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# Modelling the country's canal network using Aquator

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# Overview

- The previous models used
- An introduction to locks
- The Aquator lock component
- Overview of progress and challenges
- Next steps



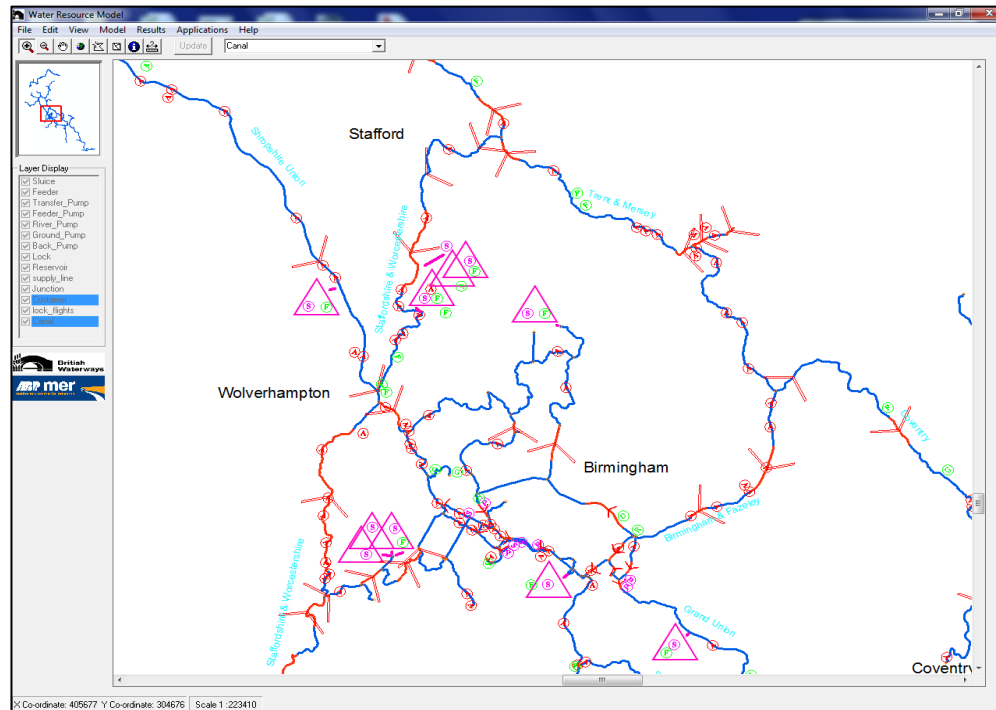
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# Previous model



# Previous model



- High risk – completely bespoke code
- Little visibility
- Chasing errors very difficult
- Changes to the model configuration restrictive
- Slowly becoming obsolete, updating would be expensive
- Run times poor

# Technical requirement

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- Water resources model
- Ability to model water movement through locks
  - Various different components
  - Interaction with canal pounds
- Flexible
- Support
  - Developer
  - Industry use
- No need for hydraulic transfers
- Transparent





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# An introduction to locks



# An introduction to locks

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Flow



Elevation change



Plan view



# An introduction to locks

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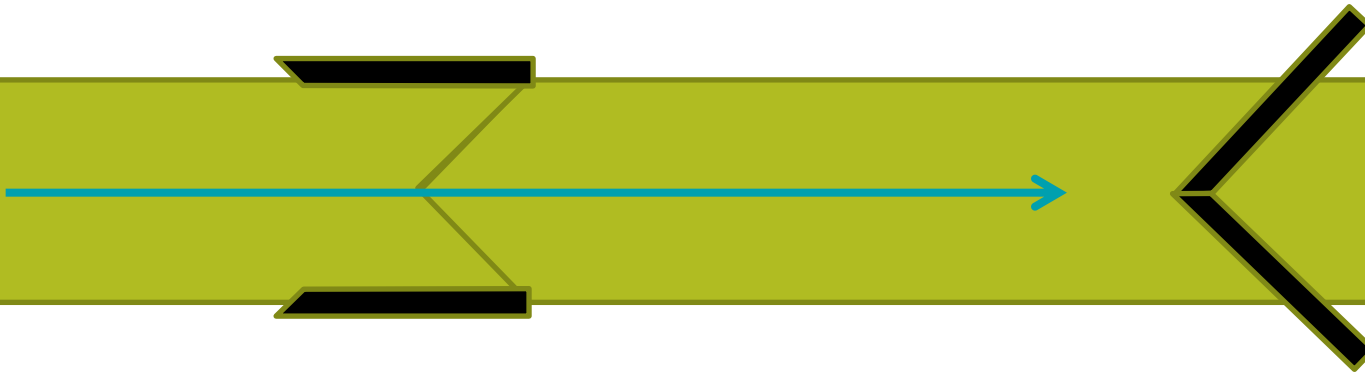
# An introduction to locks

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Flow



Lockage



# An introduction to locks

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Flow



Leakage through gates



# An introduction to locks

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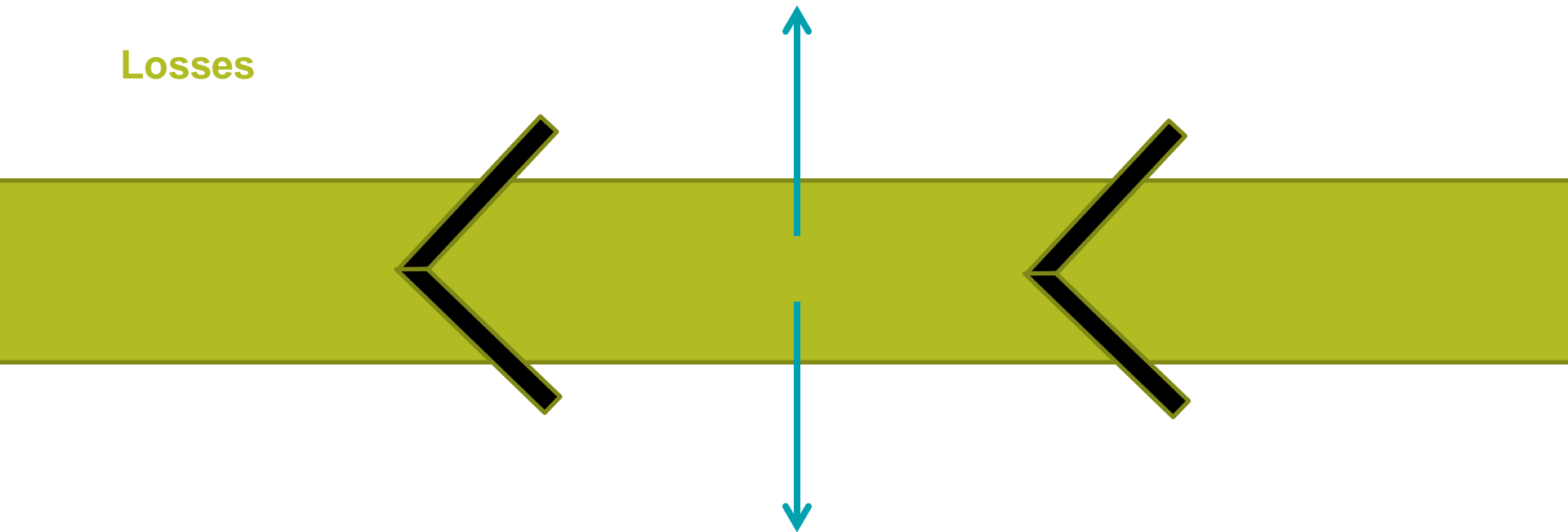
# An introduction to locks

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Flow



Losses





# An introduction to locks

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Flow



Bypass flow (or sluice)



# An introduction to locks

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Flow



Weiring over gates



# An introduction to locks

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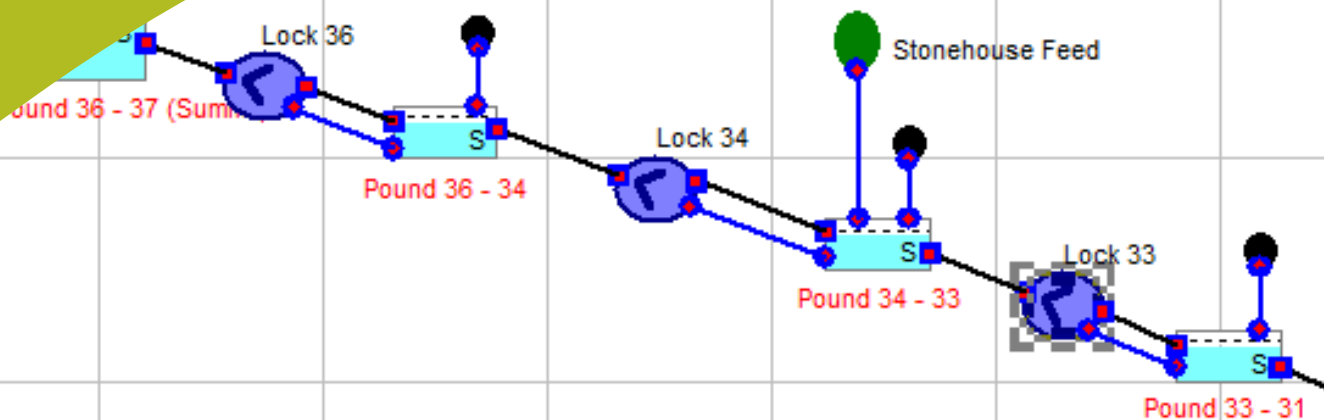




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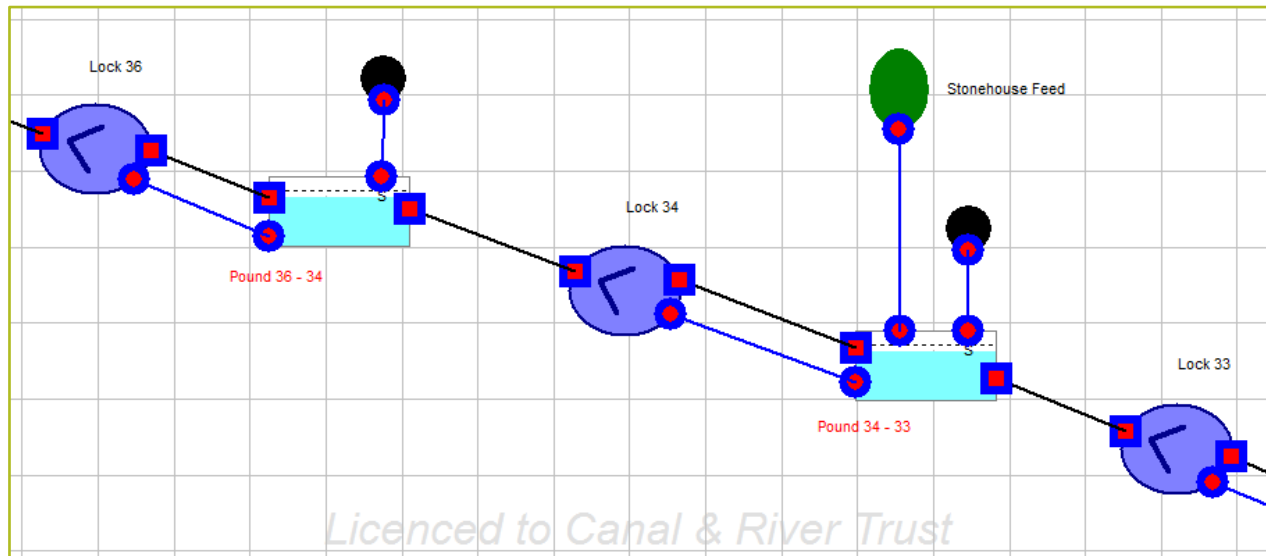
# The Aquator lock component





# The Aquator lock component

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# The Aquator lock component

Lock setup: Lock 34 (LC34)

Summary Lock Leakage Losses By weir Sluice Gates Paddles Back pump Ordering

	Present	Use	Status
Lock	Yes	Yes	OK
Leakage	No	n/a	n/a
Losses	No	n/a	n/a
By weir	Yes	Yes	OK
Sluice	No	n/a	n/a
Gates	Yes	Yes	OK
Paddles	Yes	Yes	OK
Back pump	No	n/a	n/a

☐ Allow VBA to be altered  
This component must be 'Customized' first to allow VBA code control

OK Close

# The Aquator lock component

Lock setup: Lock 34 (LC34)

Summary **Lock** Leakage Losses By weir Sluice Gates Paddles Back pump Ordering

Volume (Ml)

Pound floor elevation (maOD)  
(Bottom line in the diagram below)

Annual lockage

Lockage method

Steps per day for weir flow calculation

Warning Levels (maOD)

Coping level  
(upper warning level)

Standard navigational depth  
(lower warning level)

The diagram illustrates a cross-section of a lock. A horizontal blue line represents the water level. Above this line, there are two points labeled 'd, maOD' and 'x, maOD'. Below the water level, there are two points labeled 'n, m' and 'p, m'. To the right of the lock, there is a point labeled 'v, maOD'. The distance between the water level and the bottom line is labeled 'h1, m'. The bottom line is a horizontal black line.

Profile named 'Northern Lockage Sclar' is providing the lockage distribution

☐ Allow VBA to be altered  
This component must be 'Customized' first to allow VBA code control

OK Close

# The Aquator lock component

Lock setup: Lock 34 (LC34)

Summary Lock Leakage Losses **By weir** Sluice Gates Paddles Back pump Ordering

☒ Present  
☒ Use

Datum level (maOD) (crest elevation) 175.590  
 Max capacity (Ml/d) 100.000  
 Flow scale factor 1.000

Formula Test  
 Head above crest (m) 0.000 --> Calculated flow (Ml/d)

Formula  
 Hydraulic formula Standard By-Weir  
 VBA formula name Standard ByWeir

Parameters

Parameter	Description	Range	Value
[01] b	Effective weir breadth (perpendicular to flow), m	Not set	4.560
[02] C2	Coefficient	0.6 - 0.7	0.610
[03] s	Slot height, m	Not set	0.140
[04] L	Length of weir in direction of flow, m	Not set	0.280
[05] P	Height of crest above pound base, m	Not set	1.300

[01] b =

Where  $x < v + s$ :  

$$Q_c = (2/3)^{3/2} g^{1/2} C_{1b} b h_I^{3/2}$$

Where  $x \geq v + s$ :  

$$Q_c = C_2 b s (2g)^{0.5} (h_I - 0.5s)^{0.5}$$

Notes

Note that the flow equations assume modular flow. If you suspect that flow at a specific by-weir is non-modular within the expected range of flows (and the difference will be significant), then a rating should be derived and the standard equations not used. As Aquator does not calculate in-pound hydraulic gradients (modelled as reservoirs with single water level), all by-weirs are treated as transverse and not side weirs.

☐ Allow VBA to be altered  
 This component must be 'Customized' first to allow VBA code control



# The Aquator lock component

Key storages		Level data table			
Row	Level (m)	Area (sq km)	Storage (Ml)	Seepage (Ml/d)	Spill (Ml/d)
1	100.000	0.196616	294.92	0.00	58.980
2 (TWL)	99.700	0.196616	235.94	0.00	0.000
3	98.500	0.196616	0.00	0.00	0.000

Edit Spill (VBA).Equation parameters (VBA)					
	Datum (m)	Width (m)	Slot Height (m)	Le	
1	99.700	3.630	0.000		OK
2	99.830	7.000	0.000		Cancel
3	99.810	8.760	0.000		Help
4	99.800	9.200	0.000		

Lock setup: Lock 65 (LC50)

Summary Lock Leakage Losses **By weir** Sluice Gates Paddles Back pump Ordering

Present ☒ Datum level (m aOD) (crest elevation) 99.630  
 Use ☒ Max capacity (Ml/d) 100.000  
 Flow scale factor 1.000

Formula Test  
 Head above crest (m) 0.000 --> Calculated flow (Ml/d)

Formula  
 Hydraulic formula Standard By-Weir  
 VBA formula name Standard ByWeir

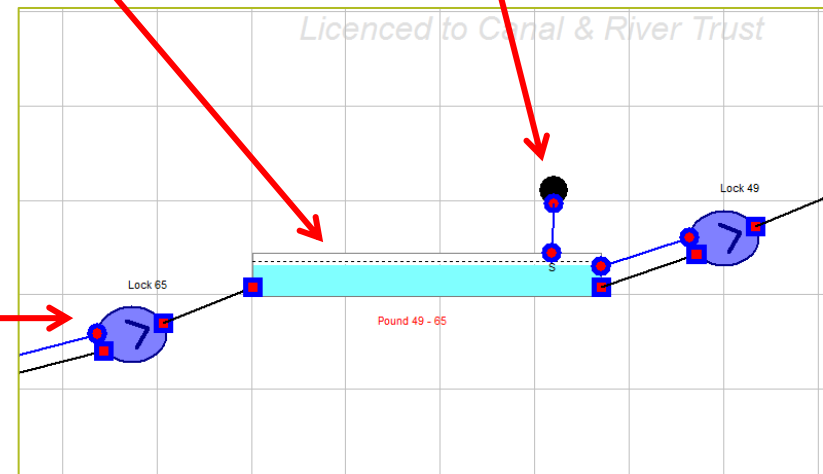
Parameters

Parameter	Description	Range	Value
[01] b	Effective weir breadth (perpendicular to flow), m	Not set	4.100
[02] C2	Coefficient	0.6 - 0.7	0.610
[03] s	Slot height, m	Not set	0.000
[04] L	Length of weir in direction of flow, m	Not set	1.500
[05] P	Height of crest above pound base, m	Not set	1.300

[01] b = 4.100

Notes  
 Note that the flow equations assume modular flow. If you suspect that flow at a specific by-weir is non-modular within the expected range of flows (and the difference will be significant), then a rating should be derived and the standard equations not used. As Aquator does not calculate in-pound hydraulic gradients (modelled as reservoirs with single water level), all by-weirs are treated as transverse and not side weirs.

☐ Allow VBA to be altered  
 This component must be 'Customized' first to allow VBA code control





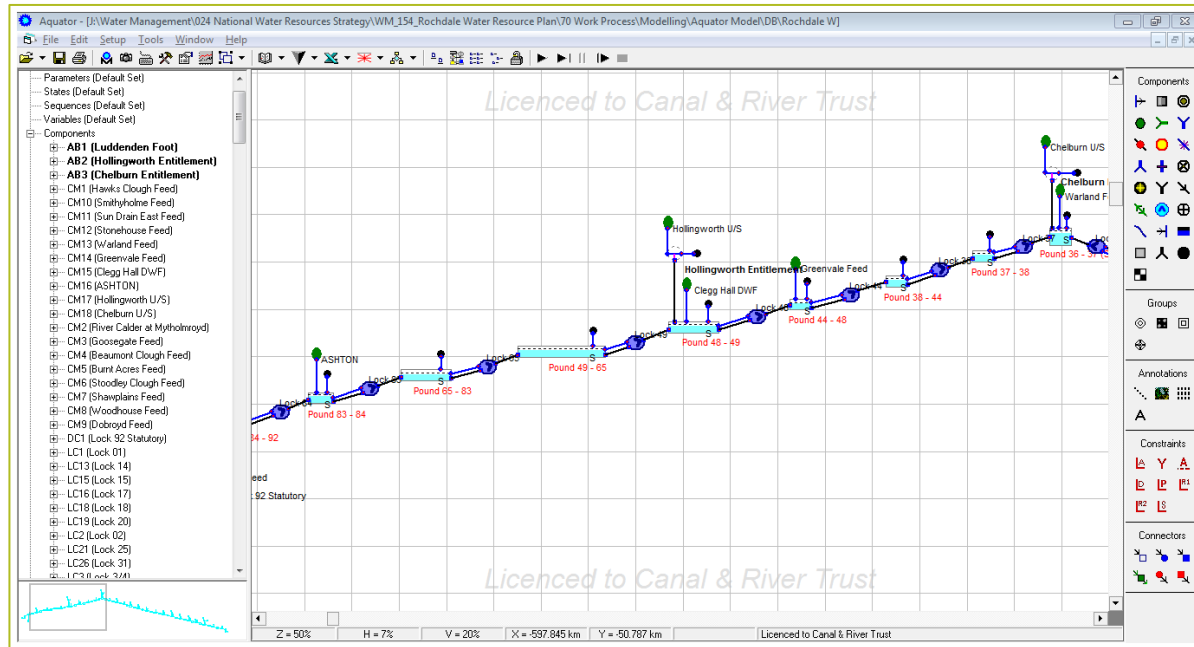
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# Progress & challenges



# Progress & challenges



## Progress

- Design and development
- Testing
- Model build – Rochdale
  - 25 locks (92), 24 pounds (91), 17 feeders, 3 entitlements
- Model runs, some issues to be resolved

## Challenges

- Data collation
- Only previously had a spreadsheet model
- Learning Aquator & lock component
- Configuration,
  - feeders as full available or entitlement?
  - Small storage in pounds

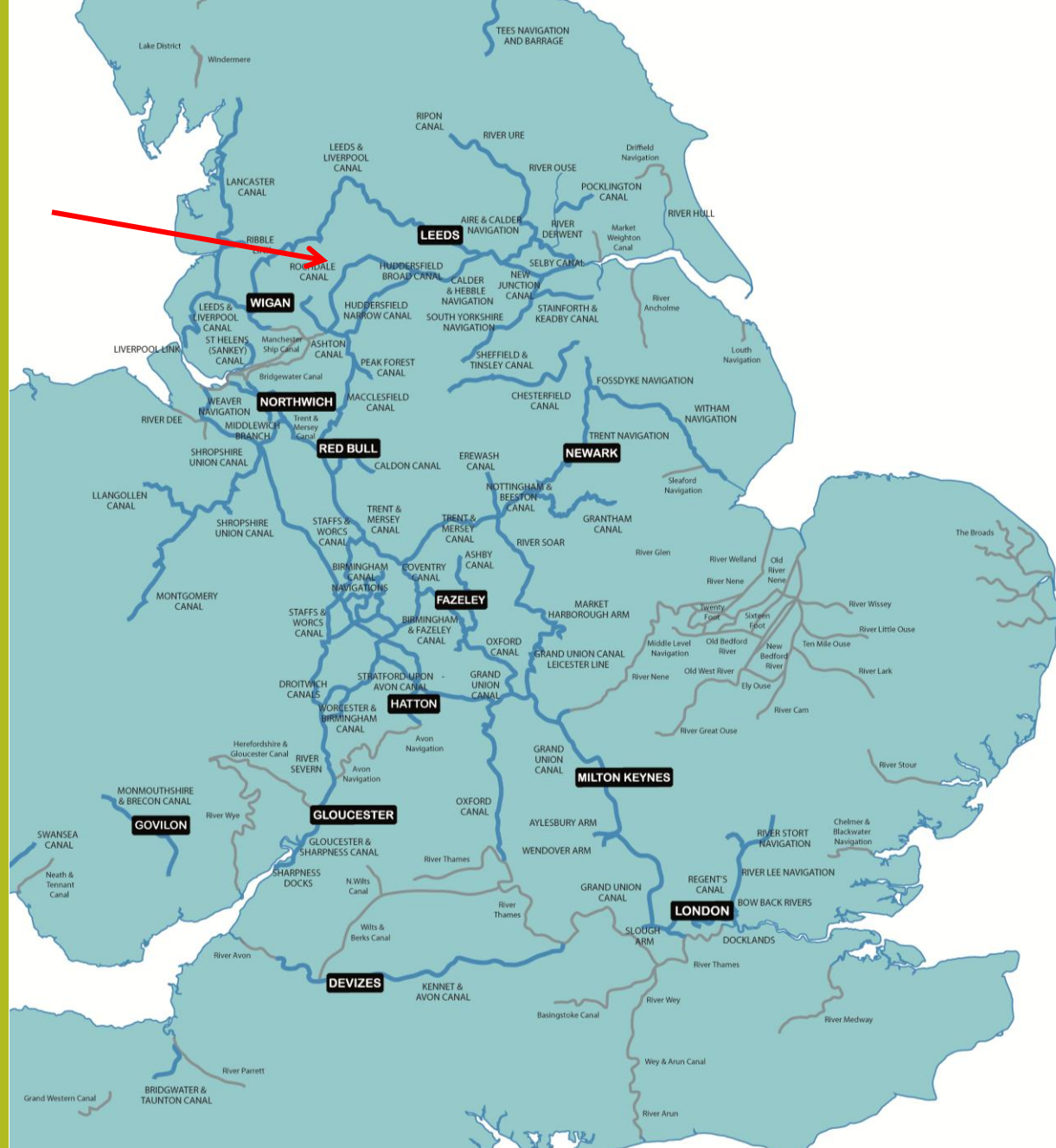
# Next steps

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- Refine the Rochdale model
  - Use early models to refine configuration of locks
  - And pounds
  - Accounting for waste (out of system)
  - Reporting
- Calibration
  - Using data from the SCADA network
- Develop Grand Union South
- Merging models into composite database
  - And then connecting up the network



# Rochdale Canal



## Map Key

- Canal & River Trust offices
- Canal & River Trust waterways
- AINA waterways



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# Aquator User Group – 2013

## Modelling the country's canal network using Aquator

Part 2: How the Lock component works within Aquator

Chris Green (OSS Ltd)

# The Canal & River Trust Aquator Lock Component

- The most complicated Aquator component ☹️
- Has both river and supply functionality ☹️
- Two types of water movement – always moved and optional ☹️
- Requires passes both down the canal system and up the system ☹️
- Sub daily calculation of weir flows ☹️

# The Canal & River Trust Aquator Lock Component

Two types of water movement – **always moved** and **optional**

**Always moved** (e.g. Lockage, by-weir flow)

Calculations proceed down the system from top to bottom early in the day

Canal now possibly in an imbalanced state

**Optional** (e.g. Sluice, back pumps and sometimes Paddles)

Calculations proceed up the canal system from bottom to top restoring the balance  
(using pound resource state)

# The Canal & River Trust Aquator Lock Component

Two types of water movement – **always moved** and **optional**

**Always moved** (e.g. Lockage, by-weir flow)

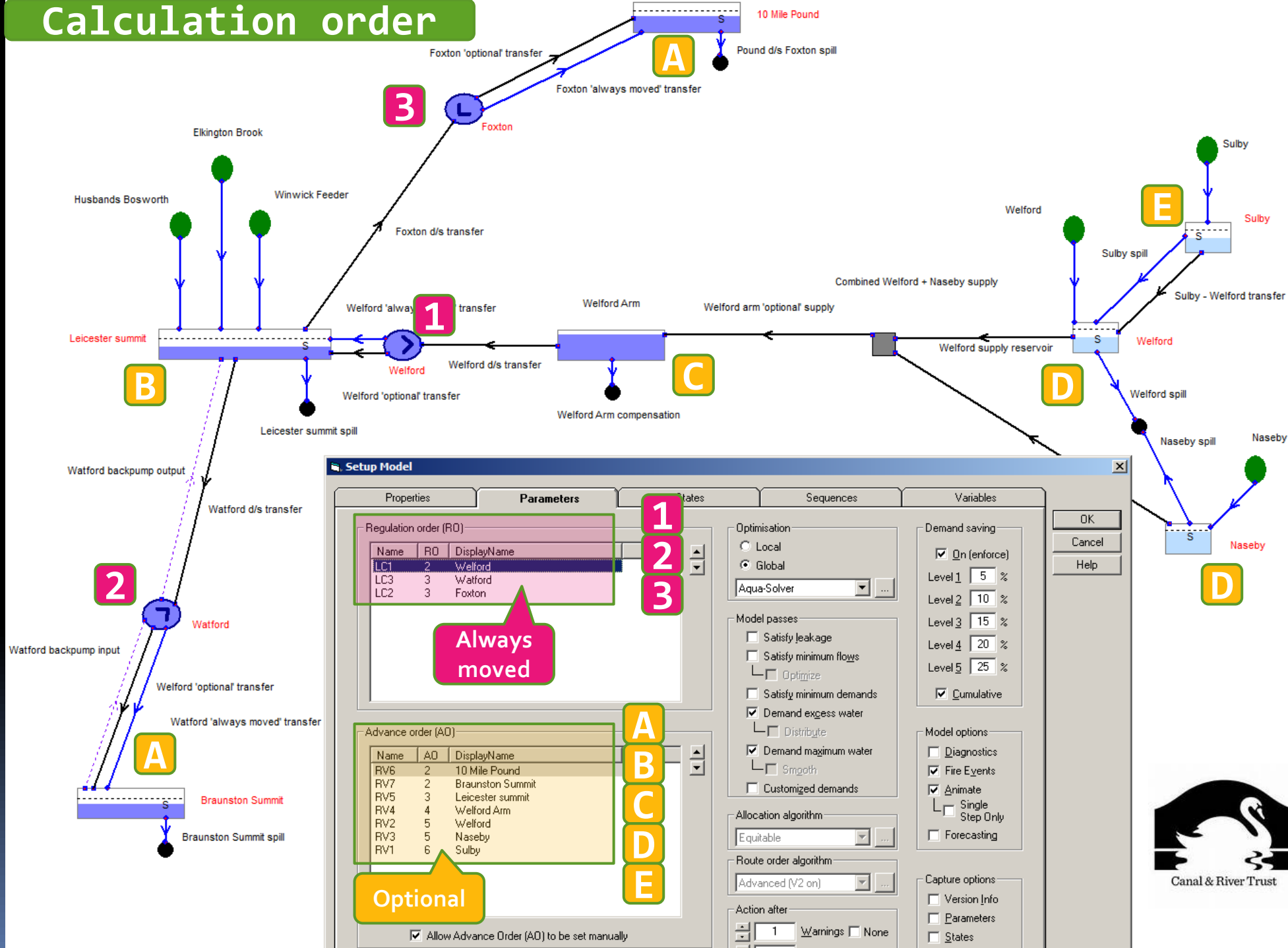
During Aquator's river regulation phase using Regulation Order (RO)

**Optional** (e.g. Sluice, back pumps and sometimes Paddles)

During Aquator's demand meeting phase using Advance Order (AO)



# Calculation order



# The Canal & River Trust Aquator Lock Component

Lock setup: Welford (LC1)

SummaryLockLeakageLossesBy weirSluiceGatesPaddlesBack pumpOrdering

This tab applies to all Locks and Reservoirs (pounds) within the model

Daily calculations take place in the following order:

(1) Reservoirs receive catchment inflow, rainfall & evaporation

(2) Aquator's river regulation phase: Starting with the topmost lock and then progressing d/s, locks should push the 'always moved' water to the pound below.  
This order is important and is currently:


Index	Order	Name	Display name
1	2	LC1	Welford
2	3	LC2	Foxtan
3	3	LC3	Watford

(3) Any demand centres in the model try and meet their demand

(4) Reservoirs (pounds) try and fill themselves to their 'fill' curves from other sources (e.g. 'optional' water from the u/s pound or back pumps).  
This order is important (starting with lowermost pound and then working upstream). It is currently:

Index	Order	Name	Display name
1	2	RV6	10 Mile Pound
2	2	RV7	Braunston Summit
3	3	RV5	Leicester summit
4	4	RV4	Welford Arm
5	5	RV2	Welford
6	5	RV3	Nasehv

(5) Reservoirs (pounds) spill if over full

The 'Order' button below can attempt generating the correct order for (2) and (4) above provided that 'Allow Advance Order (AO) to be set manually' is ticked ( ☒ Allow Advance Order (AO) to be set manually ) on the 'Parameters' tab of the Model Setup form: 

Start Regulation Order 

2

Order

If this automatic ordering does not work correctly use the Model Setp form, tick 'Allow Advance Order (AO) to be set manually', and use that form to define the order.

