



User Guide

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Introduction

TestWater uses your test results to calculate the Langelier Saturation Index using complex mathematical analysis rather than league tables to improve accuracy and display the results visually in customised reports designed by your local poolshop. TestWater performs Qualitative and Quantitative analysis of information based on rules that apply to selected options and values.

Rules can be produced by any licenced publisher and are available in the application using our automatic updating feature.

TestWater is different to other programs in that we are not trying to sell you chemicals and we are not trying to tell you the right way to balance your water instead we are providing a way for poolshops around the world to assist you in the testing of your water providing you with accurate balanced advice.

Do you have a suggestion for TestWater? Let us know.



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Installation

TestWater is designed for Windows 7/8 or 2008 x86 machines. It does not support Windows RT.

Windows 8 may attempt to block the installation, press "more info" and "run anyway" if you see this message. Our application is tested to be clean from advertising, malware and spyware.

It will operate on older windows operating systems if .NET Framework 4.5 is installed.

TestWater is automatically installed and updated using our online installer. This will install TestWater in your start menu. Every time you start TestWater the application will check for updates if an internet connection is available.



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TestWater Personal

Getting started with TestWater is easy. Simply install and go in 4 easy steps.

Getting Started

Download Testwater

You can start TestWater from the website (www.testwater.com.au)

Once installed you can also start TestWater from the start menu.

When you start the application it will check for updates and automatically install them if required.

My Details

Press the yellow My Details button to complete your contact details so professionals you communicate with can respond to you.



The screenshot shows a dialog box titled "User Details" with a close button (X) in the top right corner. It contains four text input fields:

- Name:** Christian Dunn
- Address:** 6 Bidgee Rd Ryde
- Phone:** 0413117955
- Email:** chris@chrisdunn.name

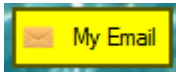
At the bottom of the dialog box are two buttons: "OK" and "Cancel".

My Email

Press the yellow My Email button to complete your email details so you can email professionals.



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Choose your email vendor and the program will prepopulate the essential information. Simply update your email and password and you can even send a test to yourself to confirm.

Email

Custom Outlook.com Hotmail.com Live.com Gmail.com Yahoo

Email Address myname@gmail.com

Mail Server smtp.gmail.com

Use SSL **Port** 25

Username (optional) myname@gmail.com

Password (optional) *****

Subject TestWater - Your test results!

Email CC

Test **TO:**

OK Cancel

My Rules

Press the yellow My Rules button to choose your testing rules.

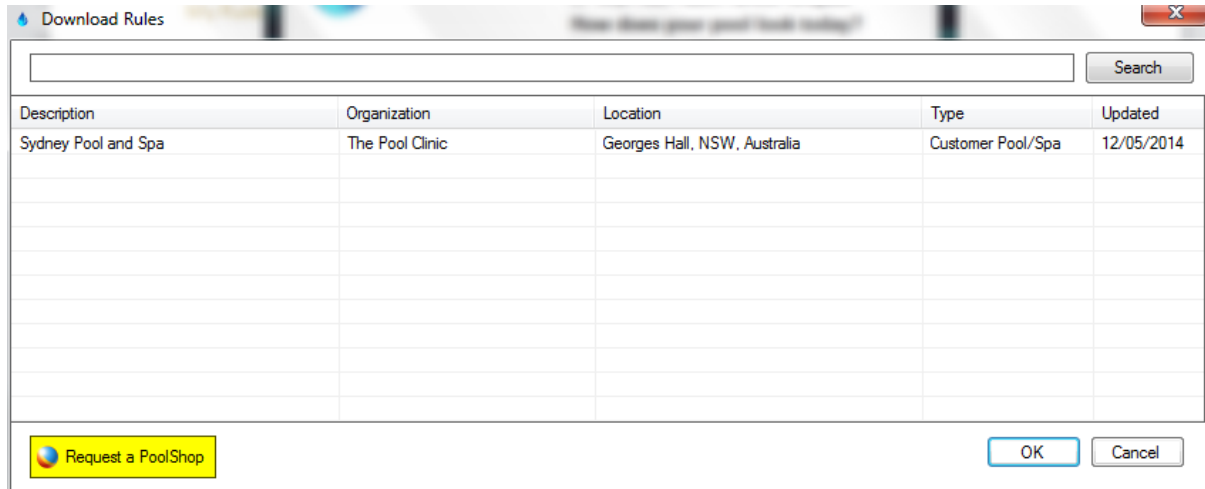


You can change or update your rules any time. TestWater uses rules to generate a useful report. The sample rules included only provide a basic summary of the water and not a detailed analysis so it is recommended to download a set of rules from a poolshop to get your started.

In the wizard simply select the appropriate rules and press OK.



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You can search by any criteria using the search bar.

If you would like your poolshop to be listed press the Request a PoolShop button and complete our online submission form.

Congratulations you are ready to start Testing!




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Running your first test

Fill in your test results

Complete all fields on the screen. The more information you provide the better results you will get.

The screenshot shows the TestWater application window. On the left, under 'Your measurements', there are input boxes for Cl (ppm) [1], pH [7.6], Alkalinity (ppm) [150], TDS (ppm) [350], Ca Hardness (ppm) [200], Temp (C) [18], Cyanuric (ppm) [100], Pool Size (L) [50000], and Running Time (Hrs) [8]. On the right, there are three sections: 'What is the surface of your pool?' with radio buttons for Concrete/Marblesheen/Pebblecrete/Aggregate (selected) and Vinyl/Tiles/Plastic/Painted/Fibreglass; 'How does your pool look today?' with checkboxes for Clear (checked), Cloudy, Leafy, Dirty, Stained, Bright Green, Green, Brown, and Black; and 'Which equipment do you have?' with checkboxes for Salt Chlorinator (checked), Sand Filter (checked), Liquid Cl Feeder, Pool Cleaner, Copper Ioniser, Cartridge/D.E. Filter, and Acid Feeder. Below these is a 'Notes' field containing 'my pool looks good today' and a button to add more notes. At the bottom, there is a 'Langelier Saturation Index (LSI)' section with a slider from 'Corrosive' to 'Scaling' and a 'Test' button. A 'Database' button is also present. The bottom navigation bar includes icons for help, settings, 'My Details', 'My Email', 'My Rules', and a 'Clear' button.

You can enter any additional notes you require. The  button enables you to add additional notes.

Once complete press the  button to run the test.

Within a few seconds you will see your LSI.

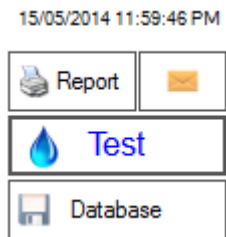
The screenshot shows the 'Langelier Saturation Index (LSI)' section. The LSI value is 0, displayed in a green box. Below the value is a horizontal slider with 'Corrosive' on the left, 'Balanced' in the middle, and 'Scaling' on the right. The slider is positioned at the 'Balanced' mark.




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An LSI of 0 is perfectly balance. An LSI between -0.3 and +0.3 is considered acceptable.

Some new options will now appear.




You can see the time and date the test was run.

Press the  button to see in your web browser your test report customised by the pool shop you selected under My Rules.

If you wish to test using a different poolshop use the My Rules button to select the new rules and press the Test button again to rerun your tests.

Emailing your test results

If you want to send your test report to your selected poolshop for review or to any other email address press the  button.

In this window you can enter a personal message and select or enter the appropriate email address.

The Pool Clinic (Richard Dunn) poolcli

TO: poolclinic@poolclinic.com.au

Subject: TestWater - Your test results!

Message: Can you please verify my results?
Christian

Your test results will be sent with this email message

Email Cancel

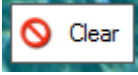
You do not need to enter your contact details as they are automatically included in the report.

Once your email is sent you will be returned to the main screen.

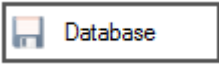


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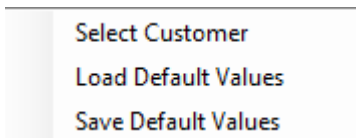
Clearing your test results

If you wish to clear all test data from the screen press the  button.

Saving your test results

If you want to save your test results press the  button.

A menu will appear.

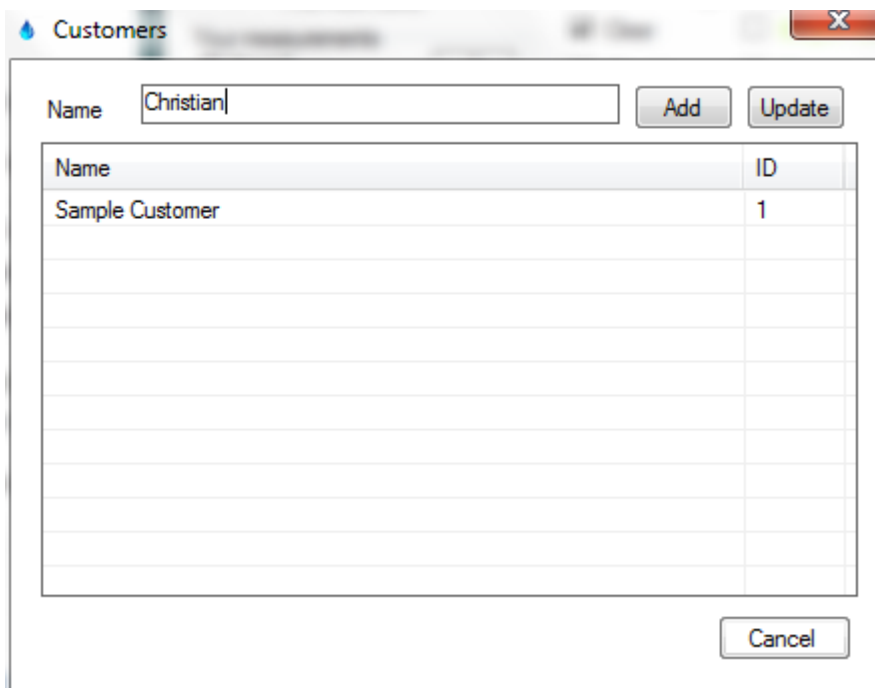


You can use the Save Default Values to save your current test data as the default which you can Load in the future to save you re-entering the basic information.

To save the current test results use the Select Customer Option.

Enter your name and press Add.

If you wish to correct an entry, select it, retype in the correct name and press Update.



Double click your name to see your test results.



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Date	Name	ID
1/12/2013 8:51:59 PM	Sample Test	1

Enter the name of your test and press Save Test to save it.

Double click any test to open it.

When you open a test you can instantly view the report you created previously without having to rerun your test.

When finished testing press the Exit button to close the program



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TestWater Professional

The Professional features of TestWater are designed for water testing professionals and pool shops to configure their own rules and reports.


It is free to access and use all features however unlicensed users are limited to creating a maximum of 50 rules and only running rules created by other users.

Users licensed as Creators can create and save rules as drafts that only they can run.

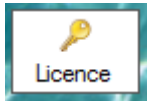
Users licensed as Publishers can create and save rules that other users can run.

Getting Started



Press the  button to access the Professional settings.

Licence the program



Press  to enter and validate your licence in the Licence Window.

Once licensed the appropriate features will become available.

Creators can save draft rule sets up to their allowed number of rules. They can open and edit these rules anytime. These rules cannot be shared with other users. This is designed for pool servicemen or poolshops looking for a single user testing application for in house usage.

Publishers can create published versions of rules which can be run by any user of TestWater but cannot be edited and are secured.

Creating Rules

When creating a new set of rules you will initially be restricted to the default 50 rule maximum. To override this insert the special rules for licencing in the order they appear in the function menu. These


The Professional Window



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Order	Name
00001	**AUTHOR
00002	**INFORMATION
00003	**RULESNAME
00004	**COMPANY
00005	**WEBSITE
00006	**LICENCE
00007	**LOGO
00008	**EMAIL
00009	Header
00010	Perfect Pool
00011	Not Perfect Pool
00012	Low LSI
00013	Great LSI
00014	High LSI

The summary information related to the current rules will appear at the top of the program.

By default you will see the rules you have currently loaded. If these are not your rules you cannot modify them. To get started modifying rules you can press  to start with blank rules.

Alternatively you can press  to load the sample rules which are editable.

Creator and Publisher users can use the  button to load a rules file.

When working with licenced Draft rules a Save button will appear to save them. When working with licenced Published rules a Publish button will appear to save them.

Sorting and using rules

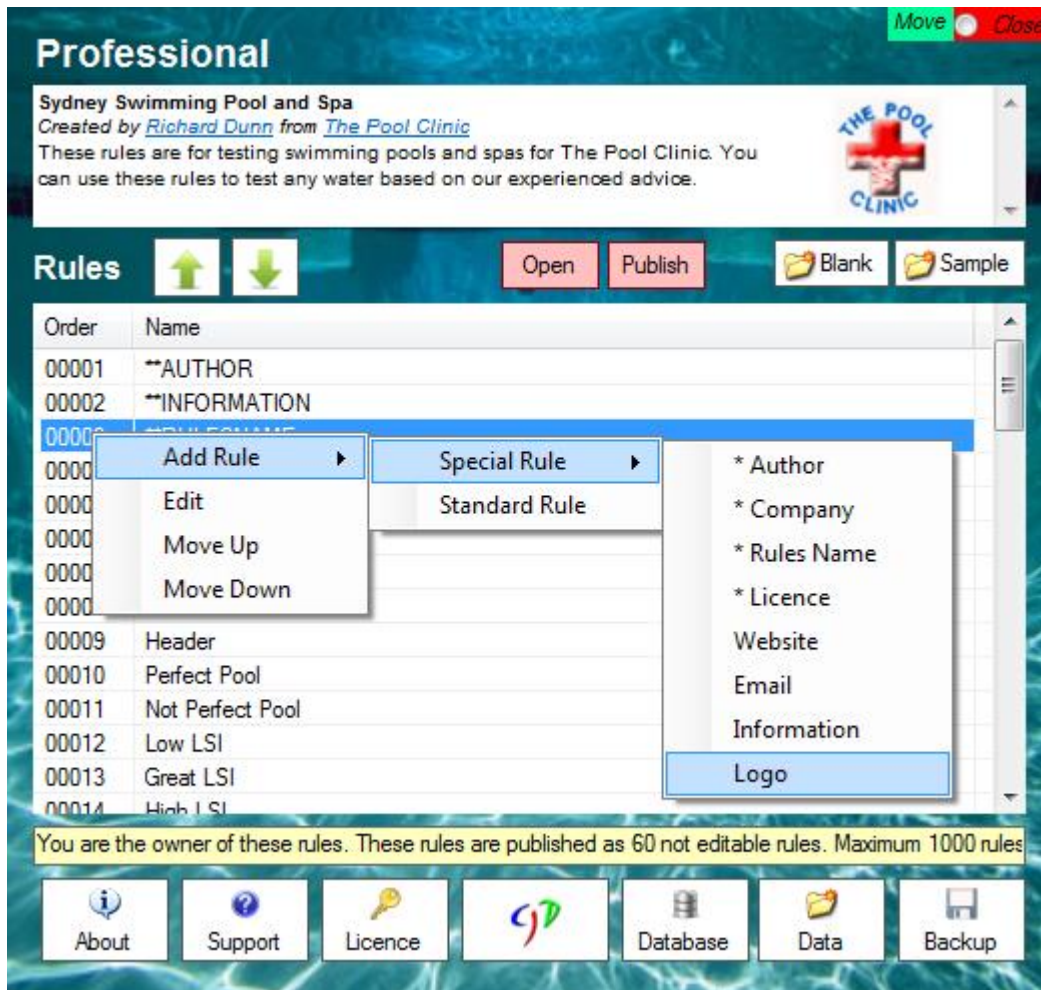


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Rules are sorted and processed in order. The order of rules can be adjusted using the **green arrows**.

Special rules are designated with "***". These should be run before other rules and provide additional information regarding your rules. These also provide the summary information for the rules.

Right clicking in the rules window opens the rules editing menu.



Double clicking on a rule, or right clicking and choosing **Edit** will open the rule. This will open the **Rules Editor Window**.

A **Special rule** is a rule used for licencing the rules or for providing summary or report information for publishing rules. Information in these special rules can be inserted into your report as parameters.

A **Standard Rule** is a rule for testing water using a test based on values entered to generate html data for the report.

The **About** button provides application information.

The **Support** button opens the TestWater support website.



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The **Licence** button allows you to configure your licencing.

The **CJD** button opens the developer website.

The **Database** button allows you to relocate the application testing database.

The **Data** button opens the user data folder.

The **Backup** button backs up all user data to a specified location. This includes the testing database.

Licencing your rules

When creating a new set of rules you will initially be restricted to the default 50 rule maximum. To override this insert the special rules for licencing in the order they appear in the function menu. These rules provide the summary information to inform users the purpose of your rules and are also used to encrypt your rules so they cannot be modified by other users. Once all **'**'** rules are added you will be able to create more rules and save this set as a draft. The program automatically remembers the loaded rules each time you use it but you will want to save regular draft copies so you can have backups in case you make a mistake. You need to insert the draft licence in the licence rule to save as a draft.

Insert the marked **'**'** special rules for licencing in the order they appear in the menu.

The Licence rule will offer two options, one for a Draft Licence and one for a Publish Licence.

To being using Draft rules insert the **Draft Licence** in the Licence rule. The program automatically remembers the loaded rules each time you use it but you will want to save regular draft copies so you can have backups in case you make a mistake. You need to insert the draft licence in the licence rule to save as a draft. You can edit draft rules and add additional rules.

To Publish your rules, edit the Licence rule and insert the **Publish** Licence. You can then use the Publish button to save them. You cannot add new rules to published rules. To change these back to a draft simply edit the licence rule.

Special Rules

A **Special rule** is a rule used for licencing the rules or for providing summary or report information for publishing rules. Information in these special rules can be inserted into your report as parameters.

Rules denoted with a **'**'** are mandatory for licencing and should be added in order. Ideally these should be the first rules in the rules list. The *Author*, *Company* and *Rules Name* are validated by the *Licence* which is then validated against the licence on the current computer. These values are populated from your licence upon creating the rule.

The *Website*, *Email*, *Information* and *Logo* rules are used to create the Rules Summary and as reference values to enter in your reports.



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The *Website* rule allows you to store your website URL.

The *Email* rule allows you to store your email address.

The *Information* rule allows you to create a custom description of your rules.

The *Logo* rule allows you to store a URL to an image logo for reports.

Publishing Rules

Licensed Publishers can have their rules added to the inbuilt My Rules feature.

Published rules will export to a .rules files (e.g. testwater.rules).

To add this file to the automatic download portal send this rule to chris@chrisdunn.name.

Rules Editor Window

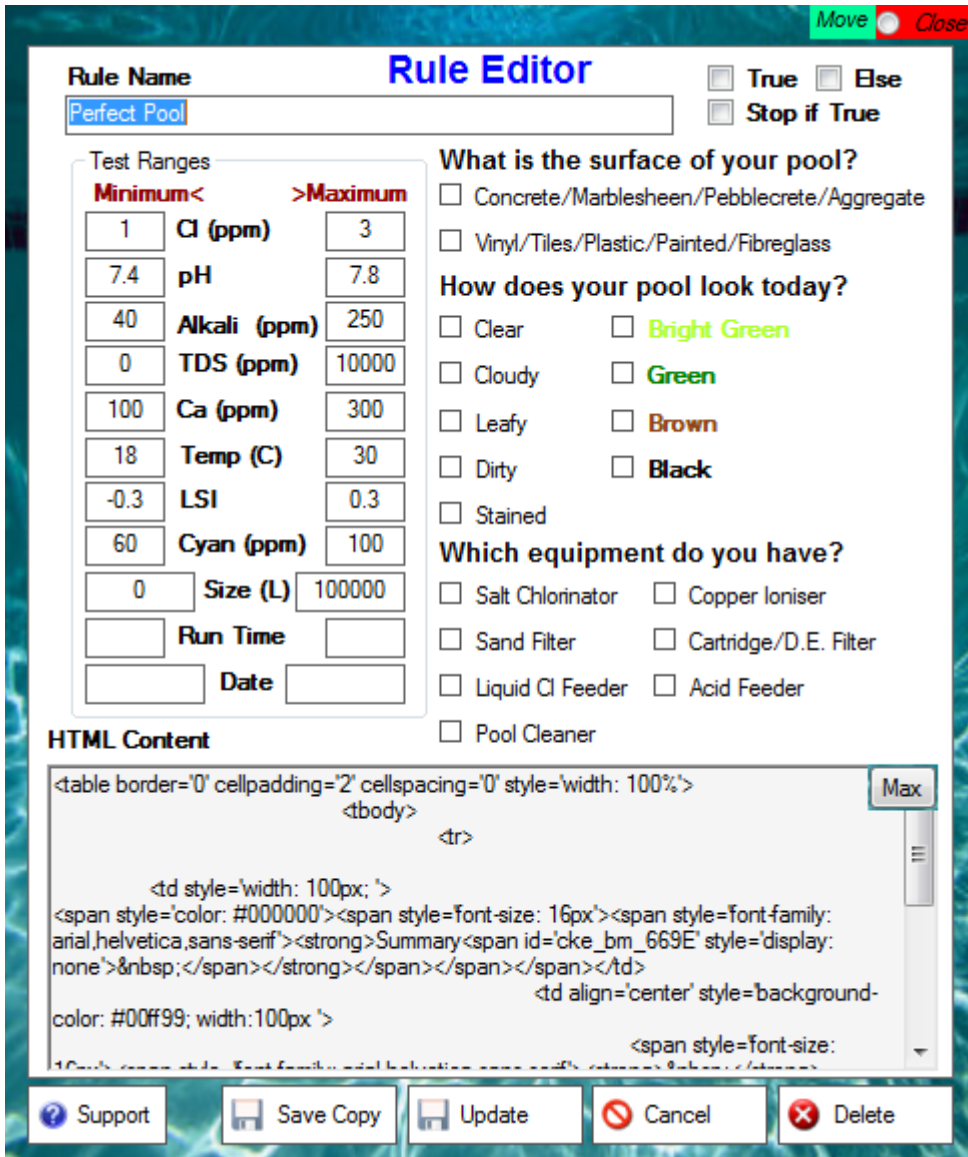
This window allows you to create and edit rules.

Rules are created with standard HTML content. By default you can enter text or results and they will appear in the report in the same order as the rules. To improve your content or add images you can use HTML and even Javascript to add better form and functionality. Any web designer can create fantastic looking reports. These can even be done in the same style as your website.

If you are not a web designer you can easily create good looking HTML using a web editor such as <http://htmleditor.in/index.html>. Simply create your HTML content in the web designer then click 'Source'. Copy and paste all the content between <body> and </body> into the content section of the TestWater rules editor.



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All Rules must have a unique **Rule Name**.

Rules are used to generate report content based on the test data. If a rule is true the HTML content is inserted in the report.

In the top right corner there are three additional rules features.

True forces a rule to be true without checking values allowing rules for formatting or headings to be created for your report.

Else forces a rule to be true if it is false. This allows you to test for values outside a range.

Stop if true will stop processing all further report rules if true. This allows you to have conditional stops in the report depending on values entered.

All Quantitative values have *minimum* and *maximum* operators. If a minimum is set then all values greater than this value are true. If a maximum is set then all values below this value are true. If both



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values are set then values inside this range are true. If **Else** is selected and both values are set then values outside of the range are true.

All Qualitative values are checkboxes. These can be used in conjunction with other variables. If a value is checked it is true if the customer also checked this value. If **Else** is selected and a value is checked then it is false if the customer also checked this value.

The **Date** values can be used to specify when a rule should be run. This can be ideal for configuring promotions on products or seasonal changes to your reports. Dates should be entered in the local regional format. Usually dd/mm/yyyy or mm/dd/yyyy.

Right clicking in the rules editor brings up the **Function Menu** to insert common functions. As the report engine uses standard html there are many more functions available.

Save a Copy allows you to create a new rule from an existing rule. This is great for creating an 'else' rule for reports. You must rename the rule before pressing the Save a Copy button to create a new rule with this name.

Function Menu

Right clicking in the editing window opens the function menu.

Edit

Cut allows you to cut the selected text from the editor to the clipboard.

Copy allows you to copy the selected text from the editor to the clipboard.

Paste allows you to copy text from the clipboard to the editor.

Insert Test Value

From this menu you can insert all quantitative values into report content or use them in calculations.

Calculation

Calculations are javascript functions that allow you to perform a mathematical calculation in your report. This means you can calculate the correct dosage of chemicals to be added.

When you insert a calculation you get the basic function below:

```
<SCRIPT Type="Text/javascript">document.write(Math.round([POOLSIZE] / 10000));</SCRIPT>
```

I have highlighted the function that you can edit to change the value shown in the report.

In the example I am dividing [POOLSIZE] (the test value for the size of the pool) by 10000.

I am then using Math.round to round this value to the nearest integer to make it simpler.



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This example shows a slightly more complex calculation for dosing. This script calculates how for every 1000L of water in the pool we need to add 5grams of chemical to reduce the PH by 1 to get to the required level of 7.2

```
<SCRIPT Type='text/javascript'>document.write (Math.round([POOLSIZE]/1000 * 5 * ([PH]-7.2));</SCRIPT>
```

IF the PH is 8 and the poolsize is 50000 litres then this equates to: $50000/1000 * 5 * (0.8)$.

This means that where we need 5 grams to reduce the Ph by 1 we only need to reduce it by 0.8 so $5 * 0.8 = 4$. So we need 4 grams for every 1000 litres. As there are 50 of these then we need 200 grams of chemical.

The sample code rounds the result to an integer using 'Math.round'.

There are many other possible functions you can use here which I have listed below:

function	Meaning (returns ..)
abs(x)	the absolute value of x
ceil(x)	the nearest integer greater than or equal to x
cos(x)	the cosine of x
exp(x)	the value of E raised to the power of x
floor(x)	the nearest integer less than or equal to x
log(x)	natural log of x
max(x,y)	the number with the highest value of x and y
min(x,y)	the number with the lowest value of x and y
pow(x,y)	the value of the number x raised to the power of y
random()	a random number between 0 and 1
round(x)	x rounded to the nearest integer
sin(x)	the sine of x
sqrt(x)	the square root of x
tan(x)	the tangent of x

Insert Data

This menu allows you to insert identified user data or preformatted text into the report.

The *Test Log* inserts preformatted detailed log information for diagnostic purposes.

The *Licence* information inserts preformatted licence information for diagnostic purposes.



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Insert HTML

This menu inserts common HTML functions. Reports are generated in standard browser independent HTML so all HTML commands can be used. It is important to test in multiple browsers if using complex HTML code to ensure compatibility.

Insert Special Rule

This menu inserts the special rule data (if entered) as parameters into your report content.



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Creating Rules

The Report Engine processes the data the user enters against each rule in order. HTML content is generated for each true rule sequentially generating the report.

This means instead of using one rule with lots of code to generate a table of test results, for example, you could have this table dynamically generated and change formatting or data based on results.

To get start you need to know basic HTML.

HyperText Markup Language or HTML is a plain text way of explaining or defining a web page. All elements should have a start or a stop. Some elements can have a start and stop built in.

Consider some **bold** text.

In HTML this would be:

Consider some `bold` text.

The bold section is defined by a start `` tag and ended with a `` tag.

Some attributes such as a new line `
` have the end tag built into the start tag.

That's it.

Let's look at something more complex. A table.

On paper this may look like:

```
-----  
| 1 | 2 |  
-----  
| 3 | 4 |  
-----
```

In HTML we use the following tags:

Table `<table></table>`

Row `<tr></tr>`

Cell `<td></td>`

The above table would appear as:

```
<table>  
<tr><td>1</td><td>2</td></tr>  
<tr><td>3</td><td>4</td></tr>  
</table>
```

Say we want to make this table show results i.e.

```
<table>  
<tr><td>PH</td><td>[PH]</td></tr>  
<tr><td>Cl</td><td>[Cl]</td></tr>  
</table>
```

This could be inserted in one rule or broken into many rules.

To make a dynamic table in rules the trick is two duplicate each rule. Create two identical rules but for one of them select the ELSE option or create a high and low rule as below. This will provide two options, 1 for true and 1 for false. Based on the test results only one will ever appear in the report.

Here is an example.

We had this static code:

```
<table>  
<tr><td>PH</td><td>[PH]</td></tr>  
<tr><td>Cl</td><td>[Cl]</td></tr>
```



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</table>

Let's break it into rules

RULE 1

Name: Header

Condition: TRUE

Content: <table>

RULE 2

Name: High PH

Condition: PH minimum 7.6

Content: <tr><td>PH</td><td>Your PH of [PH] is high.</td></tr>

RULE 3

Name: Low PH

Condition PH maximum 7.0

Content: <tr><td>PH</td><td>Your PH of [PH] is low.</td></tr>

RULE 4

Name: Footer

Condition: TRUE

Content: </table>

Now we have dynamic results. Remember to also add a rule for correct PH.

You can even get more advanced and color each cell, row or text based on the result.



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Calculations

Calculations allow you to accurately calculate the correct dosage of chemicals for your customers. This functionality is currently provided using javascript coding in the HTML report.

Users in the United States may like to use the calculations in this link in their rules. Many of these equations could be easily calculated based on user test data within TestWater.

<http://www.poolgeniusnetwork.com/m/blogpost?id=2303543%3ABlogPost%3A521369>

TDS is a funny value. It is a measure of salt in the water based on conductivity but it actually varies by calibration. In the United States meters are calibrated for measuring conductivity of Calcium Carbonates in the water while in Australia we measure for Sodium Chloride (table salt).

The recommended salt level for a pool with a salt chlorinator is 4000 - 6000 ppm. This would be stored in the TDS value box in TestWater. A rule to test this should also select salt chlorinator to confirm this is not a user in an area with very hard water.

In a pool with a salt chlorinator I usually recommend 1 bag of salt in a 50 000 litre pool for every 700ppm increase in salt.

I am going to convert this to a formula for salt required for use in TestWater.

If I warn at 5000 ppm that a user needs salt (give some allowance) I need to create a rule with the following values selected:

* TDS maximum 5000

* Salt Chlorinator (CHECKED)

My calculations would then be determined like this.

$(6000 - [TDS]) / 700 =$ bags of salt needed to raise TDS to correct salt level in a 50000 litre pool.

$[POOLSIZE] / 50000 =$ number of 50000 litre pools in the current pool.

The Final calculation should look like:

$\text{Math.round}((6000 - [TDS]) / 700 * ([POOLSIZE] / 50000))$

The code to display this could look like:

Your Pool Requires Salt. It is recommended you add

`<SCRIPT TYPE="text/javascript">document.write(Math.round((6000-[TDS])/700 * ([POOLSIZE]/50000)));</SCRIPT>`

bags of salt to your pool. Please remember to add salt on steps and landings in the pool and disable automatic pool cleaners until dissolved.



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The Langelier Saturation Index

The Langelier Saturation Index (LSI) is the most accurate way to balance water.

Here is Wikipedia's explanation of the Langelier Saturation Index - http://en.wikipedia.org/wiki/Langelier_Saturation_Index

TestWater calculates the LSI as it is an accepted standard in water testing however this value does not need to be used in reports.

LSI is based on three key components Alkalinity, PH and Hardness. An equilibrium should occur naturally in water for these three values. This equilibrium decides whether the water is prone to scaling or corrosion or is perfectly balanced.

The LSI calculations heavily weigh PH in favor of other values. Modifying the PH is the one value that has the most (almost direct) impact on the LSI.

Calculating LSI

The formula to calculate the Langelier Saturation Index is:

$$LSI = pH - pH_s$$

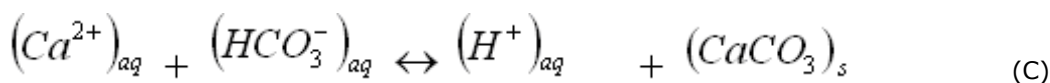
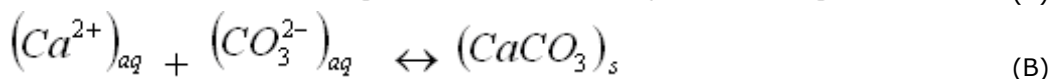
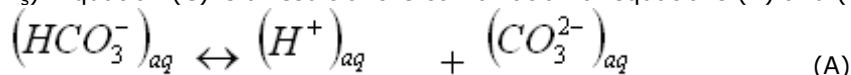
where:

LSI Langelier Saturation Index

pH_s saturation pH

pH pH value

The pH of a solution is usually known. Equations (A), (B) and (C) are used to compute the saturation pH (*pH_s*). Equation (C) is a result of the combination of equations (A) and (B).



The equilibrium constant *K_a* of equation (A) can be calculated with the following formula:



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$$K_a = \frac{\gamma_{H^+} \cdot [H^+] \cdot \gamma_{CO_3^{2-}} \cdot [CO_3^{2-}]}{\gamma_{HCO_3^-} [HCO_3^-]}$$

where:

γ_{H^+} = activity coefficient for hydrogen ion

$\gamma_{CO_3^{2-}}$ = activity coefficient for carbonate

$\gamma_{HCO_3^-}$ = activity coefficient for bicarbonate

$[H^+]$ = concentration of hydrogen ion

$[CO_3^{2-}]$ = concentration of carbonate

$[HCO_3^-]$ = concentration of bicarbonate

The equilibrium constant K_{sp} of equation (B) can be calculated with the following formula:

$$K_{sp} = \gamma_{Ca^{2+}} \cdot [Ca^{2+}] \cdot \gamma_{CO_3^{2-}} \cdot [CO_3^{2-}]$$

where:

K_{sp} = solubility product constant

The equilibrium constant K of equation (C) can be calculated with the following formula:

$$K = \frac{K_{sp}}{K_a}$$

From this point until the formula of pH_s you only have to use mathematics.

$$K = \frac{K_{sp}}{K_a} = \gamma_{Ca^{2+}} \cdot [Ca^{2+}] \cdot \gamma_{CO_3^{2-}} \cdot [CO_3^{2-}] \cdot \frac{\gamma_{HCO_3^-} \cdot [HCO_3^-]}{\gamma_{H^+} \cdot [H^+] \cdot \gamma_{CO_3^{2-}} \cdot [CO_3^{2-}]}$$

Simplify



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$$K = \frac{\gamma_{Ca^{2+}} \cdot [Ca^{2+}] \cdot \gamma_{HCO_3^-} \cdot [HCO_3^-]}{\gamma_{H^+} \cdot [H^+]}$$

If $X=Y$ then $\log(X) = \log(Y)$ So:

$$\log(K) = \log\left(\frac{\gamma_{Ca^{2+}} \cdot [Ca^{2+}] \cdot \gamma_{HCO_3^-} \cdot [HCO_3^-]}{\gamma_{H^+} \cdot [H^+]}\right)$$

$\log(X \cdot Y) = \log(X) + \log(Y)$ and $\log(X/Y) = \log(X) - \log(Y)$ so:

$$\log(K) = \log(\gamma_{Ca^{2+}} \cdot [Ca^{2+}] \cdot \gamma_{HCO_3^-} \cdot [HCO_3^-]) - \log(\gamma_{H^+} \cdot [H^+])$$

$$\log(K) = \log(\gamma_{Ca^{2+}} \cdot [Ca^{2+}]) + \log(\gamma_{HCO_3^-} \cdot [HCO_3^-]) - \log(\gamma_{H^+}) - \log([H^+])$$

$$\log([H^+]) = \log(\gamma_{Ca^{2+}} \cdot [Ca^{2+}]) + \log(\gamma_{HCO_3^-} \cdot [HCO_3^-]) - \log(\gamma_{H^+} \cdot K)$$

$$-\log([H^+]) = -\log\left(\frac{\gamma_{Ca^{2+}} \cdot [Ca^{2+}] \cdot \gamma_{HCO_3^-} \cdot [HCO_3^-]}{\gamma_{H^+} \cdot K}\right)$$

The formula for pH_s is then:

$$pH_s = -\log\left(\frac{K_a \cdot \gamma_{Ca^{2+}} \cdot [Ca^{2+}] \cdot \gamma_{HCO_3^-} \cdot [HCO_3^-]}{\gamma_{H^+} \cdot K_{sp}}\right)$$

If you have a water analysis de calcium and bicarbonate concentration are known so you have to calculate the activity coefficients. These coefficients are approximately equal to one but it is better for the accuracy of pH_s to calculate them.

The activity coefficient can be calculated by the following formula:

$$\log(\gamma) = -\frac{0,5 \cdot (Z_i)^2 \cdot \sqrt{I}}{1 + \sqrt{I}}$$



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where:

γ = activity coefficient

I = ionic strength of the solution here water

Z_i = charge on ith ionic species

$$\gamma = 10^{-\frac{0,5 \cdot (Z_i)^2 \cdot \sqrt{I}}{1 + \sqrt{I}}}$$

The ionic strength can be calculated with the following formula:

$$I = 2,5 \cdot 10^{-5} \cdot TDS$$

where:

TDS = Total Dissolved Solids in mg/L or g/m³

All the parameters are now known and the Langelier Saturation Index can be calculated:

$$LSI = pH + \log \left(\frac{K_a \cdot \gamma_{Ca^{2+}} \cdot [Ca^{2+}] \cdot \gamma_{HCO_3^-} \cdot [HCO_3^-]}{\gamma_{H^+} \cdot K_{sp}} \right)$$

The equilibrium constants K_a and K_{sp} change with temperature. The following values for the equilibrium constants are given in [1]:

Temperature °C	$K_a \cdot 10^{11}$	$K_{sp} \cdot 10^9$
5	2,754	8,128
10	3,236	7,080
15	3,715	6,020
20	4,169	5,248
25	4,477	4,571
40	6,026	3,090

The relation between the constant solubility product K_{sp} of calcium carbonate and temperature is as follows

$$K_{sp} = 9,237 \cdot e^{-0,0277 \cdot T}$$

This equation is found by adding an exponential trendline in the graph of the solubility product constant as a function of the temperature in degree Celsius.

The relation between the equilibrium constant K_a of carbonate/bicarbonate (CO_3^{2-}/HCO_3^-) and temperature is as follows:

$$K_a = 9,2 \cdot 10^{-13} \cdot T + 2,3 \cdot 10^{-11}$$



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References:

[1] :Metcalf & Eddy, Inc. Wastewater Engineering Treatment and Reuse, Fourth Edition

Read more: <http://www.lenntech.com/ro/index/langelier-explanation.htm#ixzz2DEQFpDGR>

A simple calculation:

$$LSI = pH - pHs$$

pH is the measured water pH

pHs is the pH at saturation in calcite or calcium carbonate and is defined as:

$$pHs = (9.3 + A + B) - (C + D)$$

Where:

$$A = (\text{Log}_{10} [\text{TDS}] - 1) / 10$$

$$B = -13.12 \times \text{Log}_{10} (\text{oC} + 273) + 34.55$$

$$C = \text{Log}_{10} [\text{Ca}^{2+} \text{ as CaCO}_3] - 0.4$$

$$D = \text{Log}_{10} [\text{alkalinity as CaCO}_3]$$

Understanding LSI

The **LSI** is probably the most widely used indicator of cooling water scale potential. This index indicates the driving force for scale formation and growth in terms of pH as a master variable. In order to calculate the LSI, it is necessary to know the alkalinity (mg L^{-1} as CaCO_3 or calcite), the calcium hardness (mg L^{-1} Ca^{2+} as CaCO_3), the total dissolved solids (mg L^{-1} TDS), the actual pH, and the temperature of the water ($^{\circ}\text{C}$).

The Saturation Index is typically either negative or positive and rarely 0. A Saturation Index of zero indicates that the water is “balanced” and is less likely to cause scale formation. A negative LSI suggest that the water is under saturated with respect to carbonate equilibrium and the water may be more likely to have a greater corrosive potential..

Corrosive water can react with the household plumbing and metal fixtures resulting in the deterioration of the pipes and increased metal content of the water. This reaction could result in aesthetic problems, such as bitter water and stains around basins/sinks, and in many cases elevated levels of toxic metals. A positive SI suggests that water may be scale forming. The scale, typically a carbonate residue, could clog or reduce the flow in pipes, cause buildup on hot water heaters, impart an alkali taste to the water, reduce the efficiency of the water heaters, and cause other aesthetic problems.

The LSI indicates three situations:



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- If LSI is negative: No potential to scale, the water will dissolve CaCO_3
- If LSI is positive: Scale can form and CaCO_3 precipitation may occur
- If LSI is close to zero: Borderline scale potential