NLP™ CONTROLLER

USER MANUAL

NLP™

TUCOR, INC.

FIRMWARE 2.15

FEBRUARY 2024

Contents

1 Introduction

The Tucor NLP™ controller is a powerful & flexible controller with a color touchscreen, smart decoder line (NG-Series), and web-based NLPNet software. Although features & assembly vary for different versions, the NLP can:

- Control up to 500 decoders or conventional outputs
- Independently manage up to 20 points of connection
- Manage irrigation across 50 programs
- Prioritize groups of stations or individual stations for irrigation
- Dynamically manage system hydraulics to condense total irrigation time
- Correct irrigation via remote cloud-based weather service
- Irrigate via Managed Allowable Depletion (MAD)
- Connect to a variety of sensors via 2-Wire path via SD-110 sensor decoder (digital, SDI-12, 4-20mA, and more)
- Direct custom logic scripts based on a variety of sensor inputs such as soil moisture sensors

This manual describes the basic functionality of the web-based user interface for the Tucor NLP Controller (NLP-C).

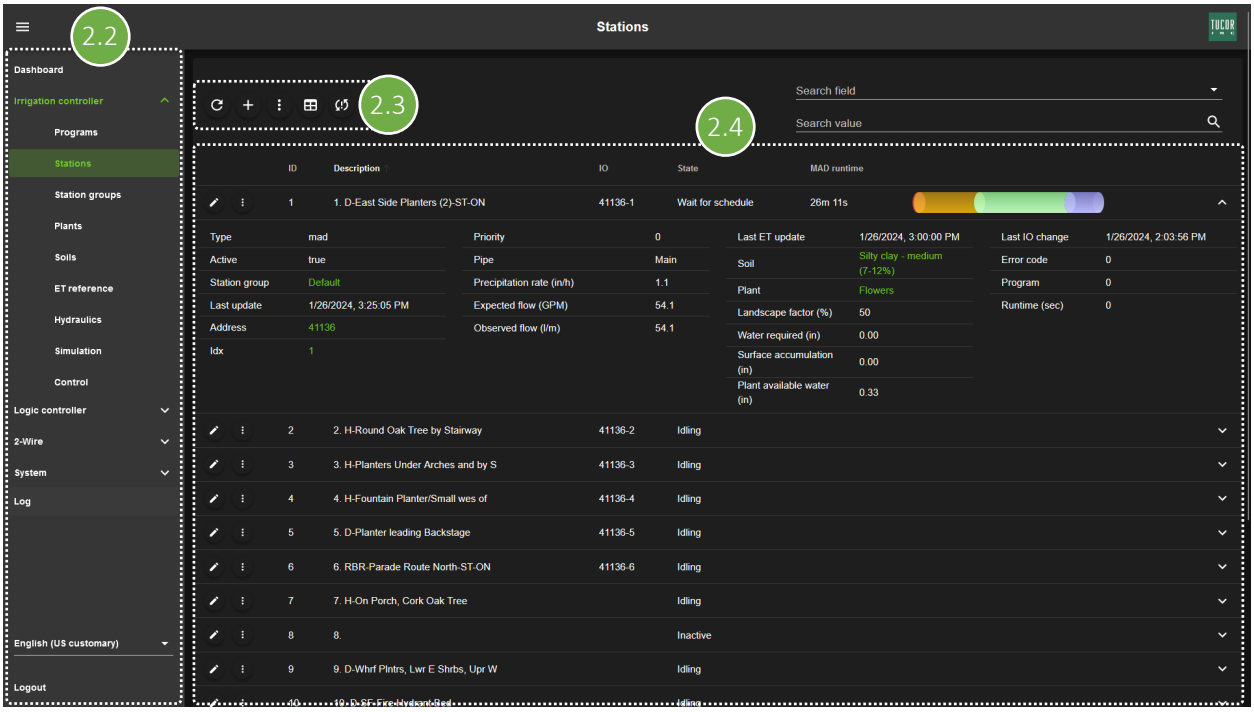
Content related to other topics such as installation will be found in other manuals.

If you receive software updates, be sure to contact your Tucor representative for the latest guide or manual updates. And be sure your controller firmware version matches the guide or manual version printed on the cover page.

2 Web Interface Overview

This section provides a general introduction to using the controller's web interface, and performing the basic operations such as adding, editing, deleting, sorting, and searching.

Contact your Tucor representative for login information.



2.1 Screen Layout

To allow use on both desktop screens and mobile phones the web interface layout is responsive. Depending on screen resolution and orientation, up to three panels may be displayed simultaneously as you drill down through information. On smaller screens where only one or two can be displayed, only the most recently opened panel is visible.

2.2 Main Menu Navigation

If space allows, a main menu is visible on the left side of the screen. If not, you can access the menu by pressing the 'burger' button ☰ located in the upper left-hand corner.

Pressing an entry displaying a down arrow takes you to a sub-menu.

You can always go to the menu for navigation. If you have gone through several layers of selections, you may appreciate the 'back' button ← which allows you to trace back through the screens that led you to where you are instead of starting over.

2.3 List/Forms Control

Along the top of each List or Form displayed to the right of the Main Menu (see below for more info on each), you may see a series of buttons that allow you to control some basic controller functions or modify content on that page.

2.3.1 Refreshing content

Screen content on the Dashboard is automatically updated every 20 seconds.

Screen content on any other page is not automatically updated. To retrieve fresh data, press the Refresh button found in the upper left-hand corner of most pages.

2.3.2 Add content

To add new data, select the Add button. In nearly all cases, a blank form related to the list will appear where you can add new data.

Fill in the required fields and press the ‘save’ button at the bottom. You will be returned to the last list view and the new entry should appear in that list.

2.3.3 Edit content

To edit content , look for the Pencil button at the beginning of the row, entry, or record that you wish to edit and click it once. A form, like the one you see when adding content, will appear with the data for that record filled into each of the fields displayed in the list.

When done, press the ‘save’ button at the bottom of the form. You will be returned to the last list view and should see that data for that entry has been updated.

Some forms may only let you edit data in a sub-section of that form. A ‘pencil’ icon will be next to that sub-section instead of at the top of the form.

2.3.4 Actions

Actions allow you to perform immediate things to the system, such as running a station for only 25 seconds, or verifying flow. Clicking on the Action button displays a small form where you can choose which station and what action from the drop-down lists.

Click ‘save’ to execute the action.

2.3.5 Change View

Most of the sections in the Web Interface contain only one ‘view’, or list, of data related to their section. But there are a few sections, such as Stations, that have multiple views. Press the ‘table button’ to cycle through all the available views.

2.3.6 Reset Errors

When available, you can reset errors that you have acknowledged or fixed in another section by pressing the reset button. Errors and/or warnings displayed should disappear within about 20 seconds.

2.3.7 Delete Content

To delete content, first edit it. In the upper right-hand corner of the edit form, you should see a 'trash can' icon for deleting the entry. Click on the icon and confirm to proceed with the deletion.

2.4 Lists

Lists provide a quick overview of structured data that can be sorted, searched, or modified.

2.4.1 Sorting

Pressing a column header sorts the lines on said column. Press again to sort in reverse order. Press a third time to cancel sorting. The sorting direction is shown with an arrow next to the column heading.

You may apply sorting on as many columns as you need.

2.4.2 Searching

You may search for values by selecting a field from the drop-down in the screen upper right-hand corner, and then typing a value.

If you do not choose a search field, a free-text search is performed.

2.4.3 Viewing related content

Some lists may contain extra buttons in each row that allow you to view related content such as listing programs or stations related to a station group.

To return to your previous content, use the back button at the top of the interface.

2.4.4 Adding sub elements to a list

When viewing sub elements of a list via the down-arrow (chevron) , an add icon is often displayed at the end of a list row, entry, or record. Click the add icon to add sub elements to the list.

2.5 Forms

Adding or changing data via the web interface is done through a form. Forms share a similar layout: zero or more icons to perform various operations like refresh, edit, or delete will appear at the top of the form followed by an ID that is auto generated by the controller. Below that, form fields are displayed where data is added or edited. At the bottom is a 'create' or 'save' button followed by a 'cancel' button.

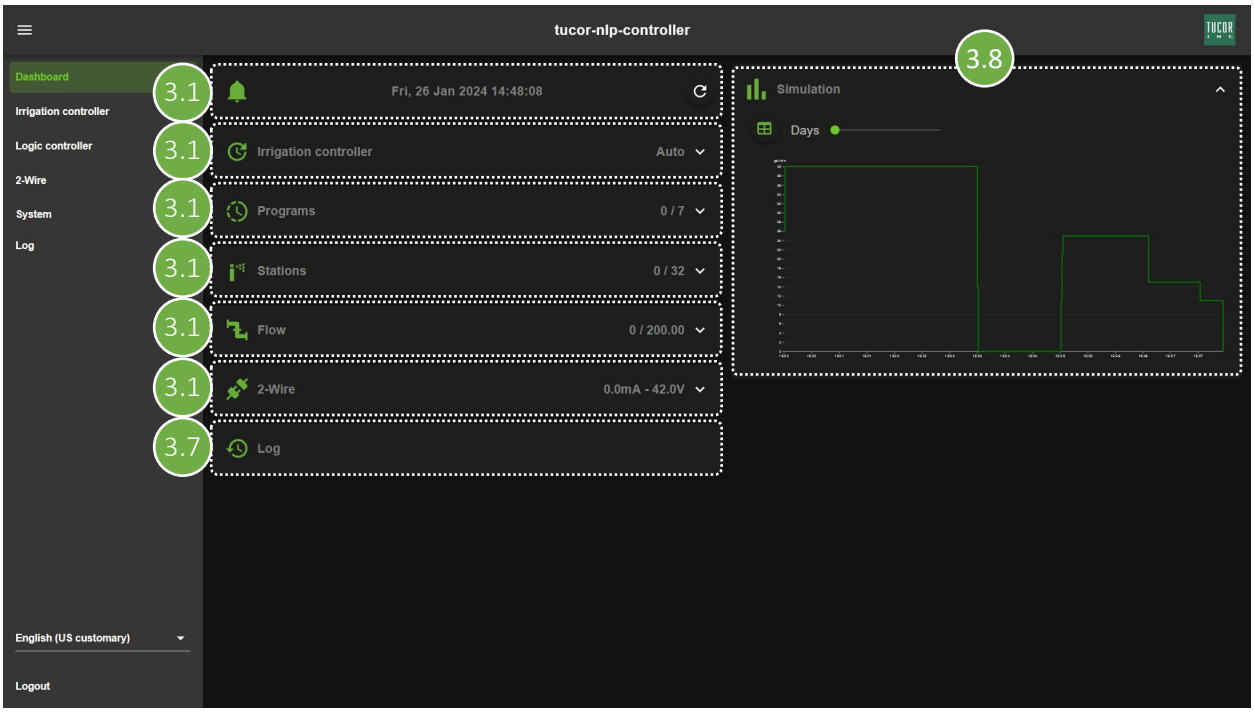
Some forms that are to be edited may require that they be unlocked first. This is done by pressing the pencil button at the top of the form. When unlocked, the pencil icon has a slash across it and the color of the form text becomes darker and accessible.

When a field is required, its header or description text will turn red, and the word ‘Required’ will appear below it. You will not be able to create nor save the entry until all required fields are filled in.

3 Dashboard

The Dashboard shows the last known status or state information for the irrigation controller. It is broken into eight sections: Status, Irrigation controller, Programs, Stations, Flow, Two-wire, Log, and Forecast. Each provides a quick look at the general health of the controller and the state of its resources.

The dashboard is automatically updated every 20 seconds. If you wish to trigger a manual update, click on the Refresh button in the Status section.



3.1 Controller Clock & Status

The top-most section provides a color-coded warning notification icon and a simple date-time stamp. The color key for the warnings is:

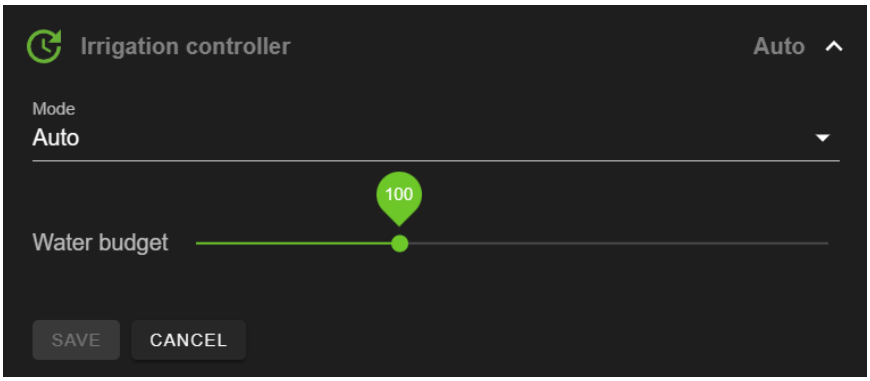
Icon Color	Number of Notifactions/Alerts
Green	0
Yellow	1
Red	2+

The Dashboard automatically updates every 20 seconds. For more frequent updates, you can use the manual refresh on the right side of the panel.

3.2 Irrigation Controller

Collapsed, the irrigation controller section shows the current mode of the irrigation controller.

Expanding the section shows a drop-down list of modes (Auto, Manual, Paused), and a global water budget slider.

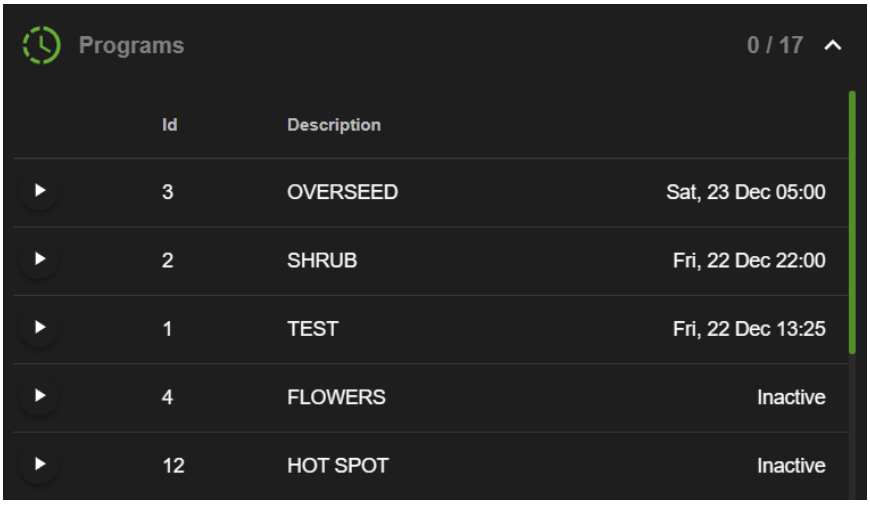


3.3 Programs

Collapsed, the header shows the number of programs currently running.

Expanding the section shows the list of the programs on that controller, each with a start/stop button so that you can start/stop programs manually.

The right-most column displays either that a program is currently running or a date-time stamp when the program is next expected to start.



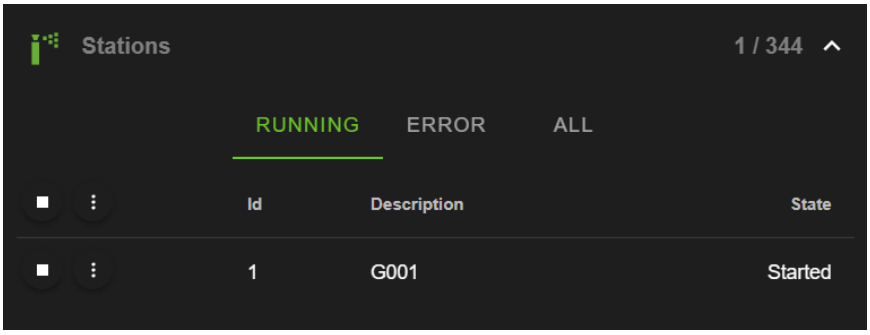
3.4 Stations

Collapsed, the header shows the number of stations that are currently running against the total number of stations available, expressed as a fraction (ex. 2/4 means 2 stations out of 4 are active).

Expanding the section displays a three-tabbed list where you can control various aspects of Stations.

Running

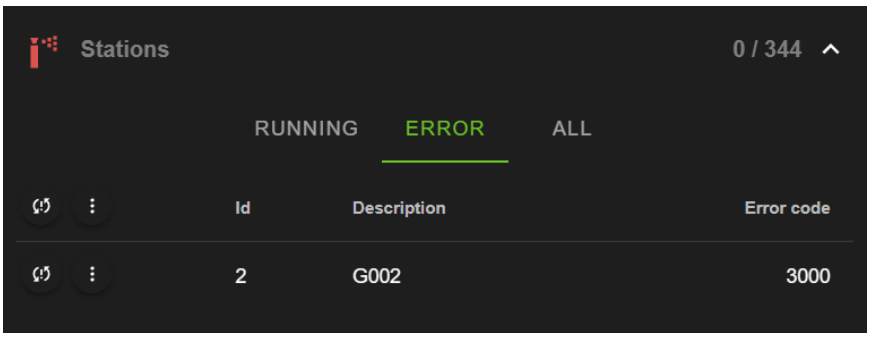
Under Running is a list of running and active programs with a stop button available so that you can stop stations manually from the Dashboard. The stop button at the top of the left-most column will stop *all* stations.



Error

The Error tab shows those stations which are experiencing an error. The error code is displayed in the last column. Error codes are explained in the Appendix.

You can clear, or reset, the error state for a station by clicking the reset button  in the left column. Clicking on the reset at the top of the column will reset *all* stations that have errors.



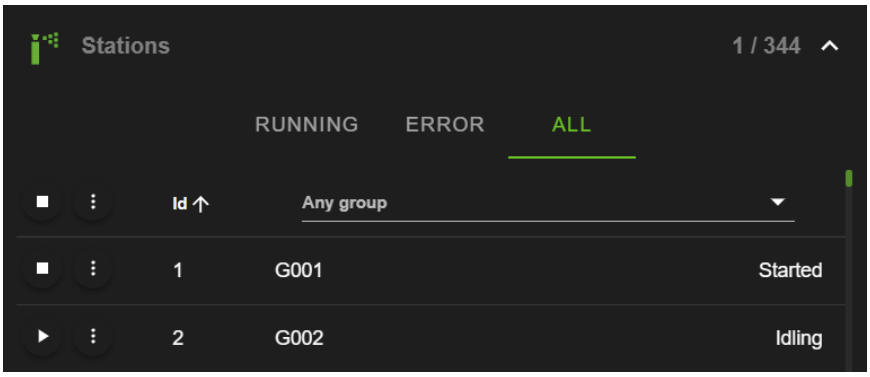
All

This last tab shows all stations that are available and their current state.

In the left-most column, there are two buttons.

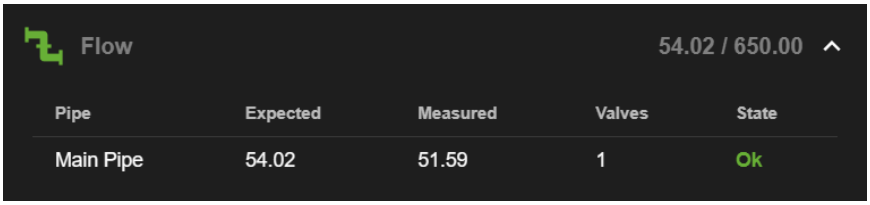
The Play/Stop button  allows you to start and stop stations of any station type manually from the dashboard. Clicking on the Play/Stop button at the top of the column will Start/Stop all stations.

The Action button ⋮ allows you to perform an action on a station. Clicking on the Action button at the top of the column will allow you to choose actions for all stations or a group of stations.



3.5 Flow

In its collapsed state, the Flow section displays expected flow and maximum system capacity for the overall hydraulics/pipe system. When expanded, you are shown the expected and measured flow rates, the number of Master Valves (MV) or Pumps and the state of each pipe section.



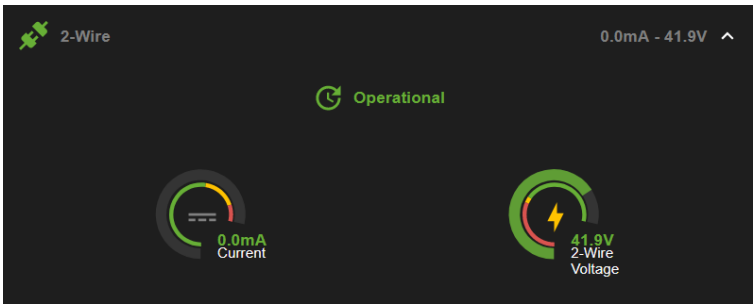
3.6 2-Wire

Collapsed, the 2-Wire section shows the last known 2-Wire current in milliamps (mA) and its DC line voltage (V).

When expanded, the section is divided into two parts. The upper section shows the 2-Wire system state (‘operational’, ‘on’, ‘charging’, etc.) as well as providing a fault code. Faults are recorded in the Log.

Selecting the 2-Wire mode brings you to a sub-menu where you can put the controller in a Short Finding mode.

The lower section displays two virtual gauges showing the last known 2-Wire current in milliamps and the lowest reported 2-Wire voltage. These are colored visual and numerical representations of the data. The radial gauges will change color when values are above or below important thresholds.



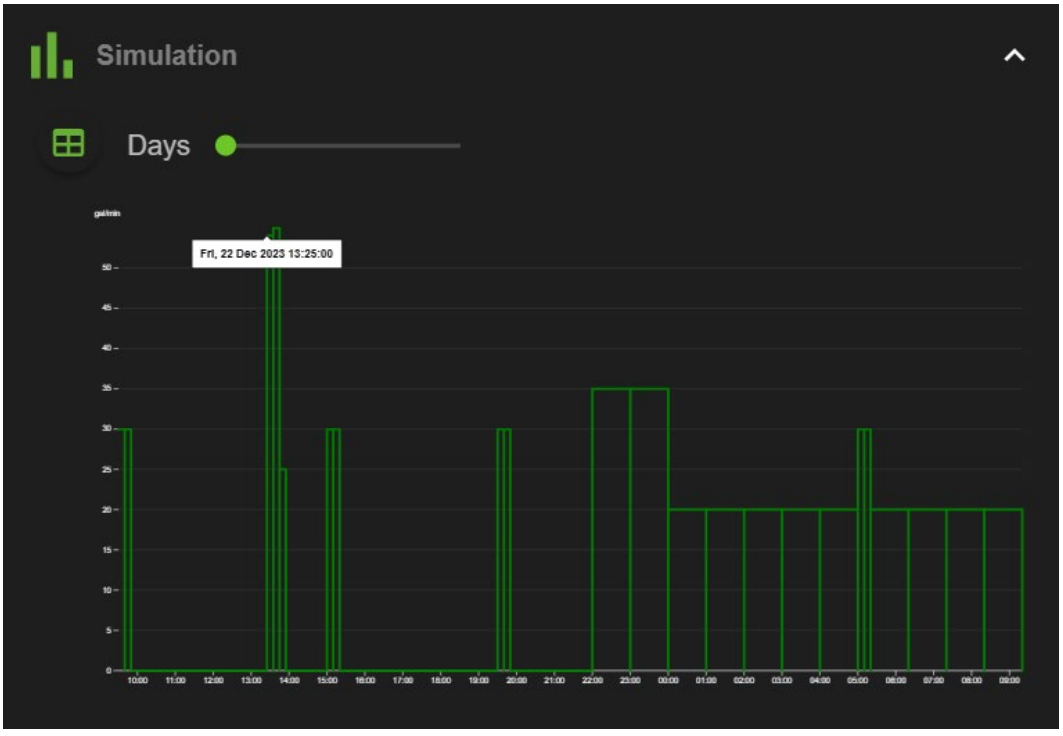
Icon Color	Current (load%)	2-Wire Voltage
Green	<60%	>22V
Yellow	60-80%	20-22V
Red	>80 %	<20V

3.7 Log

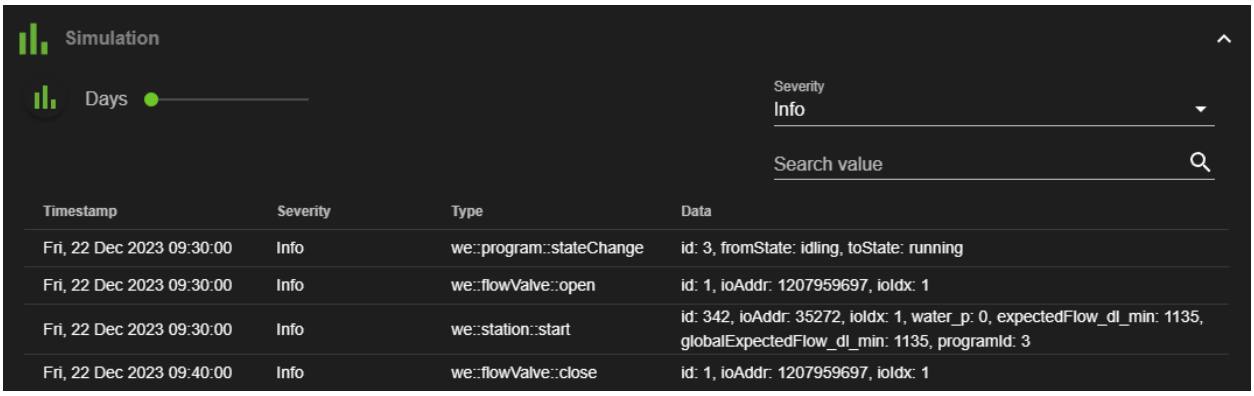
This section is a direct link to the Log section described later in this manual.

3.8 Simulation

The Simulation section defaults to an expanded state and shows a line chart forecast of irrigation over the next 24 hours. You can hover over the line chart to pick out individual dates and times where irrigation state changes. By clicking on the graph when a date appears, you will get a pop-up showing the stations, programs, and flow that would be active at that time, along with a projected total flow up to that point.



Clicking on the calendar icon will switch to a data table containing more detailed info related to the programs and stations that would be running during the simulated period.



The slider can be used to change the numbers of days to simulate, allowing you to look ahead and see how the irrigation system will perform. Currently the slider can provide up to 14 days look ahead.

4 Irrigation Controller

The NLP has flexible scheduling that can be corrected with Weather adjustments. Advanced MAD-based watering is also available.

Clicking on 'Irrigation Controller' in the main menu will show a submenu of components. Each component / sub-menu is described in the following sections, starting with 'Programs'.

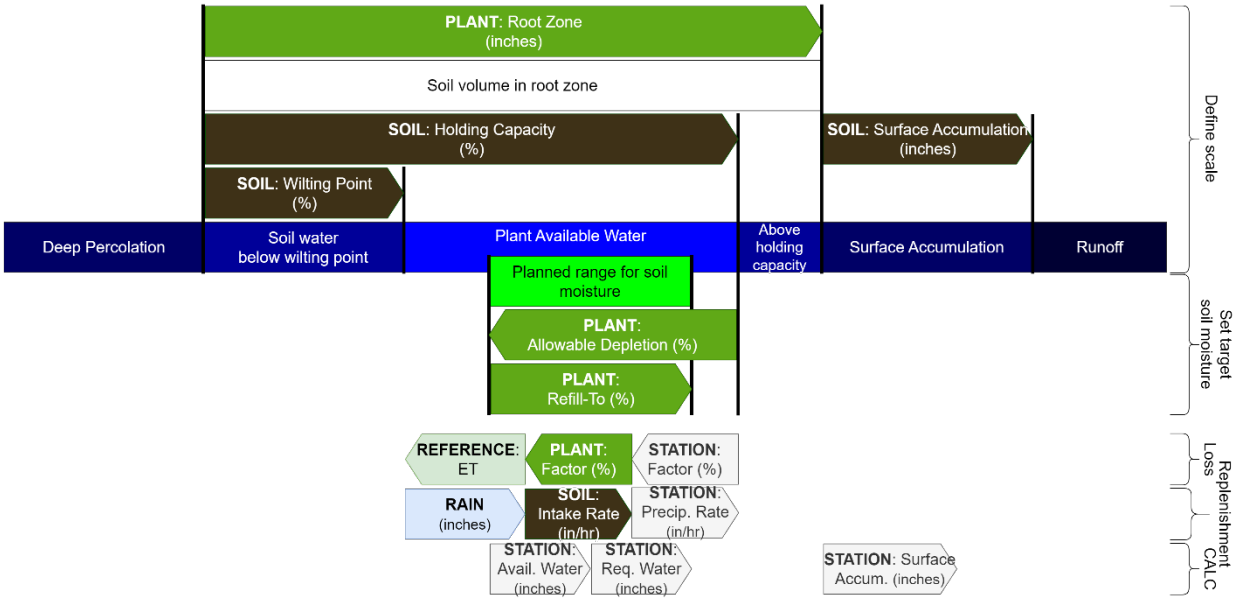
NOTE: Some objects and settings rely on others, so for your initial setup see our suggested sequence in the Appendix: 'Setting Up Your First Irrigation Controller'.

4.1 Irrigation Principles

4.1.1 MAD-Based Irrigation (Management Allowed Depletion)

'MAD-based irrigation' tracks moisture at each station and strives to keep within set depletion and refill parameters. To do so, it needs input on soil, plant, station, timing, hydraulics and more.

Parameters for MAD-based irrigation



The diagram above summarizes some of the parameters involved in MAD-based irrigation. Moving from top to bottom:

- A scale for soil water is defined by:
  - Setting the Root Zone (RZ) for the plant type.

        - It becomes the absolute depth to which we will apply water. Notice that the topmost box tells you both the object (PLANT), the related setting (Root Zone) and that it is an absolute value (inches).
    - Setting the Holding Capacity (HC), Wilting Point (WP), and maximum Surface Accumulation (SA) thresholds for the soil type.
        - This creates a range of Plant Available Water (PAW) from the minimum useful to a maximum amount of water available for the plant.
    - A scale is now available for water content in different sections shown as the blue vertical bar.
    - Water applied beyond the SA threshold is lost as runoff.
    - Water may lie on the surface, up to the SA threshold.
    - Water content may temporarily be higher than HC, but this is not considered a relevant parameter.
    - Water from WP to HC is the useful range. This becomes a scale from 0% available to 100% available.
    - Water below the WP is not available to the plant.
    - Water below the RZ is lost to deep percolation.
- A target range for irrigation is defined by:
    - Setting the Allowable Depletion (AD) of the plant type as a percentage of the PAW.
    - Setting the Refill-To (RT) of the plant type as a percentage of the PAW to a level where irrigation should be stopped or excluded.
- The target range for soil moisture is now available shown as a green bar. The controller will keep PAW within this range when set to irrigate by MAD.
- Water loss is defined by:
    - Setting the ET reference values.
        - Historical
        - Remote service (online source)
    - Setting the plant factor for the plant type.
        - This applies a general plant-specific correction to ET.
        - ET correction is updated hourly.
    - Setting the landscape factor (or efficiency) for the station.
        - This applies a station specific correction to ET.
        - ET correction is updated hourly.
- Water replenishment is defined by:
    - Setting the precipitation rate for the station.
    - Defining a rain sensor and amount.
    - Setting an intake rate for the soil type.
- Calculations done by the irrigation engine:
    - PAW is updated according to lost water.

- When PAW reaches MAD, the controller schedules irrigation.
- The amount of water to reach RT is calculated and displayed as Water Required (WR).
- Stations with a non-zero value for WR are turned on when allowed by other rules.
- While irrigating, the value for WR is decreased, while PAW is increased.
- Irrigation stops when WR = 0.
- If 'Intake Rate' < 'Precipitation Rate', a fraction of the precipitation increases the value of the SA at the station.
- If SA is reached, the station is stopped to allow the water to soak in.
- When SA = 0, irrigation may commence by turning on the station.

4.1.2 Schedule-Based Irrigation

'Schedule-based irrigation' means that you can set up a more traditional time-controlled irrigation by instructing when exactly irrigation should be applied.

Irrigation can be scheduled on an hourly- and/or daily-basis. You can choose odd/even watering, repeated watering, station-level cycle & soak, and calendar days of exclusion.

4.2 Executing Programs

The irrigation controller runs on a second basis and executes all programs which are due to run. Programs due to run are determined by the start time setup of calendar period, water days, exclusion(s), and start time. More programs can be set to run at the same time. The hydraulics and flow management determines the final execution of stations.

The strategy on a program determines how the execution of steps in the program is performed:

- In 'Auto', the NLP sets all steps due to run and leaves it to the flow management to control the order.
- In 'Sequential', the NLP starts stations in the order of the defined steps. It can start more steps if the hydraulics permits, but it will never move on to the next step until all stations in the previous step have been activated.

Each program may be divided into groups called "steps" to allow for different irrigation methods to be applied within the same program.

If a step is defined with 'Wait completion' it breaks the execution into pieces. In principle steps after the step with 'Wait completion' will look like they were stacked to run right after the 'Wait completion' step. This is useful for e.g., a golf course if you want to complete hole 1 before you move on to hole 2. "Wait completion" can be applied selectively or, if a program that mimics "sequential" irrigation is desired, may be added to every step. Refer to the section on Steps for more information.

If stations and/or station groups are defined with priorities, then these will impact the order of a station run. The stations which are set due to run by the principles above will be executed by priority from highest number to lowest. A station's effective priority is determined by the group priority * 255 + the station priority.

In general, using the 'Auto' strategy with no 'Wait completion' and no priority will utilize the hydraulics and flow management most efficiently. Please see the chapter on hydraulics.

4.3 Programs

A Program is a collection of 'Start times' and 'Steps' that define what you can control in your irrigation system and when. Clicking on 'Programs' from the main menu will display the current list of programs.

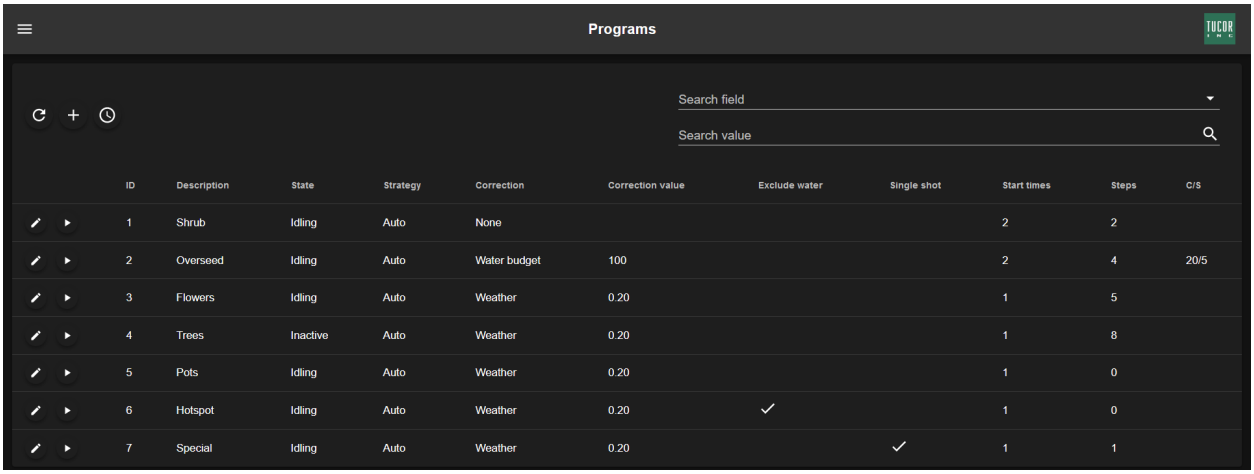
Up to 50 programs may be defined.

4.3.1 Views

The Views section comprises of three lists – a main program list, an irrigation control list, and a time slot list. Pressing on the table icon or clock-schedule icon at the top left switches between these views.

Program List – Main

This view allows you to edit a program by pressing the pencil icon for the program you want or start/stop a program manually when pressing the play/stop icon. The rest of the view displays information about the programs.



ID	Description	State	Strategy	Correction	Correction value	Exclude water	Single shot	Start times	Steps	C/S
1	Shrub	Idling	Auto	None				2	2	
2	Overseed	Idling	Auto	Water budget	100			2	4	20/5
3	Flowers	Idling	Auto	Weather	0.20			1	5	
4	Trees	Inactive	Auto	Weather	0.20			1	8	
5	Pots	Idling	Auto	Weather	0.20			1	0	
6	Hotspot	Idling	Auto	Weather	0.20	✓		1	0	
7	Special	Idling	Auto	Weather	0.20		✓	1	1	

ID

Unique identifier for that program. This number is automatically generated and assigned when you create a new program.

NOTE: If you delete one or more programs, those IDs become available for new programs again. The next time you add a new program the controller will use the lowest available next number in sequence. For example, if you have programs numbered 1 to 4, and you delete Program 3, the next time you add a program it will be given the ID of 3, not 5 as you might expect.

Description

Short text describing the program. Maximum character length: 31.

Strategy
Determines how the program is executed. Choose between either ‘Auto’ or ‘Sequential’. ‘Sequential’-based programming will run steps in order. ‘Auto’ is the default.

Correction
Determines what external resources, such as a water budget, are used to modify the program’s operation. Choose an option from the dropdown menu as necessary. Default is ‘None’.

Exclude Water (MAD-Only)
‘Exclude Water’, for example, is used to overspray MAD irrigated plants in hot periods without the extra irrigation amounts being included in the MAD calculations. Exclude Water is relevant for MAD-based stations only. This option is active when the toggle is green. ‘Off’ (greyed button) is default.

Single Shot
Allows the program to run once then terminate, overriding schedule settings ‘Off’ (greyed button) is default.

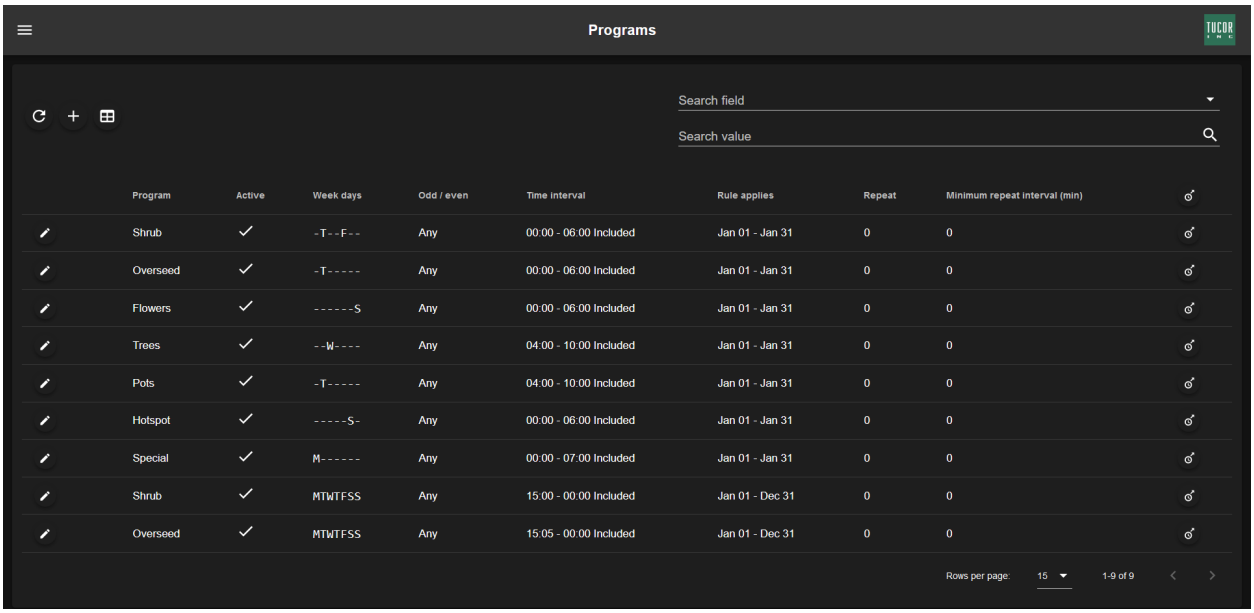
Start Times
The number of Start times registered for this program. Up to 100 start times may be defined (system wide.) For more info on defining start times, or time slots, look at the ‘Start Times’ section below.

Steps
The number of steps registered for this program.

C/S
The number of minutes each basic station will cycle and soak. E.g. 5/10 means each station will run for 5 minutes and soak for 10 minutes.

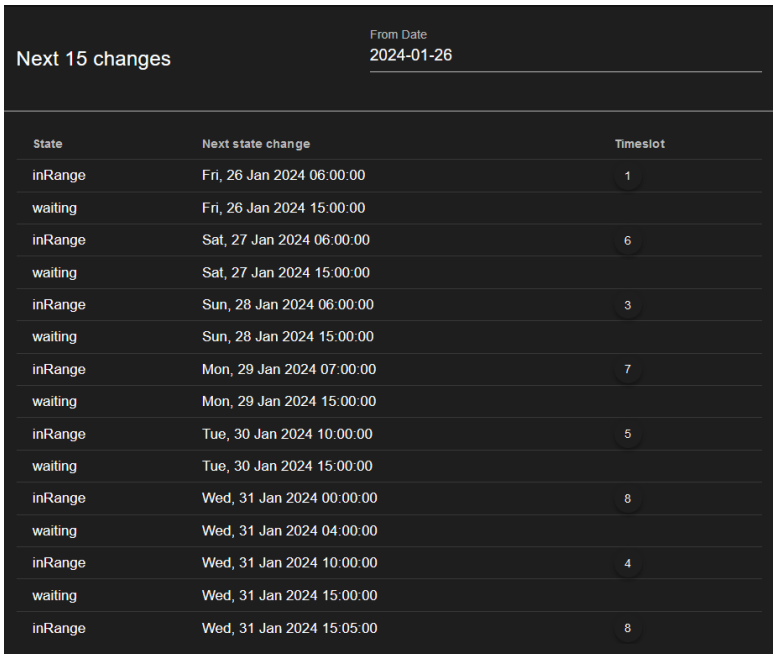
Program List – Irrigation Control

The second view will list each program and how it's controlled – via scheduled start times, a water amount, or by MAD calculations. In the case of schedule-based, the next start time is displayed. The water amount displays the measurement used for that program.



Program List - Time Slots

Clicking on the clock-schedule icon at the right end of each row will display a list of the next 15 changes for that program along with the corresponding timeslot ID.

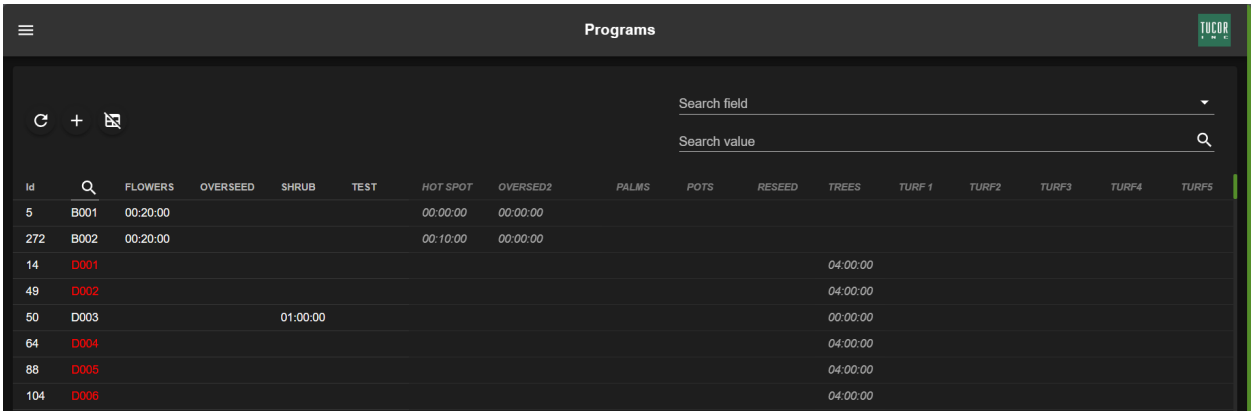


Program List – Station View

The third view displays a list of station run times by program.

Stations not included in any active programs will have a **red** font.

Inactive stations and programs will have a **light-gray *italicized*** font.



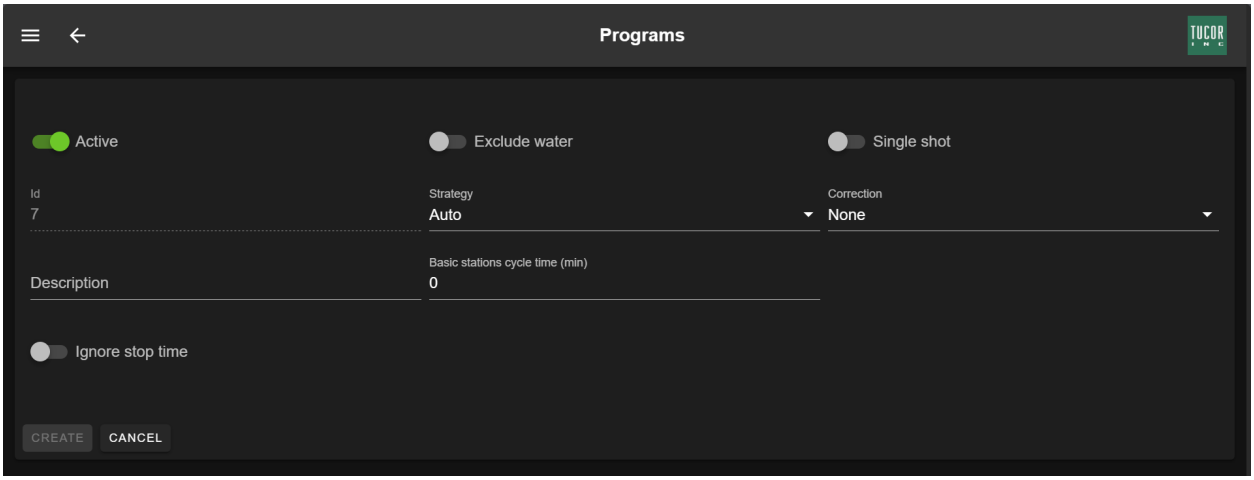
Id		FLOWERS	OVERSEED	SHRUB	TEST	HOT SPOT	OVERSED2	PALMS	POTS	RESEED	TREES	TURF 1	TURF2	TURF3	TURF4	TURF5
5	B001	00:20:00				00:00:00	00:00:00									
272	B002	00:20:00				00:10:00	00:00:00									
14	D001										04:00:00					
49	D002										04:00:00					
50	D003			01:00:00							00:00:00					
64	D004										04:00:00					
88	D005										04:00:00					
104	D006										04:00:00					

4.3.2 Creating/Editing a Program

To add a program, click the plus icon.

To edit a program, click the pencil icon next to the entry you wish to edit.

When adding or editing a program, a form will appear with the fields detailed previously, with two additional sections – Start Times and Steps, with their own add/edit functionality - below the form. All three sections should be filled out for the Program to run successfully.



4.3.3 Program setup

Active

Defines whether the program is active. Only active programs will run by dates and times. Programs not designated as Active can only be run manually. An Active program can also be run manually.

Exclude Water

As above

Single Shot

As above

Strategy

As above

Correction

Choose a correction as:

None: This is the default. The program will be defined with MAD, time, or water amount for each step.

Water Budget: This applies to all steps defined in time or amount, but not MAD. The actual water budget is defined in an additional field between 1 and 300%.

Weather: This applies to all steps defined in time or amount, but not MAD. The base ET is defined in an additional field. Base ET refers to the daily amount the step run times correspond to. The ET reference defines the ET settings used as reference. The ET reference is defined later in this guide. The run of the steps will be 'adjusted ET reference' compared to the 'ET base'. This can be used for automatic seasonal adjustments.

Ignore Stop Time

'Ignore Stop Time' allows programs to run beyond the end time defined in the time slots (see below).

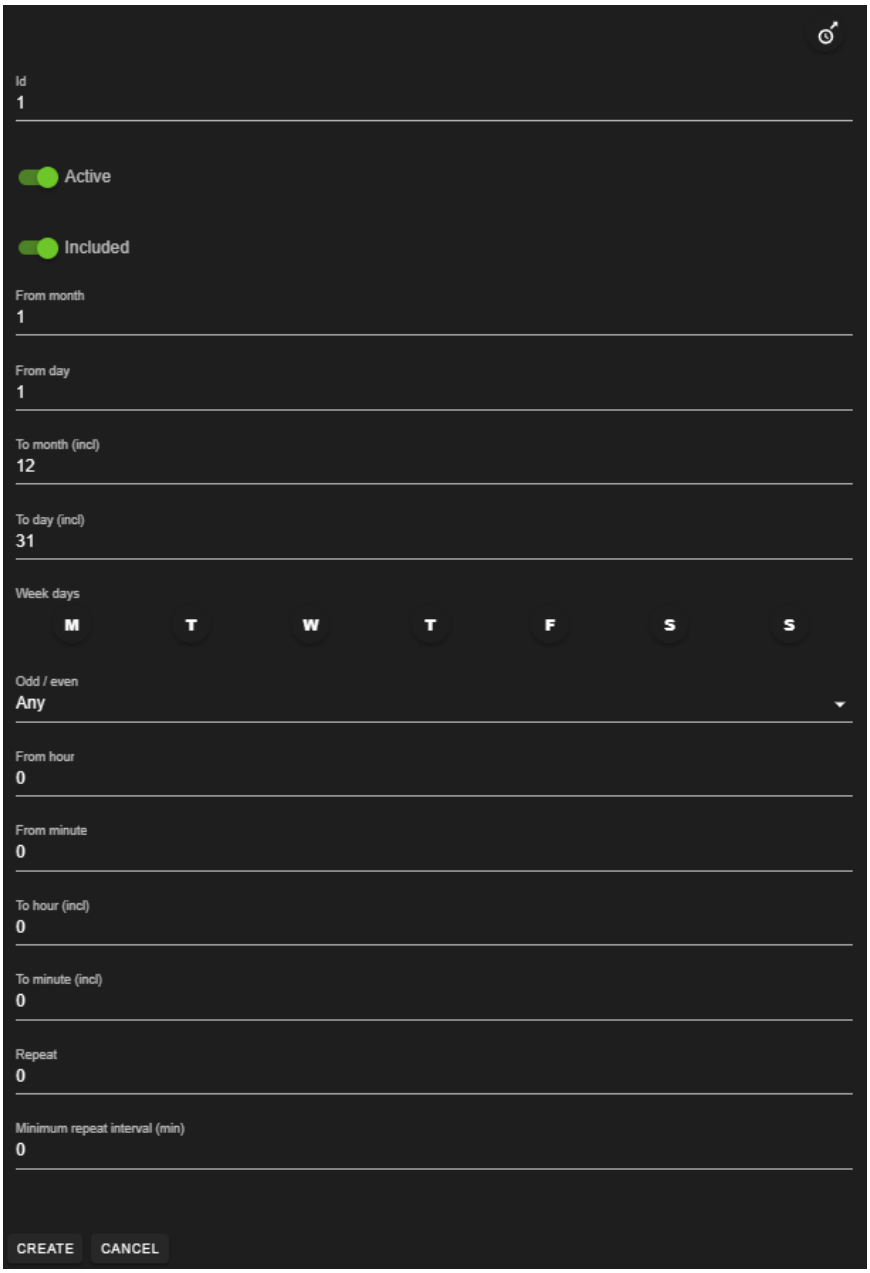
NOTE: Ignoring the stop time can allow programs/stations to run endlessly under certain conditions. Use this option carefully.

4.3.4 Start Times

'Start Times' provides a window of time, or schedule, where a program has the possibility to start and run, depending on resources. Here you define hours, days, and months for this scheduling and whether the program repeats or not.

This section displays a list of up to 100 start times (system wide).

Adding content (via the plus icon) or editing content (via the pencil icon) will bring up form to fill in or change the relevant data, described below.



Active

Determines if that schedule is active.

Included

This determines that the setup is included, i.e., the program will run on the specified days and start time.

If not included, it means the specified days and time intervals are excluded from whatever the included timeslots define, and irrigation will not occur.

From/to Month/day

Defines the month/day range of a program. This is useful for scheduling 'seasonal' irrigation. To schedule all year, use 1/1 – 12/31.

Weekdays

Defines the days of the week a program can run. Toggle the days you want. Greyed out days are not included in the program schedule.

Odd/Even

Defines odd or even dates of the month. Example usage: If you define a month range of 3 months, then select Odd from the drop-down menu, only the odd dates (1st, 3rd, 5th, etc.) of each month are available to the program.

"Odd but not last day" prevents months with 31 days running two consecutive days (31st & 1st day).

NOTE: The weekdays pattern above is also applied to odd or even dates, meaning it could be set-up to run odd dates excluding Wednesdays.

From/to Hour/minute

The from time is where the program will be set due to run. Hydraulics settings might postpone the run.

The end time defines a hard stop for the program regardless of whether it has finished or not. If there is no need for a non-irrigation window, then set end time = start time.

Uses 24-hour clock model (e.g. '17:00' is 5 PM)

Repeat

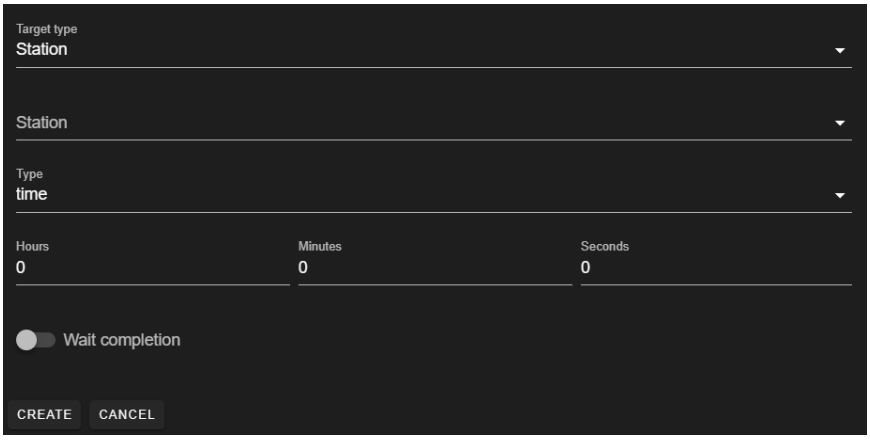
Defines the number of times that a start time will repeat. They must be within the defined window. Otherwise, they will terminate at the end time and not finish all repeats.

Minimum repeat interval

The minimum time between repeats calculated from the previous start of a run. If each run is longer than the minimum, then the repeats will stack as they can't run in parallel with each other.

4.3.5 Steps

The Steps section defines what runs during the program schedule. This can either be a Station, a Group, or all devices. Up to 500 steps can be defined per program. Adding content (via the plus icon) or editing content (via the pencil icon) will bring up form to fill in or change the relevant data, described below.



Target Type

Choose from the drop-down menu the correct target for this step. Target is either a station, a station group, or all stations.

Station/Group

Depending on what you choose for target type, this drop-down will contain either a list of Stations or a list of Groups to choose from.

Type

Specifies the type of step. The fields below this drop-down will change depending on the choice made.

Time

The amount of irrigation time in hours, minutes, and seconds for that step.

In

The amount of irrigation (inches of water) that the step should perform.

MAD

This will cause the program to use MAD algorithms based on various resources, such as water availability, to determine how long to irrigate during this step. A station must be set to “MAD” type irrigation to run a “MAD” program.

Learn Flow

Performs the ‘Learn Flow’ operation during this step.

Verify Flow

Performs the ‘Verify Flow’ operation during this step.

Wait Completion

Enabling ‘Wait Completion’ will instruct the controller to wait for this step to be completed before starting the next step.

4.4 Stations

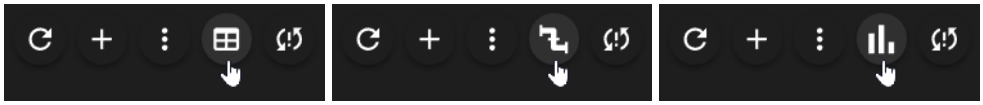
Stations are the physical points of an irrigation system. They may be pumps, valves, or any other piece of hardware that is connected to the controller via decoders, which are configured in the 2-Wire section of the controller. Up to 500 stations may be defined.

Select 'Station' from the Irrigation controller sub-menu.

To add a station, click the plus icon.

To edit a station, click the pencil icon next to the entry you wish to edit.

From the Station list, information is divided into 3 views. Press the chart / table view button (fourth from the left) to toggle/rotate between each view:

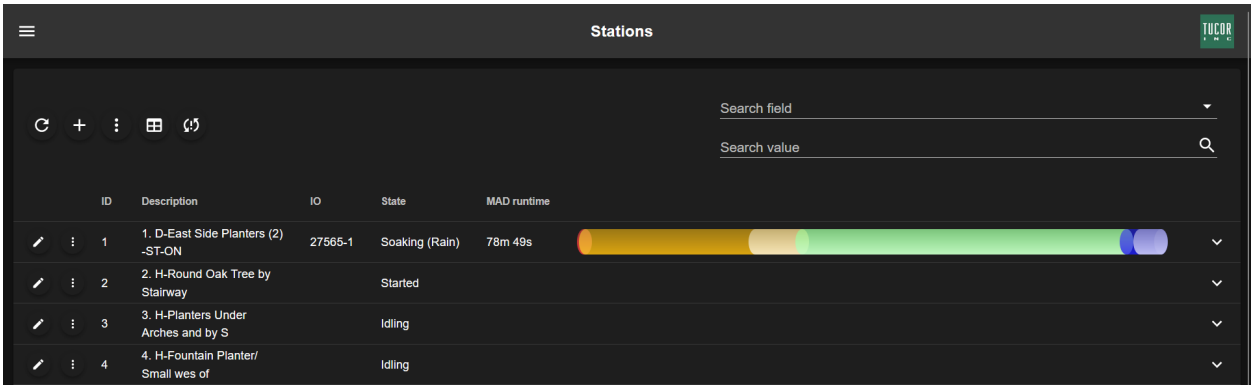


The Station List view (default), Hydraulics, and Setup view icons.

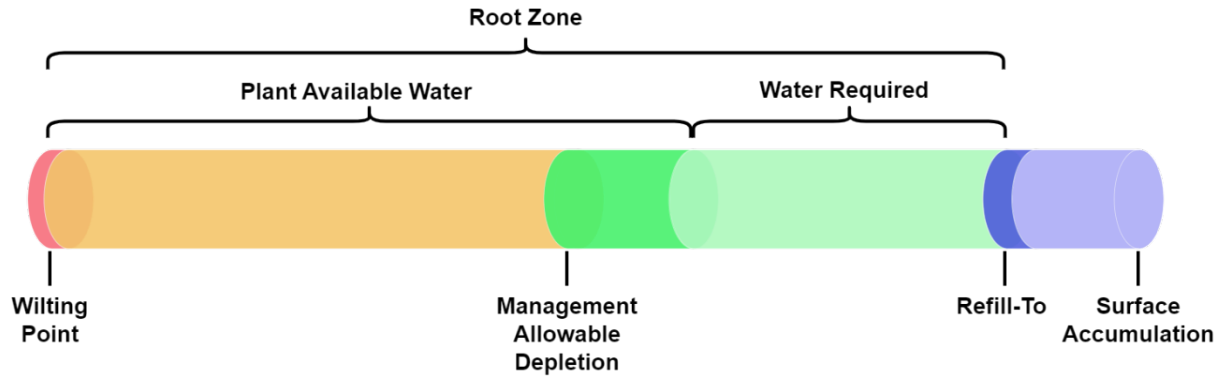
4.4.1 Views

Station List – Overview

The initial, default view shows an overview of the Stations that are set up, displaying the ID, Description, IO, current State of operation, and the MAD (Management Allowed Depletion) runtime.



For stations controlled by MAD calculations, the water parameters relevant for the plants' root zone and possible surface accumulated water are visualized in a color-coded graphical bar at the end of the station row. When Plant Available Water (PAW) falls below MAD, the system will schedule irrigation at the next available time slot. Irrigation will continue – possibly interrupted due to scheduling – until 'Water Required' reaches 0.



ID

An auto-generated system assigned read-only identifier.

Description

Standard ASCII text describing the station. Maximum character length: 31.

IO

A reference to the decoder and output port associated with this station. On the web interface, it is shown as a decoder IO name. Internally, this is referenced from the decoder address and port number.

State

The current or last known state of this station. Possible values are listed below:

Inactive

A toggle to show if this station is active or not.

Idling

The station does not require water if in this state or is not due to run for a certain time or amount of irrigation.

Waiting for Schedule

The station requires water (non-zero ‘water required) but cannot irrigate now due to a scheduler rule.

Waiting to Start

The station is waiting to start. Causes for waiting may be other stations having higher priority, limits on number of active decoders, limits on water capacity etc.

Started

The station is actively irrigating.

Waiting to Stop

The station is waiting to stop but has not yet received and/or acknowledged the command to do so.

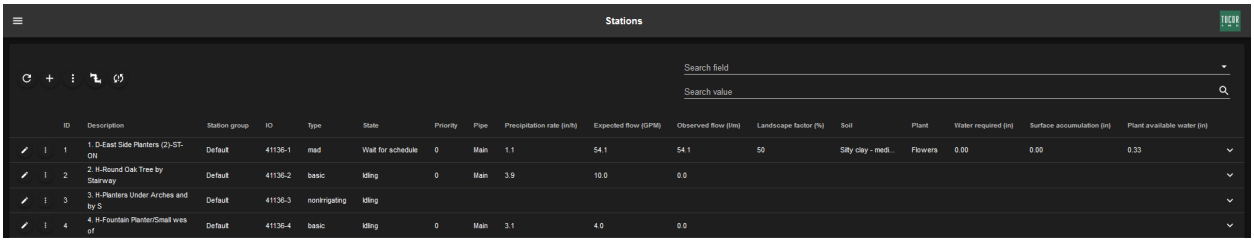
Soaking
The station is temporarily stopped due to allowed surface accumulation having been reached. Awaits water to soak in according to intake rate setting.

Error
The station has experienced an error. The error code can be found in the Station list dropdown section for that Station.

Soaking (Rain)
The state is usually triggered by a sensor such as a tipping bucket to let the system know when to enter a soaking state caused by rainfall.

MAD Runtime
The normal time to go from the maximum allowable depletion to the refill-to/replenished threshold.

Station List – Setup
The second view shows the setup for this station:



ID, Description, IO, and State were described earlier. Here are the remaining fields in this view:

Station Group
The group to which this station belongs. A station group holds stations with a common setup, e.g., are in the same field and irrigate the same plant or crop.

Type
Refers to the type of station irrigation control: basic, non-irrigating, or MAD.

Priority
Stations are started in order of priority, 255 → 0. Stations with the same priority are turned on to make the best use of the flow available.

Pipe
The pipe to which this station is connected. The pipe resource specifies the available water flow.

Precipitation Rate
This is the precipitation rate due to irrigation (e.g., inches/hour or mm/hour). Set for each station according to sprinkler, area covered, flow etc.

Expected Flow
This is the specified expected flow at this station. This value is used to determine which stations can be turned on under restricted water availability.

Expected flow (EF) and Precipitation rate (PR) are related to the area (A) covered by the station by PR=EF/A.

Observed Flow
Observed flow is the last successful result of running the 'Learn Flow' or 'Verify Flow' action on the station. If the measurement did not complete, 0 is inserted.

The observed flow may be manually typed as new expected flow, or automatically transferred for the station or a group of stations using an action.

Landscape Factor (MAD-only)
The factor, also called efficiency, is a correction applied to the precipitation rate for stations with uneven water distribution or for which ET does not directly apply.

Soil (MAD-only)
The soil at this station. The soil object specifies wilting point, holding (field) capacity and intake rate.

Plant (MAD-only)
The plant at this station. Plants affect MAD calculations in terms of root depth.

Water Required (MAD-only)
Required water at station. Updated automatically by MAD algorithms every 1 second.

If ≠0, irrigation will start as soon as possible pending available resources (time, water, power). The value tells the controller to apply the required amount.

May be changed manually to force irrigation. Observe that this does not change the net irrigation at the station, it merely changes the timing of application.

Surface Accumulation (MAD-only)
Current layer of water on the soil surface. Recalculated every second.

When Station: Precipitation rate > Soil: Intake rate, water accumulates on the surface. Surface accumulation is the current value, (possibly) increasing during irrigation, and decreasing towards 0 during the soak phase as water is absorbed by the soil.

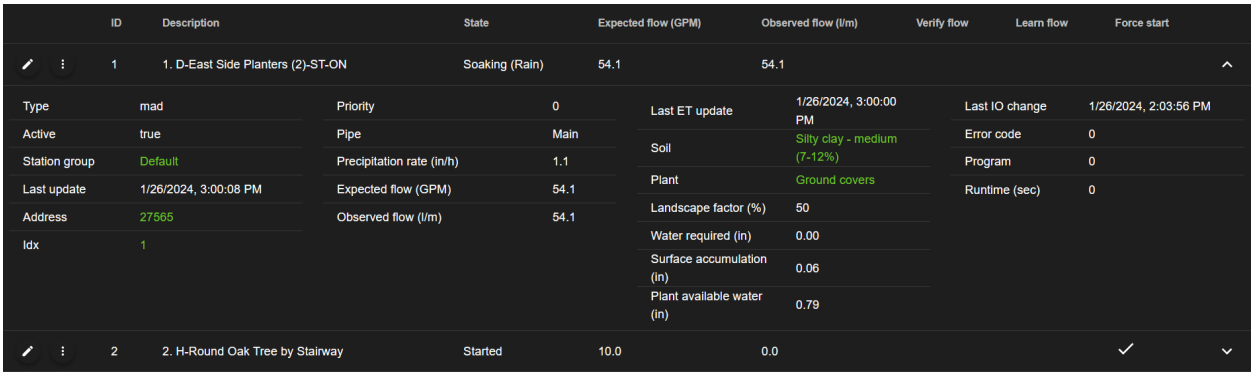
Plant Available Water (MAD-only)

Water available to the plant (e.g., inches or mm) in its root zone. Recalculated every second.

The controller aims to keep available water between the setting for MAD (Management Allowed Depletion) and Refill To values.

Station List – Dropdown View

In all three views you may press the down arrow (chevron) on the desired station to view all parameters at once, plus a few more detailed below:



Active

Shows whether this station is active or not. If deactivated its state will be set as inactive.

Address

Decoder IO address of the station. In combination with the Idx (below) helps to identify specific hardware (a pump or valve for example) connected to the controller.

Idx

The ‘index’ of specific hardware attached to a controller via Decoders. In combination with Address (above) this value helps to identify specific hardware (a pump or valve for example) connected to the controller. A decoder may have many Idx values equal to the number of inputs or outputs for that decoder.

Last Update

Last Station update that was received by the controller.

Last ET Update

Last ET update that was received by the controller.

Last IO Change

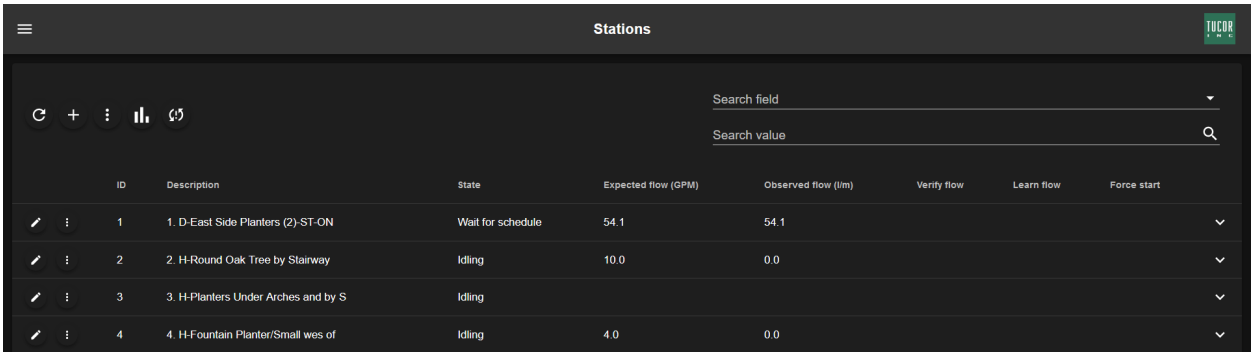
Last known IO change received by the controller.

Program

Shows which program this station belongs to when running.

Runtime (sec)
Displays station runtime in seconds.

Station List – Hydraulics
Third page shows parameters relating to hydraulics:



ID, Description, State, Expected Flow and Observed Flow were explained earlier. Below are the remaining fields visible in this view:

Verify Flow
A true/false flag if the flow at the station is to be verified.

Learn Flow
A true/false flag if the flow at the station is to be learned.

Learn Flow Failed
Flag showing if Learn flow failed (1 = failed).

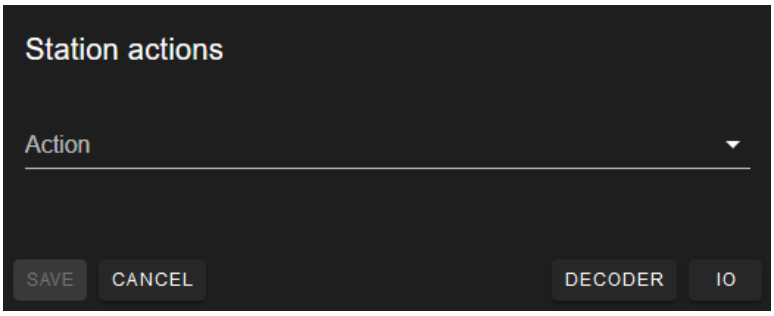
Force Start / Override Schedule and Priority
Setting force start (as shown) true means the station can turn on at highest priority disregarding actual priority and schedule, i.e., allow station to respond at earliest convenience.

Force start may be specified with actions ‘run seconds’, ‘run minutes’, ‘apply amount’, ‘learn flow’ and ‘verify flow’. The flag is automatically set false when the pending operation is done, to let the station return to normal scheduling.

4.4.2 Actions
While all behavior of stations can be controlled by changing parameters of each, it is practical to do some as a direct command, applied either to a single station or a group of stations. The action for one or more is identical, except for how it is called.

Click on the vertical 3 dots icon to initiate an Action. Actions performed from the top row of buttons above the list applies to all stations or a station group, chosen from a drop-down list. Actions set from the Station list apply only to that chosen Station.

Once an action is selected the dialog expands to collect additional information. Fill in and press the Save button to initiate the action. Press the Cancel button to leave everything unchanged.



Stop

Allows you to stop a running station or station group.

Run seconds, Run minutes, Run amount

You can trigger individual stations, or groups of stations, to either run a specified time or to apply a specific amount of water.

When specifying a runtime at each station, this action uses the precipitation rate to calculate an amount of water, which is then applied in the same way as an absolute amount.

(MAD-Only) The water applied counts towards the plant's available water so net irrigation will be unchanged. Overall irrigation changes are made through ET or plant factor settings. Changes at individual stations are made by adjusting the landscape factors or the stations' water budget.

Force Infiltration (MAD-only)

This action immediately transfers an amount recorded as current surface accumulation to the soil, incrementing the available water.

The command is used when surface accumulation is preventing a station from starting, e.g., during checks.

Verify Flow

When verifying flow at a station, the flow rule nearest upstream is placed in 'validate flow' mode. Only the relevant station downstream from the flow rule is allowed to run. Stations connected to other pipe segments are not affected. Upon successful measurement the flow is stored as 'observed flow' for the station.

Learn Flow

When learning flow at a station all flow rules back to and including a main pipe are placed in Learn Flow mode, preventing all other stations from activating. Flow paths connected to

other main pipes are not affected. Upon successful measurement the flow is stored as ‘observed flow’ for the station.

Apply Observed Flow

The measured flow resulting from ‘Learn Flow and ‘Verify Flow’ is inserted as ‘Observed Flow’ for each station. If no flow could be determined, i.e., a stable flow was not attained, the ‘observed flow’ is set at 0.

You may transfer the observed flow to become a new expected flow using this action. For each applicable station having a non-zero ‘observed flow’ the value is copied to ‘expected flow’.

Set actual soil moisture % to (MAD-only)

The controller keeps track of a calculated moisture balance at each station. You may have measured soil moisture prompting correction of the controller parameter for plant available water. The latter is an absolute value. This action sets the plant available water at each station to the entered percentage between wilting point (0) and field capacity (100%).

The action is typically used when starting the controller to set, e.g., 50% as an initial soil moisture to work from.

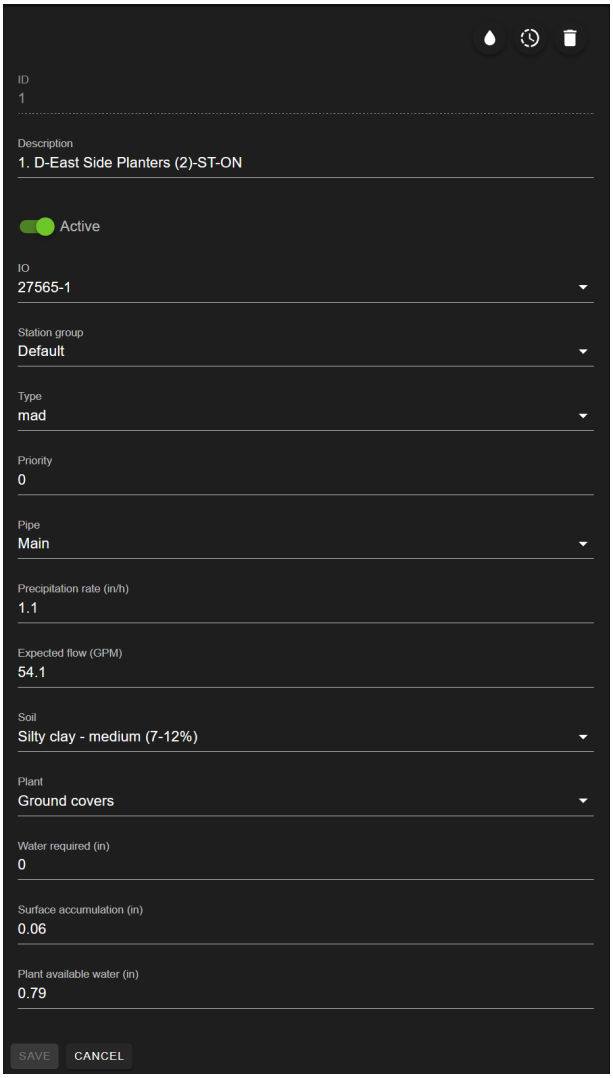
To correct the plant available water for an individual station, go to that station’s edit page.

4.4.3 Creating/Editing a Station

Click on the plus icon + to create a new Station.

To edit a station, click the pencil icon next to the entry you wish to edit.

When creating a Station, data needs to be input in the form that appears:



ID

A system assigned read-only identifier. This is auto generated.

Description

A short descriptive text. Max 31 characters.

Active

Whether this station group should be irrigated or not.

IO
A reference, by name, to the decoder and output port associated with this station.

Station group
The group to which this station belongs. In the web referenced by name, in the backend by its ID. A station group holds stations with common setup, e.g., are in the same field and irrigate the same plant or crop.

See the section below for more information on station groups.

Type
Select the type of irrigation from the drop down.

MAD
Management Allowed Depletion. This irrigation method uses information on soils, plants, hydraulics, and ET references to calculate the best irrigation time and amount for that station.

Non-irrigating
The simplest station set-up type A station set to this type does not follow any water irrigation settings, i.e., does not use any hydraulic logic or cannot water via “amount”. Another use might be to control artificial lighting via a time-scheduled program.

Basic
This sets the station to follow schedule-based rules. Although utilizing the automatic cycle & soak requires the station to be defined as MAD and thus the soil type contributes to the cycle & soak calculation.

Priority
Stations are started in order of priority, 255→0. Stations with the same priority are turned on to make the best use of the available flow capacity.

Pipe
The pipe to which this station is connected. The pipe resource specifies the available water flow.

Precipitation Rate
This is the precipitation rate due to irrigation (e.g., inches/hour or mm/hour). Set for each station according to sprinkler, area covered, flow etc.

Expected Flow
This is the specified expected flow at this station. Used to determine which stations can be turned on under restricted water availability.

Expected flow (EF) and Precipitation rate (PR) are related to the area (A) covered by the station by PR=EF/A.

Landscape Factor (%) (MAD-only)

The landscape factor, also called efficiency, is a correction applied to the precipitation rate for stations with uneven water distribution or for which ET does not directly apply. Used to offset the calculations in MAD-based irrigation.

A default value of 100% is recommended to start with.

Soil (MAD-only)

The soil at this station. Soils are defined in a separate section. The soil object specifies wilting point, holding (field) capacity and intake rate.

Plant (MAD-only)

Specifies the Plant watered by this Station. Plants are defined in a separate section.

Water Required (MAD-only)

Required water at station. Updated automatically by algorithms every second. If ≠0, irrigation will start as soon as possible pending available resources (time, water, power). The value tells the controller to apply the required amount.

May be changed manually to force irrigation. Observe that this does not change the net irrigation at the station, - it merely changes the timing of application.

Surface Accumulation (MAD-only)

Current layer of water on the soil surface. Recalculated every second.

When Station: Precipitation rate > Soil: Intake rate, water accumulates on the surface. Surface accumulation is the current value, (possibly) increasing during irrigation, decreasing towards 0 during the soak phase as water is absorbed by the soil.

Plant Available Water (MAD-only)

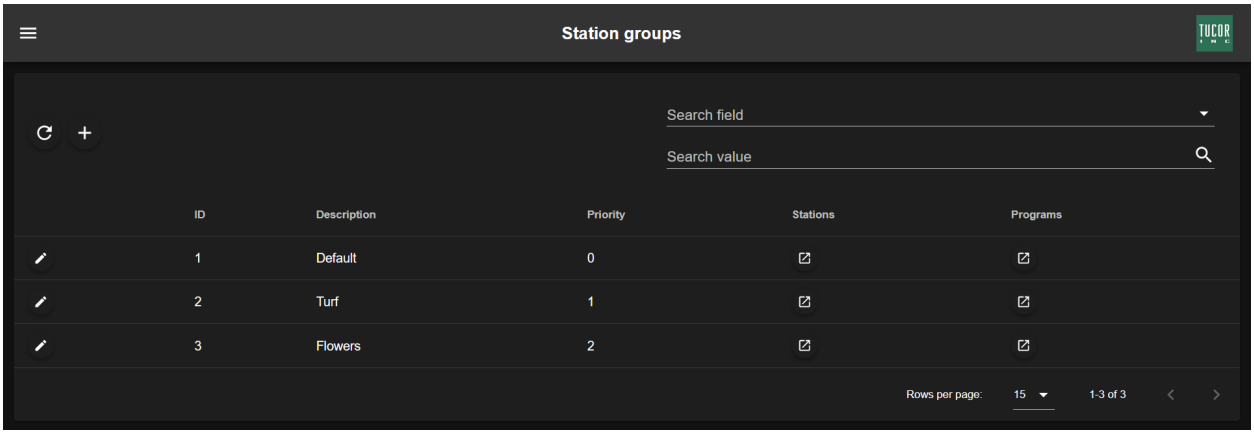
Water that is available to the plant (in e.g., inches or mm) in its root zone. Recalculated every second. The controller aims to keep available water between the setting for MAD (Management Allowed Depletion) and Refill-To values.

4.5 Station Groups

This section organizes stations into manageable groups that may share similar properties, such a field with the same plant and schedule or program.

4.5.1 View

Station Groups contains a single list view. It shows the data below and provides links to related Stations and Programs.



ID

A system assigned read-only identifier.

Description

A short descriptive text. Max characters: 31.

Priority

Station groups are started in order of priority, 255→0, with 255 being the highest priority. Groups take precedence over Stations themselves, i.e., the highest priority group will start its Stations in order of Station priority, then next highest priority group will start its own Stations in order of Station priority, and so on.

Stations

Press the button to view a list of stations assigned to this group. Use the back button at the top to return to the group list.

Programs

Press the button to view a list of programs referencing this group.

4.5.2 Creating/Editing a Station Group

Click on the plus icon to create a new Station Group.

To edit a Station Group, click the pencil icon next to the entry you wish to edit.

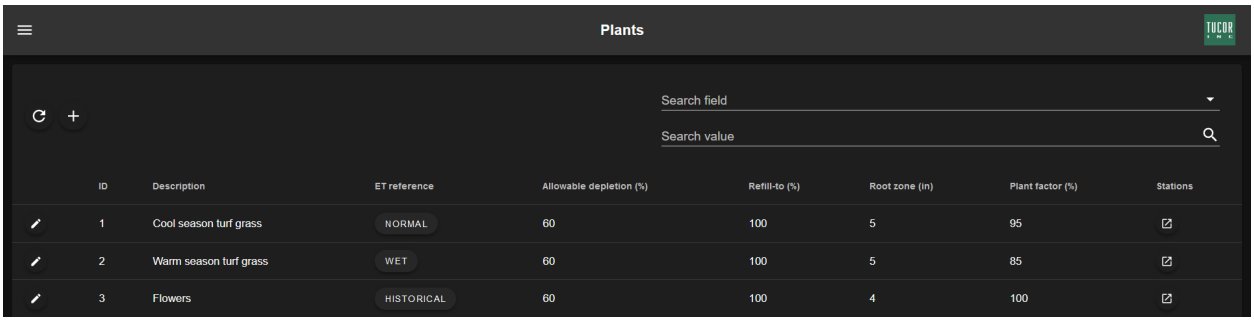
The resulting form only allows you access to the description and priority for that group.

4.6 Plants (MAD-Only)

This section allows you to define specific properties for your plants or crops.

4.6.1 View

The Plants menu contains a single list view. It shows the data below and provides links to related Stations.



ID

A system assigned read-only identifier.

Description

A short descriptive text. Use a meaningful description as it is used as reference elsewhere in the web interface. Max character: 31.

ET Reference

The ET input is used when calculating water loss for this plant. Must be specified if applying MAD irrigation. ET reference is defined in a later section of this guide.

Allowable Depletion

The allowable depletion as a percentage from soil holding capacity (maximum available water / 0% depletion) to wilting point (minimum available water / 100% depletion).

A suggested starting value is 50% from which you may deviate if you know your plants' specific needs.

Plant	Suggested MAD
Rice	20 %
Lettuce, Onions, Sweet Peppers	30 %
Turf grass – cool season	40 %
Turf grass – warm season	50 %
Citrus, Cucumbers, Soybeans, Walnuts	50 %
Alfalfa	50-60 %
Cotton, Potatoes	65 %
Corn, Sorghum	50-55%

Crop evapotranspiration guidelines for computing crop requirements. FAO Irrig. Drain. Report modeling and application. J. Hydrol.. 285. 19-40. Allen, Richard & Pereira, L. & Raes, Dirk & Smith, M.. (1998).

Refill-To

The amount of water added from wilting point (0%) to holding capacity (100%) when MAD-based irrigation applies water. Specifying up to 200% is possible, in which case water more than 100% will be lost to deep percolation. This may be meant to e.g., wash salts below root depth.

Root Zone

The root zone in which moisture content will be maintained when using the MAD irrigation algorithm. Enough water should be applied to wet the entire root zone and to encourage deep rooting. Deeper roots are better able to withstand periods of drought; shallow watering, on the other hand, leads to shallow roots and plants that are susceptible to drought and strongly affected by fluctuating temperatures.

Select values for moisture extraction depth of properly irrigated roots:

Examples	Rooting	Depth (inches)	Depth (mm)
Turf grass		6 (minimum 3)	150
Perennials/ Ornamental Grasses/ Shrubs 16”-24” (40-60 cm)	Shallow	12-18	300-450
Perennials/ Ornamental Grasses/ Shrubs 2’-6’ (60-200 cm)	Moderate	18-24	450-600
Shrubs >6’ (>2m) Trees	Deep	>24	>600

Plant Factor

This is a correction factor applied to the ET reference. Used when ET represents a different plant, and the correction is known.

Stations

Press the button to view a list of stations referencing this plant.

4.6.2 Creating/Editing a Plant definition

Click on the plus icon to create a new Plant.

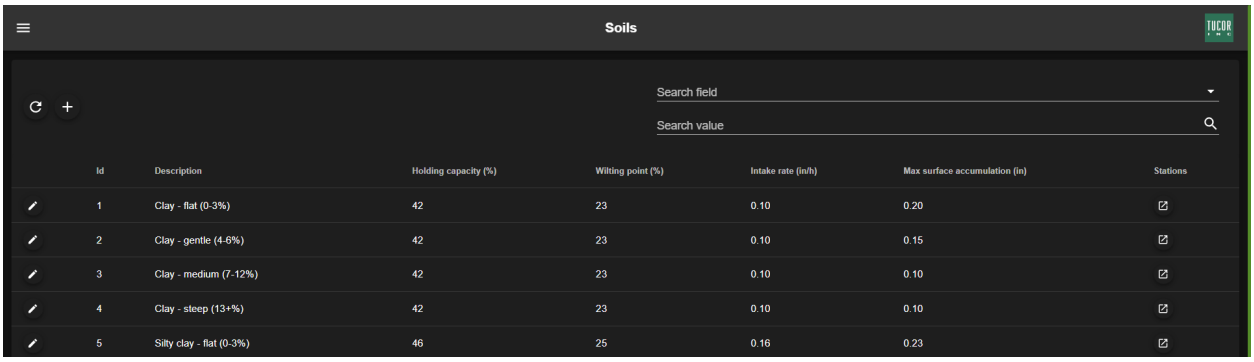
To edit a Plant, click the pencil icon next to the entry you wish to edit.

4.7 Soils (MAD-Only)

Shows a list of soils. Used in the MAD algorithm to calculate how and when to apply water. Describes common properties of a soil which may be referenced by other parts of the system.

4.7.1 View

The Soils menu contains a single list view. It shows the data below and provides a link to related Stations.



Id	Description	Holding capacity (%)	Wilting point (%)	Intake rate (in/h)	Max surface accumulation (in)	Stations
1	Clay - flat (0-3%)	42	23	0.10	0.20	
2	Clay - gentle (4-6%)	42	23	0.10	0.15	
3	Clay - medium (7-12%)	42	23	0.10	0.10	
4	Clay - steep (13+%)	42	23	0.10	0.10	
5	Silty clay - flat (0-3%)	46	25	0.16	0.23	

ID

A system assigned read-only identifier.

Description

A short descriptive text. Use a meaningful description as it is used as reference elsewhere in the web interface. Max characters: 31.

Holding Capacity (HC)

The maximum volumetric water content the soil holds against the force of gravity.

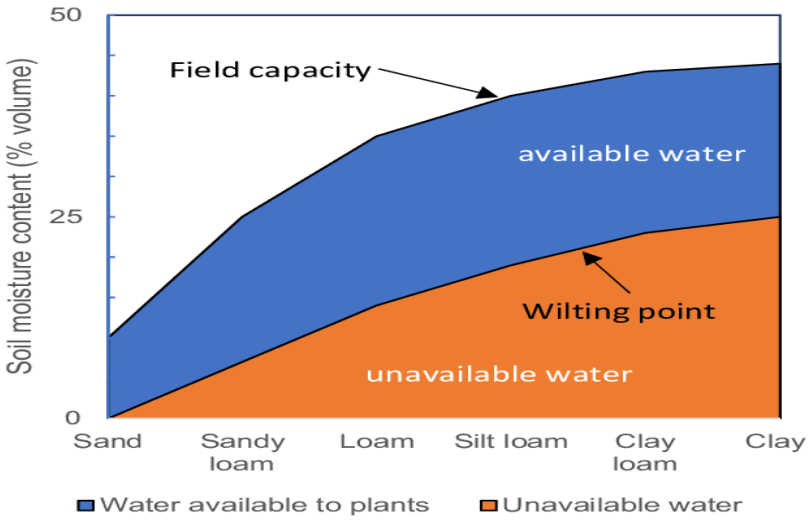
The volumetric water content is the ratio of the volume of water to the unit volume of soil. It may be expressed as percentage, ratio, or depth of water per depth of soil (i.e., inches of water per foot of soil). When the volume of water is 20 percent of the unit volume of soil containing it, the content can be reported as 20 percent, 0.20 (ratio) or 2.4 inches per foot of soil (0.2 inches/inch * 12 inches/foot).

Wilting Point (WP)

The minimum amount of water required for plant growth.

Wilting point is considered a property of the soil, since it is differences in moisture retention of the soil, rather than differences in plant moisture uptake that determine the wilting point.

The WP and HC are measures for how well different soil particle types hold on to water. The below figure suggests values for both.



Quantifying the Impacts of Compound Extremes on Agriculture and Irrigation Water Demand. 10.5194/hess-2020-275. Haqiqi, Iman & Grogan, Danielle & Hertel, Thomas & Schlenker, Wolfram. (2020)

Intake Rate

The rate of water intake (infiltration) into the soil. Set a value that represents a compromise between intake into a dry soil, and intake once the surface has been wetted.

Below we have a table that shows working values.

SOIL TEXTURE	MAXIMUM PRECIPITATION RATES: INCHES PER HOUR / MILLIMETERS PER HOUR							
	0 to 5% slope		5 to 8% slope		8 to 12% slope		12%+ slope	
	cover	bare	cover	bare	cover	bare	cover	bare
Course sandy soils	2.00 51	2.00 51	2.00 51	1.50 38	1.50 38	1.00 25	1.00 25	0.50 13
Course sandy soils over compact subsoils	1.75 44	1.50 38	1.25 32	1.00 25	1.00 25	0.75 19	0.75 19	0.40 10
Light sandy loams uniform	1.75 44	1.00 25	1.25 32	0.80 20	1.00 25	0.60 15	0.75 19	0.40 10
Light sandy loams over compact subsoils	1.25 32	0.75 19	1.00 25	0.50 13	0.75 19	0.40 10	0.50 13	0.30 8
Uniform silt loams	1.00 25	0.50 13	0.80 20	0.40 10	0.60 15	0.30 8	0.40 10	0.20 5
Silt loams over compact subsoil	0.60 15	0.30 8	0.50 13	0.25 6	0.40 10	0.15 4	0.30 8	0.10 3
Heavy clay or clay loam	0.20 5	0.15 4	0.15 4	0.10 3	0.12 3	0.08 2	0.10 3	0.06 2

The maximum PR values listed above are as suggested by the United States Department of Agriculture.
The values are average and may vary with respect to actual soil condition and condition of ground cover.

Surface Accumulation (SA)

If the precipitation rate is higher than the intake rate, moisture will accumulate on the soil surface. The max surface accumulation sets a maximum acceptable accumulation. The value will be influenced by the soil, but also of the landscape, e.g., slopes will direct a lower acceptable setting, since runoff will quickly form, while flat land can accommodate a higher accumulation.

The controller calculates the accumulation, turns off irrigation when the max has been reached, and waits for the water to seep in before commencing irrigation. This is amounts to automatic cycle and soak.

A suggested starting point is to allow 0.10” of water to accumulate on the soil surface.

Stations

Press the button to view a list of stations referencing a soil type. Use the back button at the top to return to the Soil list.

4.7.2 Creating/Editing a Soil definition

Click on the plus icon to create a new Soil definition.

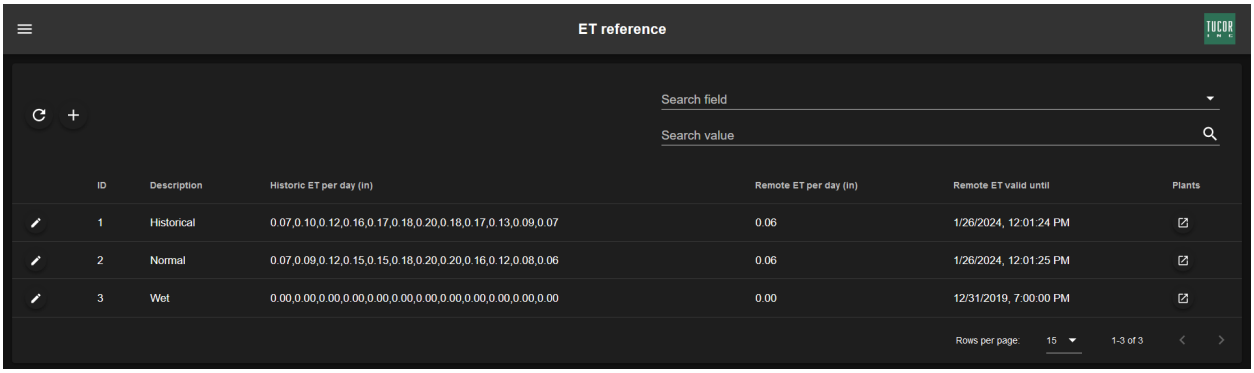
To edit a Soil definition, click the pencil icon next to the entry you wish to edit.

4.8 ET reference

Plants in the controller refer to a water reference for their evapotranspiration (ET) values. It is possible to set up different ET tables, e.g., 20-year average, a wet year, and a dry year. You can then point a plant or crop to the relevant reference according to how a season develops.

4.8.1 View

ET Reference contains a single list view. It shows the data below and provide a link to related Plants.



ID

A system assigned read-only identifier.

Description

A short descriptive text. Use a meaningful description as it is used as reference elsewhere in the web interface. Max character: 31.

Historic ET per day

12 ET values of your choice.

Remote ET per day

The amount of ET per day required to override Historic ET.

Remote ET valid to

The Date that the Remote ET is valid to.

Plants link

Press the button to view a list of plants referencing an ET Reference. Use the back button at the top to return to the ET Reference list.

4.8.2 Creating/Editing an ET reference

Click on the plus icon + to create a new ET definition.

To edit an ET definition, click the pencil icon ✎ next to the entry you wish to edit.

4.9 Hydraulics

The hydraulic structure of the controller supports up to 100 independent mainlines. Each mainline is the entry point for a tree structure of pipes comprising the hydraulics. The controller can handle a total of 100 pipe sections. Each pipe section is defined by its flow capacity and the parent (a mainline has no parent).

Any pipe section can be assigned a flow rule. The controller supports up to 20 flow rules. Each flow rule consists of general settings of limits, up to 20 flow valves and up to 20 flow sensors. The NLP can support a maximum of 20 flow sensors.

A Flow Valve can either be a pump, Normally Open or Normally Closed Master Valve, or a booster pump. Pumps, N/C MVs, and booster pumps behave the same way, the label just allows the user to define what the 'Flow Valve' is. A Flow Valve is optional for the flow rule.

A Flow Sensor can be a common or individual for the defined Flow Valve(s). If setup as individual flow sensors per Flow Valve, then the flow on the overview and dashboard represents the sum. A Flow Sensor is optional for the flow rule. If not present, then any flow related settings are ignored.

Stations in the controller are assigned to a pipe section. A station is controlled by the first upstream flow rule. This is also called a downstream station in relation to the flow rule.

4.9.1 Flow management

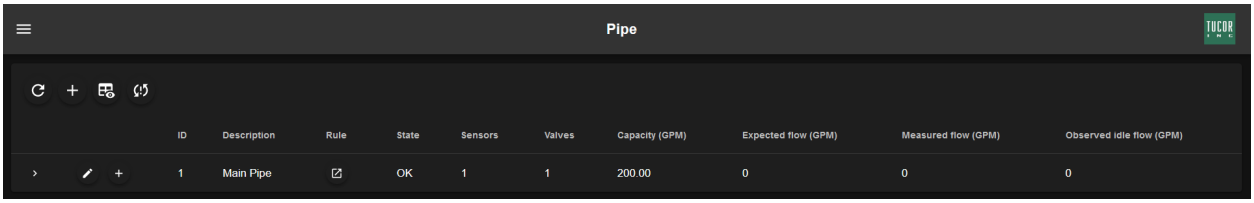
The flow management system operates on all stations which are set due to run. It doesn't matter whether they originate from programs with Auto or Sequential strategy; runs in time, water amount, or MAD; or are manually started. The flow management works on each mainline as a separate individual entity and will as such be handled equally. The only common limitation is the number of active outputs set for the system. All calculation of capacity is based on expected flow for the stations.

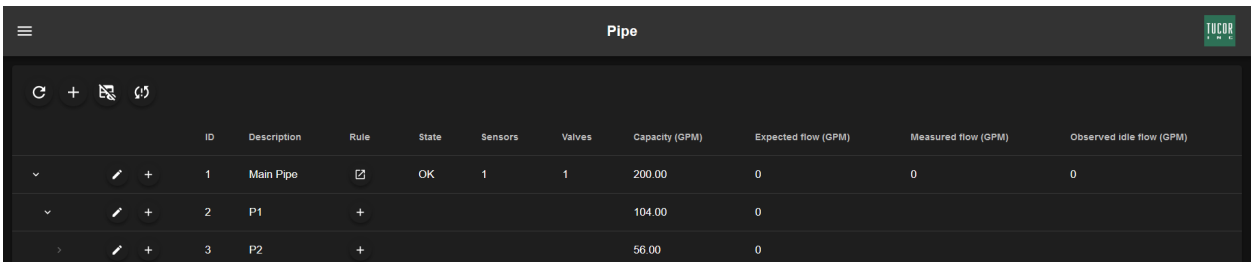
The flow management will seek to automatically utilize the capacity of the mainline by starting stations with high flow rates first and filling in using stations with lower flow rates. The NLP will traverse the hydraulic tree from the far end and upstream to the mainline when looking for stations to start. Every flow rule on the path to a given station will be considered and appropriate actions performed, like turning on Flow Valves. Whenever a station stops, the hydraulics are reevaluated to find candidates to start.

If the system is set up with priorities on station group and/or stations then these will be affecting the selection of the station run in the order of highest to lowest station group priority, highest to lowest station priority and then expected flow. This gives a controlled order of the station run but can have a negative effect on the utilization of the hydraulic system.

4.9.2 Views

The Hydraulics section has only one view but toggles between showing only the main pipes or expanding to show all pipe connections with the following information.





ID

Available when adding or editing a pipe, ID is a system assigned read-only identifier.

Description

A short descriptive text. The text is referenced in the UI e.g., when assigning stations to a pipe. Maximum 31 characters.

Rule

The rule assigned to that pipe. Press the plus button to view a rule for the selected pipe, detailed below.

State

State of the pipe, relaying error messages generated by the system. Such as ‘flow too high’ or ‘resource missing’. Default is ‘OK’.

Sensors

Number of Sensors attached to this pipe. See Flow Sensor section below for details.

Valves

Number of Valves attached to this pipe.

Capacity

The maximum flow capacity of this pipe (section).

When turning on stations it is ensured that the summed expected flow does not exceed the lowest pipe capacity of the relevant flow path. Each station is assigned to a pipe to enable such calculation.

Expected flow
The expected flow rate for that pipe.

Measured flow
The sum of flows seen by sensors connected to the rule.

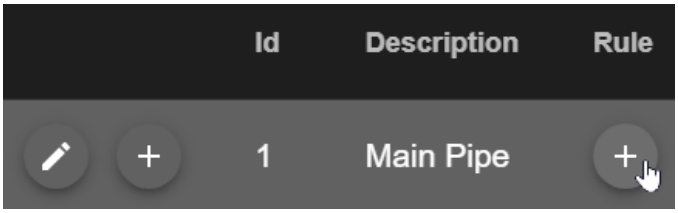
Observed idle flow
When a zero flow is expected and the rules for considering a flow stable are met, the measured flow is stored as 'observed idle flow'. The value may be used when determining a useful value for 'allow idle flow'.

4.9.3 Rules

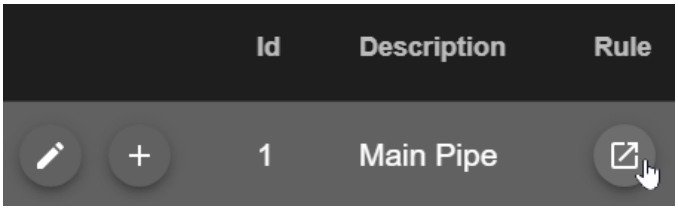
A flow rule defines how to monitor and/or control the flow in a specific pipe. Up to 20 rules may be expressed.

- Flow monitoring is by means of one or more sensors associated to the rule and thus the relevant pipe.
- System continuously monitors the flow rule and triggers actions.
    - Evaluation of the rule is suspended for 'start delay' or 'change delay' when applicable.
- Control is by means of one or more valves or pumps.

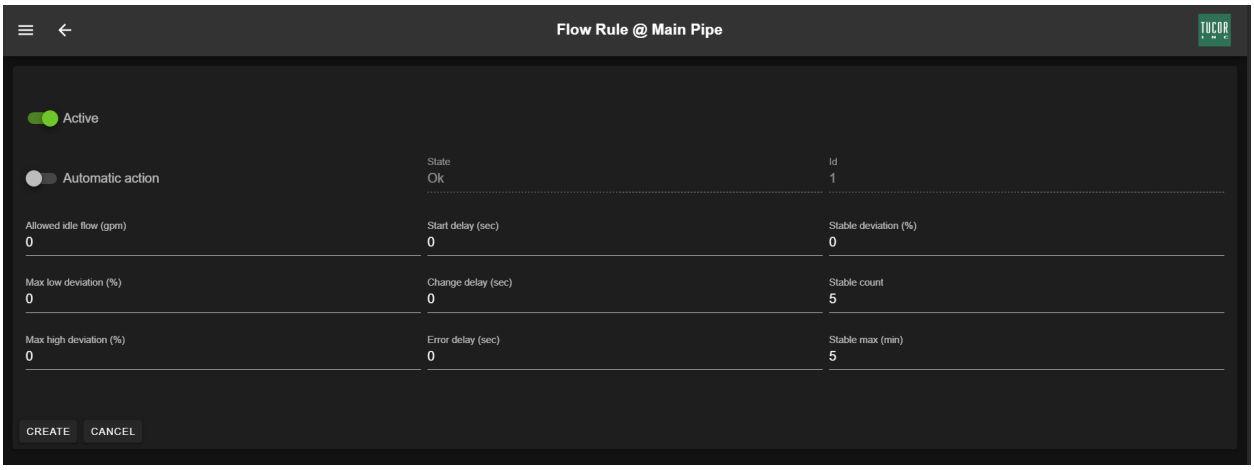
Add a rule to a pipe by pressing 'plus' icon + in the Rule column:



Edit a rule by pressing the 'window pop out' button ⧉ in the Rule column:



A form to add or edit the rule will appear:



Parameters ‘start delay’ and ‘change delay’ control an initial time for flows to stabilize before applying the rule.

‘Measured flow’ is then compared to an expected flow calculated as the sum of relevant stations expected flows, the acceptable deviations ‘max low deviation’ and ‘max high deviation’ and taking ‘allowed idle flow’ into account.

‘Error delay’ ensures the error is persistent before reporting.

To produce reliable measurements for ‘learned flow’, ‘validate flow’ and ‘idle flow’ the parameters ‘stable deviation’, ‘stable count’ and ‘stable max’ are applied.

The flow rule may have associated flow sensors. If so, the measured flow rule is evaluated against the expected flow.

The flow rule may have associated valves or pumps. If so, these are opened when the relevant pipe has an expected non-zero flow. The flow rule closes its associated open valves and pumps if certain error conditions are raised.

When a fault affects multiple flow rules, e.g., a leak, the downstream rule is handled first. After that, if the fault persists for ‘error delay’ at the next upstream rule, said rule is handled. This recursive handling continues until all faulted rules have been handled.

When learning flow at a station, all flow rules back to and including a main pipe are placed in ‘learn flow’ mode, preventing all other stations from activating. Flow paths connected to other main pipes are not affected. Upon successful measurement, the flow is stored as ‘observed flow’ for the station.

When verifying flow at a station, the flow rule nearest upstream is placed in ‘validate flow’ mode. Only the relevant station downstream from the flow rule is allowed to run. Stations connected to other pipe segments are not affected. Upon successful measurement the flow is stored as ‘observed flow’ for the station.

Active

This toggles the flow rule active/passive. In passive state it will still operate Flow Valves and monitor any flow, but no alarms will be generated.

Automatic action

This toggles whether any flow alarms will actively stop pumps & close valves (active) or just warn (passive).

State

The current state of the rule. Possible values are:

- **Ok** - The state when no other state is active. The flow rule is in the normal state.
- **No Flow** - The flow rule is in no-flow state meaning it has not seen a flow after start of a Flow Valve. The period it looks for a flow depends on the flow sensor assignment. If the pump has a flow sensor assigned (see Flow Valve setup below) it will use the start/change delay, otherwise it will use start/change delay plus the error delay. The Flow Valve(s) will be stopped if Automatic action is enabled.
- **Unexpected Flow** - There is a flow above the Allowed idle flow when no Flow Valves are active. A N/O MV will be activated if the Automatic action is enabled.
- **Flow Too Low** - The flow is too low. All downstream stations are marked for verify flow if the Automatic action is enabled.
- **Flow Too High** - The flow is too high. All downstream stations are marked for verify flow if the Automatic action is enabled.
- **Resource Missing** - The flow rule points to a non-existing output or input.
- **Verify Flow** – Verify Flow is designed for testing & validating flow for individual stations. In Verify Flow mode, only one downstream station will run at a time. It will continue to run until no further downstream flow rules are active. Stations connected to other ***pipe segments*** are not prevented from irrigating. Upon successful measurement, the flow is stored as 'observed flow' for the station.
- **Learn Flow** – Learn Flow is the more precise option when calibrating observed flow values, as normal irrigation is halted across all pipe sections (for controllers with one main). In Learn Flow mode, only one downstream station will run at a time and continue running until no further downstream flow rules are active. For controllers supporting multiple mains, irrigation for other ***main pipes*** is not prevented from irrigating. Upon successful measurement, the flow is stored as 'observed flow' for the station.

Allowed idle flow

Allows for (background) flow unrelated to the controller. E.g. a hose bibb or quick coupler.

- Prevents an error condition from being raised when zero flow cannot be attained.
- Is subtracted from measured flow when evaluating against expected flows.

Start delay (sec)
Defines the number of seconds the system shall wait from activation of the Flow Valve(s)/Pump(s) before checking for alarms.

Stable deviation (%)
Defines the maximum % deviation from previous reading before a flow reading is considered stable for learn flow and verify flow.

Stable count
Defines the interval in counts of 5 seconds where the readings shall be within the stable deviation % for accepting the flow for learn flow and verify flow.

Stable max (min)
Defines the maximum minutes to find a stable flow before it gives up finding a stable flow for learn flow or verify flow. The result will be set to 0 for the station.

A stable flow is required to:

- record an observed flow when learning or verifying flow. May be copied as new 'expected flow'.
- record an observed idle flow when zero flow is expected. May be copied to 'allowed idle flow'.

The flow is considered stable when 'Start delay' has elapsed, 'Stable count' consecutive values (taken at 5 sec intervals) are within 'stable deviation' percent of the first value, and the 'stable max' value (in minutes) has not been exceeded.

The requirement for a stable flow does not apply under normal operation where, instead, after the 'start delay' or 'change delay' the momentary measurements are used.

Max low deviation (%)
The maximum low deviation in % of the expected flow for the active downstream stations.

Max high deviation (%)
The maximum high deviation in % of the expected flow for the active downstream stations.

Change delay (sec)
Define the number of seconds the system shall wait for a change in running downstream stations before checking for alarms.

Error delay (sec)
Defines the number of seconds an error shall be observed before it triggers the alarm.

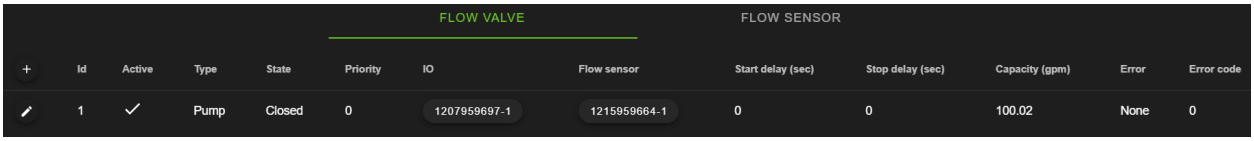
Stable max (min)
Number of minutes to wait for a stable maximum flow.

4.9.4 Flow valve – Master Valve or Pump

This sub-panel appears at the bottom of the Rule edit page.

Zero or more valves or pumps may be associated with a flow rule. In the web interface these valves are found in the Hydraulics menu, under the relevant pipe and flow rule.

- They are activated when the expected flow through the associated pipe is non-zero.
- The valve(s) are assumed to be placed at the beginning of the pipe so that they control all flow into the pipe, which leaves the pipe either to stations or to downstream pipes.
- These are activated when flow through the pipe is called for.
- These are deactivated in case the rule does not evaluate ok.
- The system ensures that the flow capacity of a pump or valve is never exceeded.



ID

A system assigned read-only identifier.

Active

This toggles the Flow Valve active or passive. In passive state it will be ignored.

Type

This is either Pump, Normally Open Master Valve, Normally Closed Master Valve or Booster pump. The pump, N/C MV and booster pump are activated when there is a need, whereas the N/O MV is activated in case of an alarm to close the water stream.

A pump or valve can be categorized as one of several types. Choose the one you want from the drop down:

State (not in edit form)

The state of the Flow Valve. The state can be:

- Open: The Flow Valve is active.
- Closed: The Flow Valve is passive.

Priority

Defines the priority of the Flow Valve. This is a number from 0 to 255. The higher the number is the higher priority it has. The controller starts Flow Valves from highest to lowest priority until it has achieved the needed capacity. Flow Valves with the same priority will be started cyclic to obtain equal usage.

IO
A reference to the decoder output controlling the pump or Master Valve.

Flow sensor
A reference to a sensor decoder input for a flow meter assigned to the Flow Valve. This is optional but reduces the reaction time on no flow.

Start delay
A delay in start from the first downstream station starts until the pump or MV is activated.

Stop delay
A delay in stop from the last downstream station stops until the pump or MV is activated.

Capacity
The flow capacity of the valve or pump. The system will not allow stations to turn on if it cannot open valves or start pumps to supply the expected water flow.

Error/ Error code
Errors related to the hydraulics system. Possible Error State values:

- None: This is the normal state.
- IO: There is an issue with the IO. See Error code.
- No Flow: There is no flow for the Flow Valve.

Error codes: refer to the general error codes in the appendix of this manual.

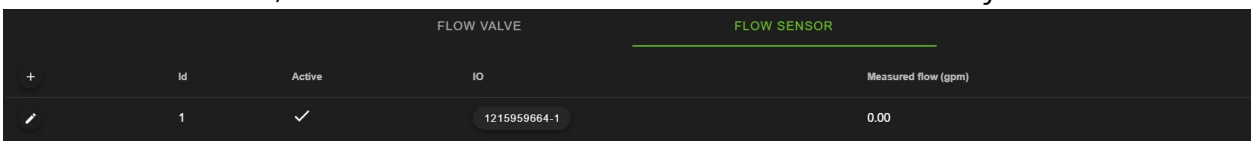
4.9.5 Flow sensor

This sub-panel appears at the bottom of the Rule edit page.

Zero or more flow sensors may be associated with a flow rule. ‘Measured flow’ of the rule is the sum of ‘measured flow’ from its active sensors.

- The sensors provide ‘measured flow’ input to the rule.
- The sensor(s) are assumed to be placed at the beginning of the pipe so that it measures all flow into the pipe, which leaves the pipe either to stations or to downstream pipes.

In the web interface, flow sensors are found under the rule to which they refer.



ID
A system assigned read-only identifier.

Active
Whether this sensor should be ignored or not.

IO
The 2-Wire decoder from where input is acquired. Observe that the IO object contains settings for update frequency and conversion of actual sensor input to a volumetric flow.

Measured flow
The last known measured flow.

4.10 Simulation

Simulation allows you to use current controller settings to create a graphical representation of expected station flow rates for programs and stations schedule to run in the future. The outcome is expressed in a simple line chart where you can choose points along the line to see which programs and stations are running, and the expected flow at that point in time.

It runs the controller code fast forward showing what will happen months or even years into the future using the current controller settings. To better support it being used for decision making, you can adjust the system while the controller is in forecast mode, then just re-run the forecast.

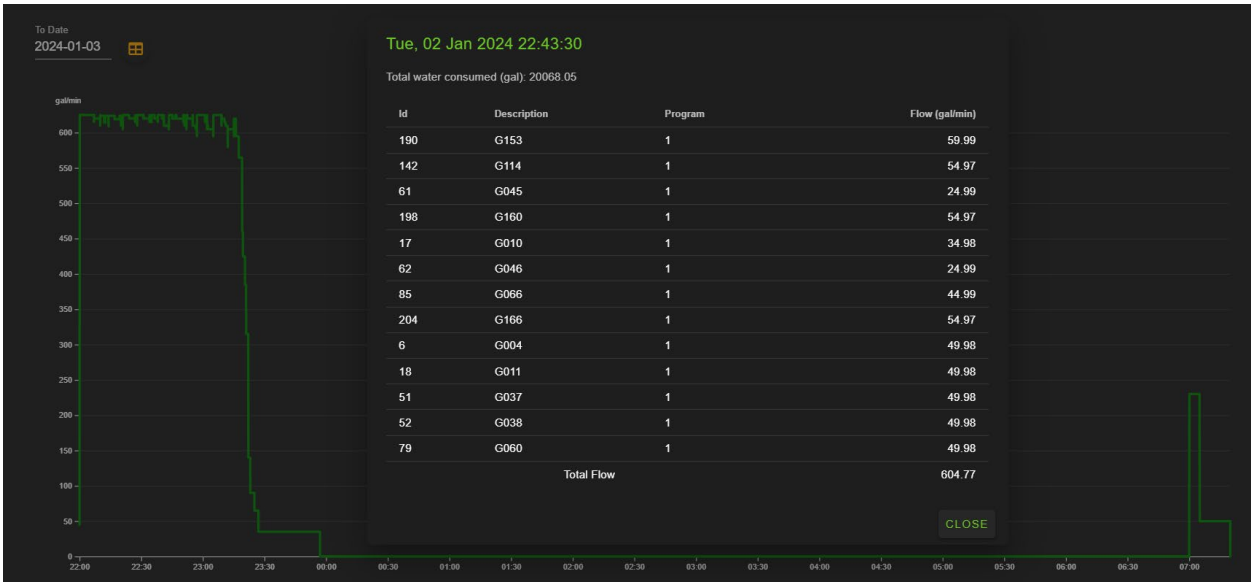
The Simulation runs a copy of the controller code inside your browser to generate the fastest results.

4.10.1 Views

Simulation Graph

The simulation starts today. Click on the date field to choose the 'end date' for the forecast, weeks, months, or even years in advance. Once the end date is selected the Simulation will run and display a chart of the expected run of programs and stations.

Hovering over the chart will display a date marker at a point closest to the mouse pointer. Clicking on the chart will switch the date marker to a small table showing you the station running, the program related to it, and the flow measured at that time.



Simulation Data

Clicking on the calendar icon will switch to table view of the simulated run log file, showing timestamps, the severity of the log entry, what happened (a station started, for example), and the raw data for that log event.

You can search through the log data generated using the search tools in the upper right of the section.

‘Severity’ filters the data based on the degree of severity of the information recorded.

‘Search value’ is an open search field. Enter partial or full info to narrow the search results.

4.11 Control

This section describes the general control settings for the irrigation controller.

View

The Control section goes straight into a form view containing the following data:

Mode

The controller can operate in different modes as shown in the dropdown list above. In addition to the listed modes, it can be in forecast mode which means the controller won't send any 2-wire commands to decoders. This is useful if no decoders are installed yet and the daily operation is under setup and test during real-time operation.

Possible modes are:

- **Auto** - is the normal operation where all programs run according to the setup of water days and start times. In that mode programs and stations can be started manually. Likewise, programs started automatically can be stopped manually by the operator.
- **Manual** - prevents any automatic start of programs. All programs and stations can be started manually in this mode. When changing mode from Auto to Manual it will stop already started programs running. When changing back to Auto it will NOT start programs which should have started while in Manual.
- **Paused** - is used to pause all running programs and stations.

Test mode

This flag means that it won't turn on decoders, but it runs at normal speed. Useful for testing out Logic Engine programs and Water Engine Schedules.

Max active stations

The maximum number of stations that can be active at a given time.

Time Zone Offset (minutes)

Offset, in minutes (positive or negative), offset from UTC. No daylight savings handled, so must be manually updated 2x/yr.

Retry failed station every x hours

This dropdown determines the behavior of stations (when trying to start?). Accepted values are: No retry, Unmodified, Disable verify and use force, Disable verify, Use force.

Station retry rule

You can modify the retry function by choosing a modifier in the provided drop-down list.

Rain IO

This dropdown allows the user to select a Rain sensor to be used with this controller. The Rain sensor can either be a contact closure (constant on for the duration of the rain) or a pulse input type (Rain bucket that gives a pulse for every given amount of rain).

For the contact closure type the sensor decoder must be configured as switch input with send of interrupt on value and clear of attention.

For pulse input type the sensor decoder must be configured as counter input with send of interrupt on value and clear of the value.

Rain start delay (minutes)

Value, in minutes, that is used to delay start of station(s) after the contact closure type rain alarm goes off or this time has elapsed since last pulse for the pulse type of rain sensor.

Rain bucket size (in)

The value of the size of the rain container used with the rain sensor of pulse input type. The value will be applied to the surface accumulator for each station on each pulse. The max surface accumulation for each station is considered for the case of any run-off. Typical value for a rain bucket is 0.01”.

For the contact closure this value should be zero to avoid rain being added to the surface when the alarm goes on. In this case the ET must include a rain correction.

Water budget

Percentage of water to be applied by the controller.

Editing the Control section

You can directly edit the fields in this form/view.

Click Save to store your changes.

5 Logic Controller

Also known as Logic Engine or Rules Engine.

The Logic Controller is a programmable automation controller capable of reading sensor decoders, performing calculations and carrying out actions, e.g., turning on or off stations or programs.

Contact Tucor to learn more about how the Logic Controller can be utilized for your site.

6 2-Wire

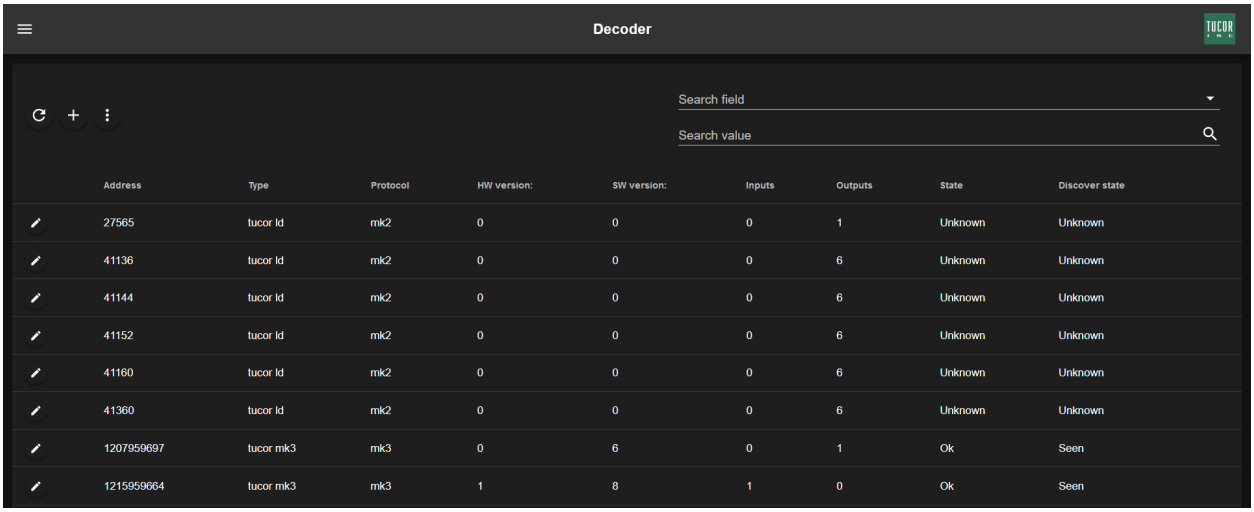
Entries under the 2-Wire main menu pertain to devices sitting on the 2-Wire path, i.e., decoders with their I/O ports and configurations.

6.1 Decoder

A decoder is described by address, type, protocol, and inputs or outputs. For multi-station output decoders, each output is assigned an address or IO Idx, and each address will populate individually.

6.1.1 View

The list of decoders represents individual decoders and their immediate properties. Each will have IO properties according to the decoders type.



Address

The decoder's address, used to identify and communicate with the decoder.

For LD (MK2) decoders, it is a 3-5 digital numerical address between 284 and 60000, which is displayed on the decoder's label.

For RKLD decoders, it is a 5-digit numerical address between 10001 and 10100, where the last 3 digits are the station number.

For NG- and SD- (MK3) decoders, it is a 32-bit address.

Type

The type of decoder at this address.

Protocol

Shows the protocol used for that decoder.

Hardware / Software versions

The currently installed versions for each part of the decoder.

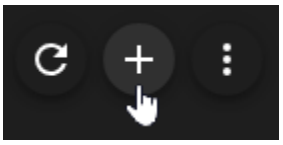
Inputs / Outputs
The number of Inputs and Outputs defined or detected for the decoder.

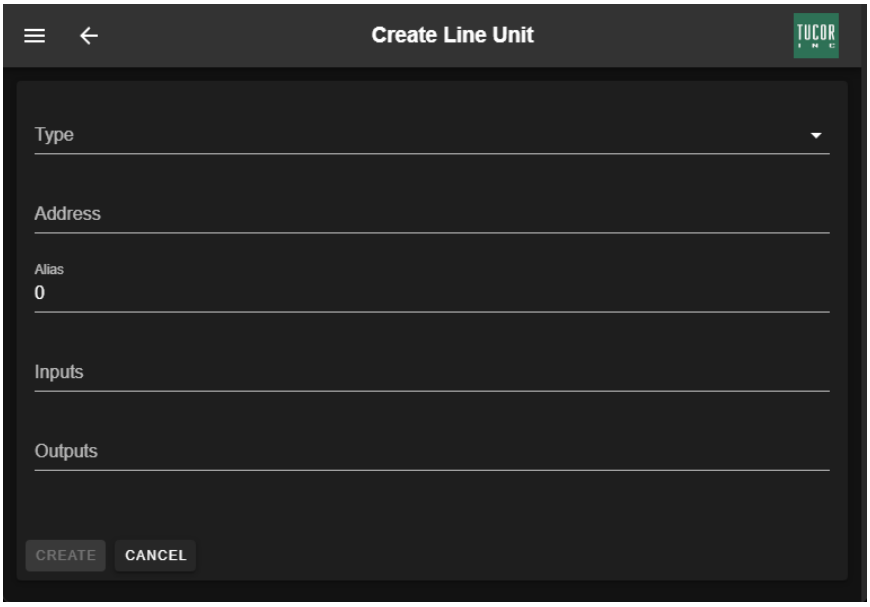
State
The current state of the decoder. Can be one of several values: Unknown, Discovered, Failed, or OK.

Discover State
The 'Discover state' of the decoder. Can be one of several values: Unknown, Not Seen, Seen.

6.1.2 Add a Decoder / Create Line Unit (Manual)

Click on the plus icon to create a new decoder entry manually. If you are installing new NG- or SD- decoders, use the Discover New Decoders function described in the following section to automatically discover and add new decoders connected to the 2-Wire path.





Type
Select the type of decoder. Possible types are:

- **Tucor RK** – for RKLD-050 decoders
- **Tucor LD** – for LD- (MK2) decoders
- **Tucor MK3** – for NG- and SD-110 decoders

Address
Enter the decoder's address.

Alias
Alias is optional and is used as an alternative identification of the decoder. The alias must be unique. Aliases are only used via the API and in any case the ID (address) of the decoder is substituted with #<alias>.

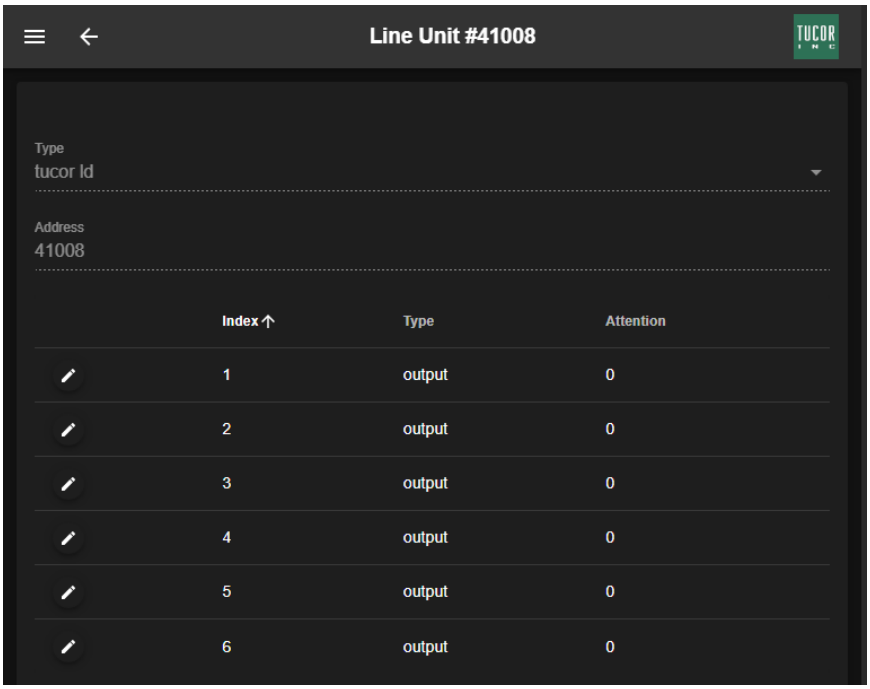
Inputs
Enter the number of inputs for this decoder. This should only be used for sensor decoders (SD-110).

Outputs
Enter the number of outputs (valve stations) for this decoder.

6.1.3 Editing a Decoder

To edit a Decoder, click the pencil icon next to the entry you wish to edit.

There is nothing to actually edit here, but 'editing' an IO will bring up a limited edit panel where you can change the description of the IO or manipulate the Control and Configure sub-panels content. Details for those sub panels can be found in later sections of this manual.



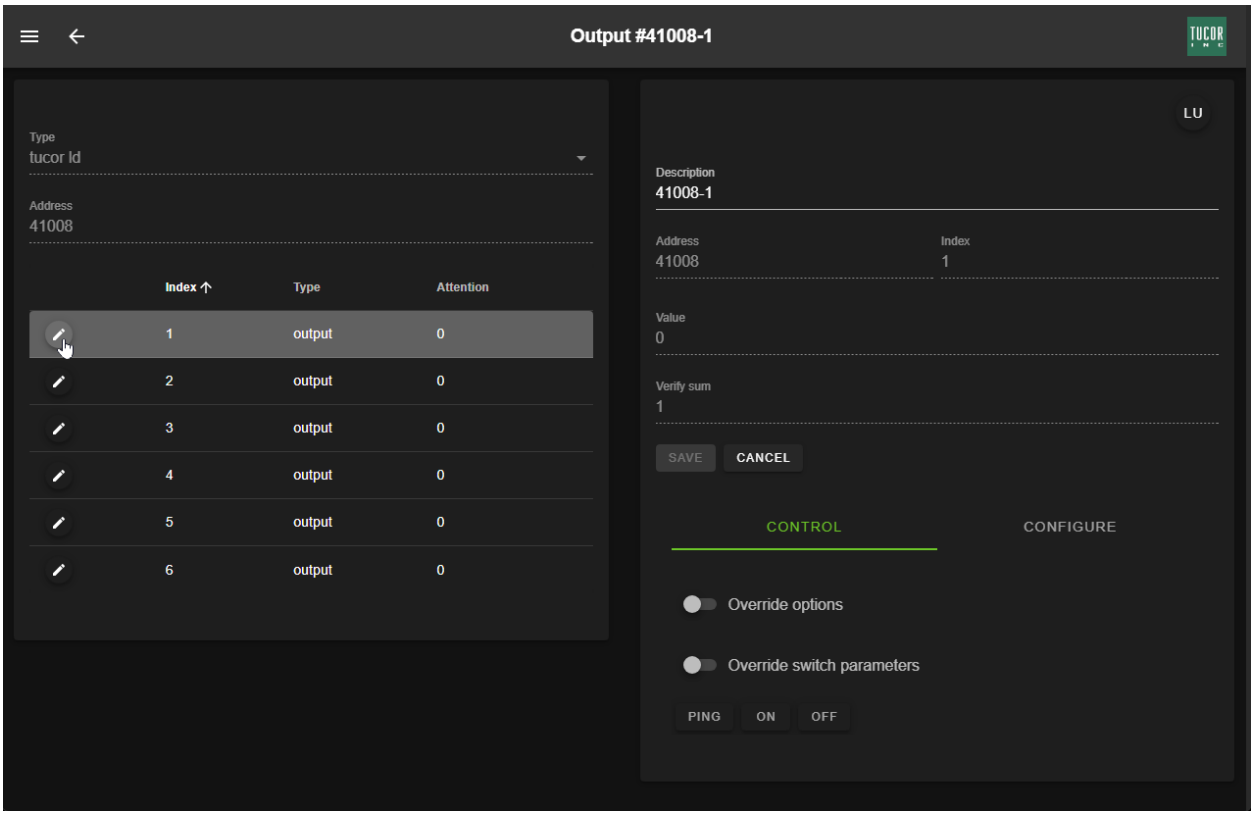
Type
The type of decoder: RK, LD, or MK3 (NG- & SD-110).

Address
The decoder's address.

IO Subpanel

Visible at the bottom of the form when editing a Decoder. It lists the I/O ports (via 'Index') and their types from that decoder.

Editing a row opens a page for the selected I/O, which is the same page accessed through editing an entry from the IO list.



Control Subpanel for MK3 decoders

When editing an NG- or SD-110 decoder, you will see an additional Control sub-panel. This relates to the decoder itself, not its I/O ports. It is not available for RKLD or LD (MK2) type decoders.

Factory reset

Press this button to factory reset the decoder. The decoder will then be left with Unknown configuration and in unconfigured Config state.

Line resistance

Press the refresh button to measure the line resistance from controller to decoder. The line resistance for 14AWG copper cable is 2.6Ω per 1000'.

Temperature

Press the refresh button to read the current decoder temperature.

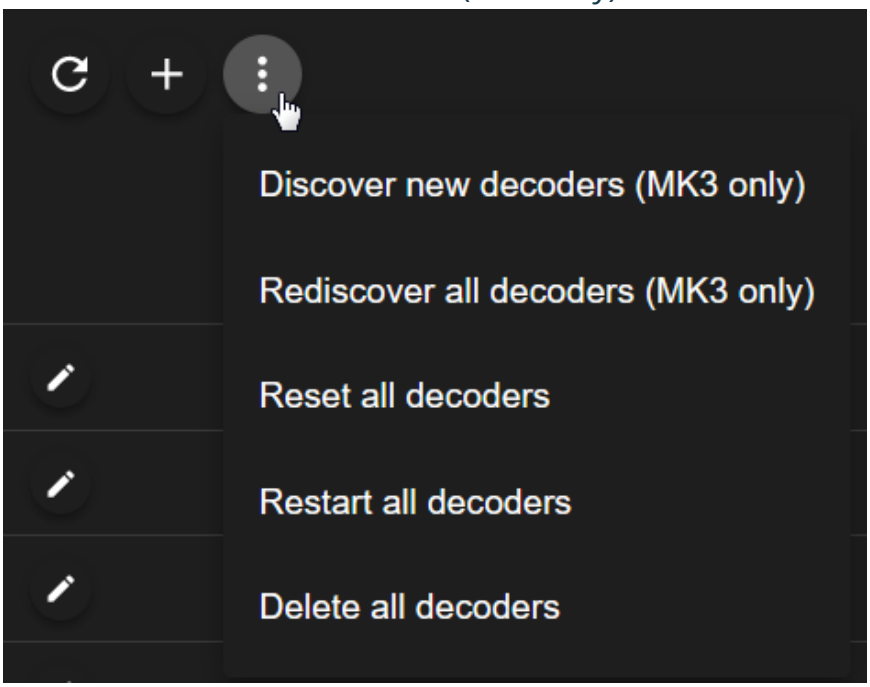
Voltage

Press the refresh button to read the current 2-wire peak voltage at the decoder. The voltage is in mV.

Leak (only NG- (MK3 output) decoders)

Press the refresh button to read the current leakage from decoder outputs to ground. This measurement is indicative of the wire and solenoid insulation state. The reading is common for all connected output.

6.1.4 Discover New Decoders (MK3 only)



This function is used to search for new MK3 decoders on the 2-wire path. It will return a list of all the new decoders. These decoders will automatically be set as known so any subsequent discovery of new decoders will not return these.

The MK3 decoder must be configured before it enters the “OK” state.

NOTE: LD (MK2) and RKLD decoders will remain in the “Unknown” state as their communication is only unidirectional, unlike the MK3 decoders.

6.1.5 Rediscover All Decoders (MK3 Only)

This function does the same as above, but it sets the status of all decoders as “Unknown” before the search. This is necessary if some of the decoders have been deleted from the NLP or were moved from another NLP.

6.1.6 Reset All Decoders

The reset sends a broadcast to stop all output decoders.

6.1.7 Restart All Decoders

The restart sends a broadcast restart (reboot) of all decoders both input and output.

6.1.8 Delete All Decoders

This function will delete all decoders from the controller including the setup of IO configurations.

6.2 IO

This section covers working with the IO ports available to the decoders.

6.2.1 View

This view details the Inputs and Outputs of a decoder.

	Description	Address	Index	Type	Configuration	Config state	Attention	Value (expr modified)	Verify sum
	S035	13730	1	Output	Unknown	Unconfigured	0	0	0
	S032	30770	1	Output	Unknown	Unconfigured	0	0	0
	S033	30771	1	Output	Unknown	Unconfigured	0	0	0
	G205	30838	1	Output	Unknown	Unconfigured	0	0	1331
	G206	30839	1	Output	Unknown	Unconfigured	0	0	1308

Description

A description of the actual IO. Used as reference for setup of stations, pumps, flow etc., in the water engine.

Address, Index

The decoder address and I/O port number.

Check out the Appendix: API Primer on ways to manipulate data.

Type

Describes the type of decoder, either input or output.

Configuration

The actual configuration of the decoder. Read-only. Must be set under the configure sub-panel.

Config state

State of configuration. Must be in state “configured” to be operational.

Attention

If ‘1’ it indicates the IO has set the attention flag. Normally the API handles REST commands and their responses including feedback from a decoder to which the command was sent. State changes happening in decoders outside of commands have no return path. The state change gives rise to a 2-Wire interrupt which is reported in the heartbeat as the attention bit.

An example of an attention is if 2-Wire voltage is detected low while in hold state. This can happen any time between turning on and turning off the decoder.

Value (expr modified)

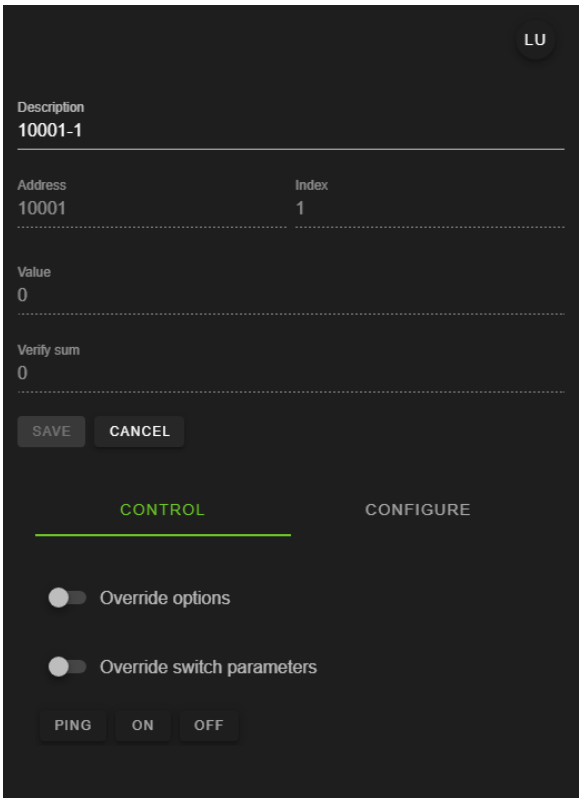
The value of a sensor decoder input modified via the expression defined in the setup.

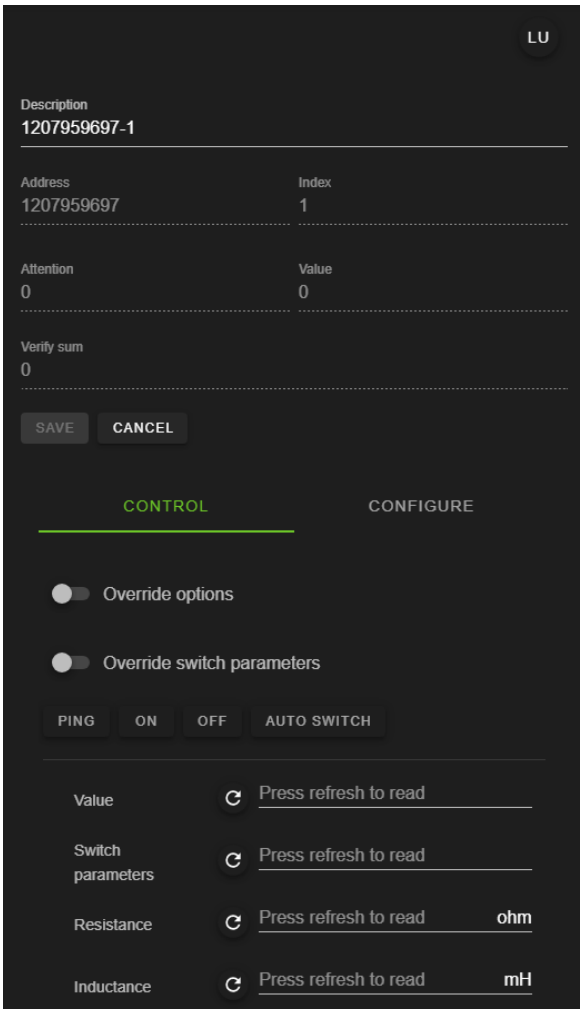
Verify sum

This is a verification sum for the activation of an output. The value shall be > 100 for a positive confirmation. If less than 100 then tweak the inrush and folding parameters as described below.

6.2.2 Editing an IO port

To edit an IO port, click the pencil icon next to the entry you wish to edit.





Below we describe each part of the list and/or edit form. The different sub-panels will follow.

Description

A description of the actual IO. Used as reference for setup of stations, pumps, flow etc., in the water engine.

Address, Index

The decoder address and I/O port number.

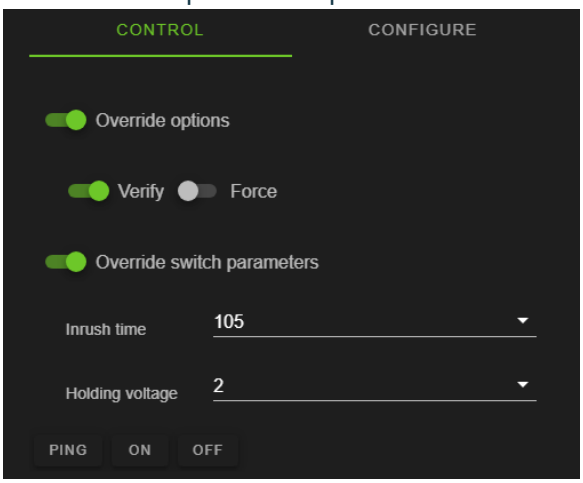
Value

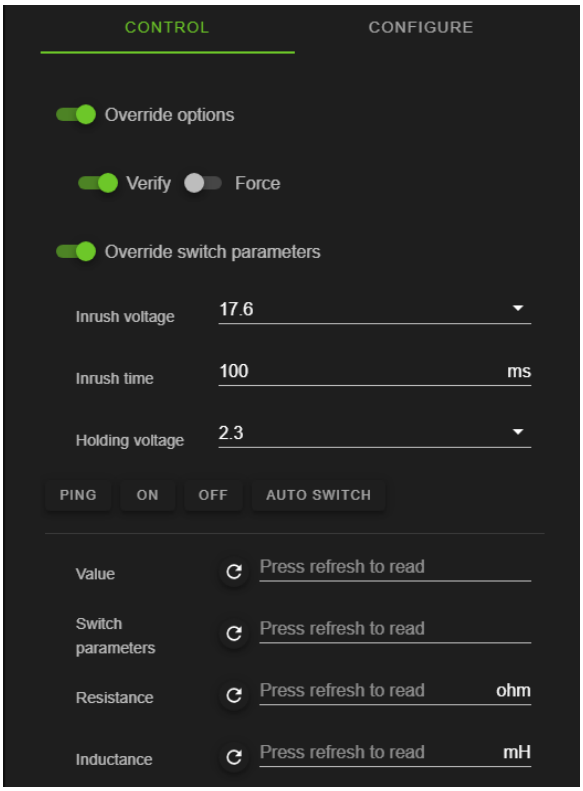
Actual value of the IO. For output it is 0 for OFF and 1 for ON. For input it is the raw value read, or an expression converted value if specified in the sensor decoder configuration.

Verify sum

This is a verification sum for the activation of an output. The value shall be > 100 for a positive confirmation. If less than 100 then tweak the inrush and folding parameters as described below.

Control Subpanel: Output decoder





Override options

This setting allows overriding the default Verify and Force options as set in the IO configuration. Changes are only used while doing operations from the control panel. The Irrigation engine will use the configuration.

Verify

Only available if overriding default options.

Force

Only available if overriding default options.

Override switch params
This setting allows overriding the default switch parameters as set in the IO configuration. Changes are only used while doing operations from the control panel. The Irrigation engine will use the configuration.

Inrush voltage
Only available if overriding default switch parameters, and supported by decoder (i.e., not RKLD).

Inrush time
Only available if overriding default switch parameters.

Hold voltage
Only available if overriding default switch parameters.

Ping
This is a function to check the decoder. The function performs a decoder ON followed by an immediate OFF with the set options. The decoder will be ON less than one second.

On
This turns on the output of the decoder. The decoder will stay ON until it is turned OFF by the OFF button. Any water usage is not accounted for in the Irrigation engine.

Before turning on a decoder (solenoid valve) the controller ensures it is safe to do so. The following checks are applied. All blocks are reported as '2-wire load too high (1003)'.

1. The lowest MK3 voltage is queried. Must be >=25V.
2. The 2-Wire voltage is checked. Must be >=21V. The 2-Wire voltage is indicative of the lowest voltage anywhere in the system. MK2 decoders can operate safely down to 21V.
3. The current is checked. Must be <=75% of controller capacity (which may be e.g., 800, 1000 or 1500mA depending on controller version).

Some controllers are equipped with relays for each 2-wire path. These can be used to switch on and off wire paths for troubleshooting. This can be obtained via the API.

Off
This turns off the output of the decoder.

NOTE: If the decoder was turned ON by the water engine, it will start again.

Auto switch
This function performs an auto switch in the decoder. It is only available for MK3 decoders.

Value, with Refresh

Refresh triggers the web interface to read the raw value as '1' for ON and '0' for OFF. With verify flag, it will do a hold test of the plunger.

Switch params, with Refresh

Refresh triggers the web interface to read the actual switch parameters used for the decoder. If override switch params have been used, it will be those values. Otherwise, it will be the values from the configuration. The values are in 1/10 of a Volt and millisecond (ms) respectively.

Resistance, with Refresh

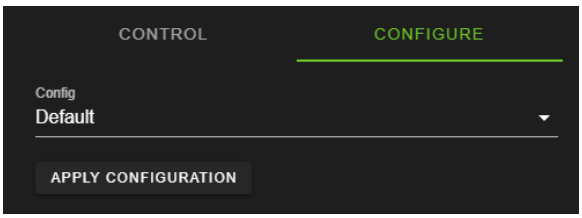
Refresh triggers the web interface to read the solenoid resistance. The resistance is updated on every ON command. The value is in Ohms (Ω).

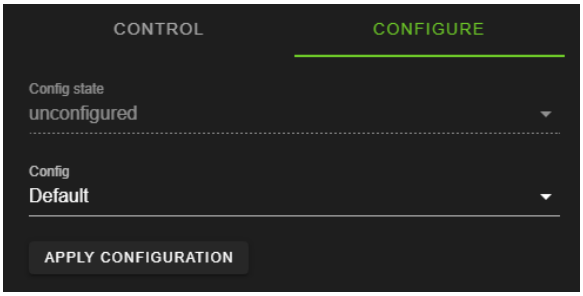
Inductance, with Refresh

Refresh triggers the web interface to read the solenoid inductance. The inductance is updated on every ON command. The value is in millihenries (mH).

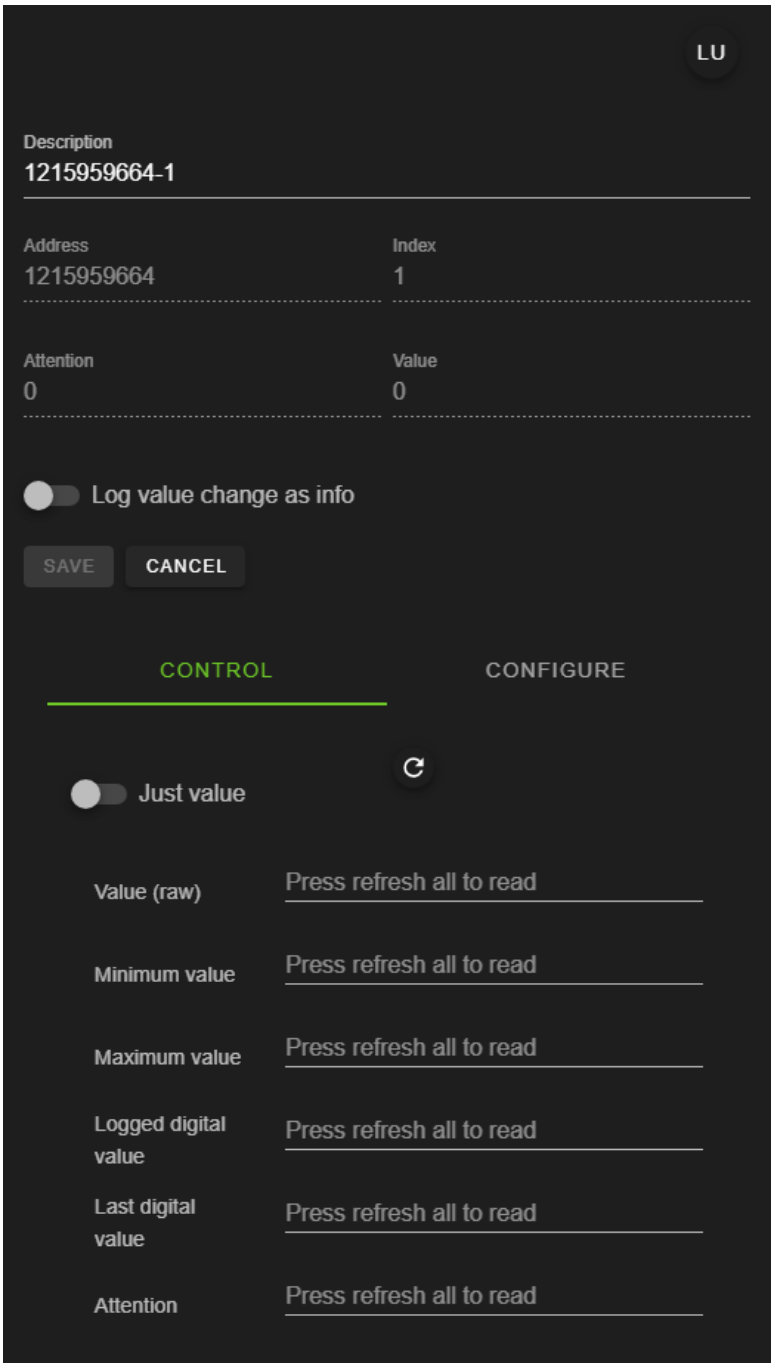
Configure Subpanel, Output decoder

Configure the IO by choosing a configuration from the dropdown list and clicking the apply configuration button.





Control Subpanel, Input decoder



Just value

This toggle defines whether the refresh button just reads the actual 'raw value' of the sensor decoder or all values.

Refresh

Reads the sensor decoder.

Value is the actual raw value from the sensor decoder.

Minimum and Maximum value
The minimum and maximum values registered since last clear.

Logged digital value
Last digital value is the time from last input pulse until the decoder read in milliseconds (ms). It is a 32-bit pulse counter.

Value
Shows the raw value read from the sensor decoder. The value is stored in volatile memory in the sensor decoder.

Minimum value
Shows the minimum value registered by the sensor decoder since last clear of this particular value. The value is stored in volatile memory in the sensor decoder.

Maximum value
Shows the maximum value registered by the sensor decoder since last clear of this particular value. The value is stored in volatile memory in the sensor decoder.

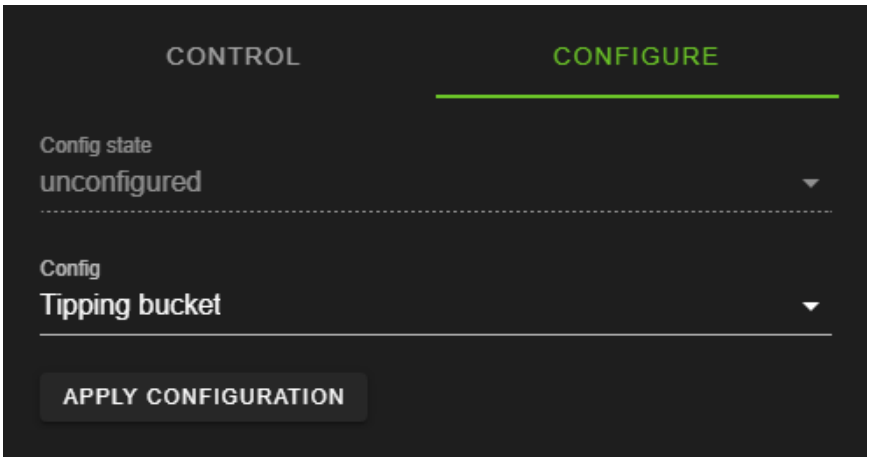
Logged digital value
Shows the total counter value registered by the sensor decoder since last clear of this particular value. Only for digital input. The value is stored in non-volatile memory in the sensor decoder and updated on a regular basis and upon power down.

Last digital value
Shows the time in milliseconds since the last pulse input registered by the sensor decoder. Only for digital input. The value is stored in volatile memory in the sensor decoder.

Attention
Same as above.

Configure Subpanel, Input decoder

Configure the IO by choosing a configuration from the dropdown list and clicking the apply configuration button.



Info Side panel

While on the edit page for an input or output decoder, you can access the decoders Info sub-panel by clicking on the 'LU' button at the top of the edit page. It provides some relevant info about the type and a list of Inputs or outputs associated with that decoder. Refer to the sub-panel in the previous Decoder section for information on each field in that form.

6.3 IO configuration

The NLP is pre-loaded with custom IO configurations for quick set-up of sensors. IO configurations may also be used to modify decoder parameters to control non-standard outputs, such as large valves or relays (referred to as Switch Codes in prior Tucor controller models). For more information, contact Tucor.

6.3.1 View

A list of the configurations available for your IO devices.

	Id	Protocol	Type	Description
	0	rkd,mk2,mk3	output,input	Unknown
✎	1	mk2	input	Contact input SD, sourcing power
✎	2	mk2	input	Contact input, external sourcing power
✎	3	mk2	input	Pulse input, SD sourcing power, flow rate, up to 200 pulses/sec
✎	4	mk2	input	Pulse input, external sourcing power, flow rate, up to 200 pulses/sec

ID

A system assigned read-only identifier.

Protocol
Generation of 2-Wire decoder product. Available options are RKD for RKLD-050, MK2 for LD-, and MK3 for NG- and SD-.

Type
Input or output.

Description
Short text to describe the configuration. The text is used for dropdowns for assigning a configuration to a decoder.

6.3.2 Creating/Editing an IO configuration
Click on the plus icon to create a new configuration.

To edit a configuration, click the pencil icon next to the entry you wish to edit.

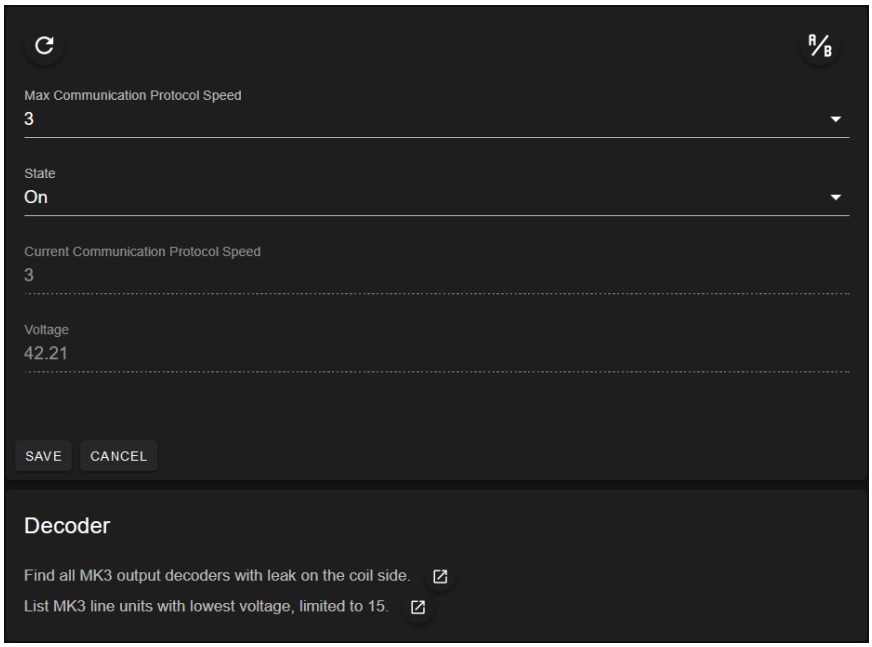
Contact Tucor if you require a different IO configuration than those listed.

6.4 Control

This section holds general control settings for the 2-Wire engine.

6.4.1 View

The Control section goes straight into a form view containing the following data:



Max Communication Protocol Speed (CPS)

The maximum setting for communications speed along the 2-Wire. A value of 0 is the slowest speed and a value of 3 (about 2x as fast as CPS1) is the fastest speed. The value can be set under *System -> 2-Wire.*

State

The state of the 2-Wire can be 'Off', 'On', 'Short Finding' or 'Leak Finding' mode. The short and leak findings generate a selectable 50 or 60-Hertz signal into the 2-Wire to help technicians find various faults in the system.

Short Finding toggles the 2-Wire out-of-phase, letting the decoder draw current such that it can be read with a clamp meter.

Leak Finding toggles the 2-Wire in-phase, letting the decoders be shut down such that any leak current can be read with a clamp meter.

NOTE: When turning the 2-Wire to ON, it will do a charging of all the decoders on the 2-Wire path. When it reaches the ON state, the controller will broadcast a 'Stop all decoders' command to make sure they are all in a known OFF state.

This shows the actual communication speed. It can never be more than defined above but might need to be lowered due to capacitive load. The value cannot be set from the GUI, but only via the API.

Voltage
Measurement of the controller supply voltage.

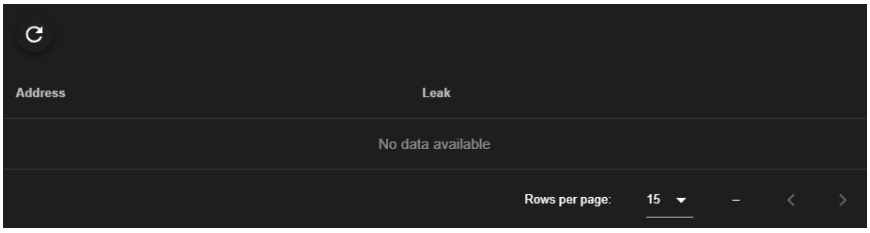
6.4.2 Creating/Editing the Control section

There are no separate 'add' or 'edit' functions for this section compared to other areas of the web interface. Set the Max Communications Protocol Speed and State directly via their dropdown menus and click 'save' when done.

6.4.3 Decoder

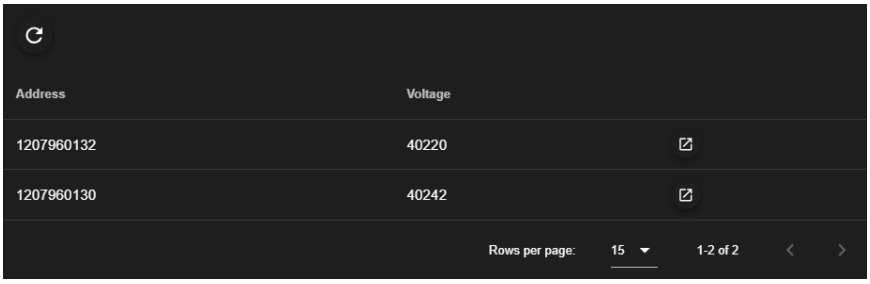
Find all MK3 output decoders with leak on the coil side.

Click the 'open new window' button to view a list of NG decoders that currently have a current leak on their output/solenoid.



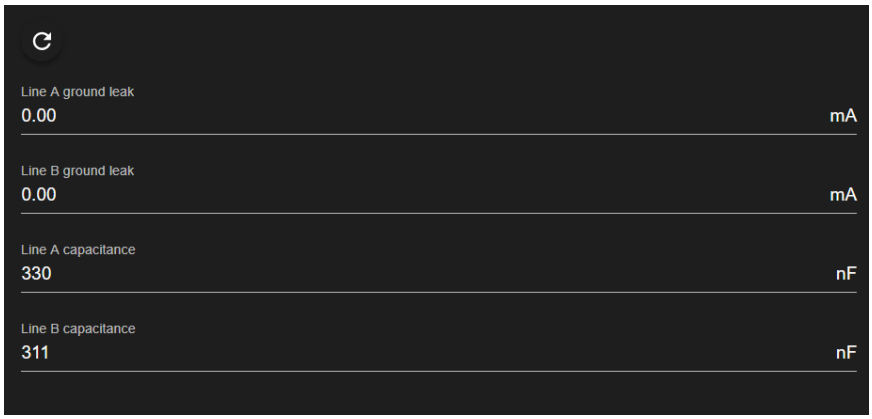
List MK3 decoders with lowest voltage, limited to 15.

Click the 'open new window' button to view a list of up to 15 NG- and SD-110 decoders with the lowest 2-Wire voltage.



6.4.4 A/B (2-Wire test)

The 2-Wire test section contains information about the 2-Wire path's ground leak current (in milliamps (mA)) and capacitance (in nanofarads (nF)).
The ground leak current has an impact on the ability to drive the system. The value should not exceed 16mA.


Line A ground leak
0.00
mA
Line B ground leak
0.00
mA
Line A capacitance
330
nF
Line B capacitance
311
nF

7 System

The System section contains data, settings, and operations related to the controller itself.

7.1 Info

Contains relevant device information such as hardware and software versions, uptime, and ID of the product.

Hostname:	tucor-nlp-controller
Id:	[redacted]
Uptime:	1121603
Time (UTC):	2024-01-02 18:53:51
Hardware version:	1
Software version:	214
Cu hardware version:	3
Cu software version:	122

7.2 Hostname

The hostname uniquely identifies the controller. Under the menu *System -> Hostname* you can create or edit this value. The maximum number of characters is 31, and the name is required.

7.3 Ethernet

Here you find all the settings related to your ethernet connection. If the mode is set to ‘dynamic’, IP, netmask, gateway, and DNS server will be provided by your in-house network router (or mobile internet provider?).

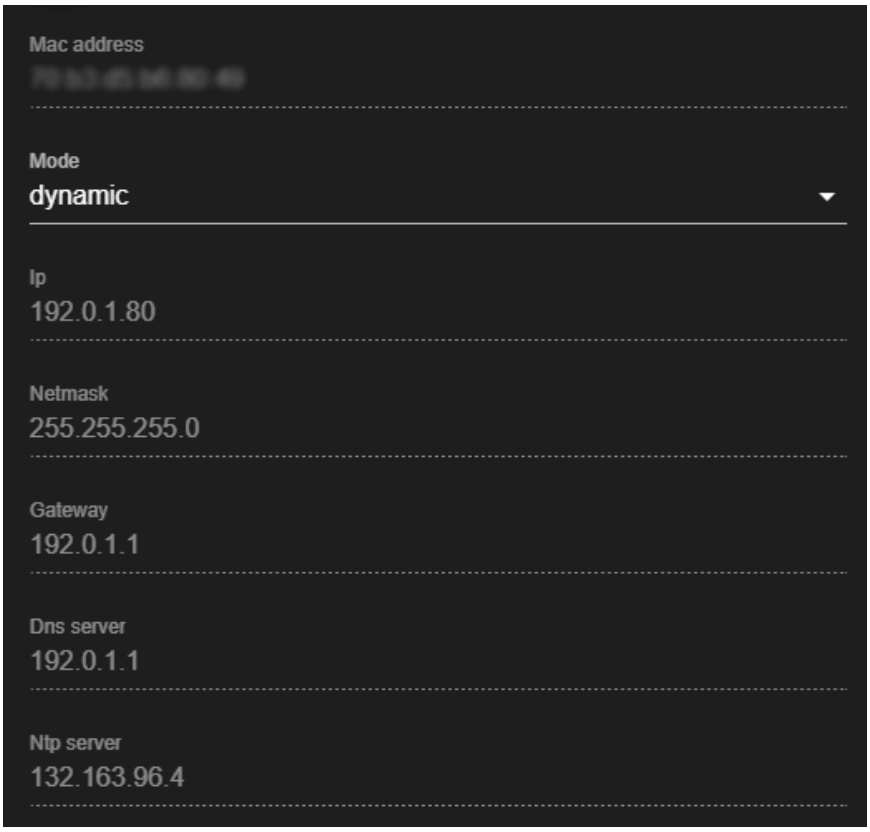
If the mode is set to static, you are required to provide that information for the Irrigation Controller to connect to a network. Consult with your network administrator for the correct values.

The NTP server IP address is optional and will auto-sync the controller clock with the chosen NTP server.

7.3.1 Creating/Editing an Ethernet connection

There are no separate ‘add’ or ‘edit’ functions for this section compared to other areas of the web interface. Set the Mode directly via the dropdown provided and fill out the other

fields in this form if necessary. Click ‘save’ when done.



IP

The IP Address of your Irrigation Controller’s ethernet interface. Either provided automatically by your network, or manually entered.

Netmask

The netmask is a 32-bit "mask" used to divide an IP address into subnets and specify the network's available hosts.

Netmask defines how "large" a network is or if you're configuring a rule that requires an IP address and a Netmask, the Netmask will signify to what range of the Network the rule will apply to.

Gateway

A gateway allows data to flow from one discrete network to another. It is defined here as an IP address of the gateway – for example between your company network and the internet. It is defined here as the IP address of the gateway itself.

DNS Server

DNS servers are responsible for translating domain names to numeric IP addresses, leading them to the correct server on the internet. This is often the job of your network’s

router or internet modem and may be the same IP address as your gateway or may be a preferred DNS service out on the internet itself.

NTP Server

The IP address for this service connects to either an internal or external Network Time Protocol (NTP) Server.

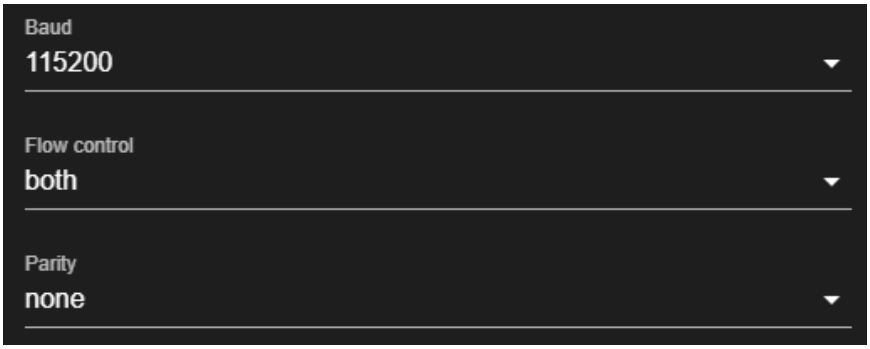
It allows the Irrigation Controller to be synchronized automatically within a few milliseconds of Coordinated Universal Time (UTC). The service runs automatically in the background.

7.4 Serial

This form allows you to define the Serial connection parameters for direct access to the NLP. A standard user should not adjust these settings.

7.4.1 Creating/Editing a Serial connection

There are no separate 'add' or 'edit' functions for this section compared to other areas of the web interface. Set the information directly via the dropdowns provided. Click 'save' when done.



Baud

The baud rate is the speed at which information is transferred across the serial communications port. It is measured in bits-per-second. The default value for the Irrigation Controller is 115200 bps.

You may need to change this value if the device (i.e., a laptop or dedicated serial device) connecting to the controller requires a different transfer speed to communicate.

Available baud rates are listed in the dropdown provided.

Flow control

Flow control is used to describe the method in which a serial interface controls the amount of data being transmitted to itself.

Select hardware control, software control, both, or none from the dropdown provided. The default is both.

Parity

Parity is used to validate the integrity of the data as a simple means of error detection. It can be set in the controller as either ‘even’ or ‘odd’ or ‘none’. ‘None’ is the default.

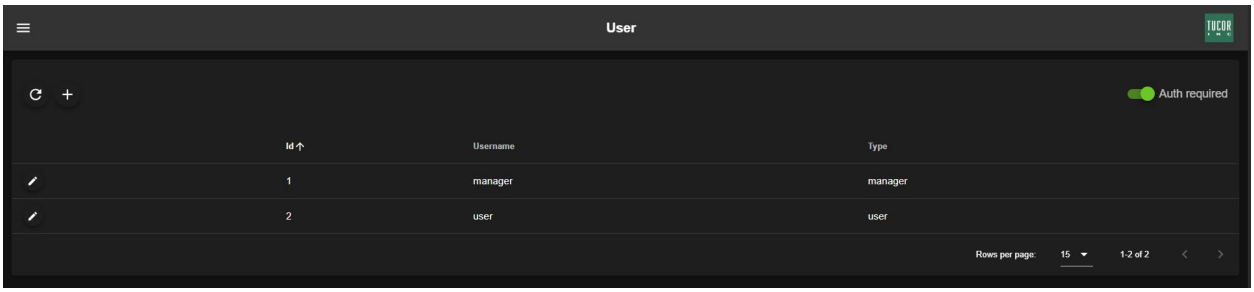
Set this only if the serial device attached is sending its data with a parity bit set.

7.5 User

The User section is used to create users and permissions for local use of the controller.

Add a user to a controller by pressing ‘plus’ icon + . After adding a local user, toggle ON ‘Auth required’ to require users that are accessing the controller locally to enter a username and password.

Edit an existing user or password by pressing the ‘pencil’ icon .



7.5.1 ID

ID is a system assigned read-only identifier.

7.5.2 Username

A name given to a person or persons to uniquely identify them on the controller. Must be 1-15 characters in length.

7.5.3 Password

A string of characters (letters, numbers, and other symbols) used to authenticate a user. Must be 1-15 characters in length.

7.5.4 Type

Type defines the user permissions. The two permission types are:

Manager

Full access to controller.

User

Limited controller access. Only the Dashboard and 2-Wire Test sections are available. Programs and Stations can be started or stopped but cannot be edited.

7.6 Log level

This determines the level of detail recorded in the Irrigation Controller's log system. Choose a level from the dropdown provided.

Debug

Logs all events listed as info, notice, warning, and error.

Info

Logs all information events plus notice, warning, and error.

Notice

Logs all notice events plus warning and error.

Warning

Logs all warning events plus error.

Error

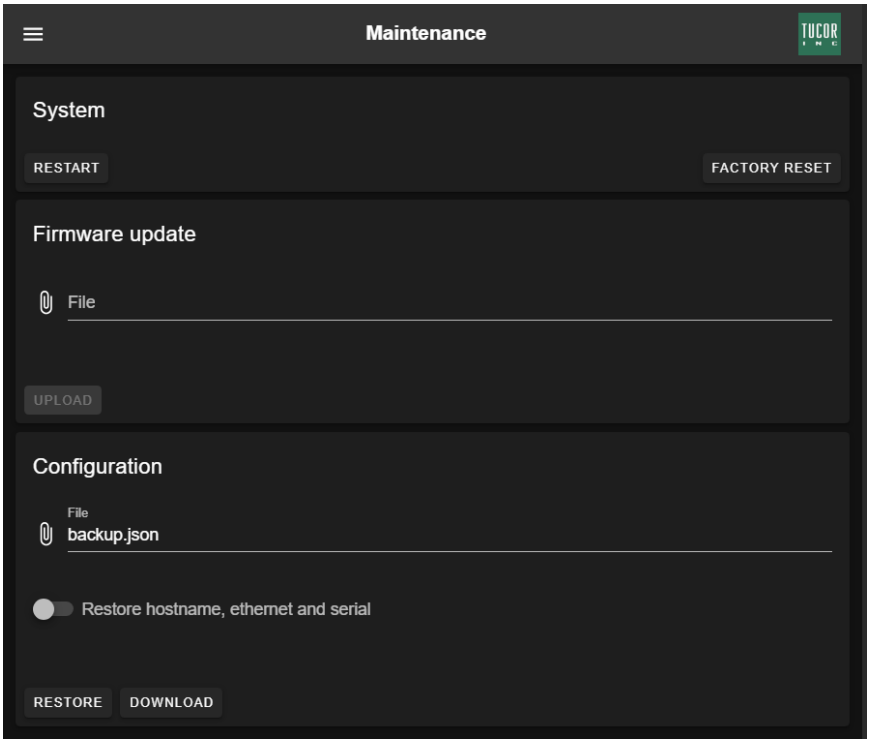
Logs all warning events.

7.7 Error codes

This is a list of currently generated error codes. You can also find them recorded in the log, or via the drop-down details section in the Station list of the Irrigation Controller. Refer to the appendix.

7.8 Maintenance

This section provides a method of uploading firmware or configuration files, as well as restarting the Irrigation controller or performing a factory reset.



7.8.1 System

Restart

Restarts the Irrigation Controller.

Factory Reset

Causes the Irrigation Controller to return to the firmware version and configuration that was set at the factory. ***This selection is never recommended unless directed by a Tucor representative.***

7.8.2 Firmware update

Clicking the File field will cause a file-manager window to pop up, allowing you to choose a firmware file to be uploaded.

7.8.3 Configuration

The Configuration section allows any NLPNet user at the “manager” or “admin” level to download controller back-ups.

Clicking the File field will cause a file-manager window to pop up, allowing you to choose a previously downloaded configuration file to be uploaded into the Irrigation Controller, over-writing the previous data in place.

Toggle ON the ‘Restore hostname, Ethernet, and serial’ button if you want to use the hostname, Ethernet, and serial settings in the configuration file. Otherwise, the current hostname, Ethernet, and serial settings will not be overwritten.

Once the file is selected, clicking the Restore button sends the file from your computer to the controller. After that procedure is complete, the controller should be restarted to load the new information.

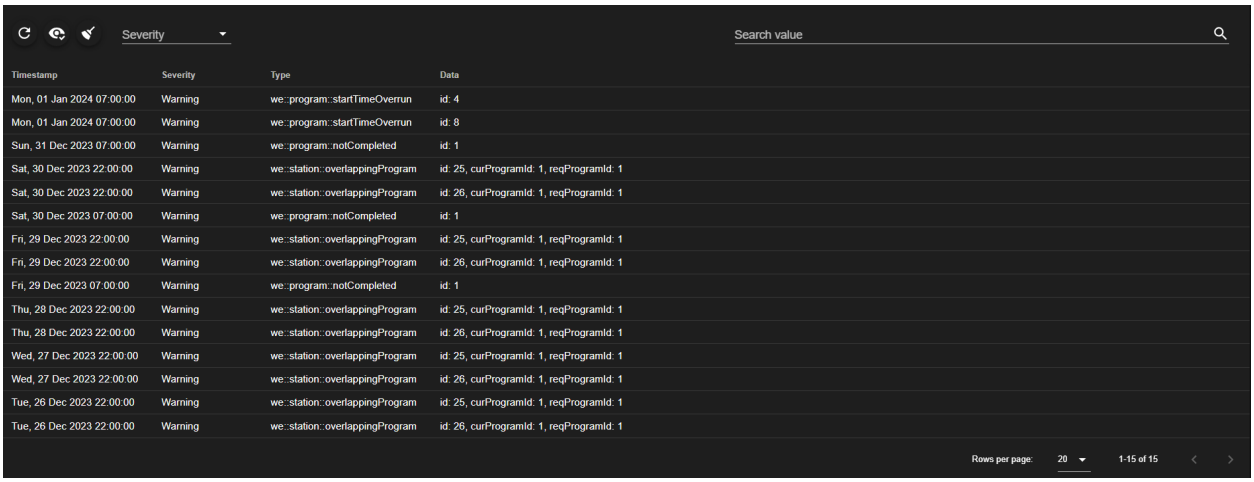
Clicking the Download button will download a .json file of the controller's current configuration. Note – this does not include server-only data, such as reports or user logs.

NOTE: This does not include server-only data, such as reports or user logs.

8 Log

The logging system holds a local 1000-line circular log.

The webpage *may* show more than 1000 lines. This is because when you refresh the log page, new log lines are added to the local data store kept in your browser rather than replacing data already available.



The log details contain a timestamp, Severity level, Type of log line (info, debug, etc.), and raw data from the system.

There are some controls for the log that are along the top of the page.

Refresh

Click the refresh button to refresh the log.

Reset Log Errors

To clear out any errors displayed in the log, click the eye button to clear them.

Clean log

To clear the log, click on the broom icon .

Severity Filter

Use this dropdown to filter out what level of information is displayed.

9 Language & Units

The controller webpages support various languages and can display values in different units accordingly.

10 Logout

A logout button is only available if you are accessing the controller through our SSL encrypted internet proxy. For this kind of access, a registered account is required. Logging out returns you to the login page.

When using the controller through a local connection, such as via a direct IP address connection, unless the Authorization Required toggle is enabled, there is no login or logout.

11 Appendix

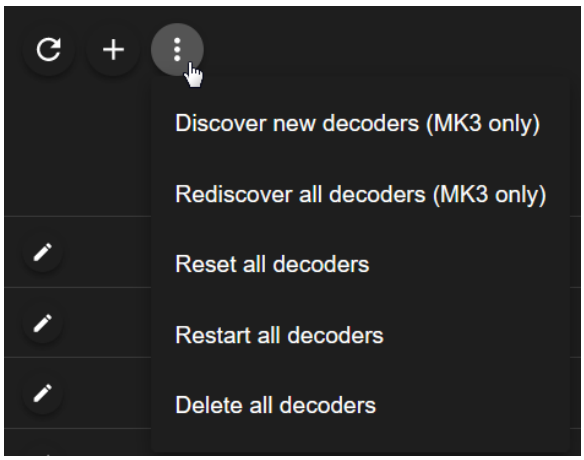
11.1 Setting Up Your First Irrigation Controller

Follow the following process to begin irrigating with your NLP. Any step listed as “Optional” has a default selection that can be modified later.

1. Add your 2-Wire decoder(s) under the “Decoders” Menu. This process can be skipped for MK3 decoders by selecting the “Discover new decoders (MK3 only)” button.

> ! **NOTE:** Decoders come with default switch code parameters as set in the “IO configuration” Menu. Tucor does not recommend adjusting the defaults.

   A. Select Type:
      i. MK3 = NG series or SD-110
      ii. Rk = RKLD-050- series decoders (RKD, RKD+ & LTD)
      iii. Ld = LD- series decoders (TWI, Procom)
      iv. Conventional Output – These are pre-configured by Tucor.



   B. Set the decoder address by either automatic discovery of new “NG-” or “SD-110” decoders, or manual addition of legacy decoders:
      i. LD-series: Enter the address found on the decoder label.
      ii. RKLD-series: Enter an address for the RKLD-050 by adding 10000 to the programmed station number. E.g.: RKD Station #1 would be address ‘10001’.
   C. Set the number of outputs for an output decoder or inputs for a sensor decoder.
2. Name the decoders in the “IO” menu. Use a reference you will remember, as you’ll be pairing this to a Station later in the process.
3. Define and name a Mainline.
   A. Set its flow capacity. At a minimum, set the expected system capacity for the “Main” pipe.
   B. Optionally add rules.
   C. Optionally add valves and pumps.

   D. Optionally add flow sensors.
4. Optional: Define and name a water reference. A default of 0 ET is set.
   A. Historic ET values, and
   B. Optionally linking it to online ET via Davis WeatherLink. If Historic ET values are established, they serve as a back-up reference if online data is not sent.
5. Optional: Define and name additional soil types.

   NOTE: Default soil types are set & can be modified. Adjustment may be needed for SD-110 depending upon sensor type. Please contact Tucor for assistance.

   To create custom soil types, you must know:
   A. Holding capacity.
   B. Wilting point.
   C. Intake rate.
   D. Maximum surface accumulation.
6. Optional: Define and name a plant. Default plant types are established. To add a new plant type, you must:
   A. Set which water reference to follow.

      NOTE: The “Default ET reference” is currently set to all plant types.

   B. Set a plant factor 100% to follow the water reference directly.
   C. Set an allowable depletion (% of scale from holding capacity to wilting point (soil properties). We recommend somewhere between 0-100% & a lower value than ‘refill-to’ point.
   D. Set ‘refill-to’ (% of scale from wilting point and holding capacity (soil properties). We recommend somewhere between 0-100% & a higher value than allowable depletion.
   E. Set a root zone depth.
7. Define and name a station group. At least one station group must be defined, but a station group can contain all stations.
   A. Set which schedule the group should follow.
   B. Set which plant is grown in the group.
   C. Optionally set the group priority for irrigation.
8. Add stations.
   A. Match the decoder “IO” to the corresponding station. It’s done by name, so be sure to use names you will remember for IO’s.
   B. Select the type. “Non-irrigating” is the simplest station to set-up & a station can be later modified to reflect more complex types. The following settings appear based on type:

i. Basic, MAD-type
    1. (Basic, MAD): Set a priority. 0 is the lowest.
    2. (Basic, MAD): Set to which group the station belongs. This implicitly defines a plant and an irrigation schedule.
    3. Set to which pipe section the station is connected.
    4. Set a precipitation rate for the sprinkler. Used to calculate how much water is applied.
    5. Set an expected flow for the station. Used to check water availability through pipes.

ii. MAD-only
    1. Set a soil. Implicitly defines wilting point, holding capacity, intake rate and allowed surface accumulation at this station.
    2. Optional: Set a landscape factor to correct ET for local conditions. The default is 100%.

9. Define and name a Program.
10. Define and name rules within the Program.
    A. Set dates, weekdays, odd/even when the rule applies,
    B. Set the time interval where irrigation can (or cannot) take place on scheduled days.
11. (MAD-Only) Set an initial soil moisture at each station.
    A. (Faster) Use the ‘set actual soil moisture % to’ with e.g., 50%, to start each station with ‘plant available water’ midway between wilting point and field capacity, or
    B. (More Precise) Set the soil moisture directly by changing the station’s ‘plant available water’.
12. Make sure everything is turned on.
    A. 2-Wire state is ‘On’.
    B. ‘Irrigation controller’ is set to ‘Auto’ mode.
    C. ‘Test Mode (no decoder activation)’ is off.

Your irrigation system is now live!

11.2 Troubleshooting

11.2.1 Error Codes

Error Code	Error	Source	Possible cause	What to do?
1000	2-Wire timeout	2WP	A command was sent on the 2-wire, but the decoder didn't respond.	Locate the decoder. Set system in short finding mode. Check the decoder draw current. If not, check for broken cable.
1001	2-Wire communication error	2WP IE	Communication with a decoder is disturbed. It could be bad connections which create noise.	Check the integrity of the 2WP by checking the current draw is as expected in short finding mode.
1002	2-Wire not operational	2WP	A command has been sent to a decoder when the 2-wire was not operational.	Check 2-wire status.
1003	2-Wire load too high	2WP	Too many active decoders, partial short of the 2-wire path, and/or faulty decoder.	Turn off several decoders if too many are active.
2000	Object not found	2WP IE	An object doesn't exist. It could be a station with a reference to a decoder, which has been deleted.	Check that the station, decoder, and IO are configured correctly.
2001	Object exists	2WP IE	Trying to create a duplicate.	Check for duplicates.
3000	Decoder failure detected	2WP	The verification of a command indicates an error. The error is followed by additional information.	Try again. If problem persists, check decoder and 2WP connections.
3001	Decoder non acknowledge	2WP	The command to a decoder was not accepted. E.g. an ON command to an output decoder already ON.	Try again. Perform the opposite action & try again. Disable 'verify' and/or enable 'force'.
5000	IO config not found	2WP IE	An IO config doesn't exist. It could be a decoder with a reference to an IO config, which has been deleted or changed.	Check that the IO config exists. Try reapplying the IO config to the decoder.

5001	Flow capacity too low	IE	A part of the hydraulic system has too low capacity compared to the expected flow requested by a station start.	Check station flow rate, pipe capacity, and flow sensor config.
6001	Value not measured	2WP	The diagnostic value was not measured in the decoder. Could be due to issues activating a solenoid.	Check solenoid & decoder. If problem persists, replace solenoid and/or decoder.
7000	Flow verify timeout	IE	Didn't manage to find a stable flow within the stable count and stable max minutes.	Check flow config. Try later when flow is more stable.
7001	Flow learn timeout	IE	Didn't manage to find a stable flow within the stable count and stable max minutes.	Check flow config. Try later when flow is more stable.
7002	Flow too low	IE	Flow is less than expected minus "Max low deviation (%)" after the start delay and change delay respectively.	Check station flow rate, pipe capacity, and flow config. Check for clogs.
7003	Flow too high	IE	Flow is more than expected plus "Max high deviation (%)" after the start delay and change delay respectively.	Check station flow rate, pipe capacity, and flow config. Check for leaks.

2WP: 2-Wire Path IE: Irrigation Engine

11.2.2 Testing Programs

The easiest way to test whether a program is running correctly, meaning it activates the correct decoders, master valves, and booster pump relays, is to run the program manually.

If you don't want to wait for the entire program just to see that everything activates in the right order, you can decrease the water budget to 1% before running the program.

11.2.3 Testing the 2-Wire Path

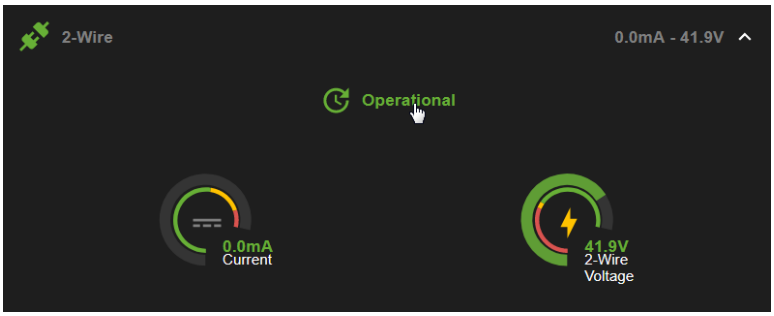
When in AUTO or MANUAL mode, the first indication that you might have a short or a fault somewhere on the 2-Wire path is that the line activity indicators will not be lit at all. Typically, a short circuit in the field is either a problem with the 2-Wire itself (cracks in the insulation, bad connections, etc.) or consequences of lightning striking the system, damaging decoders, solenoids, or other electronics attached to the 2-Wire.

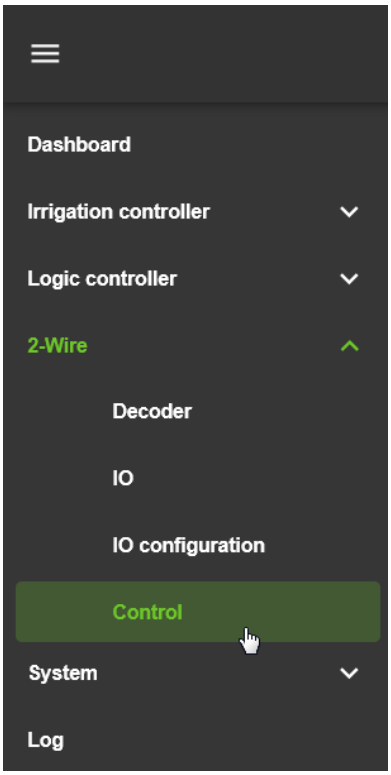
If the leak is severe (current >800mA), the 2-Wire LEDs will turn off due to the loss of voltage – this is a built-in security mechanism that prevents the controller from short circuiting however, a small amount of current will still be running on the 2-Wire path.

Short Finding

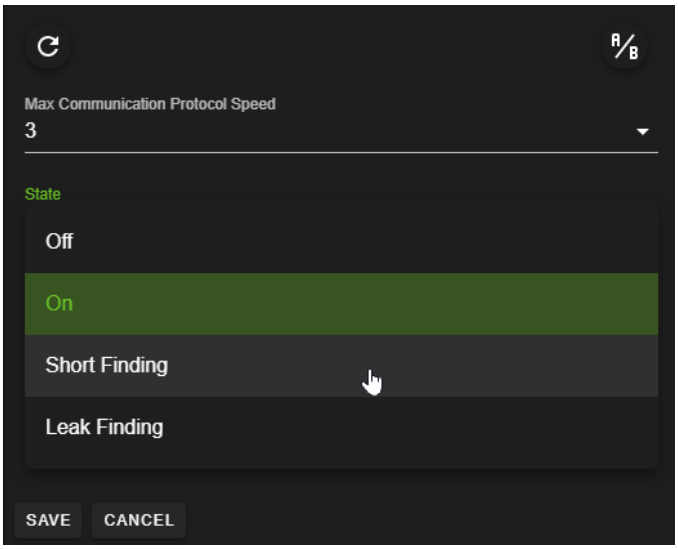
If you suspect your system to have a short somewhere in the field, you can validate your suspicion by using the built-in short finding test in the controller. Short Finding toggles the 2-wire path out-of-phase, letting the decoders draw current such that it can be read with a clamp meter.

1. From the dashboard, either extend the 2-Wire status section and click on the status OR extend the 2-Wire section in the left menu bar and open the control menu.

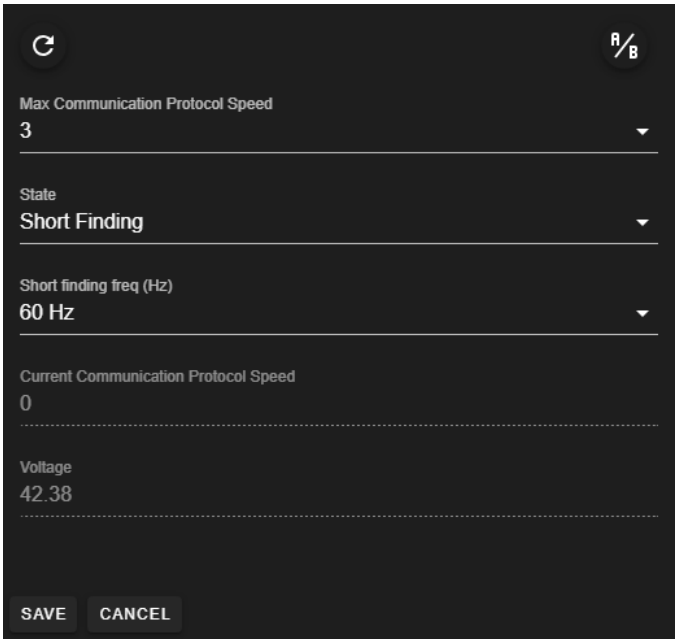




2. Click on the “State” dropdown menu and select “Short Finding”.



3. Set the short finding frequency to 60 Hz and click the save button.



4. Set your clampmeter to read AC milliamps (~mA) and ‘50/60Hz’ or ‘LPF’ mode.
5. At the controller, place the clampmeter around the red wire of the 2-Wire path and note the reading.
6. Remove the clampmeter from the red wire, place around the black wire, and note the reading. The wire with the higher reading, even if only slightly higher, will be the wire you follow into the field. If both wires gave a similar reading, you may have a leak to ground – see the next section on leak finding.

7. Go to the middle point of your 2-Wire path (halfway between the controller and further controller) and place your clampmeter around the wire that had the higher reading at the controller. If the measurement on the clampmeter is substantially lower than what you measured at the controller, you have passed where the short is located.

Leak Finding

If you suspect your system to have a leak to ground, you can validate your suspicion by using the built-in leak finding test. Leak Finding toggles the 2-wire in-phase, shutting the decoders down so they aren't consuming any current and any leak current can be read with a clampmeter.

Leaks >20mA system-wide or large differences between Red/Black wire measurements should be resolved. Complete the same process for finding a Leak as described in *Short Finding.*

11.3 Abbreviations & Acronyms

A	Area
AC	Alternating Current
AD	Allowable Depletion
DC	Direct Current
dL	Deciliter (1/10th of a liter)
EF	Expected Flow
ET	Evapotranspiration
gal	Gallon(s)
GPH, gph	Gallons per hour
GPM, gpm	Gallons per minute
HC	Holding Capacity
IE	Irrigation Engine
in, “	Inch(es)
in/h	Inch(es) per hour
L	Liters
LE	Logic Engine
lpm, l/m	Liters per minute
MAD	Management Allowed Depletion
mA	Milliamp(s)
mH	Millihenries
min, mins	Minute(s)
mm	Millimeter(s)
mS, mSec	Millisecond(s)
mV	Millivolt(s)
PAW	Plant Available Water
PR	Precipitation Rate
RT	Refill-To
RZ	Root Zone
SA	Surface Accumulation
sec, secs	Second(s)
WE	Water Engine
WP	Wilting Point
WR	Water Required

11.4 Formulas

PR = EF / A	Precipitation rate (PR) = Expected flow (EF) / the area (A) covered by the station.
ASP = (GP * 255) + SP	Actual station priority = (Group priority * 255) + Station priority

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2/19/2024