

# Flow control & spillway systems reliability



USNRC - RIC  
Rockville, MD; March 2013

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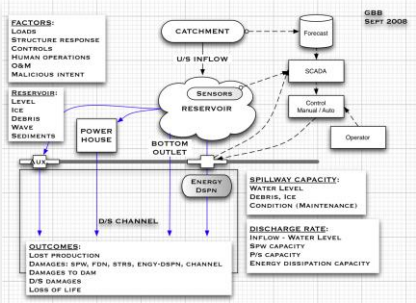
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Slide 2

# Systems thinking about flow control



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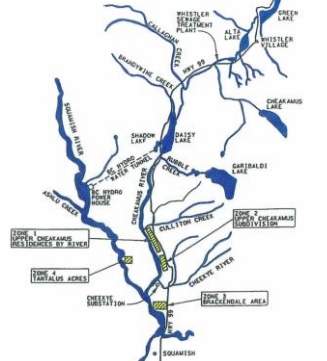
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Slide 3

# Regulated river systems



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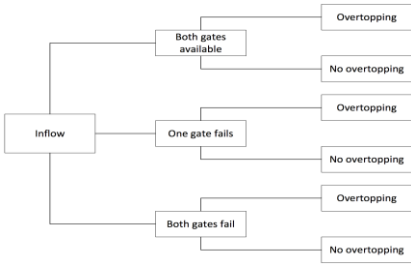
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### Flow control & dam safety



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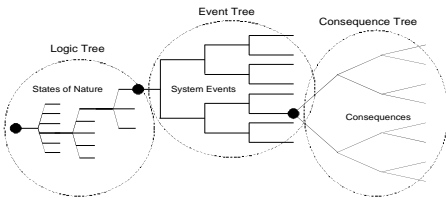
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### Systems thinking about flow control



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### Systems thinking about flow control

#### The uncommon combination of not-uncommon events

1. Extreme precipitation and high ground water level.
2. Mechanical fault in the hoisting equipment.
3. Difficulties using roads.
4. Telephone went dead.
5. Transmission poles fell, resulting in blackouts.
6. Occurred during the night.
7. Problems getting a mobile crane and crane operators.
8. Helicopters unable to fly.
9. The helicopter radio could only communicate with an airforce base – but not on Saturdays, when it is closed.
10. At Vässinkoski there were difficulties providing large capacity pumps.
11. Exhausted personnel.
12. Unforeseen high downstream water level, preventing normal opening of the gate in the diversion tunnel.
13. Complications when trying to drain the tunnels, since the raised upper water level surpassed the intake gate, filling the tunnels.
14. Staff problems – getting hold of qualified extra personnel to work 24-hour shifts during a weekend.

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### Systems thinking about flow control



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Slide 9

### Folsom Dam spillway failure 1995



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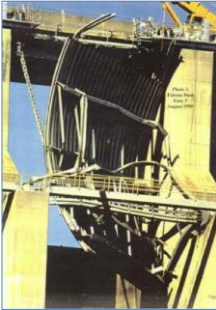
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### Folsom Dam spillway failure 1995



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### Statistics of dam failures

FAILURE	GRUNER 1967	MIDDLE- BROOKS 1953	TAKASE 1967	USCOLD 1975	BABB AND MERMEL 1968
Spillway capacity	23	30	28	38	36
Piping or seepage	40	38	44	44	30
Slides	2	15	10	9	15
Misc	35	17	18	9	19

Baecher, Pate, and de Neufville (1980), "Risk of dam failure in benefit-cost analysis," *Water Resources Research*, 16(3): 449-456

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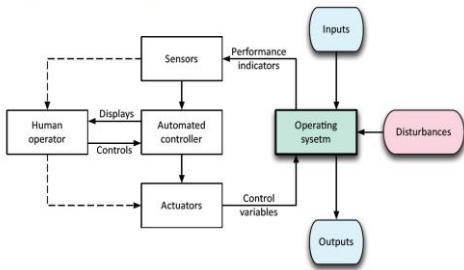
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### Systems thinking about flow control



Adapted from Levesen 2012

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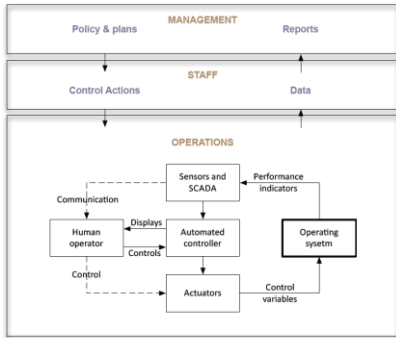
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### Systems thinking about flow control



Adapted from Leveson, 2012

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### Floating debris



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### Flow control & dam safety



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