Introduction to Active System Management

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Benefits of active management

- Reduction of flood risk.
- Protection of quality of water courses.
- Reduction of infiltration into the sewerage system.
- Maximising use of existing capacity to allow flows from new development.
- Making river flood defences more effective by closing outfall pipes to prevent reverse flow.
- Reduction of carbon footprint.

Framework for management

Knowing what is happening							

Decisions and actions

Knowing what is happening							
	Fast forecast model						
	Fast predictive model						
	Forecast model						
	Predictive model						
	Global data analysis						
	Local predictive						
	Local reactive						

Decisions and actions

Timescale of decisions

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- **Reactive Control**
  - makes control decisions based on current conditions in the sewers, or possibly rainfall or other system state.
- **Predictive control**
  - uses conditions in the sewerage system in the very recent past, the present and predictions of the very near future to improve control.
  - Timespan of one hour based on the rate of change of flow or level in the sewers or on rainfall that has already fallen.
- **Forecasting control**
  - uses longer term predictions covering several hours. These could be based on rainfall measurement using radar or on short term rainfall forecasts.
  - Rainfall forecasting techniques now exist that can provide between 1 and 6 hours forecast for rainfall across a catchment.

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Knowing what is happening	Fast forecast model						
	Fast predictive model						
	Forecast model						
	Predictive model						
	Global data analysis						
	Local predictive						
	Local reactive						
		Warnings	Dispatch	Operator	Local rules	Area rules	Optimiser
		Decisions and actions					

Method – how to make a decision

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- A **simple threshold trigger**

If this then that

- respond to conditions at a single location based on a critical threshold

- **A pre-defined matrix of decisions**

If this and this and this then that (and that)

- Combine a range of triggers to make a decision in the context of what is happening.

- **An event-specific optimised decision using**

Given all of that; what is the best decision

- Constantly analyse many potential solutions and choose the "best".

How to take actions

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- Pumping Stations (PSs)
- Combined Sewer Overflows (CSOs)
- STWs
- Storm Attenuation Tanks (Offline & Online)
- Bifurcations
- Sluice Gates In Trunk Sewers

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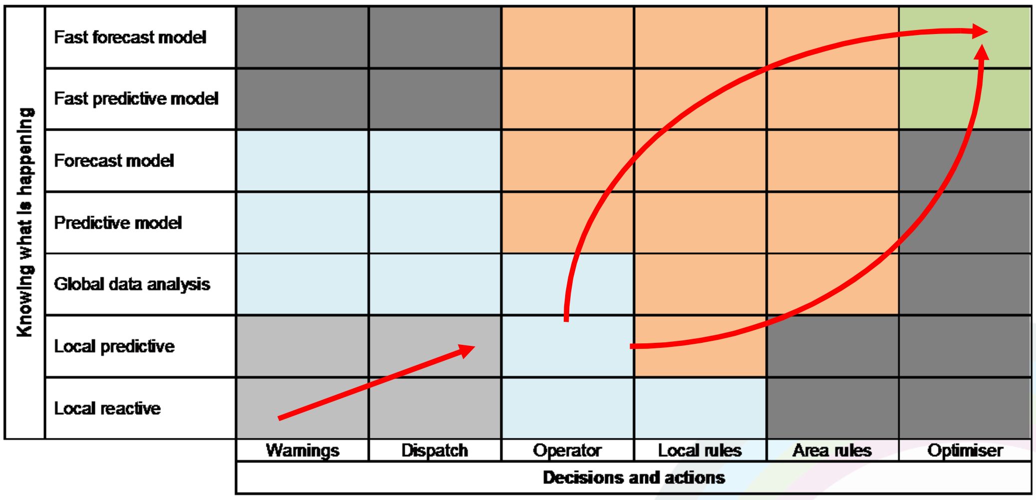
The road map



Keep the solution as simple as possible.

There are two routes to complexity – increasing knowledge or increasing action. Which is right for your catchment?

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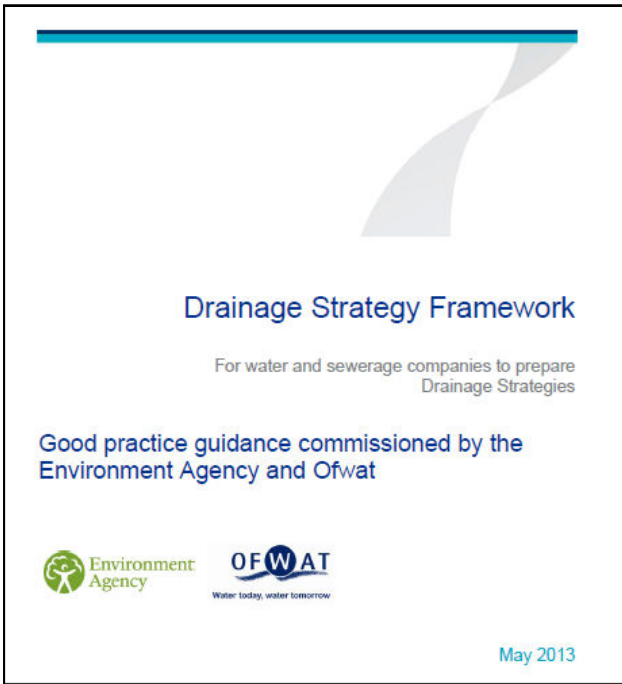
Examples of active control

- Inhibiting pumps from running when sewers or storage downstream is full.
- Starting pumps early when flows are increasing rapidly.
- Inhibiting pumps when energy costs are high and running them when costs are low.
- Holding back flows at high tide levels to reduce infiltration.
- Control gates to hold back flow to fill in-system storage when downstream levels increase.
- Control gates to retain flow in the system rather than overflowing and so meet ammonia standards in the receiving water.
- Just-in-time sewer cleansing


Drainage Strategy Framework

For water and sewerage companies to prepare Drainage Strategies

Good practice guidance commissioned by the Environment Agency and Ofwat

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- Consult stakeholders
- Set the planning horizon
  - Growth
  - Climate
  - Strategy
- Set performance targets
  - Flooding
  - River quality
  - Bathing water
- Develop outline options
- Select best option

Hierarchy of targets

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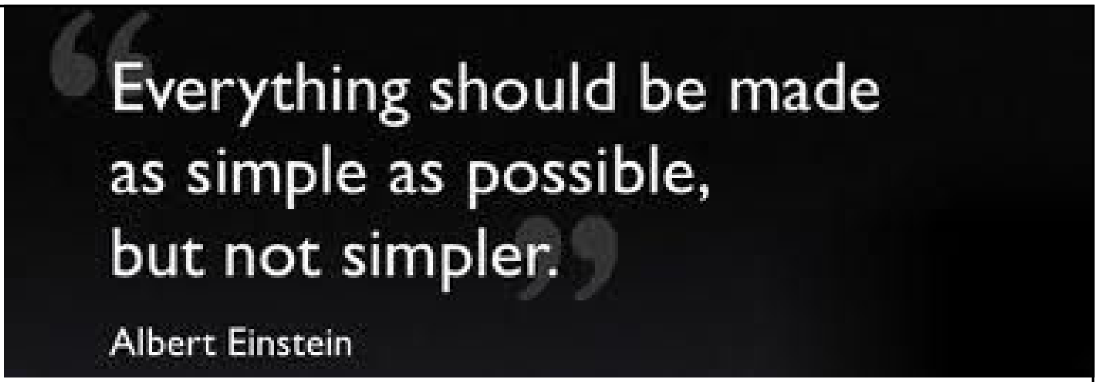
- No flooding until all CSOs are at maximum
- No spill until all tanks are at maximum
- No storage until treatment works is at maximum

- Use minimum energy
- Avoid septic sewage (long storage times)
- Maintain self cleansing velocities



- Start with local – reactive
- Only add more complexity if it makes the system better
- Not usually need to go beyond area – predictive

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Potential sensors

- Measures
  - Level (depth)
  - Date and time
  - Time since …
  - Status or position of a regulator
  - Rainfall (10 minute average intensity)
  - Velocity, flow
  - Concentration - sediment, ammonia
- Rate of change
  - Level (depth)
  - Flow

Potential control structures

• Fixed pump	On – off
• Variable capacity pump	On - off and capacity (m3/s)
• Variable limiting discharge orifice	Maximum discharge (m3/s)
• Variable crest weir	Crest level (m AD)
• Variable width weir	Width (m)
• Variable opening gate	Vertical opening (m)

Optioneering – develop options

- Start simple
- Controllers - for optioneering use simple idealised controls
  - Limiting discharge rather than moving a gate
  - Build predictive control rules based on rate of change of level
  - Don't use PID controllers
- Remember to reverse the action. For example:
  - Close Gate A when flooding is imminent
  - But when do you open it again?

Predictive rules

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- In InfoWorks variables can be used to calculate derived variables

- Define two ranges

Range	LevelA	the level at point A
Range	DLevelA	the rate of change of level at point A

- Variable D10A the change in level over 10 minutes
  Variable D10A = DLevelA * 600

- Variable FutureA the likely level at A in 10 minutes
  Variable FutureA = LevelA + D10A

Optioneering – assess options

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- Normal practice is to assess using a wide range of return periods and durations of design storms
  - A good ASC system will be more robust over a wide range
  - A poor ASC system will be less robust
  - Test both passive and ASC solutions over a very wide range
  - Best practice is to also test with rainfall timeseries
  - For large catchments using spatially varied rainfall may show even more benefits for ASC

Where can it be improved

- Flooding when not all pumps are running and not all storage is full
- CSO spill when not all storage is full

- Develop area rules, predictive rules and matrix rules
- If necessary develop forecasting and optimisation systems

A warning from a project that went wrong

A large interceptor sewer draining to a terminal pumping station had a simple real time control system to inhibit the operation of the pumps when the downstream levels were high so forcing the tunnel to fill. However the design had not considered a situation where the inflow to the tunnel was greater than the design standard. This caused flooding. The tunnel had to be modified by addition of an overflow to spill in extreme conditions.

What can go wrong 2

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- A very large pumping station with several storm pumps. The pumping station is protected from flooding by closing gates on the inlet when levels reach the high level alarm
- If the levels rise rapidly in an intense storm, the alarm level is reached and the gates closed before the pumps have reached capacity – causing flooding upstream.
- The pump controller should use simple predictive control to start the pumps earlier when the level is rising rapidly.

Designing ASC

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- Sensors
- Communications
- Control structures
- Controllers
- Time delays
- Risk of failure
  - Design out risk
  - Assess residual risk (is it greater than a sewer blockage?)

Communications

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- Leased line
- Broadband
- Dial up
- Mobile – GSM or 3G
- Radio
- Backup system is probably required

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- Movement of control structures
- Polling interval for SCADA data
- *Timestep of radar rainfall*
- Optimiser run-time
- *Manual intervention*

A note on time delays

- The only part of the InfoWorks model that can represent a time delay is the regulator structure
  - Gates and weirs can have a speed of movement
  - Pumps can have a run-up time
- We need to load all of the system delays onto these components to represent the real world

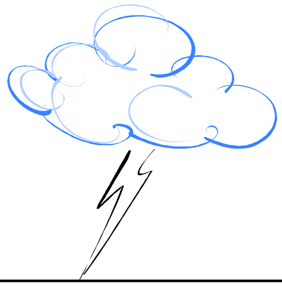
Designing – risk

- All sewerage schemes have a risk of failure
- Active control have more components to go wrong but:
  - Low probability for each failure
  - Monitoring tells the operator of failures
  - Backup systems are cheap and can keep things working

Probability					
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5
	1	2	3	4	5

Impact

- Exceedance
- Comms failure
- Power failure
- Mechanical failure
- Vandalism
- Hacking



Design out risk

- HAZOP techniques
  - Consider everything that could fail
  - How do you stop it having an impact
  - What is the action to reduce impact
- Assess residual risk
  - What is the probability of failure
  - What is the cost of the consequence
- Consider risks for passive systems as well!

Operation and maintenance

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- Maintenance strategy
- Operational response to failure
- Data capture
- Review and improvement

Golden rules

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- Know what you are trying to achieve
- Keep it simple stupid
- Think about what could go wrong
- Don’t panic!