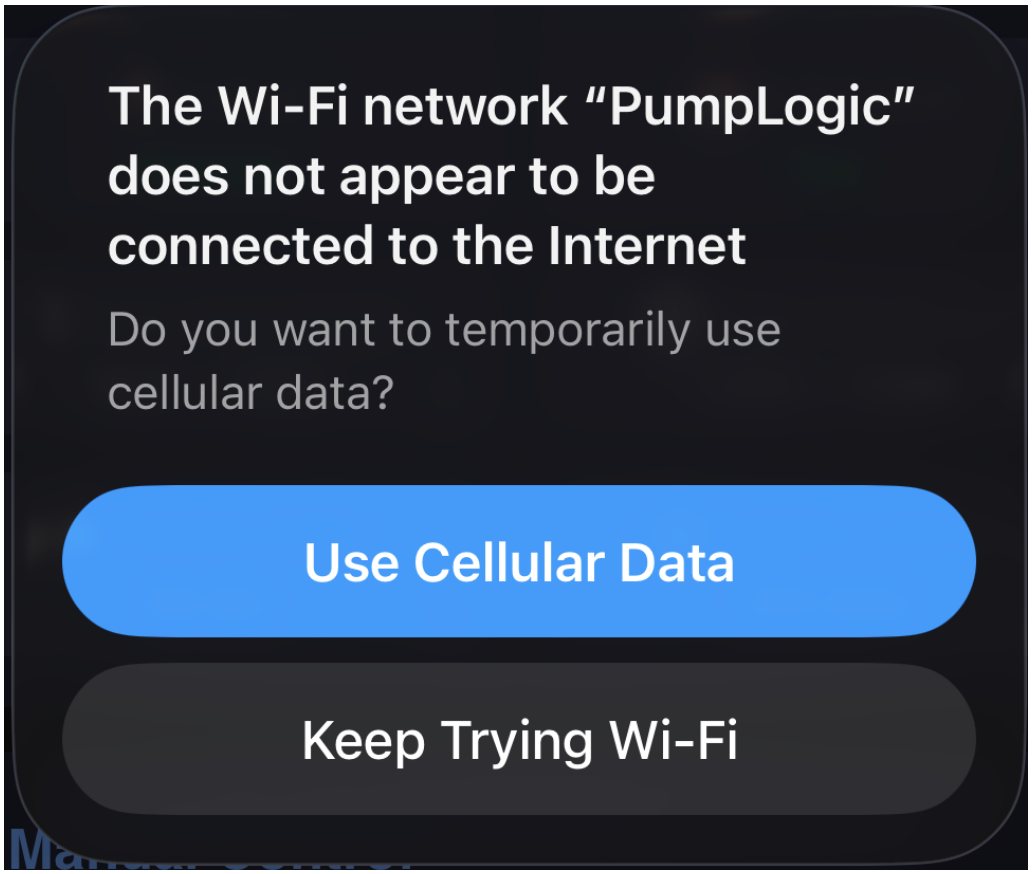


Figure: iPhone WiFi warning — select "Keep Wi-Fi" to stay connected

PumpLogic uses a **captive portal** — the same technology hotels and airports use for their guest WiFi. When your device connects, it detects the portal and opens the PumpLogic control panel automatically. You usually won't have to type the IP address at all.

On iPhone, iPad, and Mac: A "Log In" sheet slides up over whatever app you're in, showing the PumpLogic page inside. Tap "Done" when finished. The WiFi icon in the status bar stays normal — no warning triangle.

On Android: A notification appears at the top of the screen that says **"Sign in to network"** with PumpLogic underneath. Tap it and the control panel opens in a full-screen browser. Some Android versions also show a one-time prompt such as **"This network has no internet access — stay connected?"** — select **Yes** or **Keep Connection** to remain on PumpLogic's network. Some Android devices may silently switch back to mobile data if you ignore the prompt — if the control panel stops loading, check that you are still connected to PumpLogic's WiFi in your device's WiFi settings.

On Windows and most Linux laptops: A browser tab opens automatically to the control panel.

If the auto-open sheet does not appear (rare — usually after an OS caches the network as "no internet"), forget the PumpLogic network in WiFi settings and rejoin, or manually open a browser and go to **http://192.168.4.1**.

Setting the Time (First Use)

PumpLogic requires an accurate clock for scheduling to work correctly. The device has a **battery-backed real-time clock**, so once the time is set, it persists across reboots and power loss. (See the Real-Time Clock section for important information about coin cell selection — using the wrong type can damage the battery.)

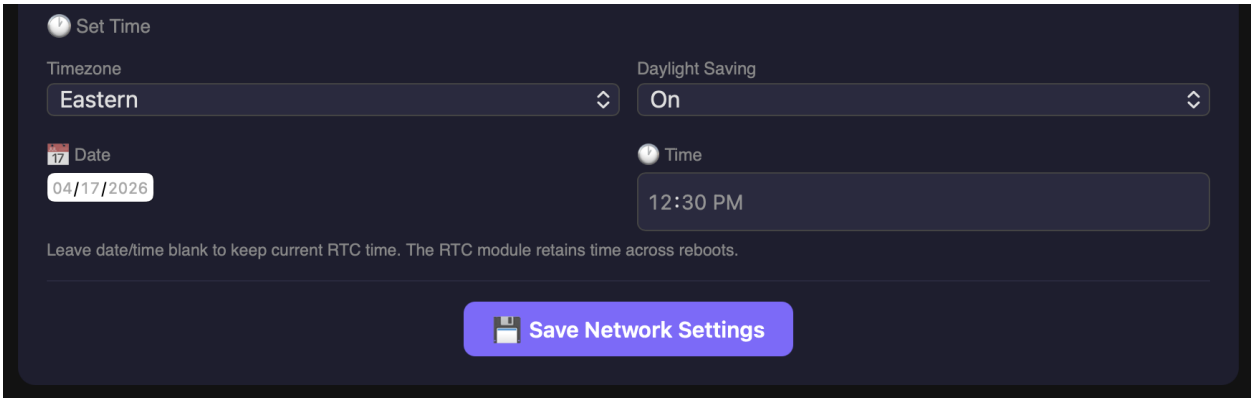
On first power-up, the RTC may not yet have a valid time. You'll know this is the case if:

- The Network card shows the **amber "■ RTC Lost Power"** badge, and
- A blinking amber **"Time not synced"** banner appears at the top of the Status card

There are two ways to set the time:

Option 1 — Automatic browser sync (easiest). When you load the PumpLogic webpage from a phone, tablet, or computer with an accurate clock, the browser sends the current date and time to the device. If the device clock is off by more than 60 seconds (or has never been set), PumpLogic updates the system clock *and* writes the new time to the RTC. The page reloads and the **RTC badge turns green** ("● RTC OK").

Option 2 — Manual Set Time. If no WiFi-capable device with the correct time is available, set the clock by hand:



Set Time controls in the Network card

1. Expand the **Network** card
2. Select your **Timezone** (Eastern, Central, Mountain, Pacific, Alaska, or Hawaii)
3. Set **Daylight Saving** to **On** or **Off** (automatically disabled for Hawaii, which does not observe DST)
4. Enter today's **Date** and the current **Time**
5. Press **Save Network Settings**

The time is written directly to the RTC and persists across reboots. Once the clock is set, PumpLogic's schedule, event log timestamps, and all time-dependent features will operate correctly. See Time Synchronization for full details.

> **Note:** The timezone and DST settings are always saved — even if you leave the Date and Time fields blank. This lets you change your timezone later without resetting the clock.

WiFi Credential Recovery

If you forget the WiFi password or change the SSID to something you can't connect to, PumpLogic provides two recovery mechanisms:

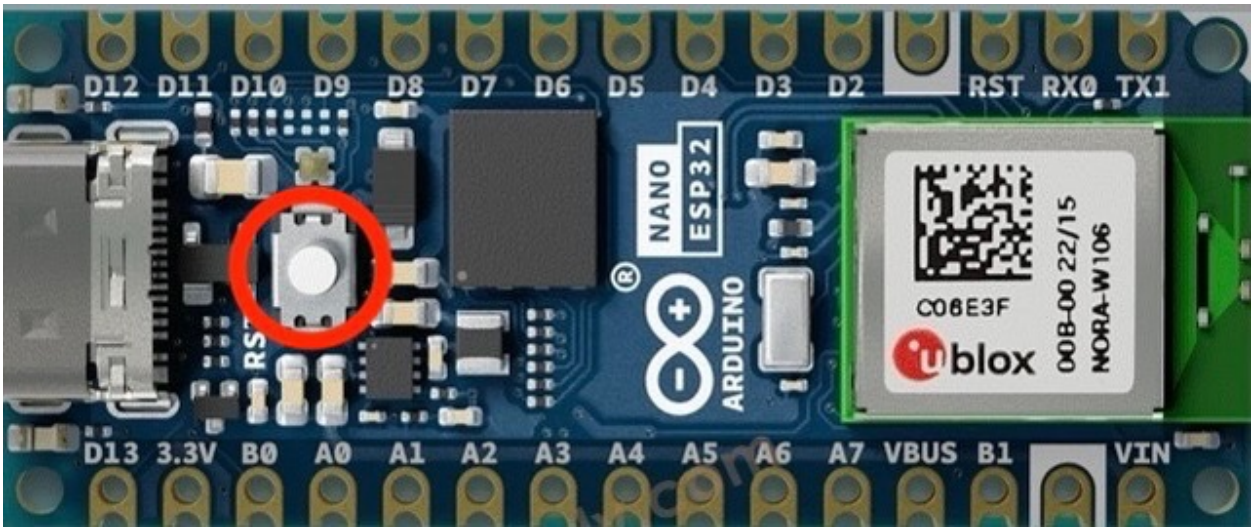
Automatic Revert (180 seconds)

When you change the WiFi SSID or password, PumpLogic starts a 180-second countdown. If no device connects to the new network within 3 minutes, the credentials automatically revert to the previous values. This prevents being locked out by a mistyped password or SSID.

Physical Reset Button

If the automatic revert period has passed and you are locked out:

1. Open the PumpLogic enclosure to expose the Arduino microcontroller inside
2. Locate the **RESET button** on the Arduino (the only button on the board)
3. Press the **RESET button 5 times within 10 seconds**
4. After the 5th press, WiFi credentials reset to the default: **PumpLogic-XXXX** (where XXXX is unique to your device) with **no password**
5. Connect to the default network and set a new password if desired



Reset Button

The reset only affects WiFi SSID and password — all other settings (schedule, temperature triggers, runtime counters, event log, etc.) are preserved.

> **Tip:** The 10-second window is measured from your first press, so press steadily — about one press per second works well. If you don't reach 5 presses in 10 seconds, the count resets and you can start over.

Understanding the Web Interface

Interface Layout and Navigation

The web interface is organized into **eight cards** stacked vertically. Each card serves a distinct purpose:

Card	Purpose	Collapsible?	Default State
Status	Real-time monitoring dashboard	No	Always visible
Charge Recovery	Charge progress during lockout	No	Hidden (appears only during lockout)
Manual Control	Direct relay and system controls	Yes	Collapsed
Network	WiFi, connectivity, uptime, clock, and RTC status	Yes	Collapsed
Battery Charge/Discharge	24-hour battery percentage graph	Yes	Collapsed
Temperature Over Time	24-hour temperature graph	Yes	Collapsed
Vacuum Over Time	24-hour vacuum graph (inHg) — visible whenever the vacuum sensor is enabled or in monitoring-only mode	Yes	Collapsed
Settings	All configurable parameters	Yes	Collapsed
Event Log	History of pump runs and events	Yes	Collapsed

Expanding and collapsing cards: Click the **arrow button** in the upper-right corner of any collapsible card header to toggle it open or closed.

Expand/Close All: Inside the Settings card, an **Expand All Cards** button lets you expand or collapse all collapsible cards at once.

Refreshing data: The Status card auto-refreshes every 30 seconds. The **Status card header** shows (left to right): the title, your **Device Name** (centered), and a **Battery gauge** with SVG fill level plus the percentage — the fill color changes based on level (green ≥50%, orange 20–49%, red <20%; green for "Charging").

Device Name: Displayed centered in the Status card title so you can identify the unit at a glance. Set the name in the Network Card — it's saved to the device and persists through reboots.

Status Card — The Main Dashboard

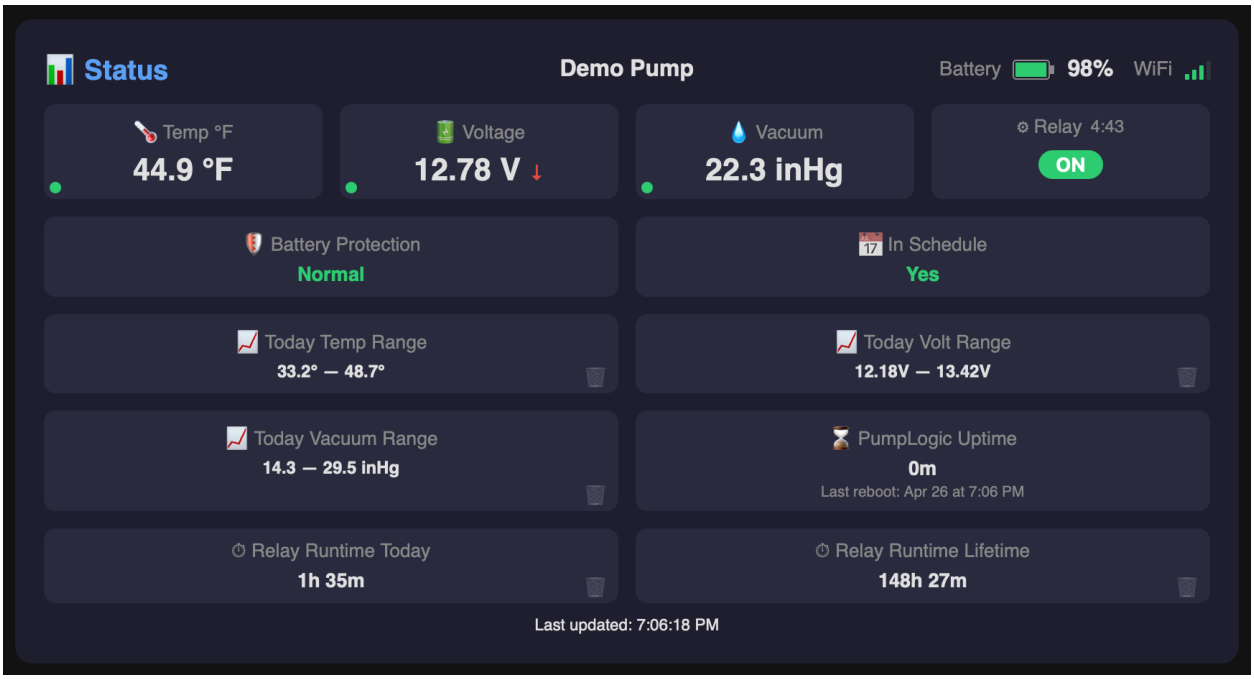


Figure: Status card showing sensor readings and system state

The Status card is the primary monitoring view. It is always visible and organized into four rows.

Row 1 — Sensor Readings and Relay State

Four equally spaced indicators across the full width:

Temperature (Temp °F)

Element	What It Means
Number (e.g., "45.0 °F")	The current temperature reading
Green dot	Temperature condition is met — **at or above** the trigger (Trigger High mode) or **at or below** the trigger (Trigger Low mode)
Red dot	Temperature condition is not met
"Error"	The sensor is disconnected or unresponsive

Voltage

Element	What It Means
Number (e.g., "12.80 V")	The current battery voltage reading
Green dot	Voltage is **above** the low voltage cutoff — condition met
Red dot	Voltage is **at or below** the cutoff — lockout may trigger

Element	What It Means
Gray dot	Voltage monitoring is **disabled** — voltage is not used as a condition
Trend arrow ↑ (green)	Voltage is **rising** (increased by more than 0.1V since the last reading)
Trend arrow ↓ (red)	Voltage is **falling** (decreased by more than 0.1V since the last reading)
Trend arrow → (gray)	Voltage is **stable** (within ±0.1V of the last reading)

Vacuum (inHg)

Element	What It Means
Number (e.g., "22.4 inHg")	The current vacuum reading from the sensor, expressed in inches of mercury
Green dot	Vacuum has **reached or exceeded** the Vacuum Trigger — target vacuum achieved
Red dot	Vacuum is **below** the Vacuum Trigger — pump override may activate
Gray dot / "N/A"	Vacuum sensor is disabled in Settings

The display is clamped to **0.0 inHg** when the sensor reads at or above atmospheric pressure (a true vacuum cannot go negative). When the vacuum sensor is disabled, the column shows "N/A" and is greyed out. If vacuum data becomes stale (no update in over 2 minutes), the value is highlighted in amber as a warning.

Relay

Element	What It Means
Green **ON** badge	Relay is energized — the pump is running
Red **OFF** badge	Relay is de-energized — the pump is stopped
Countdown timer (e.g., "8:32")	Time remaining in the current ON or OFF cycle
Empty countdown (0:00)	On/Off Timer Mode is disabled — the pump runs continuously based on conditions

When the countdown reaches zero, the status card automatically refreshes to show the new cycle state. When On/Off Timer Mode is disabled, the countdown is not used.

Row 2 — Battery Protection and Schedule Status

Two equally spaced indicators:

Battery Protection

Display	Meaning
Green **"Normal"**	System is operating normally — no voltage issues
Red **"LOW BATTERY"**	Pump is disabled due to low battery voltage. The Charge Recovery card will appear.

In Schedule

Display	Meaning
Green **"Yes"**	Current time is within the active operating schedule
Red **"No"**	Current time is outside the operating schedule
Yellow **"Quiet Hours"**	Current time is within the quiet hours window — pump blocked

The system automatically uses the weekend schedule on Saturdays and Sundays.

Row 3 — Daily Min/Max Tracking

Indicator	Description
Today Temp Range	The lowest and highest temperature readings recorded today (e.g., "28.5° — 47.2°")
Today Volt Range	The lowest and highest voltage readings recorded today (e.g., "11.92V — 13.45V")
Today Vacuum Range	The shallowest and deepest vacuum readings recorded today, in inHg (e.g., "12.4 — 24.8 inHg"). Always present in the layout, but greyed out when the vacuum sensor is disabled.
PumpLogic Uptime	Time since last reboot (days/hours/minutes). Below the uptime value, **Last reboot** shows the date and time of the most recent boot.

All ranges reset automatically at midnight. A small reset button (trash icon) in the bottom-right corner of each stat lets you manually reset the range.

Row 4 — Runtime Counters

Indicator	Description
Runtime Today	Total pump-on time today, displayed as hours and minutes (e.g., "2h 15m"). Resets at midnight.
Runtime Lifetime	Total cumulative pump-on time since first use (e.g., "148h 32m"). Persists across reboots. Saved to device memory.

Each counter has a small reset button (trash icon) in the bottom-right corner for manual reset.

Status Card During Lockout

When a low-voltage lockout is active, the Status card layout changes:

- **Row 1** expands to show Temp, Voltage, Vacuum (if enabled), Relay, Battery Protection, and In Schedule — all critical indicators at a glance
- **Rows 3–4** (min/max tracking and runtime) are hidden to keep the display focused on the lockout situation

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Charge Recovery Card

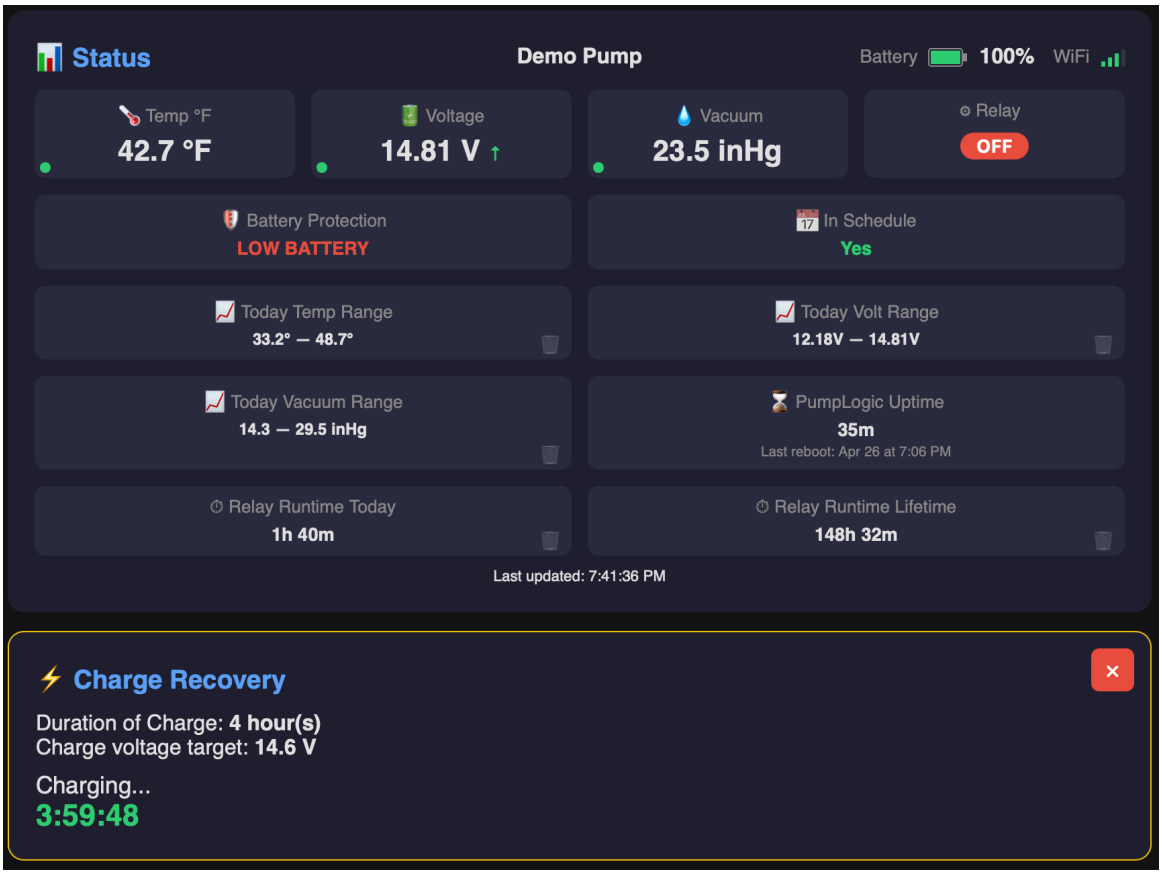
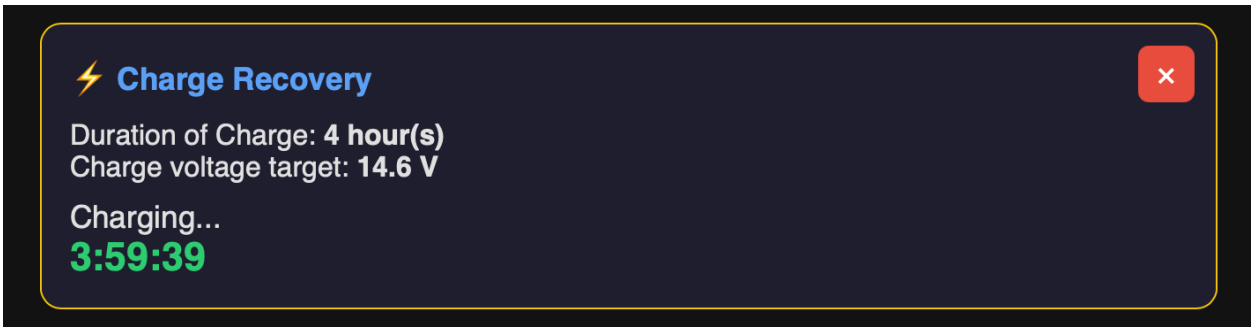


Figure: Charge Recovery card with battery protection progress

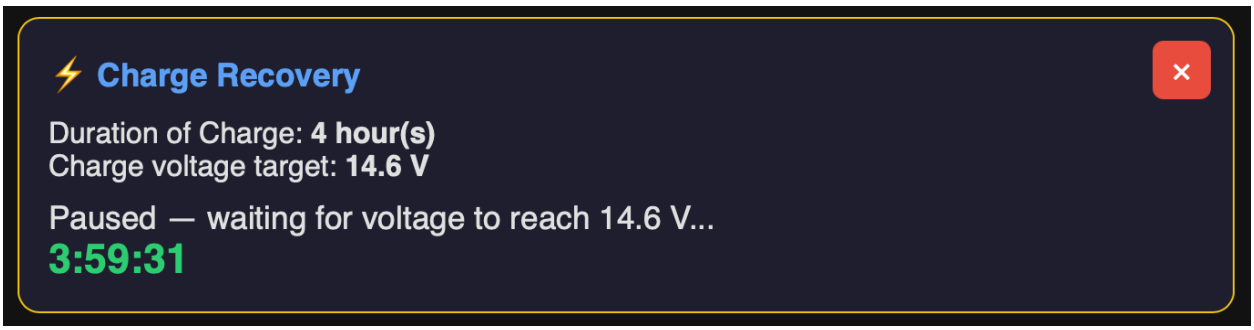
This card **only appears** when a low-voltage lockout is active. It provides real-time progress of the charge recovery process.

Field	Description
Duration of Charge	Total hours required at or above the charge voltage (e.g., "4 hour(s)")
Charge voltage target	The minimum voltage required to count toward charge recovery (e.g., "14.6 V")

Field	Description
Status	Shows "Waiting for voltage to reach XX.X V..." until voltage meets the target, then shows "Charging..." with a countdown timer. If voltage drops below the target, shows "Paused — waiting for voltage to reach XX.X V..." with the countdown frozen at its current position.
Countdown timer	Displays remaining time in H:MM:SS format. Counts down in real time while charging. Pauses if voltage drops below the charge target and resumes from where it left off when voltage returns.



Charge Recovery Activated with Timer



Charge Recovery Paused Timer

A red **X** button in the upper-right corner cancels the charge recovery and immediately resumes normal operation. See the Charge Recovery section for full details.

Manual Control Card

Figure: Manual Control buttons

A collapsible card providing direct control over the pump and system. A brief description of each action is displayed at the top, followed by four buttons in a 2x2 grid:

Button	What It Does
Force ON	Immediately turns the pump ON for the configured ON Duration, regardless of conditions. After the ON duration elapses, PumpLogic logs the run and resumes automatic cycling.
Force OFF	Immediately turns the pump OFF and resumes automatic cycling. The OFF duration timer begins counting down.
Charge Recovery	Manually initiates charge recovery. A confirmation dialog appears first. The pump is disabled until the charge recovery requirements are met. The event is logged.
Reboot	Restarts the device. A confirmation dialog appears first. After rebooting, reconnect to WiFi and reload the page.

Network Card

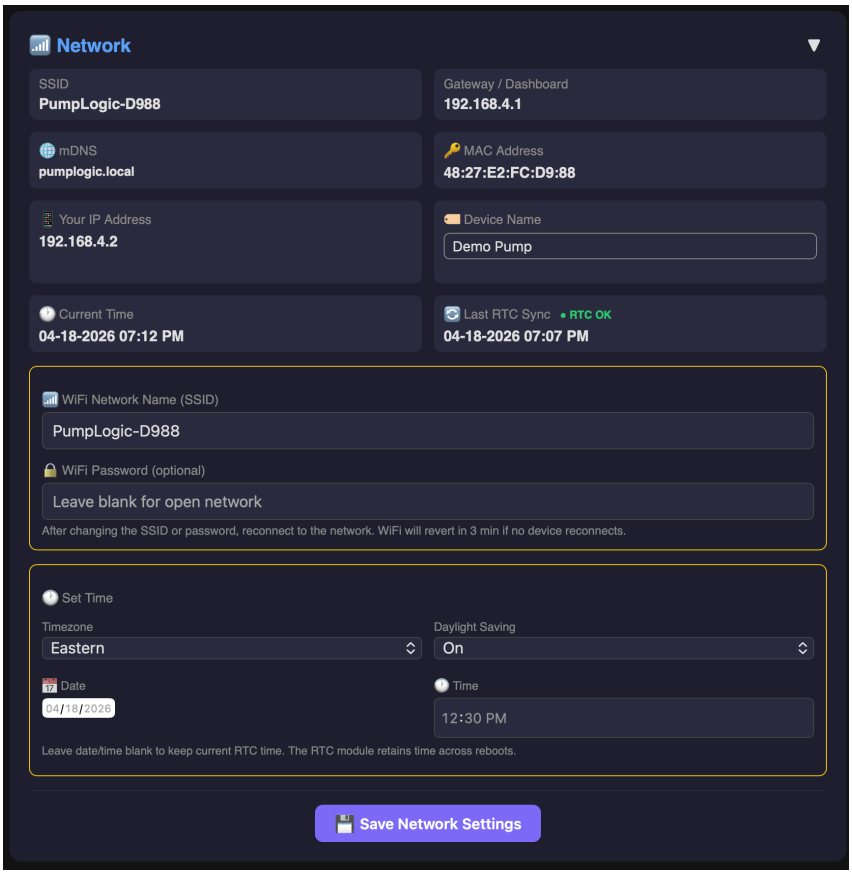


Figure: Network card showing connectivity and time info

A collapsible card displaying connectivity, system, time information, WiFi configuration, and Set Time controls. The card is organized into informational rows followed by editable fields:

Informational rows:

The Network card lays out four rows of information, each split into two side-by-side fields:

- **Row 1 — SSID:** the WiFi network name being broadcast. **IP Address:** always 192.168.4.1.
- **Row 2 — mDNS:** the shortcut URL (`pumplogic.local`). **Uptime:** time since last reboot (days/hours/minutes), with **Last reboot** timestamp shown below.
- **Row 3 — Your IP Address:** the IP of the device you're connecting from. **Device Name:** an editable text field for a custom label (e.g., "Well #3", "Barn Pump"). The name is also displayed centered in the Status card title. Saved automatically when you press Enter or tab away. Max 32 characters.
- **Row 4 — Current Time:** live date and time from the synced clock (ticks every few seconds without needing a page reload). **Last RTC Sync:** timestamp of the most recent time synchronization, plus a compact ■ **Sync** button that force-syncs time from your browser. A small **RTC status badge** appears next to the label showing the health of the real-time clock (see below).

RTC status badge (next to "Last RTC Sync"):

Badge	Color	Meaning
● **RTC OK**	Green	Real-time clock detected, coin cell healthy, clock running normally. Time persists across reboots.
■ **RTC Lost Power**	Amber	Real-time clock detected, but it reports lost power — usually because the coin cell is missing, dead, or this is the very first power-up. Normal operation resumes once a browser sync or Set Time action writes a valid time. **Replace the coin cell if this persists after setting the time.**
✕ **No RTC**	Red	Real-time clock module not detected. The device falls back to browser time sync only — time will **not** persist across reboots. Contact support.

■ Sync button (inside the Last RTC Sync box):

A compact button on the right side of the **Last RTC Sync** field. Pressing it sends your browser's current date and time to the device *immediately*, bypassing the normal 60-second drift threshold. Useful if you know the device clock is off but the drift happens to be under 60 seconds (e.g., after manually adjusting your phone's clock), or if you simply want to refresh the RTC from a trusted source. Hover (or long-press on mobile) to see the full label. The page reloads after a successful sync.

WiFi configuration fields:

Field	Description
WiFi SSID	Editable input for the WiFi network name. Max 32 characters.
WiFi Password	Editable input for the WiFi password. Leave blank for an open network. 8–63 characters if set.

Set Time section:

Field	Description
Timezone	Dropdown with 6 US zones: Eastern, Central, Mountain, Pacific, Alaska, Hawaii. Controls the UTC offset used for all displayed timestamps.
Daylight Saving	On/Off dropdown. When On, the timezone offset shifts forward by one hour during DST periods. **Automatically disabled and forced to Off when Timezone is set to Hawaii**, which does not observe DST.

Field	Description
Date	Optional. Enter the current date to manually set the RTC clock.
Time	Optional. Enter the current time to manually set the RTC clock.

Leave Date and Time blank to change only the Timezone or DST setting without overwriting the current RTC time. When both Date and Time are provided, the values are written directly to the real-time clock and persist across reboots.

Save Network Settings button:

A **Save Network Settings** button at the bottom saves all settings (equivalent to the Save Settings button in the Settings card).

After changing the SSID or password, reconnect to the new network. WiFi credentials will automatically revert in 3 minutes if no device reconnects to the new network.

All timestamps are displayed in **MM-DD-YYYY HH:MM AM/PM** format.

Time is synced automatically when you load the page. If the device clock differs from your browser by more than 60 seconds, the new time is applied to the system clock and RTC, and the page reloads. Otherwise the page load silently skips the sync. See Time Synchronization for details.

Battery Charge/Discharge Card

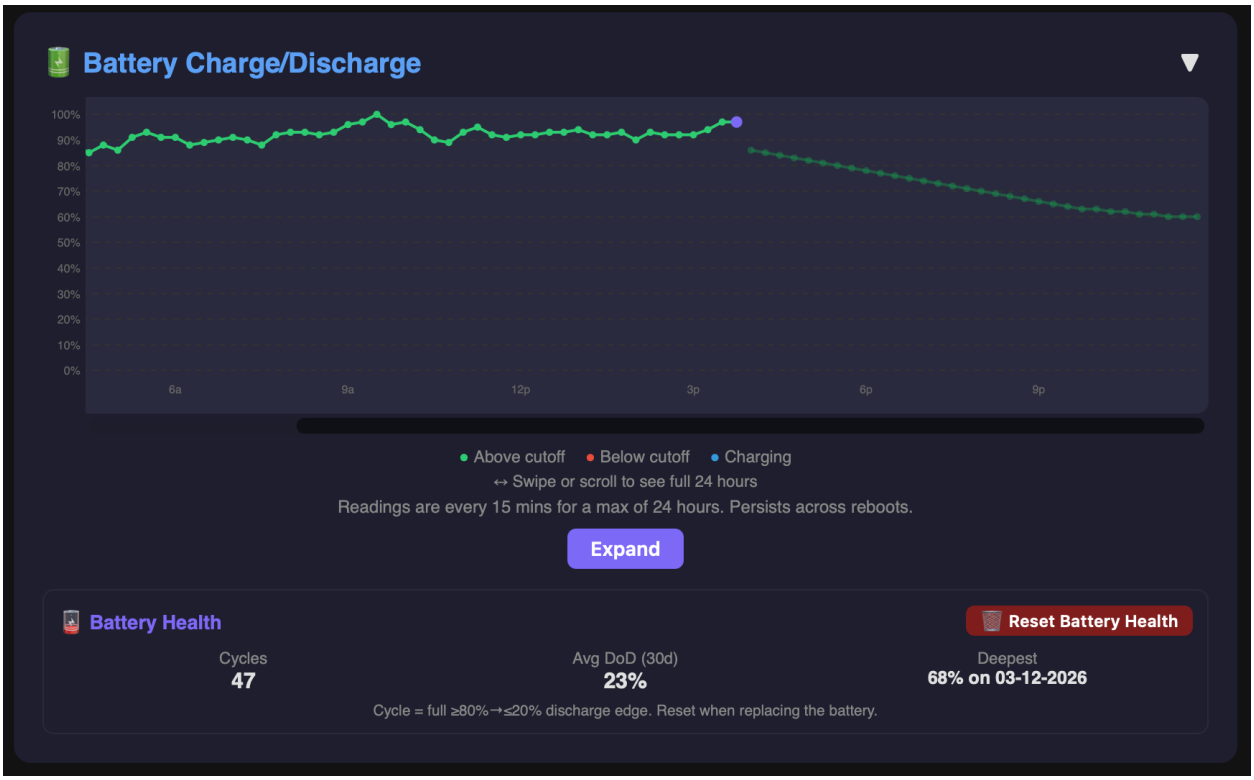


Figure: Battery Charge/Discharge card showing 24-hour battery percentage graph

A collapsible card displaying a 24-hour battery percentage line graph plus a **Battery Health** tile with long-term diagnostic stats. The graph plots battery charge percentage (0–100%) at 15-minute intervals, providing a visual overview of charge and discharge patterns throughout the day.

Element	Description
Battery%	Current battery charge percentage displayed in the card header
Line graph	Green line plotting battery percentage over 24 hours at 15-minute intervals
X-axis labels	Time labels from 12a (midnight) through 12p to 11:45p, shown every 3 hours
Y-axis labels	Percentage scale: 0%, 25%, 50%, 75%, 100%
Current slot dot	Accent-colored dot highlighting the most recent reading on the graph
Sample indicator	Text below graph indicating sample data is displayed (clears after first real reading)
Open Full View	Button that opens the graph in a dedicated full-page view at /battgraph

Element	Description
Battery Health tile	Three-up summary at the bottom of the card showing total **Cycles**, **Avg DoD (30d)**, and **Deepest** daily depth-of-discharge with the date it was recorded. Includes a dark-red ■ **Reset Battery Health** button for use when a battery is replaced. See Battery Health for the metric definitions.

On initial boot, the graph displays sample data showing a realistic 24-hour charge/discharge cycle. Once the first real battery reading is recorded (after 15 minutes), all sample data is cleared and replaced with actual readings.

The graph is horizontally scrollable within the card — swipe or scroll left/right to see the full 24-hour timeline. Readings are every 15 minutes for a maximum of 24 hours and reset on reboot.

The **Open Full View** button opens the graph in a dedicated full-page view that is optimized for both portrait and landscape viewing on mobile devices.

The **Battery Health** tile is hidden when voltage monitoring is fully disabled (constant-power installations), since state-of-charge has no meaning in that mode.

Temperature Over Time Card

Figure: Temperature Over Time card showing 24-hour temperature graph

A collapsible card displaying a 24-hour temperature line graph. The graph plots temperature readings (in °F) at 15-minute intervals, providing a visual overview of temperature changes throughout the day.

Element	Description
Line graph	Orange line plotting temperature over 24 hours at 15-minute intervals

Element	Description
X-axis labels	Time labels from 12a (midnight) through 12p to 11:45p, shown every 3 hours
Y-axis labels	Temperature scale in °F, auto-scaled to the data range
Current slot dot	Accent-colored dot highlighting the most recent reading on the graph
Sample indicator	Text below graph indicating sample data is displayed (clears after first real reading)
Open Full View	Button that opens the graph in a dedicated full-page view at /tempgraph

On initial boot, the graph displays sample data showing a realistic 24-hour temperature cycle. Once the first real temperature reading is recorded (at the next 15-minute boundary after boot), all sample data is cleared and replaced with actual readings.

The graph is horizontally scrollable within the card — swipe or scroll left/right to see the full 24-hour timeline. The **Open Full View** button opens the graph in a dedicated full-page view optimized for both portrait and landscape viewing on mobile devices.

Vacuum Over Time Card

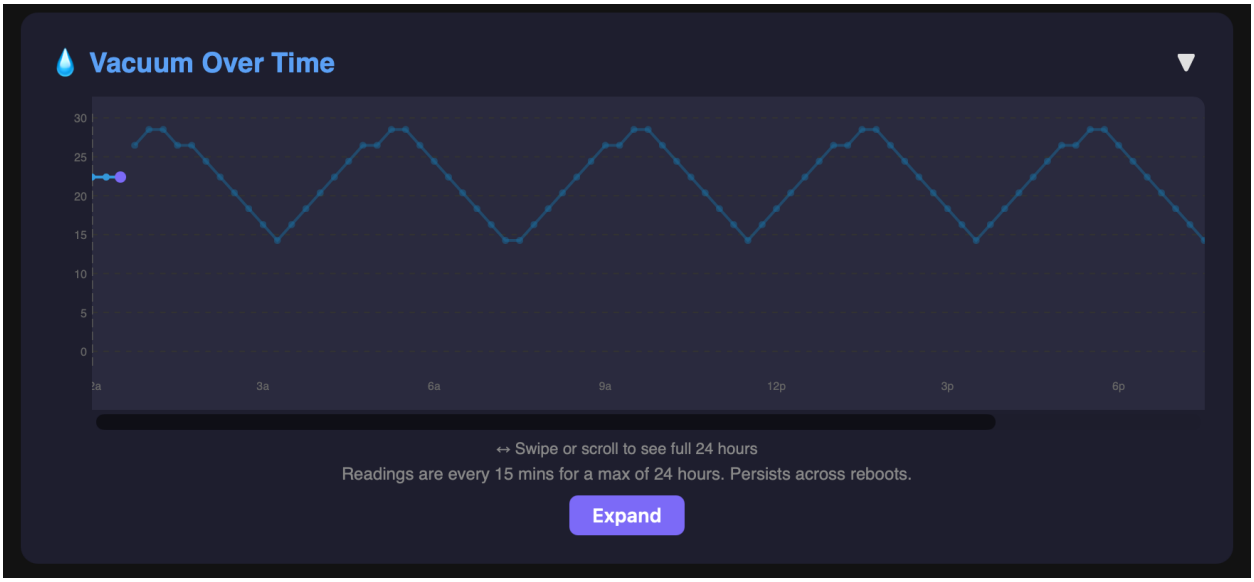


Figure: Vacuum Over Time card showing 24-hour vacuum graph (inHg)

A collapsible card displaying a 24-hour vacuum line graph. The card is visible whenever the vacuum sensor is set to **Enable + Logic** or **Monitoring Only** in Settings. Inside the card, the graph plots vacuum readings (0–30 inHg) at 15-minute intervals, providing a visual overview of vacuum changes throughout the day.

Element	Description
Line graph	Blue line plotting vacuum (inHg) over 24 hours at 15-minute intervals
X-axis labels	Time labels from 12a (midnight) through 12p to 11:45p, shown every 3 hours
Y-axis labels	Vacuum scale in inHg, with **deepest vacuum (30 inHg) at the top** of the chart and **atmospheric (0 inHg) at the bottom** — the conventional orientation for vacuum displays
Current slot dot	Accent-colored dot highlighting the most recent reading on the graph
Sample indicator	Text below graph indicating sample data is displayed (clears after first real reading)
Open Full View	Button that opens the graph in a dedicated full-page view at /psigraph

On initial boot with the vacuum sensor enabled, the graph displays sample data showing a realistic 24-hour vacuum cycle. Once the first real vacuum reading is recorded (at the next 15-minute boundary after boot), all sample data is cleared and replaced with actual readings.

The graph is horizontally scrollable within the card — swipe or scroll left/right to see the full 24-hour timeline. The **Open Full View** button opens the graph in a dedicated full-page view optimized for both portrait and landscape viewing on mobile devices.

When the vacuum sensor is set to **Disable - No Logic or Monitor** in Settings, the body of the card shows "Vacuum sensor disabled" in place of the graph.

Settings Card

A collapsible card containing all configurable parameters, organized into yellow-bordered subsections. Expand the card, adjust values, and press **Save Settings** to apply changes. Most changes take effect immediately — no reboot required. WiFi SSID/password and Set Time are configured in the Network card.

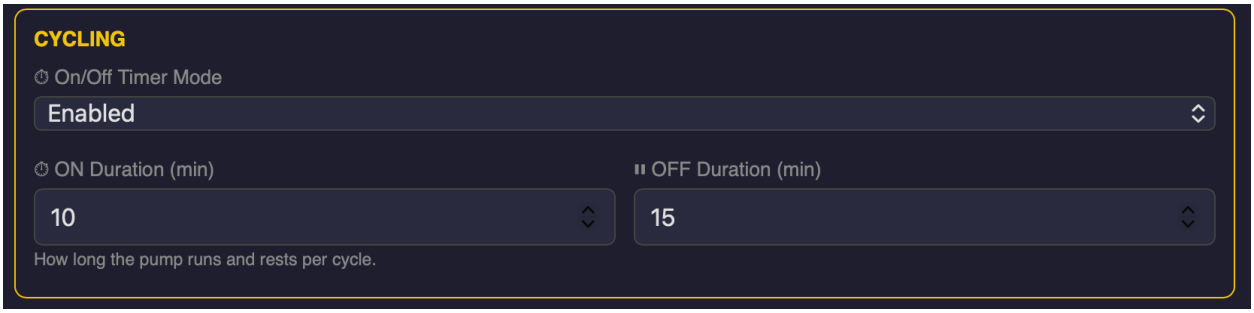
The Settings card is organized into six yellow-bordered subsections, followed by a **Settings Management** subsection. Each is shown below.

TEMPERATURE

Temperature Settings

Controls how temperature drives the pump: trigger temperature, Trigger High vs. Trigger Low direction, temperature buffer enable/disable, and buffer value (°F).

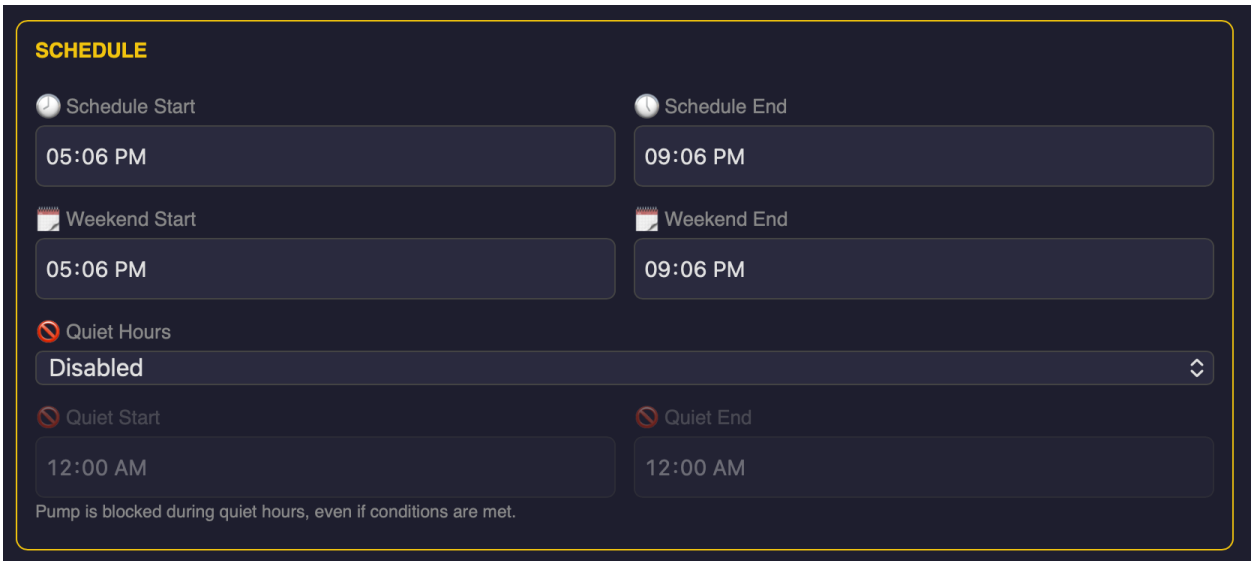
CYCLING



Cycling Settings

On/Off Timer Mode toggle, ON Duration (min), and OFF Duration (min). When On/Off Timer Mode is disabled, the duration fields are greyed out and the pump runs continuously while conditions are met.

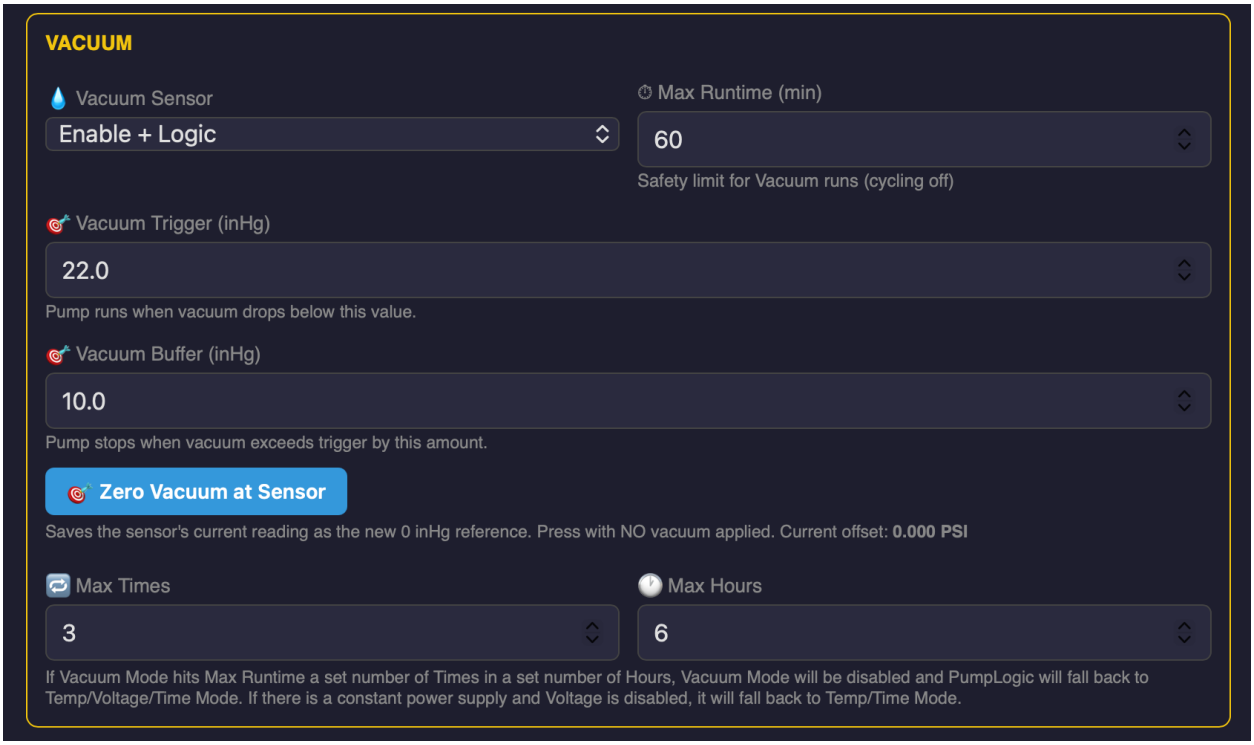
SCHEDULE



Schedule Settings

Weekday Start/End, Weekend Start/End, Quiet Hours toggle, and Quiet Start/End times. All times use 24-hour format. Schedule and quiet-hours windows both support midnight wrapping.

VACUUM



Vacuum Settings

Vacuum Sensor mode (Disable / Enable + Logic / Monitoring Only), Max Runtime (min) safety limit, Vacuum Trigger (inHg), Vacuum Buffer (inHg), the **Zero Vacuum at Sensor** calibration button (described below), and the Max Times / Max Hours failsafe fields. Trigger and buffer are entered and displayed in **inHg**.

The ■ **Zero Vacuum at Sensor** button captures the sensor's current reading at atmospheric pressure and saves it as the new 0 inHg reference. Press it with **no vacuum applied** so the dashboard reads 0.0 inHg at rest. The current saved offset is shown beneath the button.

The failsafe fields apply only when the mode is **Enable + Logic**: if the Max Runtime is reached **Max Times** within the rolling **Max Hours** window, vacuum mode is automatically disabled and PumpLogic falls back to Temp/Voltage/Time Mode (or Temp/Time Mode if voltage monitoring is also disabled).

VOLTAGE

Voltage / System / Settings Management

Voltage Monitoring mode (Disable / Enable + Logic / Monitoring Only), Low Voltage Cutoff (V), Battery Type (12V Lead-Acid or 12V LiFePO4), Duration of Charge (hours), and Charge Voltage (V). When the mode is **Monitoring Only** or **Disable**, the dependent fields grey out and a yellow constant-power warning appears.

SYSTEM

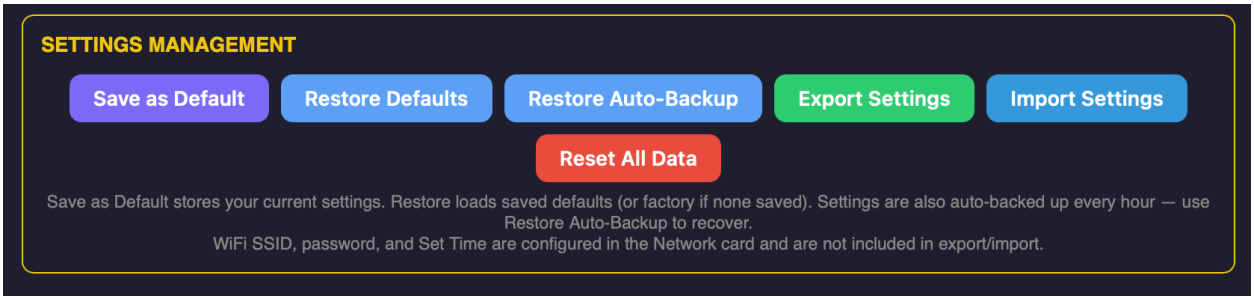
System Settings include the Watchdog Timeout (min/sec), the Welcome Greeting toggle, and a green **Detailed Cumulative Report** button that opens a comprehensive report in a new tab. The System subsection appears in the same screenshot above (the System Settings image covers Voltage, System, the action buttons, and Settings Management together).

Action Buttons

Below the subsections, three evenly-spaced buttons:

Button	Action
Cumulative Report (green)	Opens the Detailed Cumulative Report in a new browser tab.
Save Settings	Saves all current values to device memory. A green toast notification confirms the save.
Expand All Cards (blue)	Toggles all collapsible cards open or closed at once.

SETTINGS MANAGEMENT



Settings Management

A yellow-bordered subsection (outside the main form) for backing up, restoring, and exchanging settings:

Button	Action
Save as Default	Saves current settings as user defaults.
Restore Defaults	Restores user-saved defaults, or factory defaults if none saved.
Restore Auto-Backup	Restores settings from the last hourly auto-backup.
Export Settings	Downloads settings as a `.pumplogic_settings` JSON file.
Import Settings	Uploads a `.pumplogic_settings` file to restore settings.
Reset All Data	Clears graphs, event log, serial log, and daily stats. Requires double confirmation.

Save as Default stores your current settings. Restore loads saved defaults (or factory if none saved). Settings are also auto-backed up every hour — use Restore Auto-Backup to recover. WiFi SSID, password, and Set Time are configured in the Network card and are not included in export/import.

See the Settings Reference section for a detailed description of every setting.

Event Log Card

Figure: Event Log showing run history

A collapsible card showing a scrollable table of recorded events. Each row is rendered on a single line — on narrow screens, swipe the table left/right to reveal additional columns. Each row includes five columns:

Column	Description
Event	The event type — "RUN", "CHARGE", "MAX RUN", "VAC OFF", "BOOT", "CONFIG", or "WARNING"
Time	When the event occurred (MM-DD-YYYY HH:MM AM/PM)
Temp	Temperature at the time of the event (for non-Config events)
Voltage	Battery voltage at the time of the event (for non-Config events)
In Sched	Whether the event occurred within the configured schedule window (Yes/No)

Color coding:

Event Type	Badge	Meaning
RUN	Green	A successful pump run completed.
CHARGE	Yellow	Charge recovery started, completed, or was cancelled.
MAX RUN	Orange	A vacuum-triggered run hit the Max Runtime safety timeout.
VAC OFF	Red	Vacuum mode auto-disabled after too many Max Runtime hits within the failsafe window.
BOOT	Blue	Logged each time PumpLogic starts or restarts. Boot events are excluded from the pump cycle count on the dashboard.
CONFIG	Purple	Logged when settings are changed via the web UI.
WARNING	Amber	Near-threshold warning (e.g. battery near cutoff).

Settings Change Log:

When settings are changed, a **Config** event is logged with a purple badge. Instead of temperature and voltage columns, Config events display which setting categories were modified (e.g., "temp,schedule,voltage"). This helps track what was changed and when.

Storage details:

- Up to **100 events** are stored in a rolling list. When full, the oldest entry is overwritten by the newest.

- Entries older than **7 days** are automatically removed at midnight each day to free slots for new events.
- Events are saved to device memory and persist across reboots. To extend flash memory life, writes are **batched** — multiple rapid events merge into a single write after a brief quiet period.
- Temperature or voltage readings that are unavailable (e.g., sensor disconnected) display as **—** in the log rather than showing error values.
- Event log format changed in Version 2.0 — existing logs are reset on first boot after updating.
- A **Clear All Logs** button at the bottom of the card clears the entire event log.

Serial Monitor Log Card

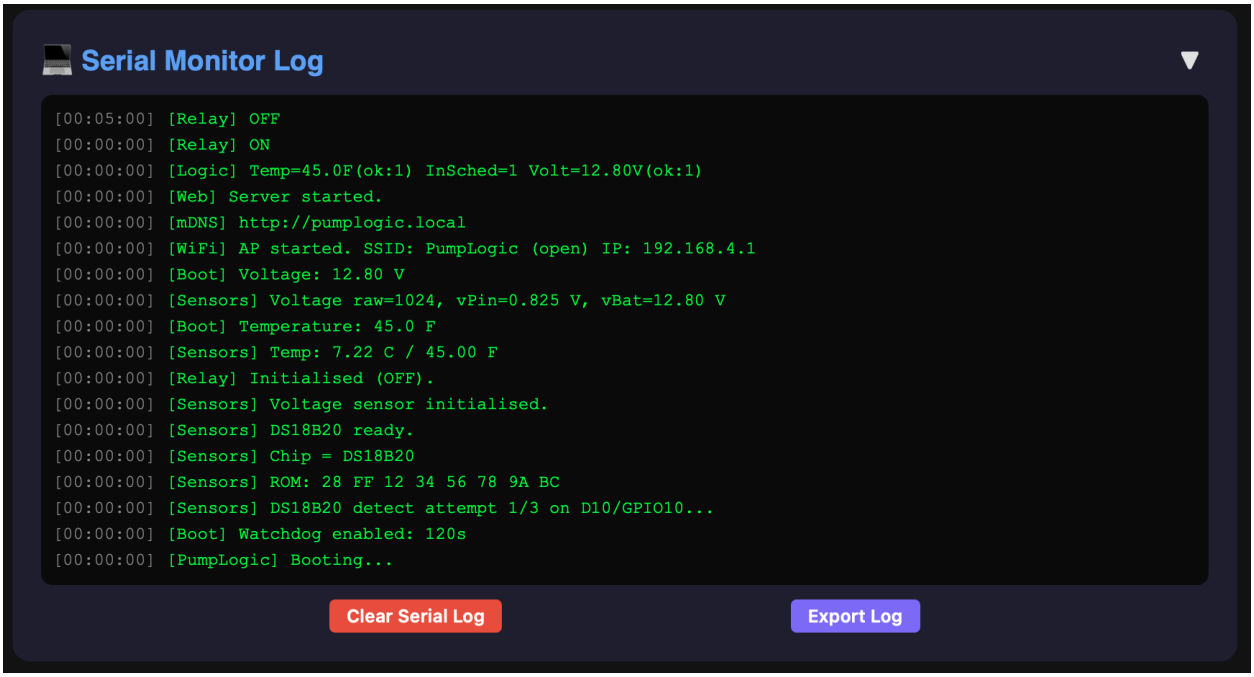


Figure: Serial Monitor Log with terminal-style debug output

A collapsible card with a dark terminal-style display showing internal system messages, accessible wirelessly through the web interface.

Display:

- Dark background with green monospace text, mimicking a serial terminal
- Each line shows an uptime timestamp in `[HH:MM:SS]` format followed by the message
- Messages are displayed newest-first, scrollable up to 100 entries

Adaptive refresh rate:

- When the card is **collapsed** (default), the page refreshes every **30 seconds**
- When the card is **expanded**, the refresh rate increases to every **3 seconds** for near-real-time monitoring

Bottom buttons:

Button	Action
Clear Serial Log	Erases all log entries from memory. A confirmation entry is recorded.
Export Log	Downloads the current log as a text file named `SerialMonitorLog-MM-DD-YYYY.txt`. The log is automatically cleared after download.

Storage details:

- Up to **200 entries** are stored in temporary memory (cleared on reboot)
- The first **50 entries** recorded during the initial 10 minutes after boot are stored in a **protected boot section** that is never overwritten by newer log entries. This ensures boot-time messages are always available for troubleshooting.
- When exported, boot logs appear first, followed by a separator line, then the rotating log entries (newest first)
- **Clear Serial Log** only clears the rotating section — boot logs are always preserved

---

Toast Notifications

All confirmations and status messages appear as brief, non-blocking toast notifications at the bottom of the screen — not as popup dialogs.

Toast Color	Meaning
Green	Success (e.g., "Settings saved!", "Relay forced ON")
Red	Error (e.g., a failed operation)

Toasts automatically disappear after 3 seconds (10 seconds for reboot messages).

How Automatic Pump Cycling Works

PumpLogic continuously evaluates conditions to decide when to turn the pump on and off. The behavior depends on which features are enabled.

Step 1 — Check Manual Override

If a **Force ON** or **Force OFF** is active, automatic logic is skipped:

- **Force ON:** The relay stays on until the ON duration elapses, then normal cycling resumes.
- **Force OFF:** The relay stays off and the OFF duration timer begins.

Step 2 — Periodic Sensor Reads

Sensors are read at fixed intervals. Between reads, the most recent value is cached and used by the decision logic.

Sensor	Interval
Temperature	Every 1 minute
Voltage	Every 30 seconds
Vacuum (inHg)	Every 30 seconds (when enabled)

Step 3 — Low Voltage Lockout Check (When Voltage Monitoring Enabled)

If Voltage Monitoring is enabled and the battery voltage drops below the **Low Voltage Cutoff**:

- The relay is immediately turned OFF
- The event is logged in the Event Log
- The pump cannot run until charge recovery completes (see Charge Recovery)
- All other automatic logic is skipped

When Voltage Monitoring is disabled, this check is skipped entirely. The system assumes a constant power supply is in use.

Step 4 — Evaluate Conditions

PumpLogic evaluates the following conditions:

Condition	Requirement
Temperature	Depends on Temperature Direction. **Trigger High:** reading is at or above the trigger. **Trigger Low:** reading is at or below the trigger.

Condition	Requirement
Schedule	Current time is within the operating window (weekday or weekend) AND not in the quiet hours window. Always required.
Voltage	When Voltage Monitoring is enabled: battery voltage is at or above the Low Voltage Cutoff. When disabled: always passes.

Step 5 — Relay ON: When to Turn Off

If the relay is currently ON, PumpLogic checks whether to turn it off based on which mode is active:

Vacuum-triggered run: The relay turns off when vacuum reaches the Vacuum Trigger plus Vacuum Buffer (e.g., 22 + 10 = 32 inHg). The Max Runtime acts as a safety limit.

On/Off Timer Mode enabled: The relay turns off when the ON duration elapses. The run is logged and the OFF cycle begins.

On/Off Timer Mode disabled (continuous mode): The relay stays on as long as conditions remain met. Temperature uses buffer hysteresis to prevent rapid cycling:

- **Trigger High:** stays on until temperature drops below (trigger - buffer)
- **Trigger Low:** stays on until temperature rises above (trigger + buffer)

The pump also turns off if the schedule window ends, voltage drops below cutoff (when voltage monitoring enabled), or vacuum reaches the target plus buffer (when the vacuum sensor is enabled).

Step 6 — Relay OFF: When to Turn On

If the relay is currently OFF:

Vacuum Override (when vacuum sensor enabled): If all conditions are met AND vacuum is below the Vacuum Trigger, the pump starts immediately — even if the OFF cooldown has not elapsed.

On/Off Timer Mode enabled: PumpLogic waits for the OFF duration to elapse. Once elapsed, if all conditions are met, a new ON cycle begins.

On/Off Timer Mode disabled (continuous mode): The pump starts immediately when all conditions are met — no OFF cooldown. If the vacuum sensor is enabled, the pump only starts when vacuum is below the trigger.

Operating Modes Summary

Cycling	Vacuum	Voltage	Behavior
ON	Any	ON	Standard: timed ON/OFF cycling with vacuum override and voltage gate

Cycling	Vacuum	Voltage	Behavior
ON	Any	OFF	Same cycling, no voltage gate (constant power assumed)
OFF	ON	ON	Vacuum drives pump: ON when vacuum < trigger, OFF at trigger + buffer. Voltage gate applies
OFF	ON	OFF	Vacuum drives pump, no voltage gate
OFF	OFF	ON	Continuous: pump ON while temp condition + voltage + schedule met
OFF	OFF	OFF	Continuous: pump ON while temp condition + schedule met

Cycle Example — Standard Mode

With default settings (On/Off Timer Mode enabled, 10 min ON, 15 min OFF, Trigger Low 32°F, 10:00–16:00 schedule):

```
10:00 AM — Temperature 28°F (below trigger), voltage 12.5V → conditions met → Relay ON
10:10 AM — ON duration elapses → Relay OFF, run logged, OFF cycle begins
10:25 AM — OFF duration elapses → Conditions re-evaluated
           If all conditions still met → Relay ON for another 10-minute cycle
           ...repeats until 4:00 PM (schedule end), or until temperature
           rises above 32°F, or voltage drops below cutoff
```

Cycle Example — Continuous Mode (Cycling Disabled)

With cycling disabled, Trigger High 80°F, buffer 5°F:

```
Temperature rises to 80°F → conditions met → Relay ON (runs continuously)
Temperature drops to 76°F → below (80 - 5 = 75°F)? No → stays ON
Temperature drops to 74°F → below 75°F? Yes → Relay OFF
Temperature rises back to 80°F → conditions met → Relay ON again
```

Settings Reference

All settings are accessible from the Settings card and the Network card. Changes are saved to device memory and persist across reboots.

Temperature Settings

Setting	Default	Description
Trigger Temperature (°F)	32.0	The temperature threshold that activates the pump. Behavior depends on the Temperature Direction setting.
Temperature Direction	Trigger Low	Controls when the pump activates based on temperature. **Trigger High** (cooling): pump activates when temperature is **at or above** the trigger. **Trigger Low** (freeze protection): pump activates when temperature is **at or below** the trigger.
Temperature Buffer	Enabled	Dropdown selector (Enabled/Disabled). When enabled, the temperature buffer provides hysteresis around the trigger point to prevent rapid on/off cycling. When disabled, no buffer is applied and the pump activates/deactivates exactly at the trigger temperature. The Temp Buffer field is grayed out when disabled.
Temp Buffer (°F)	3.0	The number of degrees past the trigger before the pump deactivates (when On/Off Timer Mode is disabled). Prevents rapid on/off cycling near the trigger point. **Trigger High:** pump stays on until temperature drops below (trigger - buffer). **Trigger Low:** pump stays on until temperature rises above (trigger + buffer). Minimum: 3°F, Maximum: 50°F. Only applies when Temperature Buffer is enabled.

Temperature is read automatically every 1 minute. This interval is fixed and not configurable.

Cycling Settings

Setting	Default	Description
On/Off Timer Mode	Enabled	Dropdown selector (Enabled/Disabled). When enabled, the pump cycles between ON and OFF durations. When disabled, the pump runs continuously as long as conditions are met (temperature buffer hysteresis prevents rapid cycling). The ON/OFF duration fields are grayed out when cycling is disabled.
ON Duration (min)	10	How long the pump runs during each ON cycle. After this time, the relay turns off and the OFF cycle begins. Only applies when On/Off Timer Mode is enabled.
OFF Duration (min)	15	How long the pump rests between ON cycles. After this time, PumpLogic evaluates conditions to decide whether to start a new ON cycle. Only applies when On/Off Timer Mode is enabled.

Schedule Settings

All times use **24-hour format** (e.g., 16:00 = 4:00 PM).

Setting	Default	Description
Schedule Start	10:00	Beginning of the weekday (Mon–Fri) operating window. The pump will not run before this time.
Schedule End	16:00	End of the weekday operating window. The pump will not start a new ON cycle at or after this time.
Weekend Start	10:00	Beginning of the weekend (Sat–Sun) operating window.
Weekend End	16:00	End of the weekend operating window.

Quiet Hours Settings

Setting	Default	Description
Quiet Hours	Disabled	Dropdown selector (Disabled/Enabled). When enabled, defines a time range during which the pump is blocked from running, regardless of the normal schedule.
Quiet Start	00:00	Beginning of the quiet hours window (24-hour format).
Quiet End	00:00	End of the quiet hours window (24-hour format).

The quiet hours window supports **midnight wrapping** — for example, setting Start to 22:00 and End to 06:00 blocks from 10 PM to 6 AM.

Vacuum Sensor Settings

All vacuum values are entered and displayed in **inches of mercury (inHg)**.

Setting	Default	Description
Vacuum Sensor	Monitoring Only	Dropdown selector with three options: **Disable - No Logic or Monitor** (sensor is not read; vacuum graphs and stats are hidden), **Enable + Logic** (full vacuum monitoring with pump override logic active), or **Monitoring Only - No Logic** (vacuum is read, displayed, and graphed but does not affect pump operation). When set to Disable or Monitoring Only, the Vacuum Trigger, Vacuum Buffer, Max Runtime, Max Times, and Max Hours fields are grayed out.
Vacuum Trigger (inHg)	22.0	The vacuum target. **Pump runs when measured vacuum drops below this value** (i.e., the system has lost vacuum). When vacuum is below the trigger and all base conditions are met, the pump starts immediately without waiting for the OFF cooldown. Only applies when set to Enable + Logic. Range: 0–30 inHg.

Setting	Default	Description
Vacuum Buffer (inHg)	10.0	Additional vacuum **above** the trigger that the pump must reach before stopping a vacuum-triggered run. For example, with a trigger of 22 inHg and a buffer of 10 inHg, the pump runs until vacuum reaches 32 inHg. This prevents rapid on/off cycling near the trigger point. Only applies when set to Enable + Logic. Range: 0–15 inHg.
Zero Vacuum at Sensor	—	Calibration button. Press with **no vacuum applied** (atmospheric pressure) to capture the sensor's current reading and save it as the new 0 inHg reference. The current saved offset is displayed beneath the button. Only available when the sensor is active (Enable + Logic or Monitoring Only).
Max Runtime (min)	60	Safety limit for vacuum-triggered runs when On/Off Timer Mode is disabled. If the vacuum target is not reached within this time (e.g., due to a leak or sensor failure), the pump stops automatically. Range: 1–1440 minutes. Only applies when set to Enable + Logic.
Max Times	3	The maximum number of Max Runtime hits allowed within the Max Hours window before Vacuum Mode is automatically disabled as a failsafe. When triggered, PumpLogic falls back to Temp/Voltage/Time Mode (or Temp/Time Mode if Voltage is disabled). Range: 1–20. Only applies when set to Enable + Logic.
Max Hours	6	The rolling time window (in hours) used to count Max Runtime hits for the failsafe. If the Max Times threshold is reached within this window, Vacuum Mode is disabled. Range: 1–48 hours. Only applies when set to Enable + Logic.

Voltage and Battery Settings

Setting	Default	Description
Voltage Monitoring	Enabled	Dropdown selector with three options: **Enable + Logic** (voltage acts as a gate — the pump is blocked if voltage drops below the cutoff, and low-voltage lockout with charge recovery is active), **Monitoring Only - No Logic** (voltage is displayed and graphed but does not affect pump operation; the warning about constant power is shown), or **Disable - No Logic or Monitor** (sensor is not read; voltage graphs and stats are hidden). When set to Monitoring Only or Disable, the Low Voltage Cutoff, Battery Type, Duration of Charge, and Charge Voltage fields are grayed out, and the constant-power warning is displayed.
Low Voltage Cutoff (V)	11.8	If voltage drops below this value, PumpLogic enters low-voltage lockout and the pump is disabled until charge recovery completes. Only applies when Voltage Monitoring is enabled.
Battery Type	12V Lead-Acid	Configures the voltage-to-percentage curve. Options: **12V Lead-Acid** (10.5V–12.8V = 0%–100%) or **12V LiFePO4** (10.0V–13.4V = 0%–100%).

Charge Recovery Settings

Setting	Default	Description
Duration of Charge (hours)	4	The total hours of accumulated charge time at or above the Charge Voltage required before the lockout is cleared. A real-time countdown timer tracks the remaining charge time. If voltage drops below the target, the timer pauses and resumes when voltage returns — accumulated time is preserved.

Setting	Default	Description
Charge Voltage (V)	14.6	The minimum voltage a reading must reach to count toward charge recovery. Typically set to the voltage indicating active charging.

System Settings

Setting	Default	Description
Watchdog Timeout	2:00 (120s)	Safety timer that automatically reboots the device if it becomes unresponsive. Set in minutes and seconds. Minimum 10 seconds. Under normal operation, the watchdog is never triggered.
Welcome Greeting	Enabled	Dropdown selector (Enabled/Disabled). When enabled, a welcome message appears at the top of the page on first load.
Detailed Cumulative Report	Button	Opens a comprehensive report in a new browser tab.

Network Settings

These settings are configured in the Network card.

Setting	Default	Description
WiFi Network Name (SSID)	PumpLogic-XXXX	The name of the WiFi network broadcast by the device. XXXX is the last 4 hex characters of the device's MAC address. Maximum 32 characters. Changing this requires reconnecting to the new network name.
WiFi Password	*(empty/open)*	Optional password for the WiFi network. Leave blank for an open network. 8–63 characters if set. Changing this requires reconnecting with the new password.

Setting	Default	Description
Timezone	Eastern	US timezone used for all displayed timestamps. Options: Eastern, Central, Mountain, Pacific, Alaska, Hawaii. Changing the timezone updates the displayed clock and all stored timestamps (boot time, last sync, event log) immediately — no reboot required.
Daylight Saving	On	On/Off toggle for Daylight Saving Time. When On, the displayed clock shifts forward by one hour during DST. Automatically disabled and forced to Off when Timezone is set to Hawaii.
Set Time (Date / Time)	—	Optional fields for manually setting the real-time clock. Enter the current date and time, then press Save Network Settings. The values are written to the clock and persist across reboots. Leave these fields blank to change only Timezone/DST without resetting the clock.

Settings Management

Feature	Description
Save as Default	Saves current settings as user defaults. Does not include WiFi SSID/password.
Restore Defaults	Restores user-saved defaults, or factory defaults if none saved. Does not change WiFi credentials. Preserves lifetime runtime.
Restore Auto-Backup	Restores settings from the last hourly auto-backup. Does not change WiFi credentials.
Export Settings	Downloads all settings (except WiFi SSID/password) as a `.pumplogic_settings` JSON file. The export includes a `settingsVersion` field used to validate future imports. Filename format: MM-dd-YY.pumplogic_settings

Feature	Description
Import Settings	Uploads a `.pumplogic_settings` file to restore settings. The import is **transactional** — every required field must be present and the schema version must match, or the whole import is rejected with a specific error message and your live settings are left untouched. Does not change WiFi SSID/password. Does not change Battery Health stats (those describe the battery, not user preferences).
Reset All Data	Clears graphs, event log, serial log, and daily stats. Does NOT reset settings, lifetime runtime, or Battery Health stats. Requires double confirmation.
Reset Battery Health	(Inside the Battery Charge/Discharge card, not the Settings Management subsection.) Zeroes the cycle count, deepest DoD, and 30-day DoD average. Use only when physically replacing the battery. See Battery Health.

Saving Settings

There are two save buttons: **Save Network Settings** in the Network card and **Save Settings** in the Settings card. Both save all settings. Press either button to save all changes. A green toast notification confirms the save.

- **Most settings** take effect immediately — no reboot required.
- **WiFi name/password changes** cause the WiFi network to restart. You will need to disconnect and reconnect to the new network name or with the new password.
- WiFi credential changes include a 3-minute safety net. If no device connects to the new network within 180 seconds, credentials automatically revert to the previous values.
- All settings are stored in **device memory** and persist across reboots.
- Settings are automatically backed up every hour. Use "Restore Auto-Backup" in Settings Management to recover from accidental changes.

Manual Controls

The Manual Control card provides four actions for direct control. Expand the card by clicking its header arrow.

Force ON

Press **Force ON** to immediately energize the relay and run the pump, regardless of whether the three conditions are met.

- **Low-voltage warning:** If the system is currently in low-voltage lockout, a confirmation dialog warns that running the pump may damage the battery. You must confirm to proceed.
- A toast notification confirms: "Relay forced ON (manual mode active)"
- The countdown timer shows the remaining ON time
- When the ON duration elapses, the run is logged and automatic cycling resumes
- Press **Force OFF** at any time to stop a Force ON cycle early

Force OFF

Press **Force OFF** to immediately de-energize the relay and stop the pump.

- A toast notification confirms: "Relay turned OFF, automatic mode resumed"
- The OFF duration timer begins counting down
- After the OFF duration elapses, PumpLogic will start a new ON cycle if all conditions are met

Charge Recovery (Manual)

Press **Charge Recovery** to proactively initiate a charge recovery cycle before the voltage drops below the automatic cutoff.

- A confirmation dialog appears before proceeding
- The relay is immediately turned OFF
- The system enters lockout mode and the event is logged
- The pump cannot run until charge recovery requirements are met (see Charge Recovery)

Reboot

Press **Reboot** to restart the device. A confirmation dialog appears first. After rebooting:

- All saved settings are preserved
- The relay starts in the OFF state
- Temperature and voltage sensors are re-read
- **Time is restored from the real-time clock within the first second of boot** — the pump schedule works immediately, no browser needed
- Wait approximately 10 seconds, then reconnect to WiFi and reload the page

Low Voltage Protection

PumpLogic monitors battery voltage to protect against over-discharge. This is especially important for solar-powered or battery-powered installations where the battery is the sole power source.

Note: Low voltage protection only applies when **Voltage Monitoring** is enabled in Settings. When voltage monitoring is disabled (for constant-power installations), low voltage lockout and charge recovery are inactive.

How It Works

1. Voltage is checked automatically every **30 seconds** for responsive lockout detection

2. If the voltage drops below the **Low Voltage Cutoff** (default: 11.8V):

• The relay is **immediately turned OFF**

• The system enters **LOW BATTERY** mode

• The event is logged in the Event Log

• The pump **cannot run** until charge recovery is complete

• The **Charge Recovery card** appears on the webpage

What Triggers a Lockout

A single voltage reading below the cutoff threshold triggers lockout immediately. This is intentionally aggressive to protect the battery from deep discharge.

Charge Recovery

When a low-voltage lockout occurs, PumpLogic requires the battery to accumulate sufficient charge time before allowing the pump to run again. This prevents rapid cycling between lockout and operation when the battery is marginal.

How It Works

1. The **Charge Recovery card** appears showing status and a countdown timer

2. Voltage is checked every **30 seconds**

3. When voltage reaches or exceeds the **Charge Voltage** (default: 14.6V), the charge countdown timer starts

4. The countdown timer displays the remaining time in **H:MM:SS** format and counts down in real time

5. A **0.5V hysteresis band** prevents rapid toggling when voltage hovers near the threshold:

• If voltage drops **less than 0.5V** below the Charge Voltage, the timer **keeps running** (within the hysteresis band)

• If voltage drops **0.5V or more** below the Charge Voltage, the countdown timer **pauses** — accumulated charge time is preserved. The status changes to "Paused" and the countdown freezes at its current position.

6. When voltage returns to or above the Charge Voltage, the countdown **resumes** from where it left off

7. When the countdown reaches zero (total accumulated time at or above the Charge Voltage equals the **Duration of Charge**), the lockout clears and normal operation resumes

Charge Recovery Example

With defaults (4 hours, 14.6V charge voltage):

1. Low voltage detected → Lockout activates, card shows "Waiting for voltage to reach 14.6 V..."

2. Charger connected, voltage rises to 14.6V → Countdown starts: **4:00:00**

3. Timer counts down in real time: 3:59:59, 3:59:58, ...

4. After 1 hour, voltage drops to 13.9V (0.7V below threshold, exceeds 0.5V hysteresis) → Timer pauses at **3:00:00**, shows "Paused — waiting for voltage to reach 14.6 V..."

5. Voltage returns to 14.6V → Timer resumes from **3:00:00** and continues counting down

6. Timer reaches 0:00:00 → Lockout clears, normal operation resumes

Cancelling Charge Recovery

If you know the battery is sufficiently charged (e.g., you connected a different power source), press the red **X** button on the Charge Recovery card:

1. A confirmation dialog appears

2. If confirmed, the lockout is immediately cleared

3. The Charge Recovery card disappears
4. Normal automatic cycling resumes (subject to the three conditions)
5. If a subsequent voltage reading falls below the Low Voltage Cutoff, lockout will re-engage

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Scheduling

Weekday and Weekend Schedules

PumpLogic supports separate operating windows for weekdays and weekends:

Days	Schedule Used
Monday – Friday	Schedule Start / Schedule End
Saturday – Sunday	Weekend Start / Weekend End

Both schedules work identically: the pump will only start a new ON cycle if the current time falls within the active window. This lets you set different hours for weekdays vs. weekends — for example, a later start on weekends when solar panels begin generating power later in the morning.

Midnight wrapping: Regular schedules support overnight ranges. For example, setting Schedule Start to 22:00 and Schedule End to 06:00 creates an operating window from 10 PM through 6 AM.

Quiet Hours

The quiet hours window is an optional feature that **explicitly blocks** pump operation during a specific time range, regardless of the normal schedule.

Use cases:

- **Quiet hours** — prevent pump noise during sleeping hours
- **Peak demand** — avoid running during times when other devices need the battery
- **Maintenance** — block operation during planned maintenance windows

Behavior when active:

- The "In Schedule" status shows **"Quiet Hours"** in yellow
- The pump will not start new ON cycles
- If the pump is currently running, it will complete its current ON cycle but will not start a new one

Midnight wrapping: The quiet hours window supports overnight ranges. For example, setting Quiet Start to 22:00 and Quiet End to 06:00 blocks operation from 10 PM through 6 AM.

To enable: Set the **Quiet Hours** dropdown to **Enabled** in Settings and configure the start and end times.

Battery Monitoring

Voltage Trend Indicator

The Status card shows a **trend arrow** next to the voltage reading that indicates whether the battery is charging, discharging, or holding steady:

Arrow	Color	Meaning	Threshold
↑	Green	Voltage is rising	Increased by more than 0.1V since last reading
↓	Red	Voltage is falling	Decreased by more than 0.1V since last reading
→	Gray	Voltage is stable	Within ±0.1V of last reading

Battery Percentage Estimation

Below the voltage reading, PumpLogic displays an estimated battery charge percentage based on the configured **Battery Type**:

Battery Type	0%	20%	40%	60%	80%	100%
12V Lead-Acid	≤10.5V	11.8V	12.0V	12.2V	12.6V	12.8V+
12V LiFePO4	≤10.0V	—	—	—	—	13.4V+

The percentage is calculated by scaling the voltage between these reference points. When voltage exceeds the top of the table, the display shows **100%**.

Note: Battery percentage estimates from voltage alone are approximate. Factors such as load, temperature, and battery age affect the actual state of charge. Use the percentage as a general guide, not a precise measurement.

Battery Charge/Discharge Graph

The Battery Charge/Discharge card provides a visual timeline of battery charge levels over 24 hours. This helps identify charging patterns, discharge rates, and whether solar panels are adequately replenishing the battery.

How it works:

- Every 15 minutes, PumpLogic records the current battery percentage — up to 96 readings (one every 15 minutes over 24 hours)

- The line graph plots these readings with time on the X-axis (midnight to midnight) and battery percentage on the Y-axis (0–100%)
- A green accent dot marks the most recent reading on the graph
- The graph is horizontally scrollable within the card for viewing the full 24 hours on mobile devices
- Graph data is saved to device memory every 15 minutes and **persists across reboots**

Sample data on first boot: When PumpLogic boots for the very first time (or after device memory is reset), the graph displays sample data showing a realistic 24-hour charge/discharge cycle. This demonstrates the graph's appearance before real data is available. Once the first real battery reading is recorded (at the next 15-minute boundary after boot), all sample data is cleared and only actual readings are displayed. On subsequent reboots, the previously recorded real data is restored from memory.

Full-page view: Press the **Open Full View** button to open the graph in a dedicated full-page view at /battgraph. This view displays PumpLogic branding, renders the graph at full viewport width, automatically adapts to portrait and landscape orientations on mobile devices, and auto-refreshes every 30 seconds.

Battery Health (Cycles, DoD)

The Battery Health tile (at the bottom of the Battery Charge/Discharge card) tracks long-term, per-battery diagnostic stats so you can see when a battery is degrading before it strands you. The metrics complement the 24-hour graph: the graph shows what *just* happened, Battery Health shows the cumulative wear.

Metric	What It Measures
Cycles	Cumulative full discharge cycles. Each ≥80% → ≤20% → ≥80% trip increments the counter by one. Hysteresis bands (≥80% / ≤20%) prevent noisy small swings from inflating the count.
Avg DoD (30d)	Average daily depth-of-discharge (in percentage points) over the last 30 days, computed from each day's max-min state-of-charge swing. Renders as **—** until at least 7 days of data have accumulated, so a fresh install doesn't show a misleading number.
Deepest	The largest single-day depth-of-discharge ever observed since the last Battery Health reset, with the date it was recorded (e.g., "68% on 03-12-2026").

How it works:

- Voltage is sampled every 30 seconds. Each reading updates both the cycle counter and today's high/low charge percentages.
- While the battery is actively charging (voltage above the charger threshold for the configured battery type), readings are treated as 100% — this avoids inflating the depth-of-discharge number while a charger is holding voltage high.
- At midnight, today's high-minus-low becomes the day's depth-of-discharge and is added to the 30-day rolling history. If it beats the previous deepest, the **Deepest** field updates with today's date.

- A full cycle counts only when the battery walks all the way down to ≤20% and back up to ≥80%. Small swings between those bands don't add to the count, so noise can't inflate the cycle total. The in-progress count is saved across reboots, so a power blip mid-cycle doesn't lose progress.

Reset Battery Health button:

The dark-red ■ **Reset Battery Health** button (top-right of the tile) zeroes the cycle count, clears the deepest-DoD record, empties the 30-day history, and resets the cycle counter. Use it **only when you physically replace the battery** — the stats describe a specific battery and would otherwise mix old and new readings. A confirmation dialog appears first.

The button does **not** appear in the **Reset All Data** flow. "Reset All Data" clears day-to-day stats and graphs but preserves Battery Health, because the battery itself hasn't changed.

When to expect "—" instead of a number:

- **Cycles** is `0` on a fresh install or after a Battery Health reset; it stays `0` until the battery walks through a full ≥80% → ≤20% → ≥80% cycle.
- **Avg DoD (30d)** shows – for the first 7 days after install or reset (or until 7 distinct daily samples are recorded — a long power loss can delay this).
- **Deepest** shows – until at least one full day has elapsed and a non-zero DoD has been recorded.
- The entire tile is hidden when **Voltage Monitoring** is set to **Disable** in Settings (constant-power installations).

The same three metrics also appear as a row in the **Detailed Cumulative Report** for printable record-keeping.

Daily Min/Max Tracking

The Status card tracks the day's highest and lowest temperature, voltage, and vacuum readings (vacuum readings are populated only when the vacuum sensor is active; the row is greyed out otherwise). These ranges reset automatically at midnight and are useful for:

- Seeing how cold it got overnight (was freeze protection needed?)
- Tracking battery voltage swings throughout the day (is the solar panel keeping up?)
- Monitoring vacuum trends to verify the pump is maintaining adequate inHg
- Diagnosing issues without being connected to the controller all day

Runtime Counters

Counter	Resets	Stored
Runtime Today	At midnight	Temporary (cleared on reboot)
Lifetime	Never (manual reset only)	Device memory (persists across reboots)

These counters are useful for maintenance scheduling and understanding overall pump usage patterns.

Vacuum Monitoring (Optional)

PumpLogic supports an optional vacuum sensor for monitoring and controlling system vacuum (typically used for sap-line vacuum pumps). All vacuum readings are displayed in **inches of mercury (inHg)**. By default the sensor is set to **Monitoring Only** (no pump logic). It can be set to **Enable + Logic** to drive pump cycling, or fully disabled in Settings.

How Vacuum Override Works

When the vacuum sensor is set to **Enable + Logic**, PumpLogic adds a vacuum override to the normal pump cycling logic:

1. Vacuum is read every **30 seconds**
2. If vacuum drops below the **Vacuum Trigger** (default: 22 inHg) and all three base conditions (temperature, schedule, voltage) are met, the pump starts immediately — even if the OFF cooldown has not elapsed
3. The pump runs until vacuum reaches the **Vacuum Trigger + Vacuum Buffer** (e.g., 22 + 10 = 32 inHg)
4. If the target vacuum is not reached within the configured **Max Runtime**, the pump stops as a safety measure and the **MAX RUN** event is logged
5. If Max Runtime is hit too many times within the failsafe window, vacuum mode is automatically disabled (a **VAC OFF** event is logged) and PumpLogic falls back to Temp/Voltage/Time Mode (or Temp/Time Mode if voltage monitoring is also disabled)
6. After a vacuum-triggered run completes, the system resumes normal cycling

The vacuum override does **not** bypass the three base conditions — temperature, schedule, and voltage must all be met before vacuum can trigger a pump start. If vacuum data becomes stale (no update in over 2 minutes), the vacuum override is blocked as a safety measure.

The dashboard reading shows **0.0 inHg** when the sensor reads at or above atmospheric pressure — vacuum cannot be negative.

Zero Vacuum Calibration

Vacuum sensors typically produce a small offset at atmospheric pressure, which would otherwise show a small false vacuum reading at rest. The ■ **Zero Vacuum at Sensor** button in the VACUUM subsection of the Settings card calibrates this offset out:

1. Make sure the sensor is at atmospheric pressure (i.e., **no vacuum applied** to the line)
2. Expand the Settings card and find the VACUUM subsection
3. Press ■ **Zero Vacuum at Sensor**
4. Confirm the prompt
5. The current raw reading is captured and saved as the new zero offset; future readings are calculated relative to it

The current offset is shown beneath the button. The offset is saved to device memory and persists across reboots. Re-zero whenever you replace the sensor or notice a non-zero resting reading.

Vacuum Over Time Graph

When the vacuum sensor is set to Enable + Logic or Monitoring Only, a 24-hour vacuum graph is available in the Vacuum Over Time card. The graph records vacuum readings every 15 minutes (96 data points per day) and displays them as a blue line graph with **deepest vacuum (30 inHg) at the top** and atmospheric (0 inHg) at the bottom. Graph data is saved to device memory and persists across reboots.

Time Synchronization

PumpLogic maintains accurate time using a **battery-backed real-time clock**, supplemented by automatic browser-based drift correction.

Real-Time Clock

PumpLogic includes a **battery-backed real-time clock** that keeps accurate time even when the device is unpowered. The schedule resumes the moment power is restored — no browser connection or WiFi needed.

Why this matters: Because the clock retains time independently, the pump schedule starts running immediately on boot, event timestamps stay correct across power loss, and scheduled operations continue without intervention.

> ■ **Important — Coin Cell Selection (read before replacing the battery):** > > The real-time clock uses a small coin cell battery for backup. Two cells fit the same holder, and **installing the wrong type can cause the cell to overheat, leak, or rupture**: > > - **LIR2032** — rechargeable, 3.6 V. Designed to be continuously kept topped up; rarely needs replacement. > - **CR2032** — non-rechargeable, 3.0 V. Typically lasts 5–10 years. > > Always replace with the **same type** that came installed. If you are unsure which type your unit uses, default to **LIR2032** for safety.

RTC Status Indicator

A small color-coded badge next to "■ Last RTC Sync" on the Network card displays the health of the real-time clock at a glance:

Badge	Color	Meaning	Action
● **RTC OK**	Green	Real-time clock detected, coin cell healthy, clock running and retaining time across reboots.	None — everything is working correctly.
■ **RTC Lost Power**	Amber	Real-time clock detected, but it reports that power was lost. This is normal on very first boot. If it persists after the clock is set, the coin cell is missing or dead.	Set the time via browser sync or the Set Time form. If the amber badge returns after the next reboot, **replace the coin cell** (positive side up). Use the correct type — see the warning above.
✕ **No RTC**	Red	Real-time clock module not detected. The device falls back to browser time sync only — **time will not persist across reboots.**	Contact support — the clock module may need to be replaced.

The badge updates live every refresh (roughly every 30 seconds), so replacing a dead coin cell is reflected in the UI within a minute.

The badge also appears on the **Detailed Cumulative Report** (green/amber/red row labeled "Real-Time Clock").

How Time Stays Accurate

PumpLogic uses three mechanisms to keep the system clock correct:

1. Boot restore from RTC. When PumpLogic starts, it reads the time directly from the real-time clock and sets the system clock. This takes less than a second and happens before WiFi initialization, so the schedule begins evaluating immediately.

2. Browser drift correction (on page load). Every time you load the PumpLogic webpage, your browser silently sends its current time to the device. PumpLogic compares this to its internal clock:

- If the drift is **more than 60 seconds**, the browser time is applied to both the system clock and the RTC, and the page reloads.
- If the drift is **60 seconds or less**, the sync is silently skipped — no reload, no visible change.

This replaces the older "sync on every page load" behavior with a drift-based check that avoids unnecessary reloads.

3. Hourly RTC → system clock resync. Once per hour, PumpLogic re-reads the real-time clock and corrects the system clock if it has drifted more than 2 seconds. This guarantees the system clock stays in sync with the RTC over long uptimes.

Timezone and Daylight Saving

Unlike the previous version, PumpLogic no longer relies on the browser's timezone offset. Instead, you configure the timezone **once** via the Network card:

Timezone	Standard Offset (UTC–)	DST Offset (UTC–)
Eastern	5 hours	4 hours
Central	6 hours	5 hours
Mountain	7 hours	6 hours
Pacific	8 hours	7 hours
Alaska	9 hours	8 hours
Hawaii	10 hours	*no DST*

When Timezone is set to **Hawaii**, the Daylight Saving dropdown is automatically disabled and forced Off, since Hawaii does not observe DST.

Effect of changing timezone or DST: The displayed clock and all stored timestamps (boot time, last sync, event log entries) update immediately to reflect the new offset. The underlying RTC time is not touched — only the display offset changes. You do not need to re-enter the date and time after changing the timezone.

Set Time

If no WiFi-capable device with the correct time is available, use the **Set Time** fields in the Network card:

1. Expand the **Network** card
2. Select your **Timezone**
3. Set **Daylight Saving** to On or Off (auto-disabled for Hawaii)
4. Enter the current **Date** and **Time**
5. Press **Save Network Settings**

The date and time are written directly to the real-time clock and persist across reboots. You'll see **"● RTC OK"** turn green on the next page refresh (if it wasn't already), confirming the clock is now holding valid time.

To change only timezone/DST without resetting the clock, leave the Date and Time fields blank. Only the Timezone and DST settings will be saved.

Important Notes

• **Time accuracy** for the initial set depends on your browser's clock being correct — ensure your phone or computer has the correct date and time before connecting.

• **After a reboot**, time is restored from the RTC within the first second of boot. No browser connection is required.

• **Sync status** is shown in the Network card under "Last RTC Sync" with the RTC health badge.

• **"Not synced"** appears if the RTC has never been set (first boot with lost-power state) and no browser has yet connected.

• **Warning banner:** When time is not synced, a blinking amber banner appears at the top of the Status card: "Time not synced — Refresh the webpage to sync your device's time, or use Set Time in Settings." The banner disappears automatically once the clock is set.

• **Boot events** are recorded in the event log each time PumpLogic starts. The Detailed Cumulative Report includes a **Boot/Reboot History (48h)** section listing all boot events from the last 48 hours.

• **Coin cell lifespan:** A non-rechargeable CR2032 typically lasts 5–10 years; a rechargeable LIR2032 is continuously kept topped up and rarely needs replacement. When the cell starts to fail, you'll see the amber "RTC Lost Power" badge after a power cycle. Replace with the correct cell type (see the warning earlier in this section).

Troubleshooting

Cannot Connect to WiFi

Possible Cause	Solution
Wrong network name	Look for **PumpLogic-XXXX** in your WiFi settings (XXXX is unique to your device). If the name was changed, it may be different.
Forgotten password	Use the physical reset button to restore the default WiFi settings. See WiFi Credential Recovery.
Out of range	Move closer to the device — typical range is 10–30 meters (30–100 feet) indoors.
Phone switched to mobile data	Your phone may have automatically switched back to cellular. Check your WiFi settings and reconnect to the PumpLogic network.

Webpage Does Not Load

Possible Cause	Solution
Not on PumpLogic WiFi	Confirm you are connected to the PumpLogic network, not your home WiFi.
Wrong URL	Navigate to **http://192.168.4.1** (not https). Also try **http://pumplogic.local**.
Browser cache	Try a different browser or clear your cache.
Device is still starting up	After a reboot, wait approximately 10 seconds for the device to finish starting, then reconnect to WiFi and try again.

Time Shows "Not synced"

Possible Cause	Solution
Page not fully loaded	Reload the webpage — time syncs automatically on page load.

Possible Cause	Solution
First boot with fresh RTC	If this is the very first power-up, the clock may show "■ RTC Lost Power" until a browser sync or Set Time action writes a valid time. Reload the page from a device with the correct clock, or use Set Time in the Network card.
Coin cell dead or missing	If the amber "■ RTC Lost Power" badge returns after every reboot, the coin cell has failed. Replace with a fresh cell of the correct type (positive side up).
RTC module not detected	Look for the red "✕ No RTC" badge on the Network card. Without the clock, time will not persist across reboots. Contact support.
Incorrect phone/computer clock	Ensure your phone or computer has the correct date and time — PumpLogic's first sync uses your browser's clock.
Browser issue	Try a different browser. Ensure your browser allows scripts to run.
No WiFi-capable device available	Use the **Set Time** controls in the Network card to manually enter the date and time.

RTC Badge Shows "■ RTC Lost Power"

The real-time clock is detected but reports that its backup power was lost. This causes the module to forget the time until a new time is written.

Cause	Solution
First boot after a new unit is installed	Normal — set the time via browser sync or the Set Time form. The badge will turn green ("● RTC OK") once the new time is written.
Coin cell depleted	If the amber badge returns after every reboot even though the time has been set, the coin cell is dead. Replace with a fresh cell of the **same type** (positive terminal, marked "+", facing up). Installing the wrong type (LIR2032 vs. CR2032) can damage the battery — see the Real-Time Clock section.
Coin cell missing or loose	Check that a coin cell is installed and seated firmly in its holder.
Coin cell installed backwards	Verify the positive side is facing up (usually the side with text/markings). Reversed cells cannot power the clock.

RTC Badge Shows "✕ No RTC"

The real-time clock module is not responding. The device falls back to browser-only time sync and **time will not persist across reboots** until the clock module is replaced. Contact support if this badge persists.

Pump Won't Start

Check the Status card to verify all conditions are met:

1. Temperature: Is the colored dot green? Green means the temperature condition is met (at/above trigger for Trigger High, at/below trigger for Trigger Low). If the value appears in **amber**, the reading is **stale** — the sensor has not updated recently and the pump is blocked as a safety measure.

2. Schedule: Does "In Schedule" show "Yes"? The current time must be within the operating schedule window.

3. Voltage: Is the colored dot green? (voltage is above the cutoff). A **gray dot** means voltage monitoring is disabled. An **amber** value means the reading is stale.

4. Battery Protection: Does it show "Normal"? If it shows "LOW BATTERY," the pump is disabled until charge recovery completes.

5. OFF Duration: Is the countdown timer still counting down? If so, the system is in its rest period between cycles. Wait for it to reach zero.

6. Vacuum (if enabled): Is the vacuum value displayed in amber? If so, vacuum data is stale and the vacuum override is blocked.

Pump Runs Continuously or Won't Stop

Possible Cause	Solution
ON Duration too high	Check and reduce the ON Duration setting in the Settings card.
Immediate stop needed	Press **Force OFF** in the Manual Control card to immediately stop the pump.
Schedule End incorrect	Verify the Schedule End time is set correctly in Settings.
On/Off Timer Mode disabled	When cycling is disabled, the pump runs continuously as long as conditions are met. Enable On/Off Timer Mode in Settings to use timed cycles.

Settings Not Saving

Possible Cause	Solution
Button not pressed	Make sure you press **Save Settings** or **Save Network Settings** after making changes.

Possible Cause	Solution
No confirmation toast	If the green "Settings saved!" notification does not appear, try reloading the page and saving again.
Browser issue	Try a different browser. Some older browsers may not fully support the interface.
Need to recover previous settings	Use **Restore Auto-Backup** in the Settings Management section to recover the last hourly backup.

WiFi Password Forgotten

If you changed the WiFi password and can no longer connect, see WiFi Credential Recovery in the Getting Started section. PumpLogic provides a 3-minute automatic revert window and a physical reset button for recovery.

Graphs Show No Data

Possible Cause	Solution
Too soon after boot	Graph data is recorded every 15 minutes. Wait at least 15 minutes after startup for the first data point to appear.
Sample data displayed	On first boot, sample data is shown. This is replaced with real data after the first 15-minute reading.
Data was cleared	If someone pressed **Reset All Data**, all graph data is erased. New readings will begin accumulating automatically.

Event Log is Empty After Update

The event log format changed in Version 2.0. Existing log entries are automatically cleared on first boot after updating to the new version. This is expected — new events will be recorded going forward.

Device Rebooted Unexpectedly

If PumpLogic appears to have restarted, the built-in **watchdog timer** likely triggered an automatic reboot due to a system hang. This is a safety feature that ensures the device recovers automatically. Check the **Event Log** for blue **Boot** badges showing when reboots occurred, or view the **Detailed Cumulative Report** for a Boot/Reboot History covering the last 48 hours. The **Serial Monitor Log** preserves boot-time messages for diagnostics. The watchdog timeout is configurable in Settings (default: 2 minutes).

PumpLogic — Automated pump control with flexible temperature triggers, configurable cycling, battery protection, vacuum monitoring (inHg), settings management, and web-based monitoring.